**Vol. 1, No. 1 (August 1996)**: TNDM Casualty Forcasting in Bosnia, TNDM Revision History, Simulating Suppression, How the TNDM Measures Fortifications.

**Vol. 1, No. 2 (October 1996)**: Goose Green/Darwin 28 May 1982, Planned Improvements to the TNDM, Developing a Logistics Module for the TNDM, Validation of the TNDM at Battalion Level, What Happens When the Rate of Fire Goes to Zero?

**Vol. 1, No. 3 (December 1996)**: Modeling Operations Other Than War (OOTW), The Modern Contingency Operation Database, The Butterfly Effect in History, Dispersion Is Not Played in the TNDM, The Effect of Dispersion on Combat.

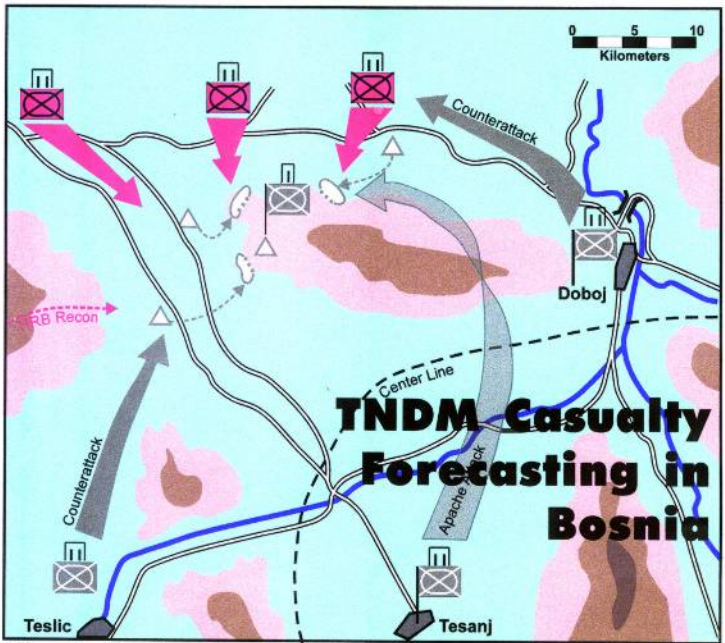
**Vol. 1, No. 4 (February 1997)**: Verification, Validation, and Accreditation (VVA), Military History and Validation of Combat Models, 76 & 112 Battalion-Level Battles, Casualties, Time, Winners and Losers Using BLODB, How to Run TNDM from Windows 3.1 and Win95.

**Vol. 1, No. 5 (April 1997)**: Survey of the Battle of Britain; Air Model Historical Data Study; The Dupuy Air Campaign Model; TNDM Validation: Predicting the Winners; TNDM Validation: Predicting Casualties.

**Vol. 1, No. 6 (June 1997)**: The Defense of Dï¿½m Butgenbach; CEV Calculations in Italy, 1943; Artillery Effectiveness versus Armor; Armor OLIs: Calculation and Correction; Use of Armor in the 76 Battalion-Level Engagements.

Volume 1, Number 1 August 1996

# THE INTERNATIONAL TNDM NEWSLETTER




## TNDM Casualty Forecasting in Bosnia

Also in this issue:

- TNDM Revision History
- Simulating Suppression
- How the TNDM Measures Fortifications

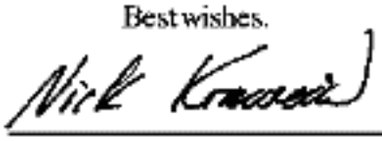
# INTRODUCTION

The most remarkable achievement of Colonel Trevor Dupuy as a military historian was the development of the Quantified Judgment Model (QJM) and later the Tactical Numerical Deterministic Model (TNDM). Underpinning these models with a vast amount of historical data and with some reasonably quanitifed judgments, Trevor pioneered history's entry into the world of social and behavioral science. He took the study of military history out of the realm of story telling and simplistic interpretation into a realm of systematic and impartial analysis of available recorded data. Over the years, the QJM and the TNDM have proven to be more faithful representations of what happened in the past or what could occur in future contemporary campaigns. Furthermore, historical data provided by The Dupuy Institute (TDI) is now being used to improve and validate two US Army combat simulation models.

Today, in tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. This newsletter provides information on these efforts.

All of us at TDI hope that this publication will be of use and interest to you, its readers. Your comments are welcome.

Best wishes.



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*Publisher*
The Dupuy Institute

*Editor*
Christopher A. Lawrence

*Production Manager*
Jay Karamales
Olórin Press

*Contributing Editors*
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

*Founder*
Col. Trevor N. Dupuy

*President*
Gen. Nicholas Krawciw

*Executive Director*
Christopher A. Lawrence

*Board of Directors*
George A. Daoust, chairman
Frances B. Kopper
John D. Kettelle
Nicholas Krawciw
James C. Pfautz
Abraham Wolf

*Administrative Offices*
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
73612.3222@compuserve.com

# From the Editor...

This is the first newsletter written as part of the Support Contract efforts for the TNDM. This newsletter will come out every two months, and will address topics and subject related to the TNDM and to modeling combat. It is a product of The Dupuy Institute, headed by Nicholas Krawciw, Major General, USA, Rtd. General Krawciw replaced Trevor N. Dupuy as president of the Institute after Trevor's unfortunate death in June of 1995. I will be serving as the editor of this newsletter until I can enlist a more qualified editor to take my place. This newsletter is intended to be a permanent part of our support efforts for the TNDM. In the past, Col. Dupuy took care of support activities as a labor of love.

Our support efforts over the next year will include trying to update the documentation on the model and making at least one revision to the model. We are also looking to establish a regular interface with all the users of the model so as to develop a dialog about its usage, problems and future development.

The Tactical Numerical Deterministic Model (TNDM) was created in 1990 and 1991 by Col. Dupuy. It was a new model that stemmed from the original Quantified Judgement Model (QJM) that Trevor had created in the early 1970s and documented in his book *Numbers, Predictions and War*. The Tactical Numerical Deterministic Model now consists of the following:

1. Computerized version 1.85, dated 23 June 1996
2. Manual of Rules and Procedures, dated October 1994
3. User's Guide, dated October 1994
4. Guide to TNDM Versions and Enhancements, dated 1 August 1996 (included in this newsletter)

If anyone who has a current support contract with The Dupuy Institute does not have the most recent editions of these, please contact me and we will forward updated versions to you immediately.

I expect this newsletter to evolve. I am very interested in knowing what you are looking for and need from the TNDM. I hope that I can improve this newsletter to better fulfill your needs, but we do need to know what those needs are.

One of the concepts behind the newsletter is that we are preparing it using much "off the shelf" material. In two of the articles of this issue, we wrote a brief introduction, explaining what the attached material is and where it came from. We then reprinted the material from the referenced study without any further editing. This allows us to minimize the effort to produce the newsletter.

This first issue is much thicker than originally planned. Part of this is due to the extensive multi-page history of the versions of the TNDM that José Perez produced. Since this may be a useful source document for some users, it was included here in its entirety. It is the only list showing the changes to the model since the documentation was last updated in October 1994.

"The Programmer's Cubicle" is intended to be a regular feature, and will address all the software concerns brought up by the people working with the software. José Perez, the column's editor, is intimately familiar with the model, having programmed the original QJM and the TNDM. He is *the* expert on all programming aspects of the model.

Also in this issue we have two papers prepared by David Bongard. The first paper describes how the TNDM was used to support the casualty estimates that we provided for the Joint Chiefs of Staff (JCS) for the Bosnia intervention. Included are the 18 pages from that report that relate to the TNDM. We have purposely left out any other material from the report, including our final estimates. We may release them at a later date.

The second paper is a discussion of how the TNDM is being used to support a study on the suppressive effects of artillery that is being done by JHF and TDI.

I have also added copies of the material that we prepared for a brief study on the effectiveness of mines that we did for the JCS. Prior to this study, I had never looked at how

the defensive factors in the TNDM were developed. This report may be enlightening for the reader.

To make sure that everyone involved in this effort is given their due, I wish to also thank Dr. George Daoust, our Chairman of the Board, for supporting the TNDM and his help with The Dupuy Institute; John Kettelle, Chairman of the Board of Advisors, for his continued contributions and alternative views; our office manager, Yun Zhang; and Jay Karamales, who produced the graphics for this newsletter and the excellent maps from the Bosnia study that are reprinted here.

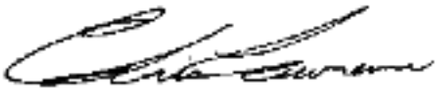
We expect all issues of the newsletter to be at least 20 pages, and knowing the inherent verbosity of most historians, we expect to regularly exceed that. I am also interested in any letters or contributions you may have for this newsletter. As this is a limited distribution newsletter, it is a good forum in which to develop and publish new ideas.

The next issue will include a description of the use of mines and fortifications at Kursk, including some measurement of their effectiveness; a discussion on the use of Lanchester equations in the TNDM; a discussion of the weather factors used in version 1.84 (The Swedish version); an analysis of Goose Green using TNDM and modern history; and a discussion of the improvements planned for the TNDM.

In future issues we are looking at including an article written by Col. Dupuy that has never been published called "Technology and the Human Factor in War." I have also talked to Dr. James Taylor about producing an article or two. He was the one who developed the application of the Lanchester equations as used in the TNDM. We will also have articles on model validation issues, reflecting "stealth" in TNDM OLIs, our first attempts to create an model of the Air Campaign, and Trevor's original analysis of what would be involved in creating a "Naval QJM." I am also trying to get some people in the operations research community to write up a critique of the TNDM. With RAND's permission, I will be assembling a brief description of the RAND Strategy Assessment System (RSAS). RSAS has a Main Theater Warfare Model that is very similar in concept to the TNDM and uses some factors adopted from the QJM. Finally, I expect to be publishing a series of preliminary papers and having an open discussion on how we can model low intensity operations, contingency operations, and peacekeeping operations. The TNDM is fundamentally designed for division-level force-on-force operations. Making estimations for casualties in peacekeeping operations like Bosnia requires looking at elements other than force-on-force models. We have already started work on some of these other methodologies.

Finally, thanks to Arnold C. Dupuy of NOVA Publications, we have arranged for everyone receiving this newsletter to also receive a copy of *If War Comes...How to Defeat Saddam Hussein*. This book came out 4 days before the start of the Gulf War air campaign in 1991 and provided the lowest public estimates of US losses in the Gulf War. These estimates were developed using the TNDM and is a very interesting book to read after the war. In exchange for his favor, I have included a copy of his current catalog with this mailing.

In the future, I will serve as the point of contact at The Dupuy Institute for all TNDM related questions. If you have any questions, please call me at (703) 356-1151.



# The TNDM and Casualty Forecasting for Bosnia Peacekeeping


**by Dave Bongard**

Late last autumn, The Dupuy Institute (TDI) prepared a brief study about potential casualties in a multinational peacekeeping operation in Bosnia. Part of the scenario TDI developed for the peacekeeping operation involved a relatively large-scale conventional attack by indigenous Bosnian Serb or Bosnian Moslem-Croatian forces against U.S. or NATO forces.

As part of the study, 15 TNDM runs were performed, each comprising 3 sub-elements to reflect the governing scenario. The scenarios varied considerably, on the basis of (1) enemy forces, either a "heavy brigade or a "light" brigade; (2) rolling rugged vs. rolling gentle terrain; (3) substantial, minor, and no surprise; (4) forest vs. "mixed" vs. open vegetation-ground cover.
[Slides 1 to 5]

The scenarios were separated into two groups: ten covering an attack on U.S. IFOR units by a renegade "heavy" (mechanized) brigade, and five dealing with a similar attack by a renegade "light" (non-motorized infantry) brigade, with a small mechanized battalion attached to the brigade. The U.S. forces were the same in all 15 scenarios.
[Slides 6 to 8]

Each scenario comprised a total of six hours of combat action. In the first ten scenarios, an indigenous mechanized brigade attacked a position heldby a U.S. company Task Force. In the first period (15 minutes) the US force received support from a direct-support 24-tube M-109A6 155mm howitzer battalion. The second period, of 45 minutes, saw the arrival of air support in the form of 4 F-16C fightera and an attack helicopter company (7 AH-64D attack and 4 OH-58D observation/reconnaissance helicopters). The third period, 5 hours long, covered the appearance of a "tank-heavy" company-sized reaction force dispatched from brigade headquarters, comprising 14 M-1A2 tanks, an M-2A2 mechanized infantry platoon, a section of 2 self-propelled 120mm mortars, 4 Avenger AD HMMWVs, and 8 "heavy" recon HMMWVs with machineguns and 40mm automatic grenade launchers. That force had 8 F-16C and 4 A-10 aircraft in support, along with a second attack helicopter company.

U.S. forces received a 1.5 Combat Effectiveness Value (CEV), reflecting superior doctrine, training, leadership, and C3I. This could easily be a conservative estimate, considering the evident 3.0-4.0 CEV which Coalition had over the Iraqis during the Kuwait War of January-February 1991.
[Slide 9]

The indigenous mechanized or "heavy" brigade contained about 2,200 personnel. Among its major weapons were 35 T-72 tanks, 40 BMP-2 type IFVs, 40 tracked APCs, 6 self-propelled and 12 towed 122mm howitzers, 6 120mm mortars, 4 SA-9 SAMs, and 16 20mm and 30mm AA guns.
[Slides 10, 12-15]

The other five scenarios concerned an attack by an indigenous infantry brigade against a US strongpoint held by a standard mechanized infantry company task force. The infantry brigade contained roughly 1,800 personnel, and disposed of 16 105mm howitzers, 8 76mm mountain guns, 21 60mm and 81mm mortars, 12 20mm AA guns, and a small mechanized force with 10 T-72 tanks and 30 IFVs and APCs. The event sequence for the "light" brigade attack is slightly different than in the first 10 scenarios.
[Slides 11, 16-18]

The conditions and results of the TNDM runs for the two scenarios are outlined on Slides 19 and 20. Unlike ordinary TNDM outputs, the data presented on those two slides show only personnel deaths, not simply casualties, and further show armored fighting vehicle losses rounded to the nearest whole number. Personnel deaths for the indigenous, or renegade, forces was calculated by dividing total personnel battle casualties by 3.5 (28.6% KIA), meaning that 5 out of 7 personnel casualties were wounded. U.S. personnel deaths were calculated in a similar fashion, dividing total personnel battle casualties by 6 (16.7% KIA), so that 5 casualties in 6 werewounded. The much lower proportion of fatal U.S. battle casualties is due both to widespread employment of kevlar body armor, and to notably superior trauma and shock treatment in forward aid stations, a good helicopter-borne casualty evacuation system, and generally superior medical care. Both of theae considerations were based on evaluation of U.S. battle casualties from the Kuwait War and Operation JUST CAUSE in Panama (1989).
[Slides 19, 20]

As the slides do not provide the complete casualty figures, but only battle fatalities (KIA), a condensed version of the original TNDM results is provided here; armor losses were rounded to the nearest whole number.

The scenarios disclosed several interesting results. First, the indigenous forces never did very well. In large measure this was because of the 1.5 CEV provided to U.S. forces, but probably more important was the superior weaponry of U.S. forces (especially their antitank weapons and artillery), along with their airpower assets. Indigenous force advances (not shown on these slides) were, when they occurred at all, quite minor (under 250 meters). Moreover, their personnel losses were generally two to three times as high as those of U.S. units, and the imbalance in armor

| Scenario | Surprise | Topography | Cover | Weather | Attacker Personnel | Attacker AFVs | Defender Personnel | Defender AFVs |
|---|---|---|---|---|---|---|---|---|
| Heavy 1 | Substantial | Gentle | Open | Clear | 67 | 5 | 39 | 1 |
| Heavy 2 | Substantial | Gentle | Mixed | Clear | 30 | 1 | 27 | 1 |
| Heavy 3 | Substantial | Rugged | Forest | Clear | 50 | 4 | 28 | 1 |
| Heavy 4 | Minor | Rugged | Mixed | Lt Snow | 30 | 2 | 11 | 0 |
| Heavy 5 | None | Gentle | Mixed | Clear | 73 | 3 | 21 | 2 |
| Heavy 6 | None | Gentle | Mixed | Lt Snow | 59 | 5 | 34 | 1 |
| Heavy 7 | None | Gentle | Forest | Hvy Snow | 31 | 4 | 8 | 0 |
| Heavy 8 | None | Rugged | Mixed | Clear | 36 | 2 | 16 | 0 |
| Heavy 9 | None | Rugged | Forest | Clear | 53 | 4 | 14 | 0 |
| Heavy 10 | None | Rugged | Forest | Hvy Snow | 26 | 2 | 7 | 0 |
| Light 1 | Substantial | Rugged | Forest | Clear | 72 | 4 | 18 | 0 |
| Light 2 | Substantial | Rugged | Forest | Socked In | 54 | 3 | 16 | 0 |
| Light 3 | Minor | Rugged | Forest | Socked In | 44 | 2 | 13 | 0 |
| Light 4 | Minor | Gentle | Mixed | Clear | 82 | 4 | 17 | 0 |
| Light 5 | None | Rugged | Forest | Socked In | 43 | 2 | 12 | 0 |

losses was usually even higher. Finally, snowy weather, along with rugged or more heavily wooded terrain, meant fewer casualties all around, and smaller advances.

The TNDM scenarios, and their analysis, were only part of TDI's analysis of potential casualties for peacekeeping in Bosnia. TDI's analysis also considered casualties from several other sources: those suffered during the entry into Bosnia by road and air, losses to road accidents and landmines during the peacekeeping operation, losses from small-scale terrorist attacks and ambushes, and losses due to harrassing fire by mortars. None of these sources of casualties was capable of being modelled by the TNDM, so TDI employed other methodologies for those elements. ⊕

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**List of relevant slides/pages from final report appearing on the following pages:**

1. The Tactical Numerical Deterministic Model (TNDM)
2. General Characteristics of the TNDM
3. Essence of the TNDM
4. Weapon Characteristics for Operational Lethality Index
5. TNDM Outputs
6. Deaths Resulting from Renegade Brigade Attacks (section title slide)
7. Terrain and Road Net (color map)
8. U.S. Brigade Sector and Battalion Areas of Operation (color map)
9. U.S. Company Team Organization and Reinforcement Schedule
   A couple of corrections need to be made on this slide, to wit: the initial mechanized company TF should have only 5 M-113s, not 7; The reinforcing armored company TF should have only 8, not 9, F-16C aircraft in support.
10. Renegade "Heavy" Brigade Organization (Main Combat Elements)
11. Renegade "Light" Brigade Organization (Main Combat Elements)
12. "Heavy" Renegade Brigade –HRB) Attack — 1
13. "Heavy" Renegade Brigade –HRB) Attack — 2
14. Attack by Heavy Renegade Brigade on U.S. Company –color map)
15. IFOR Support to Tusla (color map)
16. "Light" Renegade Brigade (LRB) Attack — 1
17. "Light" Renegade Brigade (LRB) Attack — 2
18. Attack by Light Renegade Brigade on U.S. Company (color map)

## The Tactical Numerical Deterministic Model (TNDM)

1. It is both a model and a theory of combat, developed by Trevor N. Dupuy over a period of twenty years.

2. It is a qualified judgement method that:
   - Applies historically-conditioned professional military judgement to an historical engagement database, and
   - Assigns, then refines, standard values for weapons and variables in order to:
     - Compute the relative combat power of opposing forces
     - Explain or predict respective combat losses

3. The next four charts describe the TNDM.

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## General Characteristics of the TNDM

- A computer-assisted, numerical, validated model of combined-arms combat
- A transparent, deterministic simulation
- A closed system; *all* outcomes reflect effects of *all* factors on *all* inputs
- Human behavioral factors are expressly considered and represented
- An aggregated model, operated usually at the level of division or corps

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## Essence of the TNDM

- **Basic input: "proving ground" weapons values**
- **Modified to reflect all identifiable variables**
  - Environmental (weather and terrain)
  - Operational (posture and mobility)
  - Behavioral (surprise and effectiveness)
- **Combat Power (P) - Wx variables**
  - P(Attacker) / P(Defender) > 1: Theoretical Success
  - P(Attacker) / P(Defender) < 1: Theoretical Failure

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## Weapons Characteristics for Operational Lethality Index

### "Proving Ground" Values

- Rate of fire
- Number of potential targets per strike
- Effective range (or muzzle velocity)
- Accuracy
- Reliabilty
- Mobile fighting systems (i.e., tanks and aircraft)
  - Battlefield mobility
  - Radius of action
  - Punishment factor
- Dispersion factor

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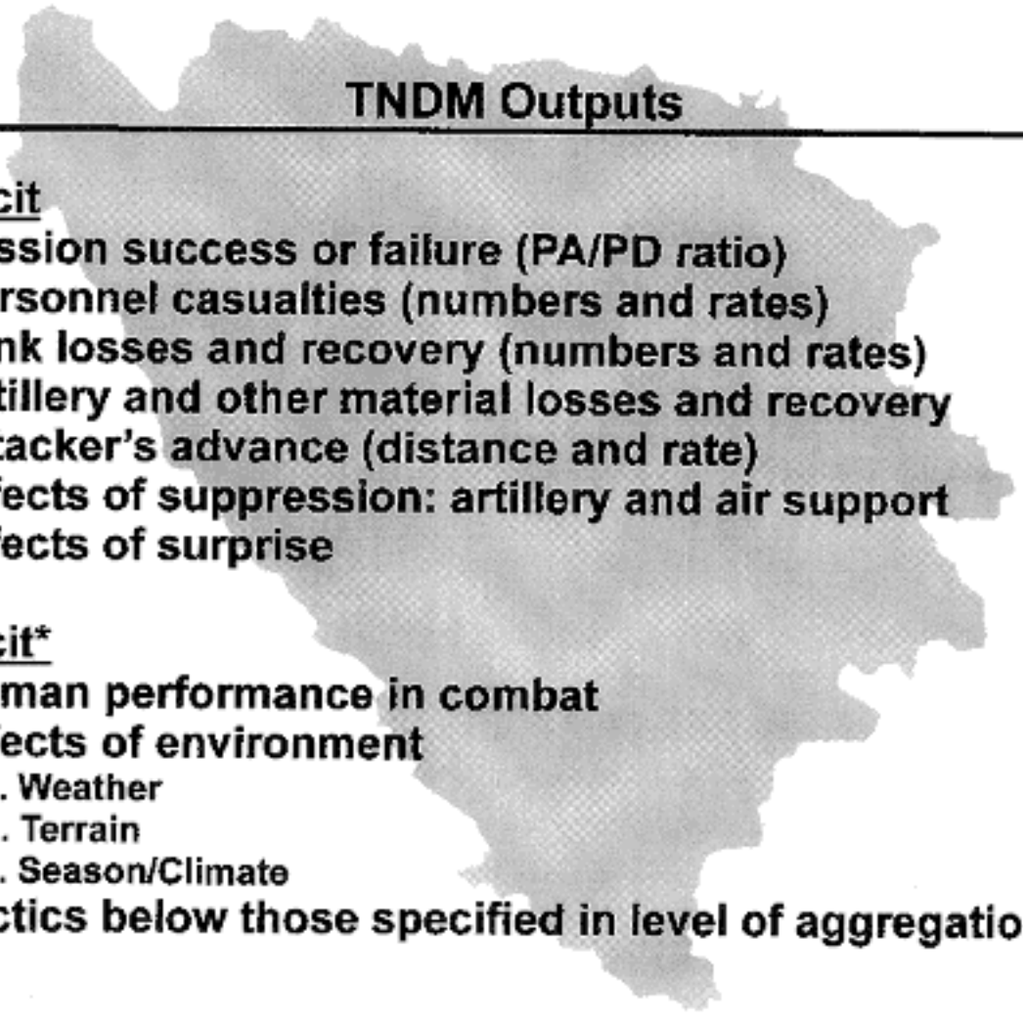
## TNDM Outputs



**Explicit**

1. Mission success or failure (PA/PD ratio)
2. Personnel casualties (numbers and rates)
3. Tank losses and recovery (numbers and rates)
4. Artillery and other material losses and recovery
5. Attacker's advance (distance and rate)
6. Effects of suppression: artillery and air support
7. Effects of surprise

**Implicit***

1. Human performance in combat
2. Effects of environment
   a. Weather
   b. Terrain
   c. Season/Climate
3. Tactics below those specified in level of aggregation

*Embedded in Outcome

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## Deaths Resulting From Renegade Brigade Attacks

**Illustrative Assumptions:**

- During the Winter 1995-1996, armed elements within both Bosnian states who are in opposition to what has happened, form renegade brigades intent on disrupting the peace arrangement by attacking American units.
- One of these brigades is a tank/mechanized unit on the Bosnian Serb side. Due to the terrain, weather, and its training needs, it could not be ready for action before Spring 1996.
- The other, a rebel light infantry brigade or a light partially armored Serb brigade, becomes a threat by mid-Winter.

**American forces would have at least an hour's warning of an impending attack by the heavy brigade, but might have only 5 to 15 minutes' warning (virtual surprise) of the attack by one of the light brigades.**

(Note: see the sequence of maps on the following slides)

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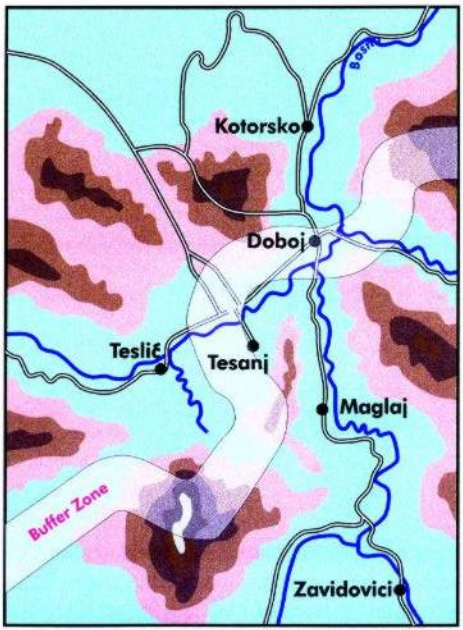
## Terrain and Road Net

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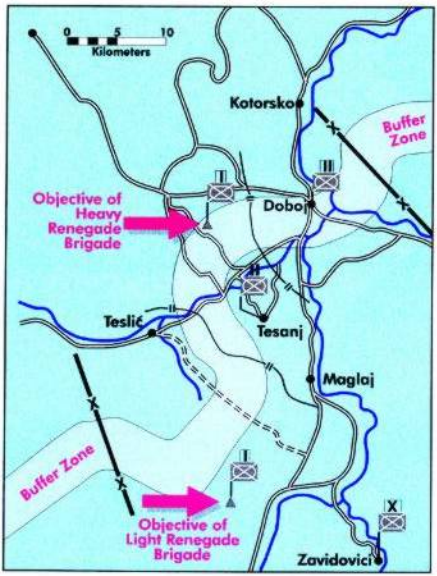
## U.S. Brigade Sector and Battalion Areas of Operation

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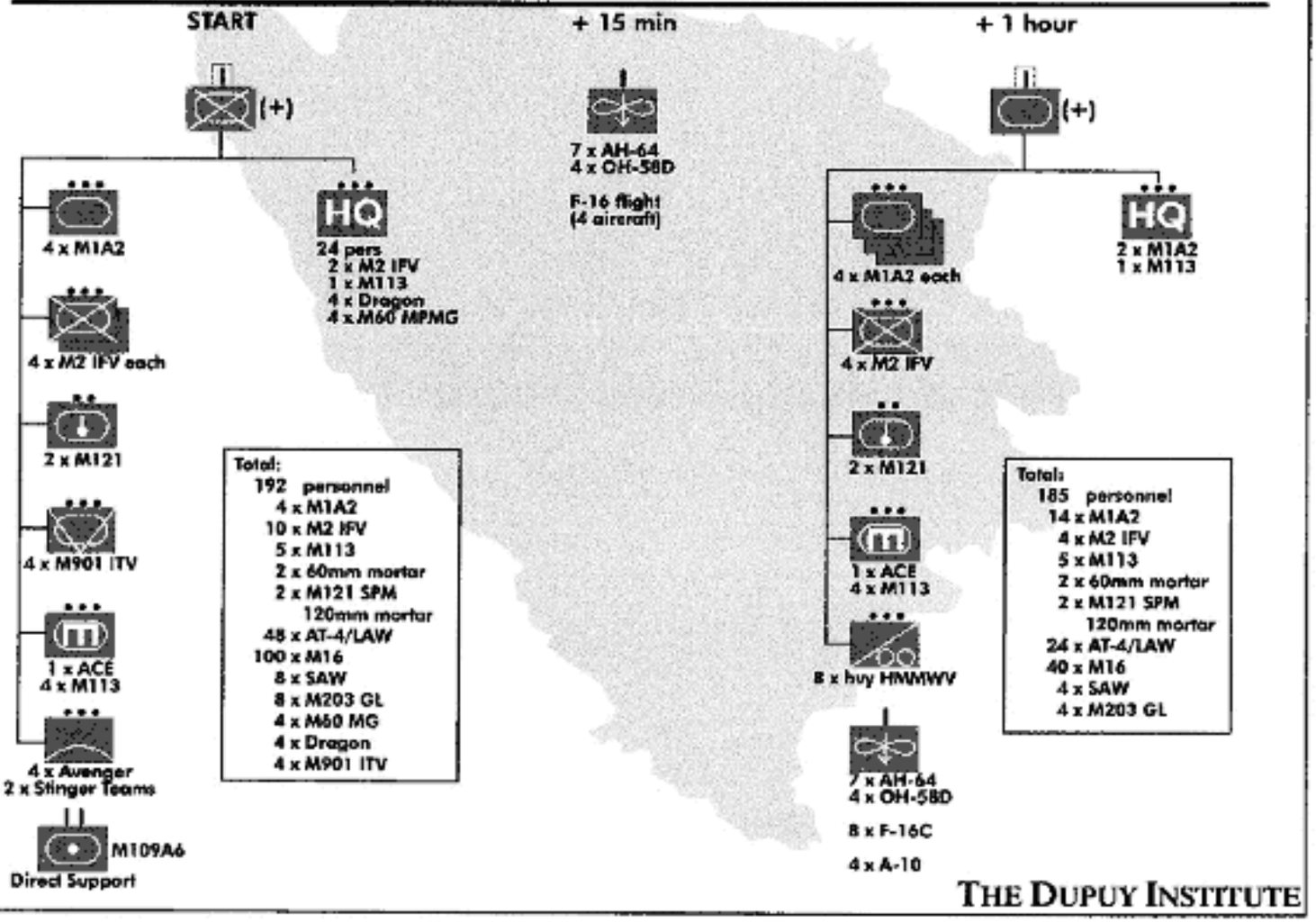
# U.S Company Team Organization and Reinforcement Schedule



## Renegade "Heavy" Brigade Organization (Main Combat Elements)

See attached organizational chart for complete organization

| | |
|---|---|
| 1 tank battalion | 35 T-72 tanks |
| 2 mechanized infantry battalions | 80 BMP/APC infantry fighting vehicles |
| 1 motorized infantry battalion on trucks | |
| 1 mixed artillery battalion | 6 self-propelled 122mm howitzers<br>12 towed 122 mm howitzers |
| 1 mortar battalion | 6 120 mm mortars<br>12 81 mm mortars |
| 1 air defense battalion | 8 towed 20 mm AA guns<br>4 twin 30 mm AA guns<br>4 triple 20 mm AA guns<br>4 SA-9 surface-to-air missile launchers |
| Brigade strength | 2,200 |

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## "Heavy" Renegade Brigade (HRB) Attack (1)

**Sequence of Events:**
**(After the "Heavy" Renegade Brigade finishes planning its attack on a US tank/mech infantry company team's position in the buffer zone)**

1. HRB starts moving out from hide areas 30 km east of Banja Luka (H-3)
2. US intelligence reports movement (H-2)
3. Units in US brigade sector are alerted (H-1)
4. US company team pulls back from outposts to prearranged fighting positions (H-45 min)
5. US brigade commander formulates and starts executing one of his prearranged battle plans. US battalion commander assumes control of action in the battle area (H-45 min)
6. Reaction forces (air, Army aviation, and 3 company team reaction forces) start moving out (H-30 min)
7. HRB begins artillery fire (H-20 min)

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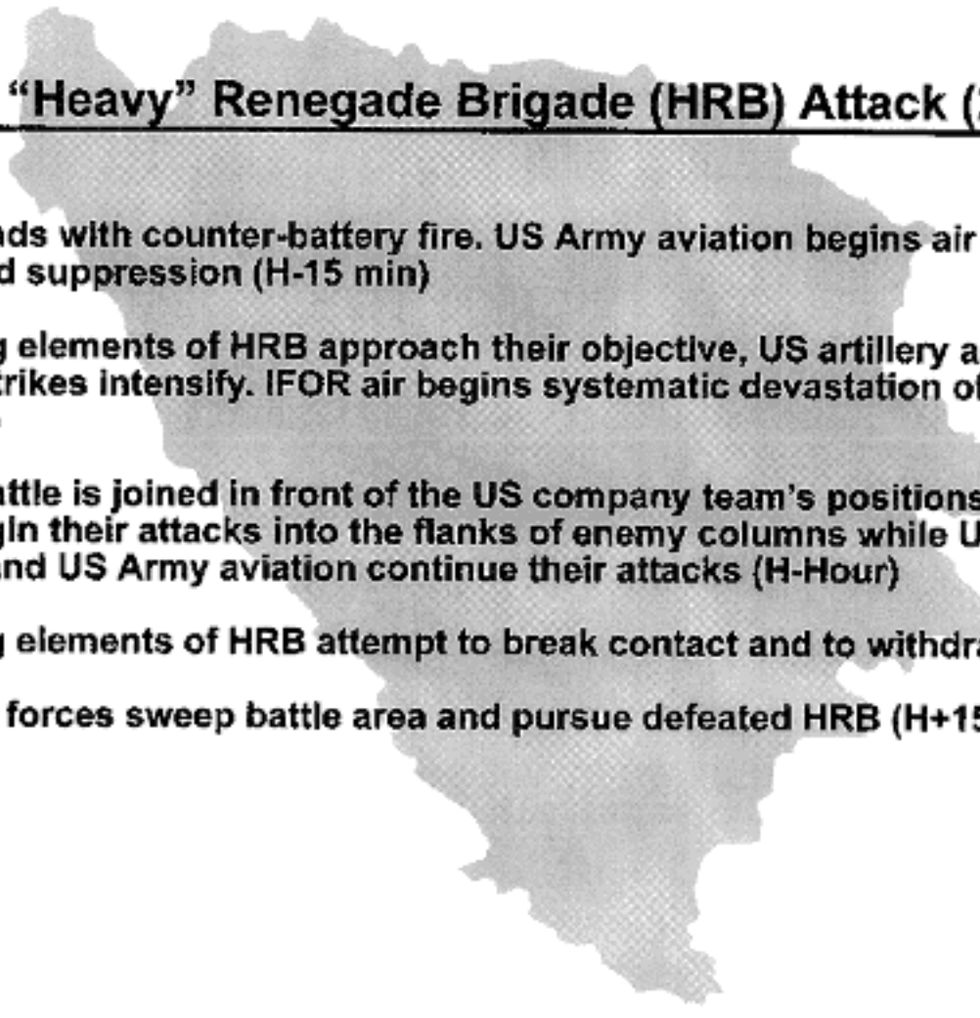
## "Heavy" Renegade Brigade (HRB) Attack (2)



8. US responds with counter-battery fire. US Army aviation begins air defense search and suppression (H-15 min)

9. As leading elements of HRB approach their objective, US artillery and US Army aviation strikes intensify. IFOR air begins systematic devastation of HRB columns (H-15 min)

10. As the battle is joined in front of the US company team's positions, reaction forces begin their attacks into the flanks of enemy columns while US artillery, IFOR air, and US Army aviation continue their attacks (H-Hour)

11. Surviving elements of HRB attempt to break contact and to withdraw (H+15 min)

12. Reaction forces sweep battle area and pursue defeated HRB (H+15 until recalled)

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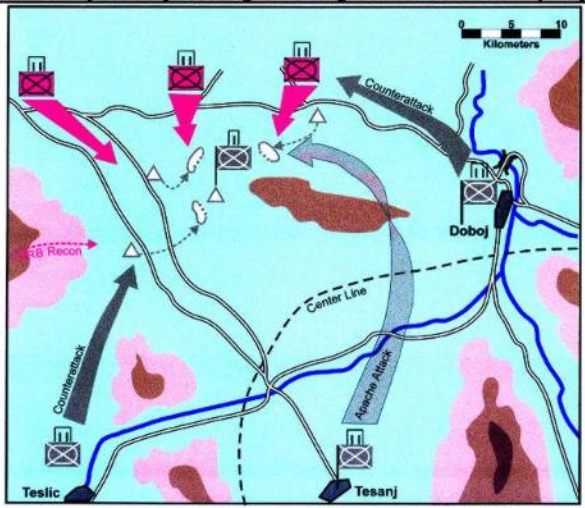
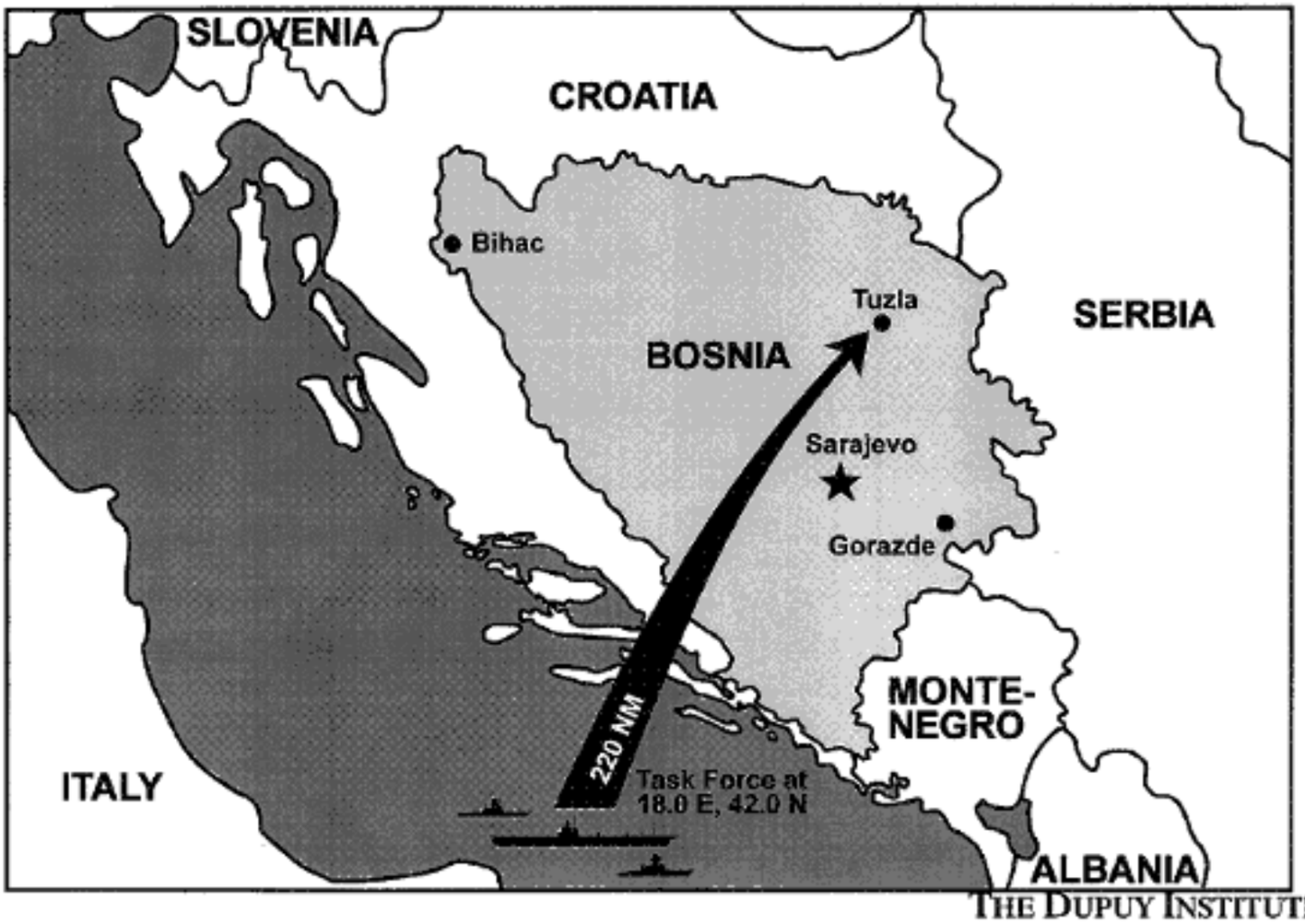
## Attack by Heavy Renegade Brigade on U.S. Company



## IFOR Support to Tuzla



## Renegade "Light" Brigade Organization (and Main Equipment)

(Possesses 65 miscellaneous trucks and jeeps)

| | |
|---|---|
| **3 infantry battalions (bn)..... (approx. 500 men per bn)** | **machine guns, assault rifles<br>antitank grenade launchers (RPG-7)<br>shoulder-fired ground-to-air missiles (SA-7)<br>antitank recoilless rifles (82 mm)** |
| **1 towed artillery bn.....** | **16 105 mm howitzers<br>8 76mm howitzers** |
| **1 medium mortar battery.....** | **12 81 mm mortars<br>9 60 mm mortars** |
| **1 air defense battery.....** | **4 triple 20 mm AA guns (M-55)<br>8 20 mm AA guns (M-75)** |
| **Brigade strength.....** | **1,800** |

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## "Light" Renegade Brigade (LRB) Attack (1)

**Sequence of Events:**
**(After extensive reconnaissance of a selected US tank/mechanized company team's positions, operational procedures, and security habits)**

1. At midnight of their attack day (H - 5 hours), LRB moves out of its dispersed hide areas.

2. LRB assembles in forward assembly areas by H - 2 hours, occupies nearby battalion attack positions by H - 1 hour. LRB brings mortars and artillery to concealed firing positions.

3. LRB begins attack by direct and indirect (mortars and artillery) fire (H - 15 min)

4. LRB assault elements from two battalions begin attack along two axes of advance (H - 10 min)

5. Defending US company team employs massive direct and indirect fire on attacking forces now fully visible on thermal sights of M-1 tanks and Bradley fighting vehicles.

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## "Light" Renegade Brigade (HRB) Attack (2)

6. US quick reaction elements (Apache attack helicopters) arrive over battle area and engage attacking LRB forces (H - Hour).

7. US battalion and brigade ground reaction elements break up LRB assault by flank attacks (H+15 min to H+30 min). IFOR joins the battle.

8. Pursued by US Army air and ground forces, LRB retreats to concealed positions (H+30 min to H+2 hours).

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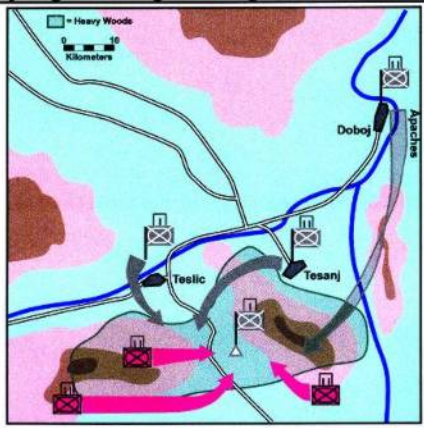
## Attack by Light Renegade Brigade on U.S. Company

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# Guide to TNDM Versions and Enhancements

**by José Perez**

This is not a comprehensive listing of all the TNDM versions. It does include all the versions shipped to clients. It also includes some internal versions used only within The Dupuy Institute or its predecessor, T. N. Dupuy Associates. There are a number of undocumented changes; they do not appear in here.

The versions are listed in order by the release date, not by version number. Some of the version numbers were not recorded, so an arbitrary version number was assigned when the release date was recorded without a version number. These versions are indicated by an asterisk (*).

In general, version numbers used for development are in the form of X.yyy. Versions shipped to a client are usually numbered X.y or X.yy. Only in the case of the customized version update for Sweden was a version in the form X.yyy used.

## TNDM version 0.1 Release date: 19 November 1990

**Change:** Convert TNDM from BASIC into Turbo Pascal.

*Notes:*

- This version does not have the capability to handle historical engagements. Since this is a desirable feature, it will be added when the more basic features of the model have been fully implemented.
- The method by which a user verifies that an engagement selected for modification/reprint/continuation is the correct one, is clumsy.
- When an engagement is continued, the days printed in the continuation are incorrect. Instead of starting on the day after the engagement ended, the continuation prints "Day 1." The loss calculations are correct but this can cause some confusion.
- If the report frequency is not evenly divisible into the maximum elapsed time of the engagement, the calculated results become incorrect. For example, if the report frequency is every 24 hours, but the engagement is running for only 36 hours, the losses during the last 12 hours are not computed. The results are correct if the report frequency is changed to every 12 hours.
- Only a few help screens have been typed in.
- The software used to display the help screens has not been registered. This causes a reminder message to appear at the top of the screen whenever Help is accessed. There is an alternate software program for displaying the help screens that I plan to explore as soon as possible.
- After using help, it is necessary to press the Esc (Escape) key twice in order to return to the screen being used.
- Because of changes that I made, the entry fields for the CEV and Set-Piece Factors for both the X and Y Forces need to go into an entry screen that is separate from the manual units entry screen. Currently, it is not possible to change the CEV or Set-Piece Factors if the analyst is not entering a unit manually.
- Setting the Weapons Sophistication is not an option.
- When I incorporated the Posture var (Advance Rate) factor table into the model, I had to make several assumptions in order to make it match Dr. Taylor's adaptation of the Posture Table. I am not entirely sure that my assumptions were correct and it may account for casualty rates being higher than expected.
- This model does not make allowances for differences in certain factors over time. For example, the mobility equation for World War II engagements should produce lower values than 1980-1990 engagements.
- This model does not allow the analyst to enter the depth or width of the front.
- This model does not differentiate between fixed wing and rotary wing aircraft. The loss rates for all aircraft are assumed to be the same.
- Casualties are not broken down by branch (Armor, Infantry, Artillery and Other).
- This model does not adjust the loss rates when there is an extremely large number of tanks to personnel in a force.
- The calculations for non-battle personnel losses have not been included.

## TNDM v. 0.2 Release date: 12 December 1990

**Addition:** Historical Results equations have been added.
**Change:** The method by which an engagement is selected and verified for modification/re-print/continuation has been changed. If the selected engagement is the correct one, the user only has to press Enter to continue. If it is not correct, the user must press the letter N to select another engagement.
**Correction:** The calculation of hours elapsed since the engagement has been corrected for continuations.
**Change:** The report frequency period no longer has to be evenly divisible maximum duration of the engagement. However, this does require additional testing to verify that it is working properly.
**Change:** The help software has been changed to another product. However, the help software has been implemented only in the Main Menu.
**Change:** It is no longer necessary to press the Esc key twice in order to return to the screen being used.
**Change:** I have tentatively moved the data entry fields for the CEV and Set Piece Factors to a screen separate from the manual units entry screen. This CEV may now be redundant because of other changes that were requested.
**Addition:** Weapons Sophistication is now an option. The user must enter a complete engagement date in order for a correct Weapons Sophistication factor to be assigned.
**Addition:** The Posture var (Advance Rate) factor table has been recreated to match the factors used in *Numbers, Prediction and Warfare*.
**Change:** The constant used to calculate the Mobility Constant used in the Mobility Factor equation is set to 20 for ? - 1945, 15 for 1945 - 1960, and 12 for 1960 - present. Weapons Sophistication is now assigned by year. Surprise is adjusted by year also.
**Change:** The Front Density calculation was not working properly. Until I have determined why the problem was occurring, the user will be able to enter depth information only for historical information. Otherwise, the user will not enter the width of the front or the depth of each force.
**Change:** Rotary-wing aircraft and fixed-wing aircraft are now in separate weapons categories. This will allow the user to see a higher loss rate for the more vulnerable helicopters than for fixed-wing aircraft.
**Change:** Casualties are now broken down by branch (Armor, Infantry, Artillery and Other).
**Change:** The Unbalanced Force Factor is now applied when the ratio of tanks to personnel is extremely high or extremely low.
**Change:** Calculations for non-battle losses have been included. However, this requires a complete engagement date.
**Correction:** An error in the Distance calculation was found and corrected.
**Change:** The default answer to "Do you want to continue this engagement?" was changed to N. The user has to press the letter Y if the engagement is to be continued.
**Correction:** An error in the Advance Rate calculation was found and corrected.
**Change:** The unit TO&E was modified to include all infantry weapons in one category. Also, three unnamed categories were added to allow future expansion of the TNDM.
**Addition:** A Surprise Adjustment factor was added to all surprise factors to reduce the impact of surprise in historical engagements.
**Change:** The Velocity Attrition Factor was added to the Personnel Loss Rate calculation.
**Addition:** All Terrain factors, including the Casualty factor, have been added.
**Addition:** All Weather factors, including the Casualty factor, have been added.
**Change:** Some modifications were made to the Season/Climate table to correct minor errors. Also, the Season Casualty factor was added.
**Addition:** The Mission/Posture Armor Attrition Factor was added to the Armor Loss Rate calculation.
**Addition:** All of the terrain types have been implemented.
**Change:** The option to increase/decrease Combat Intensity has been replaced with the option to modify the Combat Power, Personnel Loss Rate, Armor Loss Rate, Artillery Loss Rates and Advance Rate. This may make it unnecessary to enter a CEV for both forces.
**Change:** Today's Date is now a separate entry field from the Engagement Date. The Engagement Date has been left blank for the user to fill in. Since some of the calculations require a correct date, the Engagement Date must be entered.
**Change:** The X designation has been changed to Attacker and Y has been changed to Defender. However, the Defender retains the capability to attack. This should lay the groundwork for a counterattack model in a future version of the

TNDM.
**Change:** Coordinates are entered as five-digit numbers with two decimal places.
**Change:** The Force Mission/Posture options have been put in to one menu. The Static Defense option has been removed. The Mission/Posture tables have been revised to reflect this change.
**Change**: Main Zone was changed to Main Effort in the TNDM User's Guide.
**Change**: The description of Delay was changed to "is using delay tactics" in the TNDM User's Guide.
**Change**: The description of Medium Artillery Fire was changed from 8-inch to 6-inch in the TNDM User's Guide.
**Change**: The River/Stream Width Menu now appears even if a Shoreline Vulnerability Factor was not selected.
**Change**: All OLI's/Firepower scores in the Forces Database are now totals rather than averages in each weapon category.
**Change**: In the TO&E Summary, Forces Database, and Manual Units Entry, "Number of armored, non-fighting vehicles" was changed to "Number of non-armor tracked vehicles."

## TNDM v. 0.21 Release date: 4 January 1991

**Change**: This version is compatible with version 0.2, except, if a Lighting Level of Limited Visibility or Night was used, it will have to be re-entered.
**Change:** Losses are computed for both the strength levels (number of weapons and vehicles) and the OLI scores in each weapon category. This allows the user to enter OLI scores for Infantry Weapons, Anti-Tank, Artillery, and Aircraft, without entering the number of weapons in each of those categories.
**Correction**: If more than one unit was assigned to either the attacking or defending force, only the name of the last unit entered/selected was being printed in the report.
**Correction:** If the TO&E for a force was entered manually, it was not possible to enter the force's trucks, tracked vehicles, organic aircraft and motorcycles.
**Correction**: There were two errors in the Force Strength Calculations.
**Change**: Strength levels, instead of OLI scores, were being used.
**Correction**: The Quantity Factor was not being applied to Armor and Infantry.
**Change**: The size of the data entry field for Armor OLI in the Forces Database has been increased to hold a maximum value of 9,999,999.99.
**Correction**: In the Manual Data Entry Screen, the data entry fields for Trucks were incorrectly labeled. The data entry field for APCs, SPs, and non-fighting tracked vehicles was also mislabeled. The label for the data entry field for APCs, SPs, etc. has been changed to "APCs, Self-Propelled Weapons Platforms, Tracked Vehicles".
**Change**: It appears the data entry field for the CEV in the data entry screen for CEV and Set Piece Factors is redundant. The entry for the Set Piece Factor will be moved to another screen in version 0.3.
**Correction:** An error in the Velocity Attrition Factor Table was affecting the Personnel Loss Rate.
**Correction:** An error in the Standard Advance Rates Table was producing abnormally low advance rates when the attacker had a very large P/P ration (greater than 4:1).
**Change**: The standard armor loss rate has been changed to 6.0 for the attacker and 3.0 for the defender. The Armor Loss Rate originally in the TNDM was producing loss rates that were much too high for both the attacker and the defender once the Force Strength was being calculated properly.
**Change**: The Day/Night Factors for 24-Hour Period, Night Only, Daylight Only, Mixed Day and Night (Mostly Day), Mixed Day and Night (Mostly Night) and Mixed Day and Night (Half Day) are now being used.
**Change:** At Arnold Dupuy's request, an OLI Database has now been implemented in the TNDM. This Database is used only for storing OLI scores. It cannot be used to calculate OLIs for weapons.
**Change:** When adding a unit to the Force Database or updating an existing unit, the user can use the OLI database to calculate the OLI scores for each weapon category. However, this is possible only if the desired weapons' OLIs have already been stored in the OLI Database. To use this feature, the user has to have a complete TO&E for the unit, broken down by the weapon categories used in the TNDM: Armor, Infantry, Anti-Tank, Towed Arty, SP Arty, Air Defense, Fixed-Wing Aircraft and Rotary-Wing Aircraft. When a category is selected, all the weapons in that category are displayed. The user enters the number of weapons in the category such as 25 LAVs and 50 M60A3s, and presses the Escape Key. The computer will display the original and new strengths and OLIs in the category. If the user presses Y, the new values will be assigned to the unit.
**Change**: The user can now use the OLI Database to enter a force manually for either the attacker or the defender. The procedure for using the OLI Database to create a force is identical to the procedure used to create a unit in the Force

Database.
**Addition**: A new option, CHANGE ATTACKER'S/DEFENDER'S TO&E, has been added to the Create Attacking/Defending Force Menu. This option can be used to make manual adjustments to the force's TO&E.
**Correction**: The problem of inconsistent results when re-running an engagement appears to have been corrected by the changes and corrections in the Armor Loss Rate calculations.
**Correction**: An error in the calculation of Recovered Aircraft was causing large errors in Force Strength, etc.
**Correction**: When the attacker does not have sufficient combat power superiority to advance, the attacker's position always printed as 0,0 even if the starting position was not 0,0.

## TNDM v. 0.22 Release date: 5 January 1991

**Correction**: The only difference between this version and version 0.21 is that version 0.22 has been corrected to save and read engagements correctly when running the TNDM on a floppy disk. The Runtime error number 005 should no longer be occurring.

## TNDM v. 0.23* Release date: 11 January 1991

**Addition**: Added code to trap any errors that might occur and display a descriptive error message on the screen.

## TNDM v. 0.24* Release date: 3 February 1991

**Change**: Road Quality/Density is now listed under Environmental factors.
**Change**: All factors are printed out when a detailed report is requested.
**Change**: The actual losses for each time period are displayed in the report.
**Change**: The vehicle numbers and combat systems numbers are rounded to the nearest whole numbers after losses have been subtracted.
**Change**: After the TNDM software is started, it notifies the user of the default locations for the OLI and Force databases, engagement files, and the Help file. It then asks if the user wants to change these locations.
**Change**: The CEVq, CEVl, and CEVad results are now calculated for historical engagements.
**Change**: The layout of the report has been changed.
**Change**: The listing of the countries used in selecting units from the Force database has been sped up. The pause should now be almost unnoticed.
**Change**: The user is now asked if he wants a "long report" instead of a "detailed report".
**Change**: The user is now asked if he wants to "print the report" instead of "Do you want the results on the screen?".
**Correction**: The last three letters of Horse Cavalry were not displayed in the Force Type Menu.
**Change**: If one force is in the Holding posture, the other side is automatically set to the Holding posture.
**Change**: If Weapons Sophistication is set to Unknown for one force, it is automatically set to Unknown for the other side.
**Change**: The descriptions for Shoreline Vulnerability Distance were changed.
**Change**: The Clock on Operation in Shoreline Vulnerability was removed.
**Change**: When the error message prints, it now asks the user to "Notify T. N. Dupuy Associates" instead of TNDM Associates.
**Correction**: The ISI factor calculation has been updated to match the calculation described in the latest copy of the Rules and Procedures.
**Change**: The Delete Units option was changed to prevent any of the values from becoming negative.
**Correction**: The force inventory for continuations was corrected to show the inventory before the engagement was continued. Previously, the inventory displayed by a continuation was the force at the beginning of the engagement.
**Correction**: If a force is entered manually with only OLI values, the OLI values were being dropped.
**Correction**: When a unit name is deleted from a force, the last three characters of the name were not always erased from the screen.
**Change**: The default Maximum duration of an engagement has been changed from 72 hours to 24 hours.
**Change**: All titles in items such as Road Quality/Density, Force Type, etc. have been changed to uppercase.
**Change**: In the report, when surprise was selected, the surpriser was described as "A Force" or "D Force". This has been changed to "Attacker Force" or "Defender Force".
**Change**: Total OLI is now printed in the TNDM report.

**Correction**: When a unit was selected from the Force Database, the one after it was added to the force.
**Change**: When the user enters the date of the engagement, he will not be allowed to proceed until he has entered a valid date in the form of 01/01/1991.
**Change**: When the engagement start time is entered, the user will not be able to continue until a valid starting time has been entered.

## TNDM v. 0.3 Release date: 25 March 1991

**Addition**: The analyst now has the option of disabling the ISI and IDI factors when running an engagement to analyze weapons performance.
**Change**: The menu used to select units to create a force has been changed to perform in the same manner that the weapons menu performs when a unit is being created.
**Addition**: The analyst now has the option of entering the number of days the attacker or defender has been in combat immediately prior to the engagement.
**Addition**: After setting the width of a river/stream, the analyst must indicate whether the river/stream is fordable or unfordable.
**Correction**: Corrected errors in the strength calculations.
**Correction**: Corrected the error that occurred when trying to print the TNDM results report.

## TNDM 1.0 Release date: 9 April 1991

**Correction**: In engagements with Surprise, Advance Rate, Vulnerability, Personnel Loss Rate and Armor Loss Rate were calculated incorrectly. This has been fixed.
**Correction**: A Shoreline factor is listed when this option was not selected.
**Correction**: Summary of losses showed all values as 0.0.
**Correction**: Display of attacker personnel strength on the screen is incorrect.
**Addition**: If a CEV value is entered by the analyst, it is printed in the engagement report.
**Addition**: The user can now select a fraction of a unit: one-half, 1.3, etc.
**Addition**: The user can now enter Attacker or Defender CEV.
**Addition**: Artillery Loss Rates are now included in the engagement report.

## TNDM 1.01* Release date: 14 April 1991

**Addition**: I have also changed the software to calculate the engagement results and then ask if the user wants to print the report. If the answer is N, the results are displayed on the screen, otherwise they are printed.
**Correction**: The main reason for most of the errors was that the software was expecting a four-digit year in the starting date of the engagement. The software has been changed to require a four-digit year. If an incorrect date is entered, the computer will beep and prevent the user from proceeding until a correct date is entered.
**Correction**: In reviewing Jim Taylor's approach to the Personnel Loss equation, I discovered that his new table was just the Posture Casualty Factor multiplied by the standard casualty rate of 0.04. I have changed the Posture Casualty Factor table to allow for this.
**Addition**: The title "INPUT DATA" has been inserted into the Results Report. It will precede the listing of Environmental Variables and Operational Variables.
**Correction**: The Attacker CEV was being printed in the Combat Power factor list. I have added it to the Operational Variables list in the Results Report.
**Change**: "ATTACKER'S TO&E" and "DEFENDER'S TO&E" have been changed to "ATTACKER'S ORDER OF BATTLE" and "DEFENDER'S ORDER OF BATTLE". Also, the display of the number of units has been changed to allow three digits behind the decimal point. This will allow the display of unit fractions, such as 0.667.
**Correction**: The error that was causing the Attacker Personnel to be set to zero (0) whenever the defender's forces

were changed or selected, has been corrected.
**Change:** In the Mobility and Vulnerability Factors Listings, "W/SURPRISE" has been changed to "WITH SURPRISE".
**Change:** The Artillery Loss Rates Listing has been rearranged to group the Towed Factors and the Self-propelled Factors together.
**Correction:** Correction: The listing of the Attacker and Defender losses has been corrected.
**Correction:** The Final Inventory Listing has been corrected.

## TNDM v. 1.02* Release date: 19 April 1991

**Change:** The Print option has been changed to ask the user if a pause between pages is required. If the answer is Y, the software will pause after each page is printed and will not print anything else until the Enter key is pressed. This should allow you to print the results on your Canon printer.
**Correction:** The Engagement/Continuation Selection option was not using the Location Settings to locate engagements and continuations.
**Correction:** The repetition of countries in the country listing has been corrected.
**Change:** The Loss Rates in the Results Summary have been changed to percentages.
**Correction:** The incorrect mobility factor was being printed in the Combat Power Factors Listing when surprise was present.
**Correction:** The Opposition Factor for P/P ratios between 0.1 and 0.15 was being calculated incorrect.
**Change:** The method by which an engagement is continued has been changed slightly. When an engagement is continued, the continuation will be saved, but the user will not be asked for a new name at that time. When the Continuation option is selected, the user will not be asked to enter a name for the continuation until after the "Begin Continuation" option is selected. After the name is entered, the user will be asked how many hours the continuation should run.
**Change:** When an engagement or a continuation of an engagement is run for more than one day, the detailed listing for the second and successive days will contain only those factors that have changed since the previous day.

## TNDM v. 1.03* Release date: 21 April 1991

**Correction:** The Print option has been corrected to avoid feeding a new page through the printer, if the user has asked for the printer to pause after printing each page.
**Correction:** The adjustment to the Opposition Factor calculation has been corrected so that P/P ratios between the range of 0.1 and 1.0 will be correct. I have not verified the Opposition Factor for P/P ratios greater than 1.0.
**Correction:** Pam Hilton reported a problem about two weeks ago when I was in McLean. When the location of the engagement files is set to "A:\" and a floppy is not in the A-drive, the TNDM will not run. I have corrected this problem. An error message will now appear at the bottom of the screen asking the user to insert a diskette or to change the location. The Change Locations entry screen will then appear. If a diskette is put into the A-drive, there is no need to change the location of the engagement files.
**Change:** A minor change was made to the Historical Yes-or-No question. I was unable to duplicate the problem which you experienced, but I hope that this change will solve the problem for you.

## TNDM v. 1.04* Release date: 24 April 1991

**Change:** When Surprise is in effect, Vulnerability With Surprise will be printed in the Combat Power Factors list.
**Correction:** The Surprise Effect calculation has been corrected.
**Correction:** Pam Hilton reported that it is possible to create engagements with eight-character names, such as TRYMORES, but it is not possible to modify, reprint or continue them.
**Change:** Pam suggested changing the colors used when editing the Forces Database and the OLI Database. When a unit is being edited, when the cursor is on Armor OLI for example, the Armor OLI value has the same color as the rest of the screen.
**Change:** Pam also noted that when an attacking or defending force is being created using the OLI Database, the line reading "Esc=Exit Return=Select ..." is not easy to read on the screen. The area around this line will be cleared and it

will now appear in a box.
**Change**: The option EXIT has been added to the Create, Modify and Continue Menus. This option will allow the user to exit and return to the Main Menu without saving the engagement.
**Change**: When Create A New Engagement is run, the second data entry screen will display the percentage of space remaining on the disk where the engagement files are being stored.

## TNDM v. 1.05* Release date: 27 April 1991

**Correction**: Fixed problems in calculating Advance Rate and Distance.
**Correction**: Fixed the problem of the beginning and ending inventories being identical in a continuation.

## TNDM v. 1.06* Release date: 28 May 1991

**Correction**: The Reinforcement option does appear to be working.
**Change**: Added more space for the engagement description in the Make New Engagement.
**Change**: In the Continue Engagement option, gave user the option of entering a new engagement description.
**Change**: In Modify Engagement, gave the user the option of changing the name or designation of the engagement or its description as in the Continue Engagement option.
**Correction**: When a fraction of a unit is entered to three decimal places and is later deleted, it is possible to only delete the equivalent of two decimal places.
**Addition**: Gave user the option of printing a two-page "short report".
**Correction**: Fatigue Factor calculation was not working.
**Correction**: Recovery of lost tanks is not being calculated.
**Correction**: Coordinates are not being calculated properly.
**Correction**: In small unit engagements without an armored component, got a "divide by zero" error.
**Correction**: R - R and R/R are not being calculated correctly.
**Correction**: Rewrote OLI program to fix multitude of errors and user interface.

## TNDM v. 1.5 Release date: 20 July 1991

**Addition**: The Non-Battle Loss Rate will now be printed after the Personnel Factors.
**Correction**: There was an error in the calculation of Defender Casualties by Branch.
**Change**: The labels for P/P and P'/P' have been changed from Ratio and P' to P/P Ratio and P'/P' (IMBALANCE) respectively.
**Addition**: P'/P' (IMBALANCE) and P'/P' (SURPRISE) have been added to the TNDM report. Since Surprise Effect is calculated before P'/P' (SURPRISE) is adjusted when it is greater than 3.0, it is not always possible to verify that the Surprise Effect is correct by using the values displayed in the report.
**Change**: The label "Order of Battle" has been changed to "Force & Equipment Inventory" in the TNDM report.
**Change**: The losses detail has been removed from the Short Report. There is a Beginning Inventory and a Final Inventory immediately after the Strength and Power listing.
**Change**: Most of the changes are visual; all menus now appear in a box.
**Change**: Also, for those using a color monitor, the colors have been livened up a bit.
**Change**: The OLI option has been changed to include the calculations of OLIs for single weapons and Mobile Fighting Machines (MFM). Most of the steps involved are identical to those used in the original OLI program except that this version does not ask for a file name; the weapon name should be used to describe the weapon. For example, T-80X would be given the full name of "T-80 125mm with Reactive Armor."
**Change**: In the calculation of single weapon OLIs, the analyst will be asked the weight of the projectile, missile, mortar, bomb, etc. If the weight is entered, the analyst will then be asked to select the category the weapon fits: small arms, machine gun, tank gun, aircraft gun, bomb, etc. Based on the selected category, its equivalent caliber in millimeters will be calculated. The analyst will have the option of using the calculated caliber or entering another value. If a weight of zero is entered, the analyst will have to supply the caliber.
**Change**: In the calculation of single weapon OLIs, the analyst will be given a list of weapon categories and their respective accuracies. If the selected accuracy is not correct, the analyst will be given the option to enter his own value.
**Change**: In the calculation of single weapon OLIs, the Burst Area will be calculated from the caliber for calibers of 15mm or greater. This version allows the analyst to change the Burst Area.
**Change**: In the calculation of MFM OLIs, the analyst will not have to enter the Vehicle Punishment Factor. This

factor will be calculated based on the MFM's weight.
**Change**: In the calculation of MFM OLIs, the analyst will first have to enter the factor for each of the primary, secondary, etc. weapons. Presently, these weapons should all be entered in the category of Infantry Weapons. Once these weapons are entered, the analyst will select the MFM's weapons from a list of weapons. This should it make it easier to calculate OLIs for aircraft with different bomb loads and configurations. When the report for an MFM is printed/displayed, the factors for the primary, secondary, etc. weapons will not be printed. The analyst will have to print the report for that particular weapon if the factors are desired.
**Change**: If a weapon's OLI has already been calculated and stored, the Report option in the OLI Menu can be used to display or print an individual weapon's factors and OLI. The Report option can also be used to print a summary report of all Weapons' OLIs in the OLI Database.
**Addition**: Included on the diskette is a file called OLI.RPT. This file is used by the OLI Report option to print/display a summary report of the Weapons' OLI. It can be used with any version of the TNDM.
**Addition**: I have created a program called OldToNew. This program is designed to convert the old OLI database for use with TNDM version 1.5. Before converting the old OLI database, it will rename it from OLI.DBF to OLDOLI.DBF.

## TNDM v. 1.51* Release date: 1 August 1991

**Correction**: TNDM.INI no longer has to be deleted after the TNDM is copied from a hard disk to a floppy or vice versa.
**Correction**: Some minor problems in the OLI portion of the software were fixed.
**Change**: Made new version of OLDTONEW.EXE to update TNDM and OLI databases.

## TNDM v. 1.52* Release date: 11 August 1991

**Correction**: Reinforcements. After reinforcements were added to a continuation, the reinforcements were not being included in the force inventory.
**Correction**: Division by Zero Error. All of the equations have been reviewed and changed to prevent any equation with a division operation from dividing by zero.
**Change**: The Weapons Sophistication Menu has been modified to show Israeli and Arab rather than Arab and Arab.

## TNDM v. 1.53* Release date: 13 August 1991

**Correction**: Addition of reinforcements to the defender in a continuation. The OLIs of the reinforcing units were added correctly, but the equipment amounts (armor, infantry, artillery, etc.) were being added to the attacker's equipment. In other words, if the defender was given reinforcements of 10 tanks with a total OLI of 9000, the defender's armor OLI increased by 9000, but the defender's tanks did not increase.

## TNDM v. 1.6 Release date: 22 September 1991

**Change**: Added Visibility, Low-light Capability, Power Traverse, Stabilization, Range Finding and Ballistic Computer factors for the calculation of armored fighting vehicles.
**Correction**: The Strength-Size Factor and Opposition Factor calculations in the TNDM have been corrected.
**Change**: The TNDM report has been changed to print the Vulnerability and Mobility Surprise factors.
**Change**: The "Set Options" selection in the Main Menu now brings up a menu with the options of Directory Locations, Color Settings and Reindex Databases.
**Change**: Updated OLDTONEW.EXE to convert earlier versions of OLI database to the 1.6 version.

## TNDM v. 1.61* Release date: 7 November 1991

**Change:** Make OLI data entry more user-friendly.
**Correction:** User was not able to enter a Muzzle Velocity for a weapon.
**Change:** Option 8, Set Options, will now display another menu that has an option called "Color Settings". This option allows anyone to change the color setting of each "color" used in TNDM.

## TNDM v. 1.62* Release date: 15 December 1991

**Change:** Modified the equation for calculating the Mobility Modifier. It now has a slightly higher value than it previously did.

## TNDM v. 1.63* Release date: 12 January 1992

**Change:** The Air OLI coefficient in the Mobility calculation has been changed to 15.
**Correction:** Item 5 in the Day/Night Menu was incorrectly labeled "Mixed Day and Night, Half Day." It should have been labeled "Mixed Day and Night, Mostly Night." If item 5 was selected, the value for Mostly Night would have been used.
**Correction:** Item 3 in the Season/Climate Menu was incorrectly labeled "Tropical." It should have been "Semi-Tropical".
**Correction:** Also, item 4, "Tropical", was not listed as an option. If item 3 was selected, the values for Semi-Tropical would have been used; it was not possible for the Tropical values to be used because of this error.

## TNDM v. 1.64* Release date: 22 January 1992

**Change:** The Air and Artillery OLI coefficients in the Mobility calculation have been changed to 20.
**Change:** Also, I have made some changes to the help file (TNDM.HLP) and the database conversion utility (OLDTONEW.EXE, OLDTONEW.PAS).

## TNDM v. 1.65* Release date: 17 February 1992

**Correction:** Updated the Aircraft Loss equation.
**Correction:** Corrected Penetration Factor equation.
**Correction:** Modified the OLI calculations for missiles to allow a Minimum Arming Range as small as 1 meter.
**Change:** Changed the Penetration Factor equation to calculate values for penetrations of less than 500 mm.

## TNDM v. 1.66* Release date: 5 May 1992

**Change:** The headings, field labels, etc. have all been set to change to display Personnel, Infantry, Artillery and Horses whenever the year of the engagement is 1900 or earlier.
**Addition:** When calculating the OLI for an armored fighting vehicle, reduce speed by 10% and mobility by 10% when the vehicle weighs more than 60 tons.

## TNDM v. 1.67* Release date: 12 May 1992

**Change:** Advance rate is now calculated as: Advance Rate = 1.6 * Sr * mc * rm * hm * RQ * RD * St * uar * dn * Su * ff
**Change:** The casualty rate is now calculated as: Casualty Rate = CN * N * uc * DEVd * Su * op * tz * rc * hc * zc * vl * ShD * dn * ff
**Change:** The standard tank loss rate is now calculated as: a) for the attacker, 4.0 * the attacker's personnel casualty rate; and b) for the defender, 1.5 * the defender's personnel casualty rate.

## TNDM v. 1.54 Release date: 13 August 1992

When this version was released for internal evaluation, I referred to the documentation for version 1.53 and it was

mislabeled as version 1.54. It probably should have been labeled as version 1.68. To maintain consistency, the numbering sequence for follow-on versions uses 1.54 as the starting basis.

**Change/ Correction:** It has a number of problems, but all the corrections and changes to the OLI calculations have been made. For the purposes of adding/updating weapon OLIs, it should run without any problems.
**Note:** If you wish to run an engagement, do not attempt to use any of the Manual Units options when creating a force. I am in the process of revising these options and none of the changes appear to work reliably at this time.
**Additions:** As a result of suggestions and requests made by KIDA (Korean Institute for Defense Analyses), some options have been added to several menus and menus have been added to the OLI section.

## TNDM v. 1.541* Release date: 28 August 1992

**Change:** Change the x, y coordinates to hold 4-digit numbers.
**Change:** When creating an engagement, make it possible to backup to a previous menu.
**Addition:** Add North Korea and South Korea to the Weapons Sophistication Menus.:
**Correction:** Fix PageUp and PageDown when creating a unit manually and using the OLI database.
**Change:** When creating or updating a unit's OLIs, save the original OLI value and give analyst the option of adding the new OLI to the original OLI or replacing the old OLI.
**Change:** When creating a unit, save the Table of Equipment for each category, but only in the Force Menu.
**Addition:** When creating an engagement, if a unit is created manually, give the analyst the option of saving it into the force database.
**Addition:** Add the option to save an engagement when creating an engagement.
**Correction:** When an engagement runs for 48 hours, why don't the results for second 24 hour period print?
**Change:** Why are there several weapons with the same name, such as 81mm mortars, that have different OLIs? Display the Country name to help distinguish weapons with similar names but different OLIs.
**Change:** In the OLI calculation, use the Weight of Bomb/Warhead only for bombs and rocket/missile warheads.
**Correction:** The Rate of Fire calculation is incorrect.
**Change:** Change ER in the OLI Rate of Fire tables to display as "Estimated Range."
**Change:** Make it possible to backup to a previous menu when entering a weapon's factors.
**Change:** Change the default value for the Rate of Fire Multiplier to 1.0.
**Change:** Use the Rules of Thumb Table only when cyclic rate of fire is used.
**Addition:** When creating an MFM, obtain the rate of fire for the primary weapon from the OLI database. Allow the analyst to override this value.
**Change:** In the Force menu, PageUp/PageDown are too slow when moving through the weapons list for any weapon category.
**Addition:** Should the user forget to select any units for an engagement, either prompt the user for attacker/defender units or avoid "divide by zero" errors when dividing by zero personnel.
**Correction:** Correct the error that occurs when non-standard date formats are used. User should be able to use any date format regardless of how computer is set up. Not sure that it works properly.
**Addition:** Add an Exit/Abort option to the OLI menus.
**Correction:** Use the Rate of Fire multiplier only for automatic weapons in the OLI calculation.
**Correction:** For the Rate of Fire Multiplier, use the table on page C-14 of the Rules and Procedures Manual.
**Change:** For calibers of less than 15 mm, calculate the burst area.

## TNDM v. 1.542* Release date: 21 September 1992

**Correction:** A number of errors in the TNDM software were discovered in the process of updating the User's Manual

## TNDM v. 1.543* Release date: 7 November 1992

**Correction:** Reinforcements are now added in before the results for an engagement continuation are calculated.
**Change:** The OLI Weapons' Summary Report has been modified to print the weapon type and nation.
**Change:** The Screen Display of reports has been modified. The changes are cosmetic and do not affect its operation.

## TNDM v. 1.544* Release date: 17 November 1992

**Change**: "CEVq" was changed to "CEVt".
**Change**: The Combat Power Factors, Attrition Rate Factors, etc. are now printed between the Historical Factors and the Units List.
**Correction**: CEVt is now calculated as the square root of $\text{Casualties}_A / (0.01 * \text{Personnel}_D)$
**Change**: R/R was being printed as P"/P". This has been changed to R"/R" and has been moved after Historical Results.
**Correction**: Incorrect P/P. This has been corrected and the calculated P/P matches the results which you obtained manually.
**Correction**: When an engagement is continued, the final inventory was not being saved.

## TNDM v. 1.545* Release date: 21 January 1993

**Change**: Modified menu system to allow analyst to translate menu options, help, etc. with affecting calculations.

## TNDM v. 1.55* Release date: 14 March 1993

**Correction**: If a new unit is created using the OLI database, all of the OLI scores of weapons in each category are lumped together and saved into the category.

## TNDM v. 1.591* Release date: 1 August 1993

This version of the TNDM was used to evaluate changes in the OLI calculations for Armored Fighting Vehicles in the TNDM software. A number of changes were made to follow-on versions. One set of changes included making it possible for the analyst to modify factors that are normally not user-accessible. The bulk of the analysis and evaluation was performed by Chip Sayers.

**Change**: Battlefield Mobility Factor = 0.035 * SQRT[ (Horsepower/Weight) * Speed / Ground Pressure], where SQRT = square root of
**Change**: Vehicle Punishment Factor = Weight / (2 * Height * Length)
**Change**: Radius Factor = 0.1 * Radius
**Change**: Vehicle Supply Factor = SQRT[ 6 * Load / ((6 * Load) + Firing Rate of Primary Weapon) ], where SQRT = square root of
**Change**: Both the Battlefield Mobility Multiplier (0.035) and the Radius Factor Multiplier (0.1) can be changed when a weapon's OLI is calculated. Please note the Radius Multiplier for other weapons has been given a value of 0.14.
**Addition**: All of the new factors (Height, Length, Ground Pressure and Horsepower) can be entered in the Weight option of Armored Vehicles. Height, Length and Ground Pressure must be values between 0.001 and 100.0; Horsepower must be between 0.001 and 10,000.
**Correction**: In a recent letter, Trevor mentioned that Dave Bongard had encountered an error in the Vehicle Punishment Factor (VPF): all vehicles were being given a VPF of 1.0.
**Addition**: You will note that one of the changes in this version is the appearance of a Comment box on the OLI screen. If you wish to enter a comment for a weapon, select the Comment option. When the Comment box appears, enter your comments and press the Control-End keys. Press the F1 key to get an explanation of the Comment editing commands.
**Change**: When entering a new weapon, set all the applicable factors to a default value. This will allow the analyst to skip items that are rarely used, such as the Naval Gunfire Factor.
**Addition**: Add the ability to create a new weapon by copying the OLI factors of an existing weapon into a new weapon and then modifying them to fit the new weapon. This would be useful for entering weapons that are updated models or

variations on older weapons.
**Addition**: Add the ability to add new weapons to an OLI database by copying them to a floppy, taking the floppy to another computer and then adding the new weapons from a floppy.
**Change**: Change View to list all factors in all weapons.
**Change**: On Armored Fighting Vehicles, allow the selection of Reactive Armor as either an add-on to the existing armor type or as the only armor type.
**Change**: When using the Search option, make it go to the top automatically if last record is reached.
**Change**: When entering MFM Components, do not ask if the weapon is an MFM Component twice.
**Change**: Attacker Mission. Remove the question "Is this an All-out Attack?". Change Main Effort to All-out Attack.

## TNDM v. 1.551* Release date: 16 August 1993

**Correction**: Dave Bongard reported getting an "Invalid floating point" error message. The error message "Invalid floating point operation" usually means a calculation in an equation is generating a number too large for the computer to hold. The only solution was to break up the Combat Strength calculations into several steps, one for each of the weapon categories (Armor, Infantry, Anti-tank, etc.).
**Correction**: User is unable to enter a starting time later than 0959 when creating an engagement.
**Correction**: Found that if the defender in a historical engagement was given a negative advance (for example, if the attacker advanced 20 kilometers, the defender advanced -20 kilometers), the Spatial Effect equation caused the "Invalid floating point operation" message to appear. The Spatial Effect equation had to be re-written to ignore negative numbers when using the square root operation.

## TNDM v. 1.552* Release date: 20 August 1993

**Correction**: Dave Bongard reported getting error 215 (Arithmetic overflow error) when trying to print an engagement report. If the problem re-occurs, there is a work-around solution. When the Print options appear on the screen (Screen, Printer, File), select File. Then enter a file name to save the engagement report, such as ANTIETAM.RPT. To print the report, exit from TNDM and then enter the command: TYPE ANTIETAM.RPT > LPT1: This will cause the contents of the file ANTIETAM.RPT to be printed.
**Note**: Unable to recreate the problem encountered when entering fractional Mission Accomplishment scores.

## TNDM v. 1.57 Release date: 11 October 1993

This version was customized for National Defence Research Establishment of Sweden. The most current version is 1.571, but I was unable to find a record of the changes/corrections made for 1.571.

**Addition**: Add three (3) weather conditions: Sunshine, deep snow; Overcast, deep snow; and Blizzard, deep snow. In other versions of the TNDM, when calculating the Non-Battle Losses, I have considered "Wet, Heavy, Temperate" weather to indicate tropical conditions. This is the only "tropical" condition remaining in the Swedish version of the TNDM. Because they asked to replace the "Wet, Heavy, ..." weather conditions with variations on "Heavy Snow" and remove any dealing with tropical conditions, I do not know if this is still appropriate. However, it will remain in their version of the TNDM unless you or they indicate otherwise.

## TNDM v. 1.592* 30 November 1993

Again, this is the version series that Chip Sayers was using to evaluate changes to the OLI calculations for Armored Fighting Vehicles. He expanded his work to include aircraft.

**Change**: Change "Range" to "Radius" for aircraft.
**Change**: Make the Aircraft Attack Factor a value entered by the analyst, rather than calculating it from the air speed.
**Change**: The Aircraft Vulnerability Factor should be a value entered by the analyst.
**Correction**: For helicopters, calculate the Radius of Action Factor as 0.0656 x Square Root of the radius.
**Change**: For vehicles, calculate the Radius of Action Factor as 0.14 x Square Root of the range.
**Change**: For fixed-wing aircraft, calculate the Radius of Action Factor as the Square Root of (0.0656 x the radius).
**Change**: For armored fighting vehicles, give the analyst the option of applying the Square Root to the Battlefield Mobility Factor, Radius of Action Factor, Vehicle Protection/Punishment Factor and the Vehicle Supply Factor. Please note that Vehicle Supply Factor is the result of a Square Root operation.
**Change**: For armored fighting vehicles, give the analyst the option of changing the modifiers used to calculate the Battlefield Mobility Factor, Radius of Action Factor, Vehicle Protection/Punishment Factor and Vehicle Supply Factor.
**Change**: To change the number of rounds/bombs/rockets/etc. carried by an aircraft, edit the list of weapons mounted on the aircraft. The right-hand column contains the number of rounds, etc. for each weapon. Changing that number will change the weapon's OLI.
**Note**: To enter a comment about a weapon, select the comment option on the menu. Type your comments in the box that appears on the screen. When you are done, press the Ctrl-End or Ctrl-W keys to save your comment. If you do not want to save the comment, press the Escape key. If you want additional information about how to use the comment box, press the F1 key when the comment box appears on the screen.
**Change**: Make it possible to change the modifier for the Aircraft Radius of Action Factor.

## TNDM v. 1.593* Release date: 31 January 1994

**Change**: Modified the Vehicle Supply Factor calculation to apply the square root operation only when selected.
**Addition**: Added a multiplier for the Vehicle Punishment/Protection Factor.
**Change**: Modified the Radius of Action Factor so that changes to it will "hold" until it is changed again. Please note that the value of the Radius of Action Factor is not the same for Armored Fighting Vehicles and Aircraft; you will have to make sure that the value is correct when calculating the OLI for an Aircraft.
**Change**: The Visibility Factor now defaults to 0.9.
**Change**: The Vehicle Punishment/Protection Factor has been changed to allow the use of a multiplier.
**Change**: If the Armor Type is Super Hard, the Mobility and Speed values will be left as is. Previously, these values were reduced by 10% whenever Super Hard armor was selected.

## TNDM v. 1.594* Release date: 11 April 1994

**Change**: The second multiplication of the Armor Type has been removed.
**Change**: Disabled error checking because of a problem reported by Chip Sayers. I have been unable to duplicate the problem that he experienced with the T-80 MBT with 125mm gun; it may be related to some error checking in the software.

## TNDM v. 1.595* Release date: 12 June 1994

**Addition**: The new factors have been labeled as "Morale." Morale is in the Rate Factors Menu and is applied to the Combat Power calculation in the same manner as the CEV.

## TNDM v. 1.81 Release date: 17 August 1994

The last version update sent to Chip Sayers was 1.8. This was in the series used to evaluate changes to the OLI calculations. I was unable to find any documentation that identified when version 1.8 was released. Version 1.81 merges the

changes made by Chip Sayers with the mainstream version of the TNDM.

**Change:** The lower limit for Rate of Advance modifier has been changed from 0.5 to 0.1
**Correction:** The software has been corrected to allow the times throughout the whole 24-hour clock.
**Change:** For mobile fighting machines, the listing of the weapons mounted on the MFM has been improved so that the weapons do not have to be re-selected each time that an MFM's weapons are changed.
**Change:** Armor OLI calculations have been modified to include horsepower, ground pressure, height and length as factors.
**Addition:** Comments about each weapon can now be entered. The command for saving a comment is CTRL-W: press the Control key, hold it down and then press the W key. To get a description of the other functions that can be used while editing a comment, press the F1 key while editing a comment.

## TNDM v. 1.82* Release date: 23 October 1994

This version is probably numbered correctly, but the documentation did not verify it.

**Correction:** Fixed the problem that Dave Bongard found in the printouts of engagements. The label for Anti-Air Defense was in the wrong place; it was appearing where Towed Artillery should have been and the SP Artillery label was appearing where Anti-Air Defense should have been.
**Change:** The Radius of Action equation used for Armored Fighting Vehicles (AFV) is the same one used for other Mobile Fighting Machines (MFM). The changes that were made to the Radius of Action equation affects all MFMs.

## TNDM v. 1.83* Release date: 31 December 1994

This version is probably numbered correctly, but the documentation did not verify it.

**Correction:** Division by zero error when running an OLI report.
**Correction:** In the OLI menu, nothing happened when Previous was selected.
**Correction:** In the OLI menu, nothing happened when Search was selected.
**Correction:** In the OLI menu, Clean seems to run forever.
**Correction:** In the Force menu, nothing happens when Report is selected.
**Correction:** In the Force menu, nothing happens when Next is selected.
**Correction:** In the Force menu, nothing happens when Previous is selected.
**Correction:** In the Force Menu, Clean seems to run forever.

## TNDM v. 1.831* Release date: 20 January 1995

**Correction:** The appearance of "4 =" before Shoreline Vulnerability is an error that I forgot to correct earlier.
**Correction:** The starting point in the report indicates the original starting point in the beginning engagement, not the starting point for the current engagement. I have corrected this to show the starting position for the continuation after the original starting position..
**Changed:** Prior Days of Combat has been modified to included Elapsed Time. Elapsed Time is hours of combat that occurred before the continuation. Prior Days of Combat is days of combat that occurred before the first engagement.
**Correction:** The reason that Location and Total Distance Advanced on page 3 did not match the start location on page 1 is that start location indicates the starting position for the first engagement. The correction made to show the starting point of the continuation corrects this problem.
**Change:** The Results Summary printed at the beginning of the report is only for the first day. There is currently no way of calculating a Results Summary for the entire engagement because results are calculated for each 24-hour period. The report has been modified to print a Results Summary for each period of combat.

## TNDM v. 1.832* Release date: 1 February 1995

**Correction:** T. N. Dupuy reported an error that occurred when trying to run an engagement which was created with an

carlier version of the TNDM.

## TNDM v. 1.84 Release date: 23 June 1996

Unable to modify or re-print an engagement after it has been saved. Fixed
Delete all of the files ending in .IND
Anti-tank factor is not being calculated correctly. Fixed
Modified calculation to limit IGI to the range of 1.0 - 2.5
Mobility factor is not being calculated correctly. Needs additional research.
Equation in the software is not the same as that used to calculate the results manually. See #1 below.
Vulnerability factor is not being calculated correctly. Needs additional research
Equation in the software is not the same as that used to calculate the results manually. See #2 below.
Order of weapon types in engagement report is incorrect. Fixed; this problem was fixed in version 1.82.
When entering manual units, program tracks weapons entered, but always reports total score as 0. When user presses ESC to exit, the system asks "Do you want to add this to your previous score?" User assumes Y, resulting in doubling/ tripling/etc of score. Fixed.
Removed the question "Do you want to add this to your previous score?" It is assumed that user will want to replace the existing OLI score for this weapon type.
Editing of manual units has been modified to allow the user to modify weapon counts, remove weapons or add other weapons.
When entering manual units, program does not clear buffer even if a new unit is added. Fixed.
When editing manual units, values in the summary first screen do not change when inventory is modified, even if inventory is changed manually from the menu. Fixed.
Values in factor tables do not always match factors listed in printed. Example: Terrain, Rugged Bare has an RM value of 0.5, but 0.6 is in the printout. Requires additional research.
Comparison of terrain table in software shows that it has more terrain types that in the February 1991 Rules & Procedures Manual. Factor values are also different. See #3 below.
Range check error #202 at 0032:81B2, 002F:5AAF, and 002F:5B1F. Unable to duplicate; requires additional testing.
Long Report does not always print the Attacker and Defender losses near the end of the report. Need an example to fix the problem.
When entering units from the Force database, if user adds one or more units, then pages up or down and returns to the original unit list screen, the numbers of the units are too far to the left. Fixed.

1. The Mobility equation currently in the TNDM software is:

$$M = \frac{(Na + 12Ja + Wia + 20Wga + 20Wya) \times yma / Na}{(Nd + 12Jd + Wid + 20Wgd + 20Wyd) \times ymd / Nd}$$

where 12 is replaced by 15 if year is before 1970 or by 20 if the year is before 1950.

2. The Vulnerability equation currently in the TNDM software is:

$$V_d = N_d \times (Uv_a / vu_d) \times \sqrt{\frac{S_a}{S_d}} \times yv_a \times rv_a$$

3. Factor Tables. Some changes were made to the Terrain Factor Table around the time that the customized version of the TNDM was made for the Swedes. Some additional changes were also made for the Gulf War analyses, such as adding additional desert terrain types.

## TNDM v. 1.85 Release date: 23 June 1996

**Correction**: Col. Wagner, South Africa Army College, reports that error 200 (Division by zero) occurs consistently when the Calculate OLI option is selected while trying to edit a weapon.

# The TNDM and Simulating Suppression

**by Dave Bongard**

The Dupuy Institute, in partnership with JHF, Inc. of Vienna, Va, secured a contract with the Field Element of the Human Research Laboratory-Human Resources Engineering Directorate (HRL-HRED) at Fort Sill, OK, part of the Field Artillery School there. The purpose of the contract, awarded in late 1993, was to examine the mechanism and effects of battlefield suppression (Phase I), with a further goal of providing one or more computer combat models currently used by the U.S. Army with a mechanism simulating suppression in combat (Phase II). Phase I was completed with the submission of the final report to HRL-HRED in November 1994. Phase II began in late spring 1995, is still in progress and due to be completed in December this year.

The central concept to this study is that of "suppression". Suppression may be defined as the transitory or temporary degradation of operation capability of an individual or military unit, as a result of the proximity of impact of hostile firepower. This includes both psychological and physical effects impairing normal combat performance of individuals or units who have not been rendered casualties by the firepower impact. In pithier terms, it is the non-lethal effect of firepower, especially from indirect fire, on individuals and units in combat.

The methodology employed for Phase I was to examine a number of battles from both the Pacific and European-Mediterranean theaters in World War II. The battles examined were mostly divisional-level, and were separated into "high suppression" (with large quantities of artillery and air support for one side, usually the attacker) and "low suppression" engagements. Comparing the computed CEVs for high suppression engagements with the CEVs for low suppression engagements would provide a correlation between CEV and firepower superiority, thus demonstrating both that suppression existed as a battlefield phenomena, and that it could be quantified.

The battles examined were limited to World War II engagements for two main reasons. First was the issue of data availability: engagements since 1945 often do not have decent or useful primary-source material for both sides, such as the case of the Korean War (1950-53) and the Iran-Iraq (1981-89) or Kuwait wars (1990-91). Second was the issue of relevance, since it was more likely that the customer would accept World War II data than anything earlier.

Accordingly, a total of over forty engagements were examined, listed here:

## European

**Low suppression**

1) Sele-Calore, US 45th Inf Div (12-13 Sep 1943)
2) Caiazzo
3) Santa Maria Infante, US 88th Inf Div (12-13 May 1944)
4) San Martino, US 85th In Div (12-13 May 1944)
5) Velletri, US 36th Inf Div (+) (26 May 1944)
6) Campoleone Station, US 34th & 45th Inf Divs (26-28 May 1944)
7) Fosse di Campoleone, 45th Inf & 1st Armd Divs (29-31 May 1944)
8) Krinkelt-Rocherath, US 1st & 99th Inf Divs (16-17 Dec 1944)
9) Sauer River, US 4th Inf Div (-/+) (16-17 Dec 1944
10) Celles, US 2d Arm Div (+) 24-25 Dec 1944)

**High suppression**

11) Anzio Breakout, US 1st Arm Div (23 May 1944)
12) Cisterna II, US 3d Inf Div (23 May 1944)
13) GOODWOOD, UK I & VIII Corps (1st day: 18 Jul 1944)
14) COBRA-St. Lo, US VII Corps (1st day: 25 Jul 1944)
15) Boulougne, Cdn 3d Inf Div (+) (19 Sep 1944)
16) Assensois, US CCR/4th Arm Div (26 Dec 1944)
17) VERITABLE, UK XXX Corps (1st day: 8 Feb 1945)
18) Roer River 1, US XIX Corps (1st day: 23 Feb 1945)
19) Roer River 2, US XIII Corps (1st day: 23 Feb 1945)

## Pacific

**Low suppression**

20) Eniwetok, US 106th Inf Reg't (2d day: 20 Feb 1944[1])
21) Eniwetok, US 106th Inf Reg't (3d day: 21 Feb 1944)
22) Parry, US 22d Marine Reg't (+) (22 Feb 1944)
23) Torokina Point, US XIV Corps (10-11 Mar 1944)
24) Tomb Hill-Ouki, US 7th Inf Div (9-11 Apr 1945)
25) Kochi Ridge-Onaga A, US 7th Inf Div (25-27 Apr 1945)
26) Kochi Ridge-Onaga B, US 7th Inf Div (28-29 Apr 1945)
27) Kochi Ridge-Onaga C, US 7th Inf Div (30 Apr-1 May 1945)
28) Kochi Ridge-Onaga D, US 7th Inf Div (2-3 May 1945)
29) Shuri East Flank A, US 96th Inf Div (11-13 May 1945)
30) Shuri East Flank B, US 96th Inf Div (14-18 May 1945)
31) Shuri East Flank C, US 96th Inf Div (20-21 May 1945)

[1] Although the initial assault on Eniwetok Island was a "high suppression" battle, with extensive air and naval gunfire support, the 2d and 3d days (which were treated as separate engagements because of U.S. reinforcements) were relatively "low-suppression" with minor air support and only 1 destroyer for naval gunfire support.

32) Shuri Envelopment 1, US 7th In Div (20-23 May 1945)
33) Advance to Yaezu-Dake, US 96th Inf Div (6-9 June 1945)
34) Yaezu-Dake I, US 96th Inf Div (10-11 June 1945)

**High suppression**
35) Tarawa, elements US 2d Marine Div (20 Nov 1943)
36) Roi-Namur, US 4th Marine Div (31 Jan 1944)
37) Kwajalein, US 7th Inf Div (1 Feb 1944)
38) Engebi, US 1 & 2/22d Marine Reg't (18 Feb 1944)
39) Eniwetok, US 1 & 3/106th Inf Reg't (19 Feb 1944)
40) Saipan, US 2d & 4th Marine Divs (15 Jun 1944)
41) Guam-Asan (N), US 3d Marine Div (21 Jul 1944)
42) Guam-Agat (S), US 1st Prov Marine Bde (21 Jul 1944)
43) Tinian, US 2d & 4th Marine Divs (24 Jul 1944)
44) Iwo Jima, US 4th & 5th Marine Divs (19 Feb 1945)

The results of these TNDM engagement analyses are appended to this article as a series of tables.

**Key to tables:**
*Engmt name* — engagement name
*Suc* — successful side, or winner
*Nat/Ndf* — number of attackers (personnel) divided by number of defenders Historical results (what actually happened)
*A cas* — attacking force casualties per day
*D cas* — defending force casualties per day
*%atC/%dfC* — ratio of casualties (in percent) of attacking force to casualties (in percent) of defending force
*D adv* — distance advanced by attackers, in kilometers
*Pat/Pdf* — attacking force Combat Power divided by defender Combat Power
*TNDM results* (what the model said would happen, with historical inputs) — same categories as in "Historical results"
*CEV* — model-calculated Combat Effectiveness Value for attacking force
*CEV-CEVav* — numerical difference between average attacker's CEV and engagement CEV (only for high suppression engagements)
*N Attk* — number of personnel in attacking force
*N Dfnd* — number of personnel in defending force
*P Att* — Combat Power of attacking force
*P Def* — Combat Power of defending force
*P/N Att* — Combat Power per individual in attacking force
*P/N Def* — Combat Power per individual in defending force
*Pg/N A* — Combat Power of Artillery per individual attacker
*Py/N A* — Combat Power of Air Support per individual attacker
*FPxs* — "excess firepower", measured in Combat Power (P)
*Pgy/N A* — Combat Power of Artillery and Air Support per individual attacker
*Pyg A/P D* — Combat Power of Attacker Artillery and Air Support divided by Defender's Combat Power

| | | Historical Results | | | | | | TNDM-Derived Results | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engmt Name | Suc? | Nat/Ndf | A Cas | D Cas | %atC/%df | D adv | Pat/Pdf | At Cas | Df Cas | atC/dfC | D adv | CEV | CEV-CEVav | N Attk | N Dfnd | P Atk | P Def | P/N Att | P/N Def | Pg/N A | Py/N A | FP xs | Pgy/N A | Pyg Att | Pyg A/P |
| **Low Supp ETO** | | | | | | | | | | | | | | | | | | | | | | | | |
| Sele-Calore | Def | 1.460 | 251 | 60 | 2.865 | 3.70 | 0.690 | 425 | 292 | 1.455 | 0.00 | 0.880 | -0.066 | 12,447 | 8,523 | 57,706 | 83,632 | 4.636 | 9.810 | 1.13 | 0.00 | | 1.130 | 14,065 | 0.1682 |
| Caiazzo | Atk | 2.830 | 146 | 52 | 0.992 | 1.60 | 2.800 | 359 | 350 | 1.026 | 4.80 | 0.680 | -0.266 | 18,210 | 6,435 | 94,547 | 36,364 | 5.192 | 5.651 | 1.31 | 0.15 | | 1.460 | 26,587 | 0.7311 |
| Anzio Breakout | Atk | 1.870 | 173 | 280 | 0.33 | 3.20 | 4.450 | 111 | 318 | 0.349 | 11.50 | 1.590 | 0.644 | 21,499 | 11,495 | 168,124 | 37,781 | 7.820 | 3.287 | 1.03 | 2.33 | | 3.349 | 72,008 | 1.9059 |
| S. Maria Infante | Atk | 2.020 | 265 | 518 | 0.253 | 7.00 | 3.120 | 234 | 396 | 0.591 | 2.70 | 0.960 | 0.014 | 18,702 | 9,258 | 170,655 | 54,697 | 9.125 | 5.908 | 2.50 | 1.83 | | 4.440 | 83,037 | 1.5181 |
| San Martino | Def | 2.210 | 987 | 360 | 1.241 | 0.00 | 3.110 | 228 | 359 | 0.635 | 2.70 | 0.580 | -0.366 | 17,970 | 8,131 | 98,158 | 31,562 | 5.462 | 3.882 | 1.68 | 0.88 | | 2.540 | 45,644 | 1.4462 |
| Spigno | Atk | 2.250 | 172 | 365 | 0.209 | 2.40 | 2.940 | 185 | 342 | 0.482 | 4.80 | 0.930 | -0.016 | 18,308 | 8,137 | 120,504 | 40,988 | 6.582 | 5.037 | 1.69 | 0.49 | | 2.190 | 40,095 | 0.9782 |
| Campoleone | Def | 1.800 | 172 | 193 | 0.495 | 1.10 | 1.630 | 439 | 515 | 0.852 | 3.20 | 0.800 | -0.146 | 19,047 | 10,582 | 82,990 | 50,914 | 4.357 | 4.811 | 0.92 | 0.00 | | 0.920 | 17,523 | 0.3442 |
| F. Di Campo | Def | 1.880 | 435 | 460 | 0.503 | 0.90 | 1.140 | 673 | 535 | 1.258 | 1.30 | 0.560 | -0.386 | 29,711 | 15,804 | 123,394 | 108,240 | 4.153 | 6.849 | 0.72 | 0.29 | | 1.020 | 30,305 | 0.2800 |
| Chartres | Atk | 1.880 | 113 | 579 | 0.104 | 0.00 | 5.890 | 80 | 305 | 0.262 | 4.90 | 1.019 | 0.073 | 15,646 | 8,322 | 98,801 | 16,740 | 6.302 | 2.012 | 2.41 | 0.00 | | 2.410 | 37,707 | 2.2525 |
| Krinkelt-Rocherat | Atk | 1.693 | 571 | 823 | 0.41 | 0.00 | 1.095 | 255 | 1051 | 0.243 | 0.00 | 1.056 | 0.110 | 55,026 | 32,496 | 177,992 | 162,560 | 3.235 | 5.002 | 1.34 | 0.00 | | 1.338 | 73,528 | 0.4523 |
| Celles | Atk | 1.269 | 53 | 203 | 0.206 | 8.00 | 2.903 | 101 | 221 | 0.457 | 11.93 | 1.349 | 0.403 | 18,347 | 14,455 | 177,219 | 61,054 | 9.659 | 4.224 | 1.10 | 0.38 | | 1.479 | 27,128 | 0.4443 |
| **AVERAGES:** | | **1.924** | **303** | **354** | **0.692** | **2.54** | **2.688** | **279** | **426** | **0.692** | **4.35** | **0.946** | | **22,265** | **12,149** | **124,535** | **62,230** | **6.048** | **5.134** | **1.45** | **0.58** | | **2.025** | **42,512** | **0.9568** |

| | | Historical Results | | | | | | TNDM-Derived Results | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engmt Name | Suc? | Nat/Ndf | A Cas | D Cas | %atC/%df | D adv | Pat/Pdf | At Cas | Df Cas | atC/dfC | D adv | CEV | CEV-CEVav | N Attk | N Dfnd | P Atk | P Def | P/N Att | P/N Def | Pg/N A | Py/N A | FP xs | Pgy/N A | Pyg Att | Pyg A/P |
| **High Supp ETO** | | | | | | | | | | | | | | | | | | | | | | | | |
| Cisterna | Atk | 2.040 | 814 | 539 | 0.740 | 2.40 | 5.968 | 157 | 600 | 0.262 | 0.60 | 1.210 | 27,907 | 24,275 | 11,900 | 203,228 | 34,054 | 8.372 | 2.862 | 2.75 | 3.07 | 1.80 | 5.830 | 141,523 | 4.1558 |
| GOODWOOD-1 | Def | 3.514 | 750 | 1200 | 0.178 | 8.85 | 24.372 | 344 | 503 | 0.684 | 38.76 | 0.620 | -34,461 | 58,500 | 18,650 | ######## | 74,722 | 31.131 | 4.488 | 1.22 | 26.00 | 13.26 | 27.218 | ######## | 21.3093 |
| Boulogne | Atk | 2.470 | 100 | 75 | 0.540 | 1.00 | 9.240 | 125 | 391 | 0.320 | 2.90 | 1.540 | 62,791 | 21,465 | 8,690 | 264,313 | 28,605 | 12.314 | 3.292 | 0.49 | 11.67 | 4.83 | 12.160 | 261,014 | 9.1248 |
| VERITABLE | Atk | 2.790 | 232 | 900 | 0.092 | 6.00 | 7.010 | 185 | 294 | 0.629 | 2.30 | 1.560 | 64,905 | 35,580 | 12,753 | 290,967 | 41,507 | 8.178 | 3.256 | 2.82 | 4.04 | 2.28 | 6.850 | 243,723 | 5.8719 |
| Roer River-A | Atk | 4.830 | 410 | 400 | 0.212 | 4.00 | 4.450 | 553 | 286 | 1.934 | 9.40 | 1.090 | 15,222 | 47,059 | 9,743 | 347,605 | 78,113 | 7.387 | 8.017 | 5.28 | 0.97 | 1.52 | 5.250 | 247,060 | 3.1629 |
| Roer River-B | Atk | 2.640 | 540 | 600 | 0.341 | 4.00 | 3.670 | 770 | 760 | 1.013 | 6.90 | 1.020 | 7,822 | 48,264 | 18,282 | 323,476 | 88,214 | 6.708 | 4.825 | 3.73 | 1.29 | 1.43 | 5.070 | 244,698 | 2.7739 |
| **AVERAGES:** | | **3.047** | **474** | **619** | **0.351** | **4.38** | **9.118** | **356** | **472** | **0.807** | **10.14** | **1.173** | | **39,191** | **13,003** | **641,789** | **57,536** | **12.348** | **4.457** | **2.72** | **7.84** | **4.19** | **10.396** | **455,048** | **7.7331** |

| | | Historical Results | | | | | | TNDM-Derived Results | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engmt Name | Suc? | Nat/Ndf | A Cas | D Cas | %atC/%df | D adv | Pat/Pdf | At Cas | Df Cas | atC/dfC | D adv | CEV | CEV-CEVav | N Attk | N Dfnd | P Atk | P Def | P/N Att | P/N Def | Pg/N A | Py/N A | FP xs | Pgy/N A | Pyg Att | Pyg A/P |
| **Low Supp PTO** | | | | | | | | | | | | | | | | | | | | | | | | |
| Eniwetok-2 | Atk | 4.218 | 135 | 447 | 0.072 | 1.20 | 31.641 | 91 | 487 | 0.187 | 1.57 | 1.036 | -0.238 | 3,423 | 812 | 36,746 | 1,168 | 10.735 | 1.438 | 0.88 | 6.02 | | 6.902 | 23,624 | 20.2260 |
| Eniwetok-3 | Atk | 10.252 | 135 | 447 | 0.029 | 1.20 | 50.278 | 90 | 325 | 0.277 | 1.54 | 0.816 | -0.456 | 3,332 | 325 | 35,798 | 712 | 10.744 | 2.191 | 0.90 | 6.01 | | 6.911 | 23,028 | 32.3421 |
| Eniwetok-4 | Atk | 8.357 | 508 | 779 | 0.078 | 2.10 | 53.183 | 100 | 638 | 0.157 | 1.57 | 0.751 | -0.523 | 6,510 | 779 | 52,758 | 992 | 8.104 | 1.273 | 3.07 | 1.65 | | 4.718 | 30,711 | 30.9587 |
| Shuri Line E | Def | 3.731 | 167 | 1346 | 0.033 | 0.30 | 19.604 | 363 | 678 | 0.535 | 0.40 | 1.280 | 0.077 | 19,714 | 5,284 | 203,514 | 10,381 | 10.323 | 1.965 | 3.89 | 2.95 | | 6.832 | 134,688 | 12.9745 |
| Shuri Line E-B | Atk | 4.409 | 118 | 886 | 0.030 | 0.10 | 26.892 | 335 | 693 | 0.483 | 3.86 | 1.314 | 0.111 | 20,973 | 4,757 | 270,078 | 10,043 | 12.877 | 2.111 | 5.44 | 4.14 | | 9.584 | 201,008 | 20.0147 |
| Shuri Line E-C | Atk | 4.627 | 167 | 1511 | 0.024 | 0.50 | 18.981 | 252 | 392 | 0.643 | 0.20 | 1.414 | 0.211 | 19,559 | 4,227 | 163,235 | 8,600 | 8.346 | 2.035 | 3.99 | 0.80 | | 4.816 | 94,184 | 10.9516 |
| Kochi River-O A | Def | 2.919 | 90 | 441 | 0.070 | 0.00 | 11.838 | 159 | 358 | 0.444 | 2.06 | 0.821 | -0.382 | 14,594 | 5,000 | 129,248 | 10,918 | 8.856 | 2.184 | 3.35 | 0.95 | | 4.297 | 82,715 | 5.7442 |
| Kochi River-O B | Def | 3.552 | 91 | 407 | 0.063 | 0.00 | 23.365 | 242 | 727 | 0.333 | 3.86 | 0.858 | -0.345 | 15,986 | 4,500 | 239,258 | 10,240 | 14.967 | 2.276 | 7.94 | 2.68 | | 10.609 | 169,590 | 16.5615 |
| Kochi River-O C | Atk | 3.892 | 100 | 969 | 0.027 | 0.10 | 40.899 | 161 | 524 | 0.307 | 2.97 | 2.179 | 0.976 | 15,764 | 4,050 | 375,819 | 9,189 | 13.840 | 2.269 | 13.90 | 5.74 | | 19.640 | 309,607 | 33.6932 |
| Kochi River-O D | Atk | 2.939 | 57 | 732 | 0.026 | 0.70 | 20.300 | 217 | 670 | 0.324 | 3.43 | 2.432 | 1.229 | 15,109 | 5,140 | 249,383 | 12,285 | 16.506 | 2.390 | 8.02 | 3.88 | | 11.893 | 179,698 | 14.6274 |
| Tomb H-Ouki | Def | 6.037 | 155 | 426 | 0.06 | 0.10 | 22.839 | 120 | 250 | 0.480 | 1.37 | 1.062 | -0.141 | 18,111 | 3,000 | 189,015 | 8,276 | 10.436 | 2.759 | 3.81 | 2.41 | | 6.217 | 112,594 | 13.6049 |
| Shuri Env 1 | Atk | 4.806 | 85 | 239 | 0.074 | 0.50 | 9.152 | 214 | 277 | 0.773 | 1.52 | 0.613 | -0.590 | 16,043 | 3,338 | 63,215 | 6,907 | 3.940 | 2.069 | 1.84 | 0.46 | | 2.301 | 36,910 | 5.3439 |
| Adv Yaezu Dake | Atk | 4.694 | 112 | 200 | 0.119 | 0.50 | 20.630 | 383 | 609 | 0.629 | 3.43 | 0.946 | -0.257 | 18,777 | 4,000 | 142,696 | 6,914 | 7.596 | 1.729 | 1.19 | 2.90 | | 4.085 | 76,712 | 11.0952 |
| Yaezu Dake | Atk | 4.395 | 44 | 533 | 0.019 | 0.25 | 22.815 | 287 | 656 | 0.436 | 3.80 | 1.316 | 0.113 | 18,680 | 4,250 | 120,328 | 5,274 | 6.442 | 1.241 | 2.97 | 0.00 | | 2.869 | 53,593 | 10.1617 |
| **AVERAGES:** | | **4.916** | **140** | **669** | **0.052** | **0.54** | **26.601** | **215** | **520** | **0.429** | **2.26** | **1.203** | | **14,755** | **3,533** | **162,217** | **7,279** | **10.265** | **1.995** | **4.36** | **2.90** | | **7.262** | **107,762** | **17.0214** |

| | | | Historical Results | | | | | TNDM-Derived Results | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Engmt Name | Suc? | Nat/Ndf | A Cas | D Cas | %atC/%df | D adv | Pat/Pdf | At Cas | Df Cas | atC/dfC | D adv | CEV | CEV-CEVav | N Atk | N Dfnd | P Atk | P Def | P/N Att | P/N Def | Pg/N A | Py/N A | FP xs | Pgy/N A | Pyg Att | Pyg A/P |
| **High Supp PTO** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tarawa | Atk | 1.034 | 1500 | 1618 | 0.897 | 0.20 | 16.589 | 1384 | 1921 | 0.720 | 0.50 | 1.750 | 45.470 | 5,000 | 4,836 | 257,981 | 15,551 | 51.596 | 3.216 | 27.94 | 21.04 | 5.71 | 48.983 | 244,916 | 15.7492 |
| Roi-Namur | Atk | 4.074 | 408 | 1828 | 0.055 | 0.80 | 72.943 | 416 | 2645 | 0.157 | 0.97 | 0.938 | -6.481 | 14,708 | 3,610 | 291,187 | 3,992 | 19.798 | 1.106 | 16.73 | 0.97 | 1.42 | 17.704 | 260,390 | 65.2280 |
| Kwajalein | Atk | 3.273 | 263 | 2030 | 0.040 | 1.00 | 55.669 | 301 | 695 | 0.433 | 1.36 | 0.707 | -41.230 | 9,656 | 2,950 | 338,298 | 6,077 | 35.035 | 2.060 | 27.29 | 4.98 | 3.42 | 32.275 | 311,643 | 51.2824 |
| Engebi | Atk | 3.233 | 203 | 1240 | 0.051 | 2.83 | 74.514 | 126 | 1276 | 0.099 | 5.47 | 1.156 | -3.907 | 4,125 | 1,276 | 141,542 | 1,897 | 34.313 | 1.487 | 27.00 | 3.37 | 3.16 | 30.372 | 125,283 | 66.0427 |
| Eniwetok-1 | Atk | 1.928 | 135 | 447 | 0.157 | 1.20 | 59.154 | 92 | 535 | 0.172 | 1.59 | 1.067 | -11.305 | 2,597 | 1,347 | 95,888 | 1,621 | 36.923 | 1.203 | 24.19 | 8.26 | 3.44 | 32.444 | 84,257 | 51.9784 |
| Saipan | Atk | 10.075 | 765 | 1200 | 0.063 | 4.50 | 52.789 | 105 | 679 | 0.155 | 2.42 | 0.784 | -34.830 | 40,300 | 4,000 | 417,346 | 7,906 | 10.356 | 1.977 | 7.40 | 0.45 | 0.08 | 7.581 | 316,410 | 40.0215 |
| Guam-North | Atk | 2.616 | 308 | 960 | 0.124 | 8.00 | 18.100 | 115 | 1242 | 0.093 | 8.85 | 1.408 | 17.041 | 9,550 | 3,650 | 152,622 | 8,432 | 15.981 | 2.310 | 12.75 | 0.93 | 0.87 | 13.681 | 130,652 | 15.4948 |
| Guam-South | Atk | 3.638 | 205 | 600 | 0.094 | 8.00 | 18.258 | 104 | 1144 | 0.091 | 9.85 | 1.370 | 13.882 | 8,350 | 2,300 | 103,999 | 5,696 | 12.455 | 2.477 | 9.62 | 0.90 | 0.44 | 10.527 | 87,897 | 15.4314 |
| Tinian | Atk | 1.384 | 227 | 956 | 0.172 | 2.59 | 9.478 | 124 | 801 | 0.155 | 2.60 | 1.515 | 25.935 | 11,900 | 8,600 | 208,150 | 21,962 | 17.492 | 2.554 | 12.79 | 1.66 | 0.96 | 14.452 | 171,975 | 7.8306 |
| Iwo Jima | Atk | 0.618 | 2000 | 2904 | 1.115 | 0.80 | 36.623 | 161 | 1424 | 0.113 | 4.31 | 2.049 | 70.324 | 11,305 | 18,300 | ####### | 69,032 | 223.631 | 3.772 | 118.31 | 103.73 | 29.26 | 220.993 | ####### | 36.1909 |
| **AVERAGES:** | | **3.187** | **601** | **1377** | **0.277** | **2.99** | **41.422** | **293** | **1236** | **0.219** | **3.69** | **1.274** | | **11,749** | **5,087** | **453,516** | **14,217** | **45.758** | **2.216** | **27.59** | **14.63** | **4.88** | **42.901** | **423,175** | **36.5259** |

An examination of the results shown in these tables shows that in engagements where the attacker possessed a large imbalance of firepower score, the TNDM model generally predicts a smaller margin of victory than actually occurred. The correlation is more clear with European–Mediterranean theater engagements. This may be due to the fact that all of the high–suppression Pacific engagements are amphibious assaults, and that in several cases (Saipan and especially Iwo Jima) the Japanese defenders were so heavily dug–in as to be nearly subterranean.

Still, the fact that "excess" firepower does more than simply cause greater physical losses is crucial. It means that a heavy firepower imbalance has a discreet, arithmetically definable, non–physical effect. While the defenders under suppression suffer relatively little additional physical damage, their capacity to resist is notably reduced, and they are able to inflict less damage on the attacker's forces. Essentially, these results show that the defending forces are being rendered temporarily incapable of functioning efficiently. That is, the side which suffers the firepower disadvantage is being suppressed.

# How the TNDM Measures Fortifications


**by Christopher A. Lawrence**

In April of this year, members of the Joint Chiefs of Staff (JCS) requested that we prepare a study on the military impact of the international convention to ban anti-personnel mines. Our first draft was delivered within eight days of the request, with further material submitted later. We also prepared considerable analysis after that, but no further work was contracted for, as a decision had been made by the President on the subject. We therefore ceased work on this effort.

As part of this effort, we attempted to use the TNDM to measure the impact of fighting conventional actions with AP mines and without AP mines. This led me to first conduct an analysis of how mines are modeled within the TNDM. I prepared two brief papers on the subject. One was titled "Estimating the Impact of Mines as Measured by the TNDM" and the other was called "Estimating the Impact of Mines on Force Vulnerability as Measured by the TNDM".

The first paper was included in our report "Military Consequences of Landmine Restrictions" as part of Attachment 2, "TNDM Analysis," to our report. We may issue out the results of this analysis at a later date.

The second paper was not included in our report as it was too esoteric and inconclusive for any deliverable product. We have included it here just to spark some interest in understanding the internal workings of the model. Quite simply, until now, I had never bothered to look at how the TNDM measures vulnerability. There are some surprisingly sophisticated, if not idiosyncratic, formulations in this model.

# Estimating the Impact of Mines as Measured by the TNDM

**5 April 1996**

1. The measurements for fortification and defense factors that are used in the TNDM comes from a study done for the US Army Concepts Analysis Agency called *Historical Evaluation of Barrier Effectiveness* prepared in March 1974.

2. The study confirmed Clausewitz's assertion that "the defense is the stronger form of conducting war" and indicated that the combat capabilities of a military force is enhanced, or multiplied by a factor ranging from 1.15 to 1.6, depending upon the extent to which the defensive position has been prepared or fortified.

3. According to the study, the preparation of the defensive position involves four major kinds of efforts:

1. The construction of entrenchments and other forms of field fortifications.
2. The preparation of demolitions to block pas sage of roads, defiles, or bridges
3. The preparations of various forms of constructed obstacles to block limited or broad avenues of movement.
4. The emplacement of mines or other explosive charges to impeded hostile progress across oth erwise favorable, generally broad, avenues of movement.

4. The study claimed that the historical records did not provided any direct evidence of the relative contribution of each of the four components, but the study claimed that field fortifications made up half of the defensive value. It claimed that the defensive value of the other three components (mines, obstacles and demolitions) are approximately equal.

5. When a defense is fully developed, the total bonus is 60%. Of these field fortifications account for 30%, demolitions account for 10%, mines account for 10%, and constructed obstacles account for 10%. This ratio only applies after all have been fortified.

6. In *Numbers, Predictions and Wars* , the following posture table is used:

| | Force Strength | Vulnerability |
|---|---|---|
| Attack | 1.0 | 1.0 |
| Defense (hasty) | 1.3 | 0.7 |
| Defense (prepared) | 1.5 | 0.6 |
| Defense (fortified) | 1.6 | 0.5 |
| Withdrawal | 1.15 | 0.85 |
| Delay | 1.2 | 0.65 |

7. In figure V-24 of the study, the component parts of the defensive value are:

| | Value | Demo. | Mines | Obstacles | Field Fortifications |
|---|---|---|---|---|---|
| Withdrawal | 1.15 | 0.055 | 0.05 | 0.0225 | 0.0225 |
| Delay | 1.2 | 0.07 | 0.06 | 0.035 | 0.035 |
| Hasty | 1.3 | 0.09 | 0.08 | 0.06 | 0.07 |
| Prepared | 1.5 | 0.1 | 0.1 | 0.1 | 0.2 |
| Fortified | 1.6 | 0.1 | 0.1 | 0.1 | 0.3 |

*Note: all these figures are hypothetical, and none are directly supported by data.*

8. Therefore, making an assumption, collaborated by measures of effectiveness derived from historic data (see Attachment 4), that AP mines and booby traps make up half of the mine effects accounted for, the reduction in defensive posture values for the following postures are:

| | Old Value | Degradation Amount | New Value | Percent Degradation |
|---|---|---|---|---|
| Withdrawal: | 1.15 | .03* | 1.12 | 2.6 % |
| Delay: | 1.2 | .03 | 1.17 | 2.5 % |
| Hasty: | 1.3 | .04 | 1.26 | 3.1 % |
| Prepared: | 1.5 | .05 | 1.45 | 3.3 % |
| Fortified: | 1.6 | .05 | 1.55 | 3.1 % |

* *rounded up to the nearest .01.*

9. While booby-traps are used to some extent in protecting barriers and obstacles, the measurable impact on conventional combat is considered low enough to be entirely ignored for purposes of this study.

# Estimating the Impact of Mines on Force Vulnerability as Measured by the TNDM

**5 April 1996**

1. The measurements for fortification and defense factors that are used in the TNDM comes from a study done for the US Army Concepts Analysis Agency called *Historical Evaluation of Barrier Effectiveness* prepared in March 1974.

2. This study does not address the vulnerability factors that are used in the TNDM. It only addresses the defense factors. No study has been located that discusses how the vulnerability factors were derived. In *Numbers, Predictions and War*, Col. Dupuy states that the formula concerning vulnerability came from considerable experimentation with WWII data. In that formula, the posture vulnerability factor (some number one or smaller) was divided by the terrain factor for the defensive posture (some number 1 or greater). In the case of attackers, this posture factor is one.

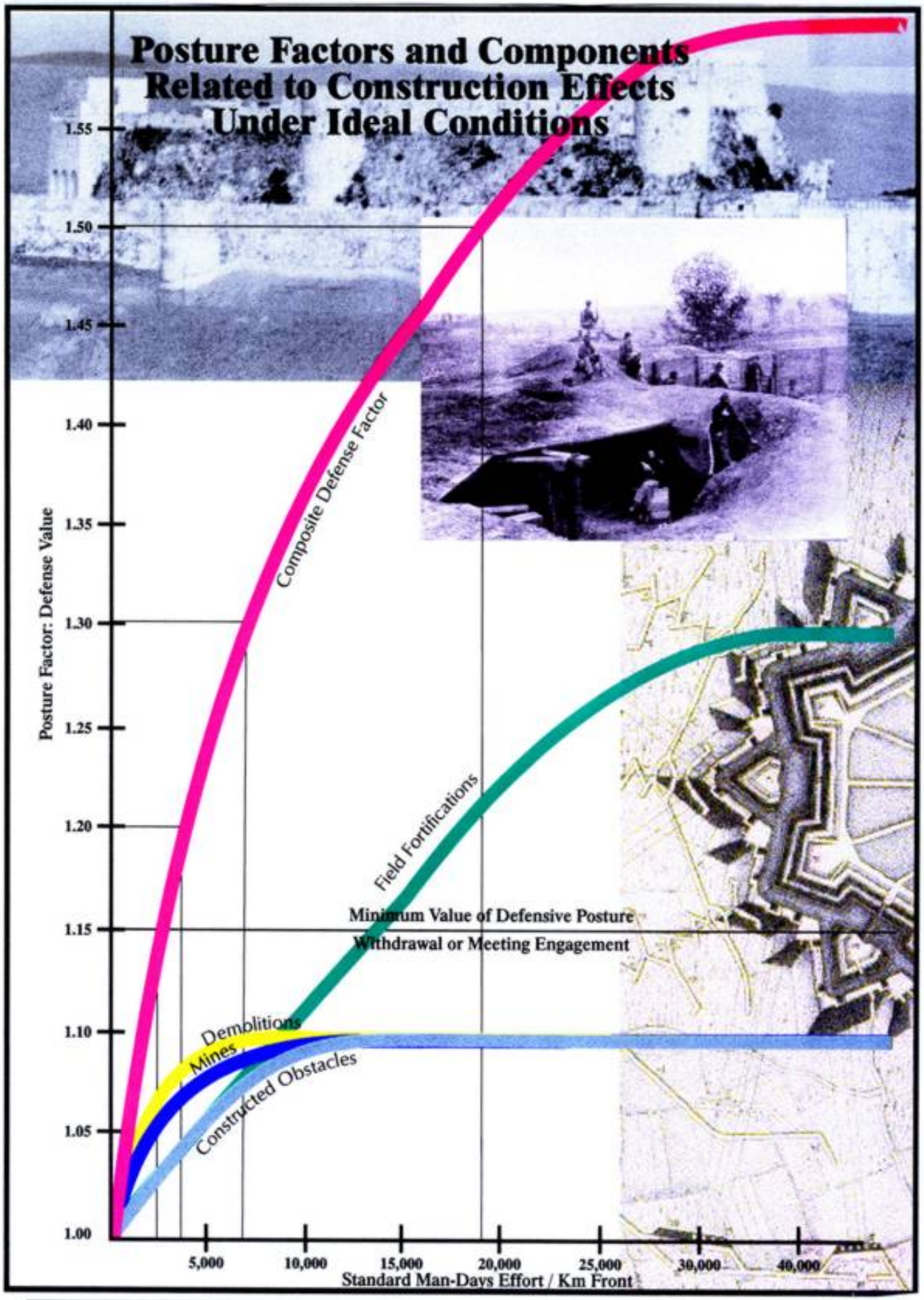
3. The end result of this formulation is intuitively that people in defense suffered lower losses if all other factors were equal. Also, people defending in rough terrain suffered lower losses than those that are not. The two reductions in vulnerability were multiplied together. There was then a second formula that effectively reduces the impact of the casualty reduction by some amount tied to the firepower scores of the weapons for a side. It also reverses the value of the numbers so that more vulnerable forces have a smaller multiplier and therefore a lower firepower score. This multiplier is then applied to the firepower scores for each side in determining the victor, and later the opposing sides vulnerability modifier is used to reduce casualties. The reasoning behind these last three steps are not fully understood.

5. In *Numbers, Predictions and Wars* , the following posture table is used:

| | Force Strength | Vulnerability |
|---|---|---|
| Attack | 1.0 | 1.0 |
| Defense (hasty) | 1.3 | 0.7 |
| Defense (prepared) | 1.5 | 0.6 |
| Defense (fortified) | 1.6 | 0.5 |
| Withdrawal | 1.15 | 0.85 |
| Delay | 1.2 | 0.65 |

6. The reductions in vulnerability scores for hasty, prepared and fortified postures seems to be tied, and probably should be tied to the amount of entrenching that has been done. The lower vulnerability for withdrawal and delay appear to be clearly tied to the posture and have nothing to do with mines.

7. Therefore, no modifications need to be made to the vulnerability factors to account for banning AP (or for that matter AT) mines.


Posture Factors and Components
Related to Construction Effects
Under Ideal Conditions
Posture Factor: Defense Value
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
Composite Defense Factor
Field Fortifications
Minimum Value of Defensive Posture
Withdrawal or Meeting Engagement
Demolitions
Mines
Constructed Obstacles
5,000
10,000
15,000
20,000
25,000
30,000
40,000
Standard Man-Days Effort / Km Front

Volume 1, Number 2 October 1996

# THE INTERNATIONAL TNDM NEWSLETTER

## Goose Green/Darwin 28 May 1982

Also in this issue:

- Planned Improvements to the TNDM
- Developing a Logistics Module for the TNDM
- Validation of the TNDM at Battalion Level
- What Happens When the Rate of Fire Goes to Zero?

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*Publisher*
The Dupuy Institute

*Editor*
Christopher A. Lawrence

*Production Manager*
Jay Karamales
Olórin Press

*Contributing Editors*
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

*Founder*
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John D. Kettelle
Nicholas Krawciw
James C. Pfautz
Abraham Wolf

*Administrative Offices*
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
73612.3222@compuserve.com

# From the Editor...

I assume that everyone has received his or her first *International TNDM Newsletter* and read it cover to cover with great enthusiasm. I know at least one person opened up the front cover, as I received an e-mail message pointing out a typo in our masthead. The first issue was thicker than I planned, as José Perez surprised me with the detailed modification listing for the TNDM. This newsletter is more typical of what you will see in the future. It is again thicker than we expected, but has three times the articles.

As we promised when we first started marketing our support contracts, we are looking at updating the TNDM. We have begun work, as part of our contract on the effects of artillery suppression, to develop a logistics module for the TNDM. My first draft of the concept behind this module is attached. I would like to thank José Perez for providing me with useful comments. I would be very interested in hearing commentary on my plans to develop a logistics module. We intend to do some basic background research on the subject during October and November, and start working on the architecture of the module in December. I am guardedly optimistic that we can have a functional module in January or February. We shall see. We will keep you informed of the progress on this effort through the newsletter.

The first article in this newsletter, by Dave Bongard, is an attempt to analyze a modern battalion–level battle. In the original conception of the Quantified Judgement Model (the predecessor to the TNDM), the idea was to use it as a tool to analyze historical engagements. This was referred to as the Quantified Judgement Method of Analysis of Historical Combat Data (QJMA). This ability to analyze a historical battle lead to the QJM, which was essentially using the historical model as a predictive tool. As one can see from this article, if one assumed that the Argentine Army was the equal to the British, then one could *not* have correctly predicted the outcome of Goose Green. If one assigned the British a CEV of 3, then one gets a reasonable predictor, even if the advance rates are too slow and casualties for both sides are too high by a factor of two. In these cases I am referring to only the first two runs of the TNDM.

Additional improvements to the analysis can be made "after the fact," as was done here with the recording of the Milans as anti–infantry weapons. But unless the analyst is particularly clever, this modification is not one that would have been seen when using the model for predictions.

The assignment of a CEV for the engaged sides is necessary for producing reasonable predictions. If you look at *If War Comes: How to Defeat Saddam Hussien*, which we included in our first issue, you will note that at the beginning of the analysis, Trevor Dupuy assigned a CEV of 3 to the US relative to the Iraqis. He stated that this was a conservative estimate and felt in private that it was a very conservative estimate. Traditionally, the Iraqi army has been one of the worst of all the armies that Israel engaged, and this was the basis for Trevor's analysis. The performance of the Iraqi army during the Iran–Iraq War had done nothing to change this opinion.

I believe that there needs to be a more rigorous methodology for developing CEVs. Right now, they can be determined only after the fact. As a predictive tool, you end up having to make a judgement call based upon past performance, plus any adjustments based upon changes to the military system, combat experience, and training regimes. While one should never underestimate the enemy, it is completely unjustified to assume that the average Iraqi soldier has the same level of skill, training, motivation and combat effectiveness as the professional US volunteer troops. If all other factors are equal, one should expect that a conscript army will be inferior to a volunteer army. This is true for British and Argentines, US and Iraqis, and almost certainly true for the US Army of the 80s and the Soviet Armies of the 80s (I am trying to provoke someone to write a letter). To assume that two armies with very different recruitment systems, doctrine, motivation, societies, etc. are the same is clearly in error. This, I believe, is the most common error in the combat modeling business.

*(cont.)*

This whole discussion will eventually lead to me produce an article in this newsletter on how to predict a CEV for an army and a proposal for a more rigorous methodology for developing a CEV.

We also have in this issue two more articles by Dave Bongard. This includes a description of how to read a TNDM printout and a discussion of the weather factors that we inserted in the TNDM version 1.84 for Nicklas Zetterling of Sweden. This article was faxed to Mr. Zetterling for comment before we published it. I believe he volunteered to make a contribution to a later issue of the newsletter on how he developed these factors. He has done considerable analysis of arctic battles, particularly the WWII battles around Petsamo. I look forward to seeing what he has.

Seeing how Dave Bongard has written many of the articles in the first two issues of the newsletter, I figured it was time to introduce him. So, as a regular feature of the newsletter, we are adding a "Who is TDI" section that will introduce the reader to the people who make up the Dupuy Institute and are writing these articles. Dave was unable to produce a satisfactory recent photo of himself for the article, so we substituted something appropriate.

I have prepared six short articles for this newsletter. Three of these describe the plans for model development that we are looking at for the TNDM. These are the articles on our planned improvements for the TNDM, the logistics module for the TNDM, and our test of changing the rates of fire in the TNDM. As you are the users of the TNDM, I am very interested in what you consider to be important, what are the shortfalls in the models and where do we need to make improvements. Please feel free to forward any comments or criticisms that you have.

The next article is on our plans for validating the TNDM at the battalion level. In writing this article, I ended up with long discursion on the original QJM. So I decided to unclutter my text and make a new article, thereby cluttering up the newsletter. This resulted in the article on validation of the QJM. Finally, there is a brief article on the Velocity Attrition Factor used in the TNDM.

Finally, José Perez has prepared an article describing how to modify the menu's in the TNDM so you can convert them to another language. Not all users of the TNDM are fluent in English, and there is an easy methodology for converting the menu's into your native language.

In the last issue, I promised to include a description of the use of mines and fortifications at Kursk and an article on the use of Lanchester Equations in the TNDM. Unfortunately, I was furiously trying to complete the Kursk database during September and have a backlog of work to do on the Suppression contract. Therefore these articles are delayed until one of the later issues.

The next issue will address dispersion and how attrition is calculated. We will take a look at issues related to our battalion–level validation, including the effects of unit size and time on the attrition calculations. We will also be looking at how to reflect "stealth" in TNDM OLIs, providing a description of the Modern Contingency Operation Database (MCODB), and will present a paper I've been developing on how to model operations other than war (OOTW—a phase I do not like, but is the currently in vogue buzz–word in the US defense community).

The fourth issue will contain an article on our initial attempts to create a model of the Air Campaign. We hope to publish the results of our validation of the TNDM as a battalion–level model. One could say that Goose Green–Darwin article is the start of this effort. It will also include an article on the use of the Lanchester equations in the TNDM.

Issue 5 will focus on the modeling of tanks and armored warfare. This will include the article on the use of mines and fortifications at Kursk. The sixth issue will include an article written by Trevor Dupuy that has never before been published, entitled *Technology and the Human Factor in War*.

Again, thanks to Arnold C. Dupuy of NOVA Publications, we have arranged for everyone receiving this newsletter to also receive a copy of *Future Wars.* This book was written back in 1992 as an attempt to analyze some of the potential conflicts of the would. Apparently it received some press in Japan due to the postulated use of the Japanese air force in a future Korean War.

That is all for this issue. If you have any questions, please contact me. Addresses, e–mail addresses, and phone numbers are in the masthead.

# A TNDM Analysis of Goose Green–Darwin, 28 May 1982

**by Dave Bongard**

The Battle of Goose Green, or more properly Goose Green–Darwin, was the first land action of the Falklands War of spring 1982. It was a resounding British success, and a severe shock to Argentinean morale. It was also welcome good news to a British public weary of naval mishaps and relatively heavy losses at sea. Although the main British objective in land operations was the liberation of Stanley, the capture of Goose Green–Darwin was an important intermediate step, as it secured a valuable airfield and screened the southern flank of the eastward cross-country British advance on Stanley.

My initial analysis of the battle (about which more will be detailed below) showed that the TNDM could not, at first pass, recreate the battle, even with carefully selected environmental and weather conditions. I thought I might have found the "exception to the rule," which the TNDM could not simulate. The following article is an evaluation of the TNDM analysis and how I was later able to improve it to more closely reflect reality.

The British attack on the Argentinean force at Goose Green and Darwin settlements on East Falkland was a classic light infantry assault on a prepared position held by numerically superior forces. The 2d Battalion, the Parachute Regiment made its assault from the north, starting about 0300, well before first light. The "2d Paras" comprised about 550 officers and men, equipped with two 81mm mortars,[1] 12 Milan ATGM launchers (the normal allotment was 16), an assortment of other infantry weapons (twice the usual allowance of GPMGs, with LAWs, Carl Gustav rockets, and rifles),[2] and supported by half of 8 Battery of the 29th Commando Regiment, R.A., with three 105mm Light Guns. The Paras were also supported by fire from the frigate HMS *Arrow's* 4.5" gun (this was sporadic, since the ammunition feed system broke down), and eventually by three Sea Harrier sorties.

Their attack moved south, with Darwin as their initial objective, and Goose Green itself as the ultimate goal. The Argentinean defenders were well dug–in, although before the battle the Paras had been told that there were only about 500–700 of them. Between the completion of their approach march in the early hours of 27 May and the start of the battle a day later, the Paras learned that there were really twice as many, some 1,300 to 1,400. This force comprised the 12th Infantry Regiment, reinforced late on 27 May by elements of the 25th Infantry Regiment, brought in by helicopter, along with 150–200 Argentinean Air Force personnel assigned to the airstrip, the three Pucara strike aircraft based there (these departed hastily soon after the attack began), and the defending antiaircraft battery.

The Paras' advance encountered unexpectedly heavy resistance as dawn broke. The Argentinean infantry blazed away, not very accurately, with rifles, machineguns, grenade launchers, and recoilless rifles from their forward entrenched positions. From the Argentine main and headquarters positions around Goose Green came fire from their 81mm and 120mm mortars, and the battery of M–56 105mm howitzers assigned to the garrison.[3] Although resolute, the Argentinean defense was only haphazardly coordinated. The British attack was further hampered when their mortars ceased fire because of ammunition exhaustion just after 0900, after HMS *Arrow's* gun had ceased firing about 0830. Eager to maintain momentum and keep the attack moving, Col. Herbert Jones (almost universally known as "H"), commander of 2d Battalion, personally led an attack against a troublesome strong-point threatening B Company's line of advance. Although the assault was successful, Jones was mortally wounded and died a few minutes later, just after 0930.[4] Command then passed to Major Chris Keeble, the battalion's executive officer. Keeble also wanted to maintain impetus, and called for the support company's Milans and machineguns to be shifted forward to the hills east of Boca House.

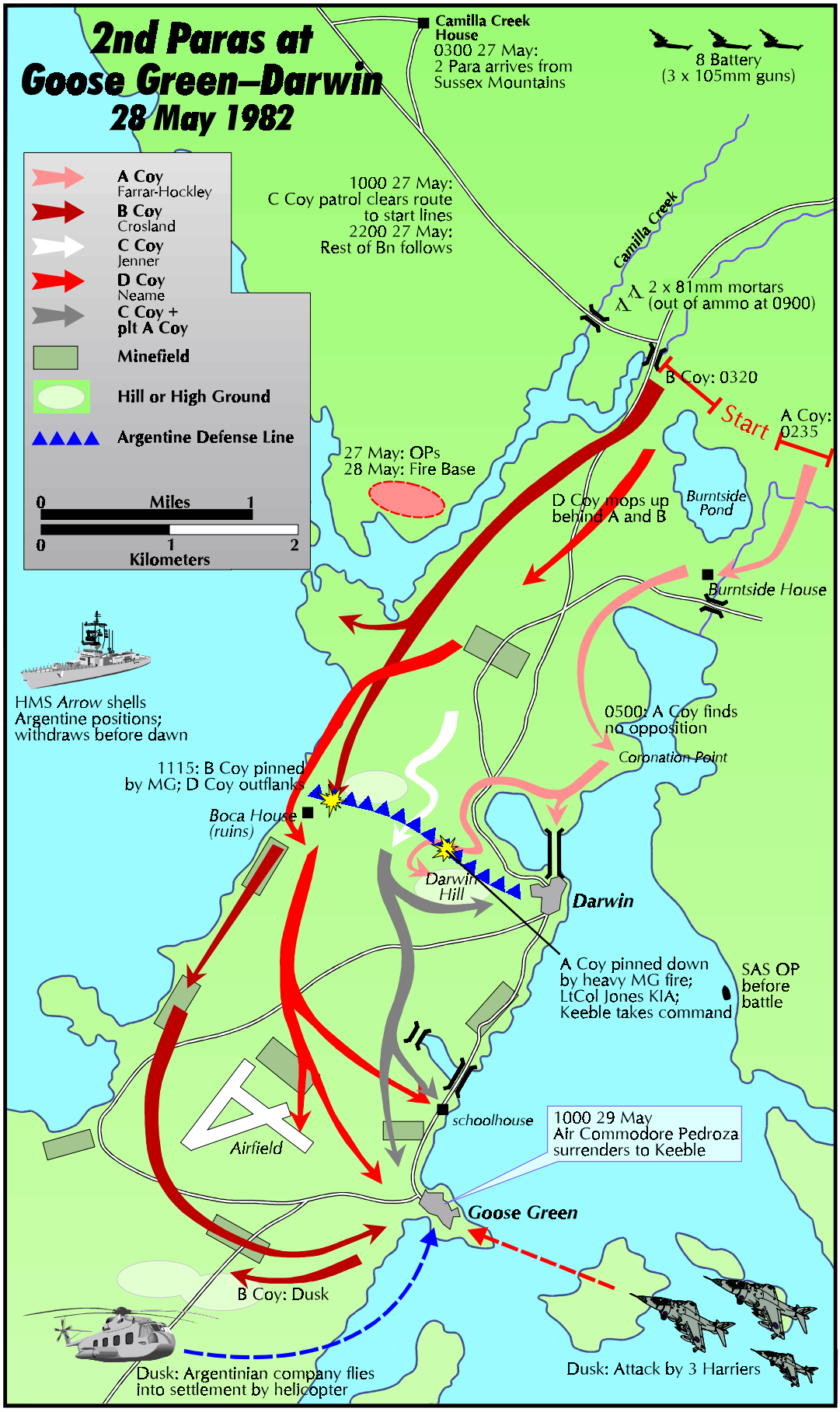
The Paras continued their attack, making their way forward to the south with dogged determination. They overran position after position held by the 12th Regiment, either capturing or killing the defenders in place (usually with rocket rounds), or driving them southward to the next position. The Argentineans mounted

[1] The choice the Paras faced, because of lack of transport, was either to have all eight mortars and almost no ammunition, or two mortars with almost as much ammo as they needed. Sensibly, they opted for the second choice, albeit not without some grumbling. British transport assets, especially helicopters, were stretched to, and past, the limit during the campaign.

[2] The 2d Battalion, The Parachute Regiment was authorized one 51mm mortar with each infantry platoon (30–32 men and 1 officer), but these had been left at San Carlos, with six of the 81mm mortars, to save weight.

[3] The battery in question had four M–56s, but one was out of action before the battle began.

[4] Lt. Col. Jones was awarded a posthumous Victoria Cross, one of two such given for valor during the Falklands War; the other went to Sgt. Ian John, 3d Battalion, The Parachute Regiment, killed in fighting on Mt. Kent.


2nd Paras at Goose Green–Darwin 28 May 1982
A Coy Farrar-Hockley
B Coy Crosland
C Coy Jenner
D Coy Neame
C Coy + plt A Coy
Minefield
Hill or High Ground
Argentine Defense Line
0 Miles 1
0 1 2 Kilometers
Camilla Creek House
0300 27 May:
2 Para arrives from Sussex Mountains
8 Battery
(3 x 105mm guns)
1000 27 May:
C Coy patrol clears route to start lines
2200 27 May:
Rest of Bn follows
Camilla Creek
2 x 81mm mortars
(out of ammo at 0900)
B Coy: 0320
Start
A Coy: 0235
27 May: OPs
28 May: Fire Base
D Coy mops up behind A and B
Burntside Pond
Burntside House
HMS Arrow shells Argentine positions; withdraws before dawn
0500: A Coy finds no opposition
Coronation Point
1115: B Coy pinned by MG; D Coy outflanks
Boca House (ruins)
Darwin Hill
Darwin
A Coy pinned down by heavy MG fire; LtCol Jones KIA; Keeble takes command
SAS OP before battle
schoolhouse
1000 29 May
Air Commodore Pedroza surrenders to Keeble
Airfield
Goose Green
B Coy: Dusk
Dusk: Argentinian company flies into settlement by helicopter
Dusk: Attack by 3 Harriers

no local counterattacks, apparently impressed enough with British firepower not to want to leave their trenches. The British were supported by effective direct fire from the Support Company's Milan ATGMs, which eliminated a number of Argentinean bunkers and positions. By mid–afternoon, the Paras had reached the edge of the airfield (in the process temporarily silencing the Argentine automatic antiaircraft cannon, and captured the schoolhouse. By this time, the Paras had captured some 74 Argentinean officers and men, about half of them wounded, and had counted over 20 corpses in positions they had captured.

As dusk was about to fall, an Argentinean air strike, comprising two A–4K Skyhawks followed within a moments by a pair of Pucara light strike–trainer aircraft, hit the British positions but caused little damage. Barely had these aircraft departed when three RN Sea Harriers came in from the west, making an almost surgically precise strike against the Argentine antiaircraft guns and other positions near the airfield and Goose Green settlement. As darkness fell, the weary Paras drew back from the edge of Goose Green settlement into the dead ground beyond the ridges, and settled down for a cold night in the open. Firing died away between 1800 and 1900. By early evening, Argentinean resistance was confined to a small lodgement near Goose Green settlement proper and the eastern edge of the airfield: it was a tiny area, barely a square kilometer, into which to cram over 1,100 military personnel and over 100 local civilians.

Although Major Keeble planned on renewing the battle next day (29 May), and there was some scattered firing during the night, this effectively the end of the Battle of Goose Green. Keeble's call for reinforcements brought him the rest of 8 Battery and 2,000 rounds of ammunition (all 840 of the initial allotment had been used), the 2d Para's other six 81mm mortars and additional mortar rounds, and several BV–200 tracked over–snow vehicles, borrowed from the Royal Marines. The following morning, before the attack was to begin at 0900, Keeble and Captain Rod Bell of the Royal Marines (who spoke fluent Spanish) undertook to negotiate the Argentineans' surrender. The Argentineans had been badly shaken by the previous day's fighting, expected no relief, and were not ready to die in a hopeless fight. They also believed they were facing most of a brigade, or at least two or three battalions. After a few delays, partly occasioned by difficulties coordinating the Air Force and Army surrenders, over 1,050 Argentineans marched out to lay down their arms. By a little after 1000 hours on 29 May, Goose Green and its grateful 112 civilian inhabitants were back in British hands.

I spent some time considering the terrain and weather conditions to get them to mesh with the TNDM. After some crude experimentation, and looking at other engagements, I chose Rolling–Gentle–Bare terrain (the ground is actually densely covered with gorse and scrub, sometimes punctuated with rocky outcroppings, but little vegetation is over 1 meter (40 inches) high. I also decided on Dry–Overcast–Extreme Cold weather. The temperatures were actually a little above freezing, with sporadic drizzle early in the fighting, but the "Extreme Cold" would limit everybody's efficiency, as seemed to have happened in the historical engagement.

Finally, there was the thorny issue of casualties. The Argentineans, naturally enough, have been reluctant to admit that their superior forces were beaten by a small force of light infantrymen, and they have not been forthcoming with casualty figures. The Argentineans officially admit to 131 killed and wounded, and the British recorded that they had captured 74 Argentine soldiers before the garrison surrendered (about half of these were wounded), so a round figure of 200 Argentine casualties is reasonable, and perhaps a trifle low, since the "official" Argentinean casualties do not count Air Force personnel killed or wounded. The British, by comparison, counted 18 dead (16 paras, one Royal Marine helicopter pilot, and one engineer) and 33 wounded, for a total of 51 casualties.

One consideration which stood out in my mind was the effect on the ground fighting of the four Argentinean antiaircraft guns. Variously noted as twin 20mm or 35mm weapons, they were employed with considerable effect against British troops, who took some care to stay off the crests of ridges. I decided to count them as two German Rh–202 twin 20mm guns, and two Swiss GDF–002 twin 35mm guns. After further consideration, I decided to count half the guns, one Rh–202 and one GDF–002, as infantry weapons, manually adding two additional systems and the appropriate OLI total to the Argentine infantry weapons figures.

My first efforts, though, which I performed over the course of several weeks in the summer and autumn of 1995, were frustrating (see pp. 9–14, for GOOSEG1A and GOOSEG1B). Notably, the TNDM indicated the British should suffer about three times the casualties they had actually lost. Moreover, the British had grave difficulty advancing any distance at all, never mind the eight or ten kilometers they covered from their first contact with Argentine defenders. Even when the British were granted a relatively high CEV of 3.0 (see pp. 11 and 13), their losses were still too high, and their advance was barely 2600 meters. If the Paras had made only such an advance, they would have halted for the day just north of Boca House, which they historically reached about 0830, five and a half hours into the assault.

Unhappy with these results, I began to consider changes. First, I decided that although I was counting the battle as 24 hours long, this was an inaccurate representation. The British began their attack about 0300 on the 28th, and firing generally died away after 1800–1900 or so that evening, so the actual "shooting" part of the battle was a matter of 15–16 hours, not 24. On the other hand,

shortening the battle would reduce the British advance rate, but after mulling the issue over for a while I opted for the 15–hour battle for my next runs.

I had spent some time thinking about the U.S. M–72 LAW (light antitank weapon), a disposable 66mm rocket used for use against enemy armored vehicles as well as bunkers and pillboxes. As far as the TNDM is concerned, the LAW is counted as an antitank weapons when fired at armor, but as an infantry weapon when fired at bunkers or pillboxes. Subsequently re–reading Hastings' account of the battle, I was struck by the fact that British took out a number of troublesome Argentine positions with Milan antitank missiles, and with Swedish–made Carl Gustav 84mm antitank rockets. This is echoed in other books on the Falklands War, notably garnering an entire chapter's coverage in *Falklands Armoury*, ed. Mark Dartford; Poole, Dorset: Blandford Press, 1985. Reflecting also on what I had done with the Argentinean air defense guns, I realized I needed to count the bulk of British AT assets as infantry weapons. Since the 2d Paras were using Milans and Carl Gustavs (and LAWs, too) just like the U.S. Marines used LAWs, I defined the Milan and Carl Gustav as infantry weapons alongside their antitank definitions. I also simply borrowed the redefined M–72 from the U.S. Infantry weapons listing. I kept 4 of the 16 British Carl Gustavs defined as AT weapons, mostly to account for relative lack of training and experience using them as infantry weapons.

Eureka! Redefining the LAW, Carl Gustav, and Milan as infantry weapons raised the total British infantry-artillery OLI from 971.7 (pp. 10, 13) to 1971.28 (pp. 16, 19). This alteration gave the British the force–ratio level needed to achieve something closer to the historical result with the model, and indicated a reasonably close battle even before I applied a British CEV (p. 15). Once I applied a CEV for the British of 2.6 (derived from the top of p. 16), the British actually won. The casualty rates were about 8% too high for both the British, and about 10% too low for the Argentineans, but were at least in the ballpark. The advance rate was not fast enough either (just over 3 km per day, rather than the actual 8.5 to 10), but on the other hand the British actually moved forward a significant distance.

The basic equipment and manpower strengths for the adversaries are readily discerned from the printouts. The details of armament for the two forces are described in the table below.

Argentine air support comprised two A–4D sorties, and two Pucara sorties; the British had three Sea Harrier sorties, one armed with rockets and two with cluster bombs. British naval gunfire support, counted as self-propelled artillery, represents HMS *Arrow's* single 4.5" (114mm) gun. The personnel figures above include aircrew.

The fact that the TNDM did only a fair–to–marginal job of recreating the Battle of Goose Green is probably attributable to several factors. First, as a small–scale engagement, luck or blind chance played a proportionally greater role than it would have in a division–level or even a brigade–level battle. Second, while the Argentineans put up a pretty stout resistance, they were overwhelmed by superior British leadership, training, and *esprit de corps*. It is worth noting that the Argentinean troops mounted no local counterattacks, and fought almost entirely from their positions, effectively waging a passive defense and leaving the initiative completely to the British. British leadership at all levels was determined, flexible, and effective, providing the Paras with a crucial edge. Third, the British made a major effort to keep their forces mobile and moving forward; Jones, Keeble, and the company commanders all led from the front, and the decision to leave behind the 51mm mortars was taken to lighten loads and enhance mobility. Together these factors, which can be reflected only partially within the TNDM, produced the historical battle of Goose Green.

| *British* | *Argentinean* |
|---|---|
| 548 personnel | 1,324 personnel |
| 380 x L1A1 rifles | 650 x FN-FAL rifles |
| 76 x L8A2 GPMGs | 90 x LMGs |
| 24 x M66 LAW RLs | 18 x FN-MAG MMGs |
| 16 x Carl Gustav AT RLs | 8 x M-2 HB .50cal HMGs |
| 12 x M79 40mm GLs | 18 x 40mm GLs |
| 12 x Milan ATGMs | 8 x 81mm mortars |
| 2 x 81mm mortars | 4 x 120mm mortars |
| 3 x 105mm light guns | 12 x M40A1 106mm RRs |
| 6 x Blowpipe SAMs | 3 x 105mm M56 howitzers |
| | 2 x Rh-202 twin 20mm AA guns |
| | 2 x GDF-002 twin 35mm AA guns |

TACTICAL NUMERICAL DETERMINISTIC MODEL (TNDM)
Compiled 12 March 1995
Version: 1.85 Copyright (c) 1990-1995 T. N. Dupuy
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09/12/1996

ENGAGEMENT FILENAME: GOOSEG1A ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by 2d/Para on 12th Inf Reg't (+) at Darwin-Goose Green; std wpns evaltn
STARTING DATE OF ENGAGEMENT: 05/28/1982
STARTING TIME OF ENGAGEMENT: 0300
ATTACKER: 2d Bn/Para Reg't
DEFENDER: 12th Inf Reg't (+)
ATTACKER'S STARTING POINT (X, Y): 0.00, 11.00
ATTACKER'S OBJECTIVE (X, Y): 0.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 0.753 | 1.327 |
| WINNER | | XXXXXX |
| DISTANCE ADVANCED | 0.000 | |
| ADVANCE RATE (KM/DAY) | 0.000 | |
| CASUALTIES | 143.683 | 114.166 |
| % CASUALTIES/DAY | 26.219 | 8.623 |
| TANK LOSSES | 0.000 | 0.000 |
| % TANK LOSSES/DAY | 0.000 | 0.000 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 24.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 24.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES

| | |
|---|---|
| LIGHTING LEVEL: | 24-HOUR PERIOD |
| TERRAIN TYPE: | ROLLING-GENTLE-BARE |
| WEATHER CONDITION: | DRY-OVERCAST-EXTREME COLD |
| CLIMATE/SEASON OF YEAR: | TEMPERATE |
| ROAD QUALITY: | POOR ROADS |
| ROAD DENSITY: | SPARSE |

OPERATIONAL VARIABLES

| | |
|---|---|
| ATTACKER'S MISSION: | ATTACK (NORMAL) |
| DEFENDER'S MISSION: | PREPARED DEFENSE |
| ATTACKER'S WEAPONS SOPHISTICATION: | BRITISH/FRENCH/NATO |
| DEFENDER'S WEAPONS SOPHISTICATION: | GERMAN/SWEDISH/S. KOREA |
| FORCE TYPE: | INFANTRY |
| NEITHER SIDE HAS AIR SUPERIORITY | |
| SURPRISE LEVEL: | NO SURPRISE |

PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied

| HISTORICAL FACTORS | ATTACKER | DEFENDER |
|---|---|---|
| CASUALTIES/DAY | 51.000 | 200.000 |
| ARMOR LOSSES/DAY | 0.000 | 0.000 |
| MISSION ACCOMPLISHMENT | 8.000 | 2.000 |
| DISTANCE ADVANCED/RETIRED | 10.500 | -10.500 |
| DEPTH | 3.000 | 9.000 |

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 2d Bn/Para Reg't w/std AT of UK
1.000 Goose Green NGS & Air of UK

DEFENDER'S ORDER OF BATTLE

1.000 12th Inf Reg't (+), GGr/D of ARGENTNA
1.000 Goose Grn Air Sppt of ARGENTNA

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER |
|---|---|---|
| NUMBER OF PERSONNEL..... | 548 | 1324 |

| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER |
|---|---|---|---|---|
| Armor..... | 0 | 0 | 0.000 | 0.000 |
| Infantry..... | 450 | 748 | 395.420 | 1940.700 |
| Anti-Tank..... | 48 | 12 | 1116.000 | 432.000 |
| Towed Artillery..... | 3 | 3 | 576.000 | 345.000 |
| Self-Propelled Artillery..... | 1 | 0 | 280.000 | 0.000 |
| Anti-Air..... | 8 | 10 | 352.000 | 606.000 |
| Fixed-Wing Aircraft..... | 3 | 4 | 1233.000 | 464.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3952 | 3788 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 4 | 12 |
| Tracked Vehicles..... | 0 | 0 |
| Fixed-Wing Aircraft..... | 3 | 4 |
| Rotary-Wing Aircraft..... | 2 | 0 |
| Motorcycles..... | 0 | 4 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 2468.430 | 3380.487 |
| FORCE RATIO..... | 0.730 | 1.369 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 3816.735 | 5066.634 |
| P/P RATIO..... | 0.753 | 1.327 |
| SPATIAL EFFECT..... | 1.661 | 1.850 |
| CASUALTY EFFECT..... | -2.093 | -3.490 |
| HISTORICAL RESULT..... | 10.208 | 3.000 |
| R/R..... | 3.403 | 0.294 |
| CEVt..... | 4.517 | 0.221 |
| CEVl..... | 1.386 | 0.722 |
| CEVad..... | 2.951 | 0.472 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 0.000 | |
| LOCATION (x, y): | 0.000 | 11.000 |
| TOTAL DISTANCE (km): | 0.000 | |

| FINAL INVENTORY | ATTACKER | DEFENDER |
|---|---|---|
| NUMBER OF PERSONNEL | 404 | 1210 |

| | ATTACKER | DEFENDER | SCORES | |
|---|---|---|---|---|
| NUMBERS OF COMBAT SYSTEMS | | | | |
| Armor | 0 | 0 | 0.000 | 0.000 |
| Infantry | 332 | 684 | 291.743 | 1773.357 |
| Anti-Tank | 35 | 11 | 823.391 | 394.749 |
| Towed Artillery | 3 | 3 | 542.014 | 338.834 |
| Self-Propelled Artillery | 1 | 0 | 240.508 | 0.000 |
| Anti-Air | 6 | 9 | 259.708 | 553.746 |
| Fixed-Wing Aircraft | 1 | 3 | 220.107 | 330.872 |
| Rotary-Wing Aircraft | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 2377 | 3392 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks | 3 | 11 | | |
| Tracked Vehicles | 0 | 0 | | |
| Fixed-Wing Aircraft | 1 | 3 | | |
| Rotary-Wing Aircraft | 0 | 0 | | |
| Motorcycles | 0 | 4 | | |

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* End of report *
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ENGAGEMENT FILENAME: GOOSEG1B ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by 2d/Para on 12th Inf
Reg't (+) at Darwin-Goose Gr; std wpns, UK CEV=3.0
STARTING DATE OF ENGAGEMENT: 05/28/1982
STARTING TIME OF ENGAGEMENT: 0300
ATTACKER: 2d Bn/Para Reg't
DEFENDER: 12th Inf Reg't (+)
ATTACKER'S STARTING POINT (X, Y): 0.00, 11.00
ATTACKER'S OBJECTIVE (X, Y): 0.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 2.260 | 0.442 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 2.696 | |
| ADVANCE RATE (KM/DAY) | 2.696 | |
| CASUALTIES | 92.325 | 278.889 |
| % CASUALTIES/DAY | 16.848 | 21.064 |
| TANK LOSSES | 0.000 | 0.000 |
| % TANK LOSSES/DAY | 0.000 | 0.000 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 24.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 24.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-BARE
WEATHER CONDITION: DRY-OVERCAST-EXTREME COLD
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: POOR ROADS
ROAD DENSITY: SPARSE

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: PREPARED DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: BRITISH/FRENCH/NATO
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
NEITHER SIDE HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied
ATTACKER CEV: 3.000

| HISTORICAL FACTORS | ATTACKER | DEFENDER |
|---|---|---|
| CASUALTIES/DAY | 51.000 | 200.000 |
| ARMOR LOSSES/DAY | 0.000 | 0.000 |
| MISSION ACCOMPLISHMENT | 8.000 | 2.000 |
| DISTANCE ADVANCED/RETIRED | 10.500 | -10.500 |
| DEPTH | 3.000 | 9.000 |

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 2d Bn/Para Reg't w/std AT of UK
1.000 Goose Green NGS & Air of UK

DEFENDER'S ORDER OF BATTLE

1.000 12th Inf Reg't (+), GGr/D of ARGENTNA
1.000 Goose Grn Air Sppt of ARGENTNA

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 548 | 1324 | | |
| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER |
| Armor..... | 0 | 0 | 0.000 | 0.000 |
| Infantry..... | 450 | 748 | 395.420 | 1940.700 |
| Anti-Tank..... | 48 | 12 | 1116.000 | 432.000 |
| Towed Artillery..... | 3 | 3 | 576.000 | 345.000 |
| Self-Propelled Artillery..... | 1 | 0 | 280.000 | 0.000 |
| Anti-Air..... | 8 | 10 | 352.000 | 606.000 |
| Fixed-Wing Aircraft..... | 3 | 4 | 1233.000 | 464.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3952 | 3788 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks..... | 4 | 12 | | |
| Tracked Vehicles..... | 0 | 0 | | |
| Fixed-Wing Aircraft..... | 3 | 4 | | |
| Rotary-Wing Aircraft..... | 2 | 0 | | |
| Motorcycles..... | 0 | 4 | | |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| | | |
|---|---|---|
| FORCE STRENGTHS | | |
| FORCE STRENGTHS..... | 2468.430 | 3380.487 |
| FORCE RATIO..... | 0.730 | 1.369 |
| POWER POTENTIAL | | |
| COMBAT POWER (P)..... | 11450.206 | 5066.634 |
| P/P RATIO..... | 2.260 | 0.442 |
| SPATIAL EFFECT..... | 1.661 | 1.850 |
| CASUALTY EFFECT..... | -2.093 | -3.490 |
| HISTORICAL RESULT..... | 10.208 | 3.000 |
| R/R..... | 3.403 | 0.294 |
| CEVt..... | 1.506 | 0.664 |
| CEVl..... | 2.702 | 0.370 |
| CEVad..... | 2.104 | 0.517 |
| TIME AND SPACE | | |
| ADVANCE RATE (km/day): | 2.696 | |
| LOCATION (x, y): | 0.000 | 8.304 |
| TOTAL DISTANCE (km): | 2.696 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | | | 456 | 1045 |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor | 0 | 0 | 0.000 | 0.000 |
| Infantry | 374 | 590 | 328.801 | 1531.908 |
| Anti-Tank | 40 | 9 | 927.980 | 341.003 |
| Towed Artillery | 3 | 3 | 555.133 | 321.367 |
| Self-Propelled Artillery | 1 | 0 | 255.326 | 0.000 |
| Anti-Air | 7 | 7 | 292.696 | 424.995 |
| Fixed-Wing Aircraft | 1 | 2 | 433.429 | 191.116 |
| Rotary-Wing Aircraft | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 2793 | 2810 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks | 4 | 11 | | |
| Tracked Vehicles | 0 | 0 | | |
| Fixed-Wing Aircraft | 1 | 2 | | |
| Rotary-Wing Aircraft | 0 | 0 | | |
| Motorcycles | 0 | 4 | | |

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ENGAGEMENT FILENAME: GOOSEG2A ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by 2d/Para on 12th Inf
Reg't (+) at Goose Gr, w/mod wpns evaltn, 15 hours
STARTING DATE OF ENGAGEMENT: 05/28/1982
STARTING TIME OF ENGAGEMENT: 0300
ATTACKER: 2d Bn/Para Reg't
DEFENDER: 12th Inf Reg't (+)
ATTACKER'S STARTING POINT (X, Y): 0.00, 11.00
ATTACKER'S OBJECTIVE (X, Y): 0.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 0.966 | 1.035 |
| WINNER | | XXXXXX |
| DISTANCE ADVANCED | 0.000 | |
| ADVANCE RATE (KM/DAY) | 0.000 | |
| CASUALTIES | 78.632 | 76.367 |
| % CASUALTIES/DAY | 22.958 | 9.229 |
| TANK LOSSES | 0.000 | 0.000 |
| % TANK LOSSES/DAY | 0.000 | 0.000 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 15.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 15.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 15.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-BARE
WEATHER CONDITION: DRY-OVERCAST-EXTREME COLD
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: POOR ROADS
ROAD DENSITY: SPARSE

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: PREPARED DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: BRITISH/FRENCH/NATO
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
NEITHER SIDE HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied

| HISTORICAL FACTORS | ATTACKER | DEFENDER |
|---|---|---|
| CASUALTIES/DAY | 51.000 | 200.000 |
| ARMOR LOSSES/DAY | 0.000 | 0.000 |
| MISSION ACCOMPLISHMENT | 8.000 | 2.000 |
| DISTANCE ADVANCED/RETIRED | 10.500 | -10.500 |
| DEPTH | 3.000 | 9.000 |

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 Goose Green NGS & Air of UK
1.000 2d Bn/Para Reg't w/mod AT of UK

DEFENDER'S ORDER OF BATTLE

1.000 12th Inf Reg't (+), GGr/D of ARGENTNA
1.000 Goose Grn Air Sppt of ARGENTNA

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER |
|---|---|---|
| NUMBER OF PERSONNEL..... | 548 | 1324 |

| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER SCORES |
|---|---|---|---|---|
| Armor..... | 0 | 0 | 0.000 | 0.000 |
| Infantry..... | 514 | 748 | 1395.280 | 1940.700 |
| Anti-Tank..... | 4 | 12 | 72.000 | 432.000 |
| Towed Artillery..... | 3 | 3 | 576.000 | 345.000 |
| Self-Propelled Artillery..... | 1 | 0 | 280.000 | 0.000 |
| Anti-Air..... | 8 | 10 | 352.000 | 606.000 |
| Fixed-Wing Aircraft..... | 3 | 4 | 1233.000 | 464.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3908 | 3788 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 4 | 12 |
| Tracked Vehicles..... | 0 | 0 |
| Fixed-Wing Aircraft..... | 3 | 4 |
| Rotary-Wing Aircraft..... | 2 | 0 |
| Motorcycles..... | 0 | 4 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 15.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| | FORCE STRENGTHS | |
|---|---|---|
| FORCE STRENGTHS..... | 2896.297 | 3380.487 |
| FORCE RATIO..... | 0.857 | 1.167 |

| | POWER POTENTIAL | |
|---|---|---|
| COMBAT POWER (P)..... | 4813.419 | 4981.910 |
| P/P RATIO..... | 0.966 | 1.035 |
| SPATIAL EFFECT..... | 1.799 | 1.708 |
| CASUALTY EFFECT..... | -2.047 | -3.464 |
| HISTORICAL RESULT..... | 10.507 | 3.000 |
| R/R..... | 3.502 | 0.286 |
| CEVt..... | 3.625 | 0.276 |
| CEVl..... | 1.532 | 0.653 |
| CEVad..... | 2.578 | 0.464 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 0.000 | |
| LOCATION (x, y): | 0.000 | 11.000 |
| TOTAL DISTANCE (km): | 0.000 | |

| FINAL INVENTORY | ATTACKER | DEFENDER |
|---|---|---|
| NUMBER OF PERSONNEL | 469 | 1248 |

| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER SCORES |
|---|---|---|---|---|
| Armor | 0 | 0 | 0.000 | 0.000 |
| Infantry | 440 | 705 | 1195.072 | 1828.763 |
| Anti-Tank | 3 | 11 | 61.669 | 407.083 |
| Towed Artillery | 3 | 3 | 558.430 | 340.925 |
| Self-Propelled Artillery | 1 | 0 | 259.134 | 0.000 |
| Anti-Air | 7 | 9 | 301.492 | 571.047 |
| Fixed-Wing Aircraft | 1 | 3 | 512.603 | 371.334 |
| Rotary-Wing Aircraft | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 2888 | 3519 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks | 4 | 12 |
| Tracked Vehicles | 0 | 0 |
| Fixed-Wing Aircraft | 1 | 3 |
| Rotary-Wing Aircraft | 0 | 0 |
| Motorcycles | 0 | 4 |

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ENGAGEMENT FILENAME: GOOSEG2B ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by 2d/Para on 12th Inf Reg't (+) at Darwin-Goose Gr; mod wpns, UK CEV=2.8
STARTING DATE OF ENGAGEMENT: 05/28/1982
STARTING TIME OF ENGAGEMENT: 0300
ATTACKER: 2d Bn/Para Reg't
DEFENDER: 12th Inf Reg't (+)
ATTACKER'S STARTING POINT (X, Y): 0.00, 11.00
ATTACKER'S OBJECTIVE (X, Y): 0.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 2.512 | 0.398 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 1.782 | |
| ADVANCE RATE (KM/DAY) | 2.851 | |
| CASUALTIES | 55.659 | 180.038 |
| % CASUALTIES/DAY | 16.251 | 21.757 |
| TANK LOSSES | 0.000 | 0.000 |
| % TANK LOSSES/DAY | 0.000 | 0.000 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 15.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 15.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 15.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-BARE
WEATHER CONDITION: DRY-OVERCAST-EXTREME COLD
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: POOR ROADS
ROAD DENSITY: SPARSE

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: PREPARED DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: BRITISH/FRENCH/NATO
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
NEITHER SIDE HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied
ATTACKER CEV: 2.600

| HISTORICAL FACTORS | ATTACKER | DEFENDER |
|---|---|---|
| CASUALTIES/DAY | 51.000 | 200.000 |
| ARMOR LOSSES/DAY | 0.000 | 0.000 |
| MISSION ACCOMPLISHMENT | 8.000 | 2.000 |
| DISTANCE ADVANCED/RETIRED | 10.500 | -10.500 |
| DEPTH | 3.000 | 9.000 |

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 Goose Green NGS & Air of UK
1.000 2d Bn/Para Reg't w/mod AT of UK

DEFENDER'S ORDER OF BATTLE

1.000 12th Inf Reg't (+), GGr/D of ARGENTNA
1.000 Goose Grn Air Sppt of ARGENTNA

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER |
|---|---|---|
| NUMBER OF PERSONNEL..... | 548 | 1324 |

| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER SCORES |
|---|---|---|---|---|
| Armor..... | 0 | 0 | 0.000 | 0.000 |
| Infantry..... | 514 | 748 | 1395.280 | 1940.700 |
| Anti-Tank..... | 4 | 12 | 72.000 | 432.000 |
| Towed Artillery..... | 3 | 3 | 576.000 | 345.000 |
| Self-Propelled Artillery..... | 1 | 0 | 280.000 | 0.000 |
| Anti-Air..... | 8 | 10 | 352.000 | 606.000 |
| Fixed-Wing Aircraft..... | 3 | 4 | 1233.000 | 464.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3908 | 3788 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 4 | 12 |
| Tracked Vehicles..... | 0 | 0 |
| Fixed-Wing Aircraft..... | 3 | 4 |
| Rotary-Wing Aircraft..... | 2 | 0 |
| Motorcycles..... | 0 | 4 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 15.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| | FORCE STRENGTHS | |
|---|---|---|
| FORCE STRENGTHS..... | 2896.297 | 3380.487 |
| FORCE RATIO..... | 0.857 | 1.167 |

| | POWER POTENTIAL | |
|---|---|---|
| COMBAT POWER (P)..... | 12514.888 | 4981.910 |
| P/P RATIO..... | 2.512 | 0.398 |
| SPATIAL EFFECT..... | 1.799 | 1.708 |
| CASUALTY EFFECT..... | -2.047 | -3.464 |
| HISTORICAL RESULT..... | 10.507 | 3.000 |
| R/R..... | 3.502 | 0.286 |
| CEVt..... | 1.394 | 0.717 |
| CEVl..... | 2.796 | 0.358 |
| CEVad..... | 2.095 | 0.537 |

| | TIME AND SPACE | |
|---|---|---|
| ADVANCE RATE (km/day): | 2.851 | |
| LOCATION (x, y): | 0.000 | 9.218 |
| TOTAL DISTANCE (km): | 1.782 | |

```
                    FINAL INVENTORY      ATTACKER DEFENDER
                NUMBER OF PERSONNEL           492     1144

                                                      ATTACKER   DEFENDER
        NUMBERS OF COMBAT SYSTEMS                              SCORES
Armor.........................        0        0       0.000      0.000
Infantry......................      462      646    1253.566   1676.803
Anti-Tank.....................        4       10      64.687    373.256
Towed Artillery...............        3        3     563.793    330.199
Self-Propelled Artillery......        1        0     265.400      0.000
Anti-Air......................        7        8     316.248    486.696
Fixed-Wing Aircraft...........        2        2     672.020    268.214
Rotary-Wing Aircraft..........        0        0       0.000      0.000
                TOTAL OLI                              3136       3135

                    NUMBERS OF MOBILITY ELEMENTS
                Trucks........................        4       11
                Tracked Vehicles..............        0        0
                Fixed-Wing Aircraft...........        2        2
                Rotary-Wing Aircraft..........        1        0
                Motorcycles...................        0        4

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                            *  End of report *
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ENGAGEMENT FILENAME: GOOSEG2C ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by 2d/Para on 12th Inf Reg't (+), Goose Gr, w/mod wpns, UK CEV=4.5, 15 hr
STARTING DATE OF ENGAGEMENT: 05/28/1982
STARTING TIME OF ENGAGEMENT: 0300
ATTACKER: 2d Bn/Para Reg't
DEFENDER: 12th Inf Reg't (+)
ATTACKER'S STARTING POINT (X, Y): 0.00, 11.00
ATTACKER'S OBJECTIVE (X, Y): 0.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 3.532 | 0.283 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 2.381 | |
| ADVANCE RATE (KM/DAY) | 3.810 | |
| CASUALTIES | 49.042 | 196.828 |
| % CASUALTIES/DAY | 14.319 | 23.786 |
| TANK LOSSES | 0.000 | 0.000 |
| % TANK LOSSES/DAY | 0.000 | 0.000 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 15.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 15.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 15.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-BARE
WEATHER CONDITION: DRY-OVERCAST-EXTREME COLD
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: POOR ROADS
ROAD DENSITY: SPARSE

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: PREPARED DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: BRITISH/FRENCH/NATO
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
NEITHER SIDE HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied
ATTACKER CEV: 4.500

| HISTORICAL FACTORS | ATTACKER | DEFENDER |
|---|---|---|
| CASUALTIES/DAY | 51.000 | 200.000 |
| ARMOR LOSSES/DAY | 0.000 | 0.000 |
| MISSION ACCOMPLISHMENT | 8.000 | 2.000 |
| DISTANCE ADVANCED/RETIRED | 10.500 | -10.500 |
| DEPTH | 3.000 | 9.000 |

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 Goose Green NGS & Air of UK
1.000 2d Bn/Para Reg't w/mod AT of UK

DEFENDER'S ORDER OF BATTLE

1.000 12th Inf Reg't (+), GGr/D of ARGENTNA
1.000 Goose Grn Air Sppt of ARGENTNA

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 548 | 1324 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 0 | 0 | 0.000 | 0.000 |
| Infantry..... | 514 | 748 | 1395.280 | 1940.700 |
| Anti-Tank..... | 4 | 12 | 72.000 | 432.000 |
| Towed Artillery..... | 3 | 3 | 576.000 | 345.000 |
| Self-Propelled Artillery..... | 1 | 0 | 280.000 | 0.000 |
| Anti-Air..... | 8 | 10 | 352.000 | 606.000 |
| Fixed-Wing Aircraft..... | 3 | 4 | 1233.000 | 464.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3908 | 3788 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks..... | 4 | 12 | | |
| Tracked Vehicles..... | 0 | 0 | | |
| Fixed-Wing Aircraft..... | 3 | 4 | | |
| Rotary-Wing Aircraft..... | 2 | 0 | | |
| Motorcycles..... | 0 | 4 | | |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 15.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| | FORCE STRENGTHS | |
|---|---|---|
| FORCE STRENGTHS..... | 2896.297 | 3380.487 |
| FORCE RATIO..... | 0.857 | 1.167 |
| | POWER POTENTIAL | |
| COMBAT POWER (P)..... | 21660.384 | 4981.910 |
| P/P RATIO..... | 4.348 | 0.230 |
| P'/P' IMBALANCE..... | 3.532 | 0.283 |
| SPATIAL EFFECT..... | 1.799 | 1.708 |
| CASUALTY EFFECT..... | -2.047 | -3.464 |
| HISTORICAL RESULT..... | 10.507 | 3.000 |
| R/R..... | 3.502 | 0.286 |
| CEVt..... | 0.992 | 1.009 |
| CEVl..... | 3.114 | 0.321 |
| CEVad..... | 2.053 | 0.665 |
| | TIME AND SPACE | |
| ADVANCE RATE (km/day): | 3.810 | |
| LOCATION (x, y): | 0.000 | 8.619 |
| TOTAL DISTANCE (km): | 2.381 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 499 | 1127 | | |
| | | | ATTACKER SCORES | DEFENDER SCORES |
| NUMBERS OF COMBAT SYSTEMS | | | | |
| Armor | 0 | 0 | 0.000 | 0.000 |
| Infantry | 468 | 637 | 1270.412 | 1652.192 |
| Anti-Tank | 4 | 10 | 65.556 | 367.778 |
| Towed Artillery | 3 | 3 | 565.300 | 328.738 |
| Self-Propelled Artillery | 1 | 0 | 267.177 | 0.000 |
| Anti-Air | 7 | 8 | 320.498 | 476.021 |
| Fixed-Wing Aircraft | 2 | 2 | 724.827 | 253.747 |
| Rotary-Wing Aircraft | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 3214 | 3078 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks | 4 | 11 | | |
| Tracked Vehicles | 0 | 0 | | |
| Fixed-Wing Aircraft | 2 | 2 | | |
| Rotary-Wing Aircraft | 1 | 0 | | |
| Motorcycles | 0 | 4 | | |

**********
* End of report *
**********

# How To Read A TNDM Printout in One Easy Lesson

**by Dave Bongard**

Since it is likely that at least some of the readers of *The TNDM Newsletter* have not had the benefit of Col. Dupuy's, or TDI's, introductory instruction course on how to use the TNDM, it seemed a good idea to provide an introduction for them, so that they will know what they are looking at when examining TNDM printouts. This will also serve as a "refresher course" for the rest of us.

The printout page and line numbers are keyed to the three– or four–page printout produced by any standard computer printer. The TNDM printouts in this *Newsletter* issue have had their format altered to allow more lines per page, so the article material and printout reproductions do not match by line number or page. Match the text of each line to resolve any confusion.

TNDM printouts comprise three pages, sometimes expanding to four if the TNDM run is being used for analysis of a historical engagement. Since the printouts included in this issue of the *Newsletter* are for a historical engagement, that will be the model used here.

The first page comprises four main parts. From top to bottom, these are (1) a 5–line heading, (2) an 11–line engagement description, (3) a 15–line result summary, and (4) a 16–line Input Data section. The heading identifies the TNDM itself, which version was utilized for the engagement, and the date the engagement run was performed. The engagement description includes the 8–character engagement filename, the analyst's name (or initials), a brief description of the engagement, the date and time when the engagement began, the names of the attacking and defending forces, and the position of the battle-line at the start of the engagement. The results summary indicates winner (a line of six Xs, [XXXXXX]) under the attacker or defender, or between them, indicating a draw of some sort, with distance advanced (if any) by day and total, total personnel and AFV casualties for both sides, and as a percentage of the total force, standardized for a 24–hour engagement. This is followed by a description of how long the engagement lasted. The input data specifies lighting, terrain, weather condition and season, road net density and quality, attacker's and defender's mission, both sides' weapons sophistication, the attacker's force type (armored, mechanized, leg infantry, or horsed cavalry), and level of surprise.

The second page contains four sections (three if the engagement is not used for historical analysis), not counting three lines at the top which conclude the Input Data section from page 1. If one side or the other has been given a CEV (Combat Effectiveness Value), that will appear immediately beneath these three lines. From top to bottom, the sections on Page 2 are (1) a 6–line Historical Factors section, (2) a 7–line Equation Modifiers section, (3) a 4– to 10– or 12–line Order of Battle section, and (4) 10–15 lines of Force and Equipment Inventory, continued on page 3. The Historical Factors describe what actually happened in the original, real–world engagement, counting total personnel casualties, AFV losses, mission accomplishment (on a 1–10 scale), distance advanced, and depth of starting positions. The Equation Modifiers show six factors which may be applied to one or both sides, on the basis of the analyst's assessment of the situation being modeled. The Order of Battle lists the Attacker's main component units, followed by the Defender's. The Force and Equipment Inventory section lists aggregate Personnel and Combat Systems (e.g., weapons) strengths for both sides, attackers on the left, with the applicable total OLI values on the far right of the page. Beneath the Combat Systems totals is Number of Mobility Elements, totalling the number of trucks (and other wheeled vehicles), non-armor tracked vehicles, fixed-wing aircraft, rotary-wing aircraft (helicopters), and motorcycles present with each side. This Mobility Elements section often continues on Page 3.

The third page of the TNDM printout contains two principal sections, following the handful of lines at the top of the page completing the Forces and Equipment Inventory. First is the 17–line Snapshot of Battlefield Outcome, and then the 18–line Final Inventory (of Personnel, Combat Systems, and Equipment). The "Snapshot of Battlefield Outcome" first specifies the time in the engagement at which the results apply, i.e. after 24 hours, or 8 hours, or some other period (this is specified by the scenario designer-cum-analyst when creating the engagement). Next, the "Snapshot" shows the Force Strength (total OLI) for each side, and then proceeds to the Combat Power (P) figures, which are the Force Strengths modified by terrain, weather, and other environmental conditions. The "Spatial Effect" line indicates the relative achievement of both sides in terms of gaining or holding terrain, while the "Casualty Effect" shows each side's relative effectiveness in causing enemy losses. The "Historical Result" is a numerical evaluation of relative mission accomplishment for both sides, basically ranging from 0 to 10. A result under 5 indicates defeat, while a result over 5 indicates victory. The sum of these three measures (Spatial and Casualty Effect, and Historical Result) are combined to produce the R/R result (a comparison of relative battlefield achievement). Finally, the "Snapshot" shows three methods of measuring

CEV. The first is CEVt, which relates R/R to P/P to yield a CEV, while the calculation of CEVl derives from a comparison of the casualty-inflicting capacity of each side. CEVad is the average of the two methods, and is generally the best guide for determining CEV in a historical engagement.

At the bottom of the "Snapshot" section are four lines titled "Time and Space", detailing the movement of the front line in relation to the attacker's objective. Following these lines is a rundown of the personnel, combat system, and equipment inventories, identical in format to that on Page 2, but showing the situation at the end of the engagement period. (It is possible, by choosing an attrition calculation period shorter than the engagement period, to produce multiple "inventory reports" within an engagement printout.) This section ends the TNDM printout, which is further distinguished by the asterix-box enclosed "End of report" message.

**Line-by-Line Description of TNDM Printout**

This is a more detailed, line–by–line description of a standard TNDM printout for a historical engagement. Where possible, the formulae for calculations have been provided, and the line descriptions are also tied to TNDM input screens, where appropriate. Line descriptions in quoatation marks, as "Results Summary" are drawn verbatim from the printout. Numerical output calculations are shown to three significant figures.

***Page 1***

line 1: title
line 2: compilation date for TNDM version employed
line 3: TNDM version numerical designation (e.g., 1.82), copyright dates
line 4: "All rights reserved"
line 5: date engagement analysis performed
*2-line gap*
line 6: Engagement filename, and Analyst's name or initials
*1-line gap*
lines 7-8: Engagement description
line 9: Starting Date of Engagement (numerical, month/day/year)
line 10: Starting Time of Engagement (24-hour/Military time)
line 11: Attacking unit designation; e.g., 1st Inf Div (+)
line 12: Defending unit designation
line 13: Attacker's starting point (center of attacker's FEBA or FLOT), by "x" and "y" coordinates, in kilometers
line 14: Attacker's objective
*1-line gap*
line 15: "RESULTS SUMMARY"
*2-line gap*
line 16: "ATTACKER" and "DEFENDER" column labels for next 8 lines
line 17: Combat Power ratio; attacker combat power/defender combat power under "ATTACKER", and reciprocal of that ratio under "DEFENDER"
line 18: Winner indicator: six-X synbol (XXXXXX) under "ATTACKER" or "DEFENDER", or in between, indicating a draw and a combat power ratio of close to 1.0.
line 19: Distance Advanced (under "ATTACKER" only) during engagement period, in kilometers
line 20: Advance Rate (Km/Day); Distance Advanced/Engagement duration in days
line 21: Casualties; Total personnel losses, in killed, wounded, missing, captured, and disease/NBI (cause and degree unspecified)
line 22: "% CASUALTIES/DAY"; [(Casualties/Engagement duration in days)/Force personnel strength] x 100.
line 23: Tank losses; total AFV losses
line 24: "% TANK LOSSES/DAY"; by similar formula to line 22.
*1-line gap*
line 25: "PROGRAM-CONTROL VARIABLES"
line 26: "TIME STEP FOR ATTRITION CALCULATION:" (how often, in hours, the TNDM calculates combat losses and adjusts inventories and total OLIs)
line 27: "TIME STEP FOR PRINTOUT OF RESULTS:" (how often, in hours, the TNDM prodcues a report of forces status and combat results)
line 28: "MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:" (maximum duration, in hours, of engagement; should not be less than val ues in lines 26 or 27.
line 29: "INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT"; this is the default setting, if it is changed, intermediate results and a greatly detailed report of input factors will be reported
*2-line gap*
line 30: "INPUT DATA"
*1-line gap*
line 31: "ENVIRONMENTAL VARIABLES"
line 32: "LIGHTING LEVEL:" verbal description of lighting, from LIGHTING LEVELS FOR ENGAGEMENT Menu (Figure 9, *TNDM User's Guide*, p. 21)
line 33: "TERRAIN TYPE:" verbal description of terrain, from TERRAIN TYPE FOR ENGAGEMENT Menu (Figure 10, *TNDM User's Guide*, p. 21)
line 33: "WEATHER CONDITION:" verbal description of weather, from WEATHER CONDITION FOR ENGAGEMENT Menu (Figure 11, *TNDM User's Guide*, p. 22)
line 34: "CLIMATE/SEASON OF YEAR:" from CLIMATE OF ENGAGEMENT Menu (Figure 12, *TNDM User's Guide*, p. 22)
line 35: "ROAD QUALITY:" from ROAD QUALITY Menu (Figure 21, *TNDM User's Guide*, p. 26)—road quality may be good, mediocre, or poor
line 36: "ROAD DENSITY:" from ROAD DENSITY Menu (Figure 22, *TNDM User's Guide*, p. 26) —road density may be European standard, moderate, or sparse
*2-line gap*
line 37: "OPERATIONAL VARIABLES"
line 38: "ATTACKER'S MISSION:" from ATTACKER MISSION IN ENGAGEMENT Menu (Figure 14,

*TNDM User's Guide*, p. 23)

line 39: "DEFENDER'S MISSION:" from DEFENDER MISSION IN ENGAGEMENT Menu (Figure 15, *TNDM User's Guide*, p. 24)

line 40: "ATTACKER'S WEAPONS SOPHISTICATION:" from ATTACKER WEAPONS SOPHISTICATION Menu (Figure 16, *TNDM User's Guide*, p. 24)

line 41: "DEFENDER'S WEAPONS SOPHISTICATION:" from DEFENDER WEAPONS SOPHISTICATION Menu, identical to ATTACKER'S (Figure 16, *TNDM User's Guide*)

line 42: "FORCE TYPE" for Attacker, from ATTACKER FORCE TYPE Menu (Figure 7, *TNDM User's Guide*, p. 20)

line 43: "... AIR SUPERIORITY" indicating ATTACKER, DEFENDER, or NEITHER SIDE has air superiority, from AIR SUPERIORITY IN ENGAGEMENT Menu (Figure 17, *TNDM User's Guide*, p. 25)

line 44: "SURPRISE LEVEL:" indicating which side (if any) has surprise, and how much, from LEVEL OF SURPRISE Menu (Figures 23 and 24, *TNDM User's Guide*, p. 27)

***Page 2***

line 1: "PRIOR DAYS OF COMBAT - ATTACKER:"

line 2: "PRIOR DAYS OF COMBAT—DEFENDER:" both of these provided through FATIGUE FACTORS Menu (Figure 25, *TNDM User's Guide*, p. 27)

line 3: Shoreline Vulnerability; recapitulates information entered in SHORELINE VULNERABILITY: WATER/BEACH OBSTACLES, SHORELINE VULNERABILITY TYPE, and RIVER/STREAM WIDTH Menus (Figures 18-20, *TNDM User's Guide*, pp. 25-26)

line 4: ATTACKER CEV (provided only if Attacker CEV does not equal 1.0)

*2-line gap*

line 5: "HISTORICAL FACTORS—ATTACKER... DEFENDER"

line 6: "CASUALTIES/DAY" for both sides, from historical data

line 7: "ARMOR LOSSES/DAY" for both sides, from historical data

line 8: "MISSION ACCOMPLISHMENT" for both sides, judgement of analyst within broad limits, on a 0–10 scale

line 9: "DISTANCE ADVANCED/RETIRED" for both sides, in kilometers, with retire indicated as a negative number (e.g., -6.5)

line 10: "DEPTH" of position for both sides, in kilometers. All these values would be entered in the ATTACKER and DEFENDER HISTORICAL FACTORS Menus (Figure 26, *TNDM User's Guide*, p. 28). If the engagement is not historical, none of lines 5-10 will appear in the printout.

*2-line gap*

line 11: "EQUATION MODIFIERS: ATTACKER... DEFENDER"

*1-line gap*

line 12: "COMBAT POWER" modifier for either or both sides

line 13: "ATTRITION RATE"; personnel attrition modifier for either/both sides

line 14: "TOWED ARTILLERY RATE"; loss rate modifier for towed artillery, either or both sides

line 15: "SP ARTILLERY RATE": loss rate modifier for SP Artillery, either or both sides

line 16: "ADVANCE RATE" modifier for Attacker only

line 17: "SET PIECE FACTORS" entered for either side (but NOT both), ranging from 1.0 to 2.0, reflecting preparation for engagement. These factors and their employment is described in more detail on p. 37 of the *TNDM User's Guide*.

*2-line gap*

line 18: "ATTACKER'S ORDER OF BATTLE"

*1-line gap*

line 19+: Listing of Attacker units, with number present, description or name, and nationality/country of origin. At least one unit will be listed.

*1-line gap*

line 20: "DEFENDER'S ORDER OF BATTLE"

*1-line gap*

line 21+: Listing of Defender units, with number present, description or name, and nationality/country of origin. At least one unit will be listed.

*2-line gap*

line 22: "FORCE'S EQUIPMENT INVENTORY: ATTACKER...DEFENDER"

line 23: "NUMBER OF PERSONNEL..." number of personnel with each force, under appropriate column heading, e.g. 26745 or 3450.

line 24: "ATTACKER DEFENDER" on right margin, designating OLI columns

line 25: "NUMBERS OF COMBAT SYSTEMS... SCORES"

line 26: "Armor...." number of armor/AFV combat systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right

line 27: "Infantry...." number of Infantry weapon combat systems, with combined OLI scores under ATTACKER DEFENDER/ SCORES on far right

line 28: "Anti-tank...." number of antitank combat systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right

line 29: "Towed Artillery...." number of towed tube artillery, MRL, or surface-to-surface missile systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right

line 30: "Self-Propelled Artillery...." number of self–propelled artillery systems, with combined OLI scores under ATTACKER/ DEFENDER/SCORES on far right

line 31: "Anti-Air...." number of SAM, AA gun, and other AD systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right

line 32: "Fixed–Wing Aircraft...." number of conventional fixed–wing aircraft combat systems, with combined OLI scores under ATTACKER/ DEFENDER/SCORES on far right

line 33: "Rotary–Wing Aircraft...." number of rotary–wing aircraft or helicopter combat systems, with combined OLI scores under ATTACKER/DEFENDER/ SCORES on far right

line 34: "TOTAL OLI" shows, at far right, total OLI figures for ATTACKER and DEFENDER rounded to nearest whole number

*1-line gap*

line 35: "NUMBER OF MOBILITY ELEMENTS"

line 36: "Trucks...." number of wheeled transport vehicles, in columns headed by line 25
line 37: "Tracked Vehicles...." number of non-AFV tracked vehicles, including but not limited to APCs, tractors, SP Artillery, etc.
line 38: "Fixed–Wing Aircraft...." number of fixed–wing aircraft; this number cannot be less than that entered for line 32 above, but may include unarmed liaison and/or transport aircraft

***Page 3***

line 1: "Rotary–Wing Aircraft...." number of helicopters; this total cannot be less than that entered for line 33, but may include unarmed liaison or transport helicopters
line 2: "Motorcycles...." number of motorcycles
*2-line gap*
line 3: "SNAPSHOT OF BATTLEFIELD OUTCOME AFTER ___.000 HOURS OF COMBAT"; number of hours determined by selection of TIME STEP FOR PRINTOUT OF RESULTS (see Printout p. 1, line 27)
line 4: "(__ TIME-STEP OF CALCULATION)"; number printed here is determined by collation of Printout p. 1, lines 26 and 27)
*1-line gap*
line 5: "FORCE STRENGTHS"
line 6: "FORCE STRENGTHS...." show each force's total OLIs, modified by terrain, weather, and season factors, with ATTACKER on left and DEFENDER on right
line 7: "FORCE RATIOS...." shows Attacker Force Strength/ Defender Force Strength on the left, with reciprocal (Defender/Attacker) on the right
*1-line gap*
line 8: "POWER POTENTIAL"
line 9: "COMBAT POWER...." (abbreviated P) shows the Force Strength (S), modified by mobility, vulnerability, posture, and CEV; ATTACKER on left, DEFENDER on right
line 10: "P/P RATIO...." shows P attacker/P defender in the ATTACKER column (left), and the reciprocal (P defender/P attacker) on the right
line 11: "P'/P' IMBALANCE...." shows the ratio with P modified by non–CEV behavioral factors (including, but not limited to, morale and fatigue)
line 12: "SPATIAL EFFECTIVENESS...." measures the ability of each side to seize or hold ground, according to the following formulae (*TNDM Manual*, D.2.(a).(2), pp. D-2, D-3):

Attacker Spatial Eff'ness = SQRT [((Sa x Usa)/(Sd x Usd)) x (4Q + Dd)/3Da]

Defender Spatial Eff'ness = SQRT [((Sd x Usd)/(Sa x Usa)) x (4Q x Da)/3Dd]

**For explanation of abbreviations and symbology, see list at end of article.**

line 13: "CASUALTY EFFECTIVENESS...." measures the ability of each sude to inflict losses on the enemy, according to the following formulae (*TNDM Manual*, D.2.(a).(3), p. D-3):

Attacker Casualty Effectiveness = $vd^2$ [SQRT ((Casd x Usa/Sd)/(Casa x Usd/Sa)) - SQRT (100 Casa/Na)]

Defender Casualty Effectiveness = $va^2$ [SQRT ((Casa x Usd/Sa)/(Casd x Usa/Sd)) - SQRT (100 Casd/Nd)]

line 14: "HISTORICAL RESULT...." shows the model's evaluation of the engagement results (see Printout p. 2, line 8)
line 15: "R/R...." shows the comparison of attacker's and defender's results, where each side's results score is the sum of Esp (Spatial Effectivess), Ecas (Casualty Effectiveness), and the historically–derived Mission Factor (MF), from line 14 above.
line 16: "CEVt...." shows the CEV as calculated on the basis of battlefield results, according to the following formula (*TNDM Manual*, D.3.(b).(3), p. D-5):

CEVt = (R/R)/(P'/P') or = (R/R)/(P/P)

line 17: "CEVl...." shows the CEV calculated on the basis of comparative effective lethality, according to the following formula (*TNDM Manual*, C.4.(f).(2), pp. C-41, C-42, C-43):

CEVl = SQRT (La/Ld), where
La = [Ka/(Usa x rua x hua x zua x (SQRT tza))], and
Ld = [(Kd/(Usd x rud x hud x zua x (SQRT tzd))]

CEVt and CEVl are calculated for the attacker, and the reciprocal is shown as the defender's CEV.

line 18: "CEVad...." shows the average of CEVt and CEVl. Since this is an airthmetical mean calculated to only 3 significant figures, it is possible to have non–reciprocal scores for Attacker's and Defender's CEVad, and even to have both scores greater than 1.0.
*1-line gap*
line 19: "TIME AND SPACE"
line 20: "ADVANCE RATE (km/day):" shows distance advanced by attacker during average 24-hour period
line 21: "LOCATION (x, y):" shows current location of center of FEBA or Attacker's FLOT. This relates to the starting location, Printout p. 1, line 13.
line 22: "TOTAL DISTANCE (km):" shows total distance advanced by attacking force during the engagement
*2-line gap*
line 23: "FINAL INVENTORY ATTACKER... DEFENDER"
line 24: "NUMBERS OF PERSONNEL", with total personnel remaining with each force under Attacker and Defender headings from line 23.
line 25: "ATTACKER DEFENDER" identifiers for combined OLI scores from inventory
line 26: "NUMBER OF COMBAT SYSTEMS SCORES"
line 27: "Armor...." number of armor/AFV combat systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right
line 28: "Infantry...." number of Infantry weapon combat systems, with combined OLI scores under ATTACKER/ DEFENDER/ SCORES on far right

line 29: "Anti–tank...." number of antitank combat systems, with combined OLI scores under ATTACKER/DEFENDER/ SCORES on far right

line 30: "Towed Artillery...." number of towed tube artillery, MRL, or surface-to-surface missile systems, with combined OLI scores under ATTACKER/DEFENDER/ SCORES on far right

line 31: "Self–Propelled Artillery...." number of self–propelled artillery systems, with combined OLI scores under ATTACKER/DEFENDER/SCORES on far right

line 32: "Anti–Air...." number of SAM, AA gun, and other AD systems, with combined OLI scores under ATTACKER/DEFENDER/ SCORES on far right

line 33: "Fixed–Wing Aircraft...." number of conventional fixed–wing aircraft combat systems, with combined OLI scores under ATTACKER/DEFENDER/SCORES on far right

line 34: "Rotary–Wing Aircraft...." number of rotary–wing aircraft or helicopter combat systems, with combined OLI scores under ATTACKER/DEFENDER/ SCORES on far right

line 35: "TOTAL OLI" shows, at far right, total OLI figures for ATTACKER and DEFENDER rounded to nearest whole number

*1-line gap*

line 36: "NUMBER OF MOBILITY ELEMENTS"

line 37: "Trucks...." number of wheeled transport vehicles, in columns headed by line 26

line 38: "Tracked Vehicles...." number of non-AFV tracked vehicles, including but not limited to APCs, tractors, SP Artillery, etc.

line 39: "Fixed–Wing Aircraft...." number of fixed–wing aircraft; this number cannot be less than that entered for line 32 above, but may include unarmed liaison and/or transport aircraft

line 40: "Rotary–Wing Aircraft...." number of helicopters; this total cannot be less than that entered for line 33, but may include unarmed liaison or transport helicopters

line 41: "Motorcycles...." number of motorcycles

*1-line gap*

End of Report message, in asterisked box.

**GLOSSARY OF Symbols and Abbreviations for the TNDM Printout**

from *TNDM Manual*, Appendix A, pp. A-1 to A-5

| | | |
|---|---|---|
| a | = | attacker identifier |
| Cas | = | casualty effectiveness (enemy casualties in flicted per 100 friendly personnel |
| CEV | = | relative Combat Effectiveness Value |
| CEVl | = | CEV (Lethality) |
| CEVt | = | CEV (TNDM) |
| d | = | defender identifier |
| esp | = | spatial effectiveness |
| h | = | weather factor |
| hu | = | weather factor (posture) |
| K | = | hit rate per 1,000 |
| L | = | Lethality |
| N | = | number of personnel |
| P | = | Combat Power |
| R | = | Result(s) |
| r | = | terrain |
| ru | = | terrain Factor (posture, defensive position) |
| S | = | Force Strength |
| Sa | = | Force Strength (attacker) |
| Sd | = | Force Strength (defender) |
| tz | = | strength-size factor |
| tza | = | attacker strength-size factor |
| tzd | = | defender strength-size factor |
| Us | = | posture factor (for force strength, S) |
| Usa | = | attacker posture factor (force strength) |
| Usd | = | defender posture factor (force strength) |
| z | = | season factor |
| zu | = | season factor (posture) |

# Modifying Menus and Screens in the TNDM

**by José Perez**

One recent modification to the TNDM software was the addition of the ability to modify the text of menus and screens. This was added to allow users to convert the text of the menus into their native languages. The User's Guide discusses how a user can modify existing menus, but it does not discuss the technical issues behind this menu system. This article discusses the organization and mechanics of TNDM's menu system.

## 1. DATABASE

The heart of the menu system is a database called RESOURCE.DBF. It contains the following fields:

| Field | Type | Length | Description |
|---|---|---|---|
| Number | Numeric | 6 | An ID number used as an identifier when the file TNCONST.PAS is created. |
| Text | Memo | 10 | The text of the menu options or screen labels. |
| Max_Size | Numeric | 6 | The maximum width of the text displayed on the screen. Not currently in use. |
| Name | Character | 25 | A unique name, with no spaces, used when the file TNCONST.PAS is created. |

## 2. USAGE

The field Number is used as follows:

| Range | Use |
|---|---|
| 1 - 1,999 | Help screens |
| 2,000 - 2,999 | Menus |
| 3,000 - 3,999 | Yes-No dialog boxes |
| 4,000 - 4,999 | Error message dialog boxes |
| 5,000 - 5,999 | Information message dialog boxes |
| 6,000 - 6,999 | Pickmenu titles |
| 7,000 - 7,999 | Data entry screens |
| 8,000 - 8,999 | Screen titles |
| 9,000 - 9,999 | Picklist titles |
| 10,000 - 10,999 | Report labels |

### 2.1 Usage—Help

The Help Screen range contains ID numbers for various help screens.
These are found in the file TNCONST.PAS. They are the only ID numbers not actually stored in RESOURCE.DBF.

### 2.2 Usage—Menus

You may notice that in each range, numbers are assigned sequentially, except in the Menus range (2,000 - 2,999). The odd–numbered numbers are for menu hints that display at the bottom of the page when a menu option is highlighted. The even–numbered numbers are for the actual menu lists. For example, the Main Menu is number 2000 and its menu hints are listed in item number 2001.

Each Menu item has a Name. That name has the format of mcXXX, where XXX is a unique descriptive word or phrase without any spaces in it. Once this name is assigned, it cannot be changed as it is used by the software. If the name is changed and TNCONST.PAS is regenerated, it will not be possible to recompile any module which references that name.

The format of a Menu item is:

```
Title
1 = first line
2 = second line
3 = third line
4 = fourth line, etc.
X = Exit
```

The Main Menu contains the following:

```
MAIN MENU
1 = Create An Engagement
2 = Modify An Engagement
3 = Reprint An Engagement
4 = Continue An Engagement
5 = Update Forces Database
6 = Update OLI Database
S = Select Options
X = Exit
```

The title is not centered as it is automatically centered when the menu is displayed. The number of menu options listed must match the number of options expected by the program. If there are too many options, the extra options will be ignored. If there are too few, the user will not be able to exit from the menu.

The Menu Hints for the Main Menu contain the following:

```
Change the forces or factors in an engagement.
Reprint an engagement's results.
Continue an engagement for additional time periods.
Change or add units to the Force Database.
Change or add weapons to the OLI Database.
Change database locations, color selections, reindex databases, etc.
Exit to the DOS prompt.
```

Each line in the Menu Hint corresponds to a menu option in the Menu. Menu hints are not required, but if a Menu Hint are not created for a Menu, the corresponding ID Number may not be used for a Menu.

**2.3 Usage—Yes–No Dialog Boxes**

Yes–No Dialog Boxes are boxes that popup on the screen when the program prompts the user to select Yes or No. They are numbered sequentially in the range of 3,000–3,999. Like a Menu, each Yes–No dialog box has a name. The name has the format ycXXX, where XXX is a unique word or phrase without any spaces.

A typical Yes–No dialog box is ycUseAnother, which appears when the user is told that a filename is in use and is asked if the file should be overwritten with new contents.

```
Filename is already in use.
DO YOU WANT TO OVERWRITE IT (Y/N)?
```

**2.4 Usage—Error Message Dialog Boxes**

Error Message Dialog Boxes are boxes that popup on the screen when the program alerts the user about a problem and suggests a method for solving it. They are numbered sequentially in the range of 4,000–4,999. Like a Menu, each Error Message dialog box has a name. The name has the format dcXXX, where XXX is a unique word or phrase without any spaces.

A typical Error Message dialog box is dcInUse, which appears when the user is told that a filename is in use and is told to try using another name. This message appears when a filename must be unique and cannot be overwritten.

```
This filename is already in use.  Try another.
```

**2.5 Usage—Information Message Dialog Boxes**

Information Message Dialog Boxes are dual–purpose boxes that popup on the screen to either alert the user about a problem or to inform the user about the status of an action. They are numbered sequentially in the range of 5,000–5,999. Like a Menu, each Information Message dialog box has a name. The name has the format dcXXX, where XXX is a unique word or phrase without any spaces.

A typical Information Message dialog box is dcCalculating, which appears after the user has selected the Print Engagement option.

```
Now calculating the engagement outcome...
```

**2.6 Usage–Pickmenu Titles**

Pickmenu Titles are used as the title for a picklist of items that is generated by the software. In a pickmenu, only one item can be selected by the user. Pickmenu Titles are numbered sequentially in the range of 6,000–6,999. Like a Menu, each Pickmenu Title has a name. The name has the format pcXXX, where XXX is a unique word or phrase without any spaces. There are two types of Pickmenu Titles: single–purpose and multi–purpose. The single–purpose pickmenu title contains only one title; the multi–purpose pickmenu title contains a list of possible titles.

A typical single–purpose pickmenu title is pcEngagementFiles, which appears after the user has selected the Modify An Engagement option.

```
Engagement——— Period Description———————————
```

A typical multi–purpose pickmenu title is pcCombatSystems, which is used to select a title for displaying a list of a particular type of weapon systems, such as Armored Fighting Vehicles or Fixed-Wing Aircraft.

```
Armor
Infantry
Anti–Tank
Towed Artillery
Self–Propelled Artillery
Anti–Air
Fixed–Wing Aircraft
Rotary–Wing Aircraft
Combat System #1
Combat System #2
Combat System #3
```

**2.7 Usage—Data Entry Screens**

Data Entry Screens are used as to display a Data Entry Screen title and the label for each item that is displayed or can be entered by the user. They are numbered sequentially in the range of 7,000–7,999. Like a Menu, each Data Entry Screen has a name. The name has the format scXXX, where XXX is a unique word or phrase without any spaces.

A typical Data Entry Screen is scPreviousNew, which appears when the user is manually changing the Strength or OLI of a weapon system category in a unit.

```
Previous Strength:
    Previous OLI:
New Strength:
    New OLI:
```

An important characteristic of Data Entry Screens is that the elements listed in it appear in the order that they are accessed or displayed. Also, the listed elements might appear on a screen in more than one column. Thus, when scPreviousNew is displayed, the four elements are listed in two columns.

**2.8 Usage—Screen Titles**

Screen Titles are used as to display a Screen Title for a displaying a list of items. They are numbered sequentially in the range of 8,000–8,999. Like a Menu, each Screen Title has a name. The name has the format

tcXXX, where XXX is a unique word or phrase without any spaces.

A typical Data Entry Screen is tcWeaponsList, which appears when the user is selects weapons from the OLI database to create or update the Strength or OLI of a weapon system category in a unit.

WEAPONS ———————————— OLI SCORE #

**2.9 Usage—Picklist Titles**

Picklist Titles are used as to display a picklist title. Unlike pickmenus, picklist enable the user to select several different items. They are numbered sequentially in the range of 9,000–9,999. Like a Menu, each Picklist Title has a name. The name has the format pcXXX, where XXX is a unique word or phrase without any spaces. There are two types of Picklist Titles: single–purpose and multi–purpose. The single–purpose picklist title contains only one title; the multi–purpose picklist title contains a list of possible titles.

A typical single–purpose Picklist Title is pcWeaponListTitle, which appear when the user is selecting a weapon system category of a unit to create or update.

SELECT WEAPON CATEGORY

**2.10 Usage—Report Titles**

Report Titles are used as to display a field or column labels in report. They are numbered sequentially in the range of 10,000–10,999. Like a Menu, each Report Title has a name. The name has the format rcXXX, where XXX is a unique word or phrase without any spaces.

A typical single–purpose Report Title is rcOLIReportHeading, which is used when an OLI report is printed for a weapon.

TNDM WEAPONS VALUES
OPERATIONAL LETHALITY INDEX
Weapon System:
Analyst:
Date:
Security Classification:

**3. GENERATING AN UPDATED *TNCONST.PAS***

There are only two reasons for creating a new version of TNCONST.PAS:

- a) some new ID numbers and names were added to RESOURCE.DBF; or
- b) an ID number or name was changed.

To create a new version of TNCONST.PAS, select "Set Options" in the Main Menu. In the Maintenance Menu, select "Edit Resource File." Next, select the "Report" option. After TNCONST.PAS has been created, a message will be displayed saying that it was created. An error message will appear saying that REPORT.RPT could not be found. Ignore the error message.

**4. CONCLUSION**

The reason that this system was originally created was to make it easier for users of the TNDM to translate menus, data entry screens, etc. without having to recompile the software. It also makes it easier to fix spelling errors, change titles and labels, and so forth without requiring the services of a programmer.

Unfortunately, not all of the menus and data entry screens in the TNDM software have been converted to take advantage of this system. As time allows, this work will continue.

# TNDM Weather Factors:

## The Swedish Version, TNDM 1.84

### by Dave Bongard

In the original QJM, as described in *Numbers, Prediction and War* (1979; paperback reprint 1985), weather effects consisted of five factors, for each of 12 weather conditions. The five factors, generally labeled as *h* for weather-related, are *h–m* (mobility), *h–ua* (attack), *h–wg* (artillery, which also applies to air defense weapons), *h–wy* (air support), and *h–wi* (tanks and AFVs).

| Characteristic | h m | h ua | h wg | h wy | h wi |
|---|---|---|---|---|---|
| 1. Dry Sunny Hot | 0.9 | 1.0 | 1.0 | 1.0 | 0.9 |
| 2. Dry Sunny Temp | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 3. Dry Sunny Cold | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 |
| 4. Dry Overcast Hot | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 |
| 5. Dry Overcast Temp | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 |
| 6. Dry Overcast Cold | 0.9 | 0.9 | 0.9 | 0.7 | 0.8 |
| 7. Wet Light Hot | 0.9 | 0.9 | 0.9 | 0.7 | 0.5 |
| 8. Wet Light Temp | 0.8 | 0.9 | 1.0 | 0.5 | 0.7 |
| 9. Wet Light Cold | 0.8 | 0.9 | 1.0 | 0.5 | 0.7 |
| 10. Wet Heavy Hot | 0.5 | 0.6 | 0.2 | 0.2 | 0.6 |
| 11. Wet Heavy Temp | 0.6 | 0.7 | 0.9 | 0.2 | 0.5 |
| 12. Wet Heavy Cold | 0.5 | 0.6 | 0.8 | 0.2 | 0.5 |

The original QJM material is reproduced below, from p. 229 (Appendix A, Table 2: Weather Factors [*h*]).

In the TNDM Manual, the numbers are unchanged, appearing on p. B-4 of Appendix B (Tables). The identifiers for the factors have been shortened to one letter (*m* for mobility, *a* for attack, *g* for artillery, *y* for air support, and *i* for tanks and AFVs), and a sixth has been added, *c* for casualties.

| Characteristic | h m | h a | h g | h y | h i | h c |
|---|---|---|---|---|---|---|
| 1. Dry Sunny Hot | 0.9 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 |
| 2. Dry Sunny Temp | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 3. Dry Sunny Cold | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 0.7 |
| 4. Dry Overcast Hot | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 | 0.9 |
| 5. Dry Overcast Temp | 1.0 | 1.0 | 1.0 | 0.7 | 1.0 | 1.0 |
| 6. Dry Overcast Cold | 0.9 | 0.9 | 0.9 | 0.7 | 0.8 | 0.6 |
| 7. Wet Light Hot | 0.9 | 0.9 | 0.9 | 0.7 | 0.5 | 0.7 |
| 8. Wet Light Temp | 0.8 | 0.9 | 1.0 | 0.5 | 0.7 | 0.7 |
| 9. Wet Light Cold | 0.8 | 0.9 | 1.0 | 0.5 | 0.7 | 0.4 |
| 10. Wet Heavy Hot | 0.5 | 0.6 | 0.2 | 0.2 | 0.6 | 0.5 |
| 11. Wet Heavy Temp | 0.6 | 0.7 | 0.9 | 0.2 | 0.5 | 0.5 |
| 12. Wet Heavy Cold | 0.5 | 0.6 | 0.8 | 0.2 | 0.5 | 0.3 |
| | | | | | | |
| a. Sunny Deep Snow | 0.65 | 0.75 | 0.65 | 0.65 | 0.65 | 0.50 |
| b. Overcast Deep Snow | 0.65 | 0.75 | 0.65 | 0.45 | 0.65 | 0.50 |
| c. Blizzard Deep Snow | 0.50 | 0.75 | 0.30 | 0.15 | 0.45 | 0.30 |

The Swedes (properly, Mr. Niklas Zetterling of the Swedish National Defense Research Establishment (NDRE), in a fax letter to Col. Dupuy of 24 September 1993, suggested three additional "characteristics" for weather effects: Sunny, Deep Snow; Overcast, Deep Snow; and Blizzard, Deep Snow. These are shown above as lines a., b., and c., respectively. Col. Dupuy evidently accepted the new "*h* factors" at face value, although he noted in his reply fax to Mr. Zetterling (24 September 1993) that the *h y* values (for aircraft) in Sunshine and Overcast conditions intuitively seemed "a little low," while the *h i* values (tanks and AFVs) for seemed "a little high."

These "Deep Snow" factors are modifications of the factors already employed for Wet Light Cold and Wet Heavy Cold, both conditions understood to mean snowfall. Many if not most of the "Deep Snow" values are clear extrapolations of the existing QJM/TNDM Weather Factors.

Mr. Zetterling essentially agreed with Col. Dupuy in his reply to Col. Dupuy's fax (27 September 1993), noting that the values were drawn from Swedish Army officers' experience with arctic operations, presumably during maneuvers and exercises. The impression which the author received from the correspondence is that while Mr. Zetterling agreed with Col. Dupuy's assessment that the *h y* values were a little low and the *h i* values a bit high, he was reluctant to endorse any changes, due to the manner in which the values had been determined, through "field experience" in the Swedish Army. The final form of the Swedish "*h* values" is uncertain, but presumably closely follows thefactors described above. Those values were incorporated into TNDM 1.84 when the Swedish NDRE was sent a new disk including the necessary modifications to the TNDM program, together with supporting documents, via overnight mail, on 1 November 1993.

# TDI Analyst Profile: David Bongard

David L. Bongard received a B.A. in History with Honors from the Honors Tutorial College of Ohio University in June 1980, and received a B.A. in Political Science from O.U.'s College of Arts and Sciences in March 1981. Mr. Bongard received a M.A. in History from the University of Maryland in December 1985. For both of his History degrees, Mr. Bongard concentrated on military history in Early Modern Europe. His undergraduate honors thesis was entitled *Theory and Practice of the Renaissance Art of War, 1494-1525*, while his master's thesis bears the title *Army of the King: Organization and Combat Effectiveness in the French Army, 1450-1560*.

Mr. Bongard began working for Data Memory Systems, Inc. in February 1986. DMSi was Trevor N. Dupuy's previous historically–oriented research and consulting organization. Unlike TDI, it was a (theoretically) for–profit company which primarily performed contract work for various sub-agencies of the Department of Defense, but also did some writing for publication. While he was with DMSi, Mr. Bongard was a co–author, with Col. Trevor N. Dupuy and Curt Johnson, of the *HarperCollins Encyclopedia of Military Biography*, and was Associate Managing Editor for the *International Military and Defense Encyclopedia*, published by Brassey's (US) in 1992. In addition to these writing efforts, Mr. Bongard worked on several other projects, including the history of the U.S. Army's Operational Test and Evaluation Agency (USAOTEA), as well as studies on "The Relationship Between Technological Trends and the Size and Composition of Armies," "Examination of Historical Air Defense Performance," and "Long War Issue Papers."

Mr. Bongard left DMSi in late July 1990 to work with Col. Dupuy on the final stages of the *International Military and Defense Encyclopedia* effort. He co–wrote, with Dupuy, Curt Johnson, and Arnold Dupuy, a book on the Kuwait War entitled *How to Defeat Saddam Hussein*, which enjoyed a one–week sojourn on the New York Times bestseller list in late February 1991. Mr. Bongard contributed to Col. Dupuy's book *Future Wars* (published in Great Britain in 1992, and in the U.S. in 1993), drafting four chapters. Mr. Bongard also co–authored, with Col. Dupuy and Richard C. Anderson, *Hitler's Last Gamble*, an account of the Battle of the Bulge based on primary source material, published in November 1994 just prior to the 50th anniversary of the battle. Mr. Bongard is currently working on phase two of a three–part study of Suppression for the Field Artillery School. He has taken part in TDI's Air Combat Historical Data Study for the Air Command and Staff College at Maxwell AFB, and in phase one of the Suppression Study. He also took part in several smaller TDI projects, among them serving as project manager for preparation of the Fourth Edition of the *Harper Encyclopedia of Military History*, by R. Ernest and Trevor N. Dupuy, published in 1993.

Mr. Bongard admits to an enthusiasm for commercial, or "hobby" wargames, which he has been playing since 1970. He is also partial to an assortment of historical periods and interests, including Bronze Age Mediterranean history, West Africa just before major contact with Europeans (1250-1600), European history from the Early Renaissance through the late 17th century, Japan during the *Sengoku Jidai*, or "Age of the Country at War" (1467-1615), the Spanish Civil War, and the Japanese Army in World War II.

# Planned Improvements to the TNDM

## by Christopher A. Lawrence

We are currently looking at making a major improvement to the TNDM to address logistics. As part of that improvement effort, I intend to also make a number of minor changes to the model. I do have an agenda for the improvement of the model.

Back in fall of 1994, Trevor appointed me his "principal policy and marketing support assistant" for the TNDM. As I was up to my ears in work on Kursk at the time, I did as little as possible on the TNDM other than stay abreast of what Trevor was doing. In early 1995, I decided to take a more active role and began to organized a complete re–validation and audit of the TNDM, as I felt this would be helpful. Work stopped on this after Trevor's death. It has now been restarted with our effort to validate the model for battalion–level engagements.

In April of this year, I decided to assemble a master list of what improvements people felt needed to be made for the TNDM. There was correspondence documenting what changes Trevor had felt were needed to improve the TNDM, and there had been many ideas discussed over the last few years, but nobody had put together any type of master plan. I therefore assembled all of Trevor's old comments and letters, and the suggestions from a number of people familiar with the model from both inside and outside of TDI. The final list, in rough order of priority is provided below. It contains recommendations from Trevor, José Perez, Dave Bongard, Dr. Brian McCue, Dr. George Daoust, and of course, me.

I have first listed the changes that I am currently planning on implementing in the next revision of the model, which I expect to come out sometime in spring of 1997. It consists of one major change (the logistics module) and a number of small ones. Next I list all the easy–to–do changes that are high priority and then the ones that are of lower priority. Then I list all the major changes that I would like see made on the model, both high priority and low priority. Of course, priorities can change at the request of our customers. Priorities can really change if funding is provided to make those changes.

I am interested in hearing from all of our users as to what changes they would suggest need to made to the model and what changes they consider to be important.

**CHANGES INTENDED FOR THE NEXT REVISION:**

1. Develop a draft logistics package.
2. Show only the defender's missions in the list of Defender's missions.
3. Make it possible to delete an engagement.
4. Make saving an engagement optional.
5. Make is possible to counterattack.
6. Allow user to choose own dispersions factor.
7. Allow user to create forces with both horses and motor vehicles.
8. When CEV is an initial input, that value should be considered when calculating new CEV.
9. Print out a one–page result sheet.

**Also Underway:** Validate model for battalion–level use.

**FUTURE CHANGES:**

**Minor Tasks (High priority):**

1. Needs to be re–validated to the QJM Database.
2. Needs to store engagements in a database.

**Minor Tasks (Low priority):**

1. The vulnerability formulae need to be reviewed.
2. Need to do an audit of software to model design.
3. Need to look into whether the model under–predicts high casualty days and over–predicts low casualty days.
4. Review and integrate the Swedish arctic values into the model.
5. Add a stealth factor to show the impact of stealth on weapons, especially AFVs, planes, and helicopters (adjust size?).
6. Make a more comprehensive help file.
7. Track individual unit strength during an engagement.
8. Modify model to run in Windows.
9. Address fanaticism.
10. Develop guidance on terrain and weather values.

**Major Tasks (High priority):**

1. Address battalion–level combat.
2. Add a graphics package, including mapping capability.
3. Revise to be used as a training tool.
4. Address low intensity combat.
5. Develop rules for battle termination.
6. Provide user guidance for CEVs.
7. Add a tank/antitank loop:
   - Would not use firepower scores (OLIs)
   - Would account for relative differences in weapon performance.
   - Would add a detailed tank breakdown, destroyed vs damaged, recovery and repair calculations for multi–day battles.

**MAJOR TASKS (Low Priority):**

1. Update documentation.
2. Add air campaign module.
3. Add electronic warfare subroutine.
4. Allow user to show trends in military affairs.
5. Make it mathematically coherent.
6. Add sector/theater capability.

# Developing a Logistics Model for the TNDM

**by Christopher A. Lawrence**

Attached are the discussion notes for my plans to develop a logistics module for the TNDM. This is conceived as a "plug–in" type module that will modify the firepower scores of the units involved in an engagement. All other functions of the TNDM will remain the same. We have already begun testing this idea, as shown in the article "Testing the TNDM—What Happens When the Rate of Fire Goes to Zero." For various reasons, I decided to keep this write-up in its original discussion note form, as opposed to making it a flowing lucid text (if that is possible). This article is an update to the 13 August letter that was sent out to some of the recipients of the newsletter. José Perez provided some additional useful comments.

**Points of Discussion:**

1. The OLI is derived from a type of firepower score.
2. The firepower score as used is the TNDM is not only a measure of the "firepower" capability of a particular weapon, but also its intrinsic combat capability. This is especially noticeable with weapons platforms like the tank, where the gun power is modified extensively by other factors, and the vehicle maintains a firepower score even with a rate of fire of zero.
3. There is no accounting for logistics in the TNDM. It is considered one of the "intangibles."
4. The TNDM is easily amenable to a logistics module. This will be designed as a simple plug–in feature that modifies firepower scores.
5. The existence of a logistics module will allow us to play air interdiction, deep–strike, attacks on command and control (partially), etc.
6. It may replace the primary and secondary attacks as currently defined in the model.
7. The input factors for the logistics modules will be the number of rounds for each major gun type. Rounds will be measured by number, not weight.
8. Round types can also be used. For example, AT and HE rounds could be tracked separately, forcing difference scores for the AT part of the calculations, if there were a significant difference in the availability of AT rounds compared to HE rounds. For certain high velocity rounds of limited production (like some of the German AT rounds during WWII), this could be significant as the antitank performance varied widely with the round used. This would be reflected by using a different muzzle velocity for each of the different round types. This will also allow us to address the rather limited but more effective smart munitions of today. This is a refinement that may be best addressed later. It will result in different ammunition types having different OLI scores.
9. The current OLIs will need to be normalized to a certain number of rounds per gun. This will be the baseline figure where if you have this amount of ammunition available (at the division level?) then the OLI will be used as is (unmodified).
10. This baseline figure (known as baseline load) should be a range, fairly wide, to indicate that only significant surpluses or shortages have an immediate effect on combat. It also would allow many of the existing "TNDM Database" battles to be run without using the logistics module.
11. The baseline load amount may be best put as a form of "basic load" or "standard issue" which would properly reflect the doctrine of the army. The range might be 0.6 to 2 times basic load for normal usage.
12. Levels below this baseline load reduce the OLIs. It is suspected that this reduction will not be linear. There will be a clear bottom limit ("0" ammunition does not equal "0" combat capability). Furthermore, it is expected that units historically have been careful about using their last few remaining rounds.
13. Levels above this baseline load increase the OLIs. It is suspected that this increase will not be linear. There will be a clear upper limit ("infinite" ammunition does not equal "infinite" combat capability). This upper limit of effect may be further constrained by the maximum amount a gun can fire in a day. This constraint may not be a factor in the model.
14. The change in OLIs can be done in one of two ways:
    - Change the rate of fire of the guns, or
    - Change the overall OLI by a multiplier.
15. The following new input values will need to be created to account for ammunition:

    *to OLI database:*
    - Maximum round fired per day

    *to the Unit database:*
    - Basic load (in rounds) x no. of guns for each type

    *to Logistics Module:*
    - Number of Rounds by type
    - Daily ammunition usage rate by type and by battle intensity.
    - Expected length of battle until resupply.
    - Baseline load for each gun time
      - Upper limit
      - Lower limit

16. The following calculations will need to be done in the logistics module:

- Effect on rate of fire (or OLI) of ammo surplus
- Effect on rate of fire (or OLI) of ammo shortage
- Ammunition usage
- Alternate ammunition usage
- Ammunition conservence calculation
- Emergency ammunition request process
- Ammunition shortage breakpoint calculation

17. Ammunition requirements will deal with all weapon types, including small arms. Some provision will have to made to deal with mines. This will include all class V supplies.

18. Will need to add a methodology to address POL (Petroleum, oil and lubricants). Right now, it is conceived that this will address four types of POL: Gasoline, Diesel, Special Fuels, and Other POL. This will be measured in liters (vice weight) and includes all class III supplies.

19. Fuel usage will be based upon a three factors: constant daily use (modified by weather), distance unit moved (modified by weather and terrain), and effects of combat.

20. The effects of combat are broken into two parts: additional fuel consumed because of combat activity (modified by weather, terrain, season and day/night) and additional fuel lost because of combat losses (from attrition and related to retreat).

21. "Subsistence Supply" will have to be considered. It will have a weight in tons of dry goods, and a volume in liters of wet goods. The amount of material consumed will be modified by activity level (out of contact, inactive or active), weather and season. This will include all class I supplies.

22. "Other Supplies" will have to be considered. It will have a weight in tons of dry goods. The amount of other materials consumed will be modified by activity level (out of contact, inactive or active), weather and season.

23. Division–level resupply will have to be factored in. Each division will have a wet and dry transport capacity. In the case of ammunition, the shells will have to be converted to a packed weight for calculating transport. This transport capacity can be supplemented from outside the division, but will probably have to be done outside of the module by the analyst. This transport capacity will serve a limit to how fast a unit (i.e., a battalion) within that division can be resupplied. Resupply calculations beyond division are not being considered at this point.

24. Attrition will have to be calculated against the supply capacity of a division.

25. The model must be able to also accept actual historical ammunition and fuel usage figures and conduct the engagement using them.

26. Attached are:

- Definitions & Detailed Descriptions
- Supply Classes
- Supply Expenditure per Day, in Tons

27. *To be continued.....*

**DEFINITIONS & DETAILED DESCRIPTIONS:**

**Alternate Ammunition Usage**: Many weapons have a significant dual–use capability, including tanks, AT guns and AA guns. If there is limited number of their primary targets available, then they may be used at an alternate target. This may result in tanks and AT guns firing mostly HE rounds (as was the case in much of WWII).

**Ammunition Conservence Calculation**: The reduced rate of fire created by the desire to conserve ammunition because the on–hand ammunition is low and resupply is not expected shortly. This will probably have to be a modifier table that is determined by "judgement."

**Ammunition Shortage Breakpoint Calculation**: If a unit is low on ammunition, it will need to terminate the battle. This will be the methodology for calculating that effect.

**Baseline Load**: Two numerical figures of rounds per gun. Any on-hand ammunition supply that is at or between these two figures makes no change to the OLIs of the unit. Any average rounds per gun figure lower than the lowest figure will produce a reduction in the OLIs of the gun, while any figure above the higher figure will produce an increase in the OLIs.

**Basic Load**: This is the number of rounds per gun that a combat unit carries with it in accordance with that army's doctrine. This number may differ at the battalion level from the division level.

**Diesel**: This is standard diesel fuel. This is also considered in the US Army to be part of Class III Supply.

**Dry Transport Capacity**: This is the total metric tons of material that can be transported by normal transport vehicles/ methods.

**Emergency Ammunition Request Process**: If the module is operating with a division–level supply system and battalion–level combat, then some system of prioritizing resupply based upon shortages needs to be determined. This will probably be a later design feature.

**Gasoline**: This is standard automobile fuel of 80 to 100 octane. Considered in the US Army to be part of Class III Supply.

**Other POL:** This is all the petroleum, oils and lubricants that are not directly consumed to move a vehicle. It includes such items as engine oil, transmission oil, an d grease. It is expected that its consumption rate will effectively be a constant, regardless of conditions or unit operations. This is also considered in the US Army to be part of Class III Supply. This, along with Gasoline, Diesel, and Special Fuels make up the entire components of what the US Army refers to as Class III Supply.

**Other Supplies**: This is anything that is not Class I (subsistence), class III (POL) or class V (Ammunition) Supplies. Includes, in the modern US system, class II, VI, VII, VIII, IX and X supplies.

**Round**: 1 fully loaded round, including propellant as loaded into the rear of the gun. In the case of mortars and other weapons with a separate firing charge, only the bomb will be counted for ammunition firing, but for any transportation portion, the weight of that bomb will be multiplied by a factor to account for the average weight of a firing charge.

**Special Fuels**: This is any fuel that is fairly unique, is used to move vehicles, and is not gasoline or diesel fuel. Aviation gasoline and other similar high–octane fuels would be included in this category. Considered in the US Army to be part of Class III Supply.

**Subsistence Supplies**: This is all food and water that is needed to keep a unit operating. The primary component (in weight) for daily consumption will be food and water. This is the same as the modern US Class I Supplies.

**Wet Transport Capacity**: This is the total liters of fuel, water or other liquid substance that can be transported. This may need to be broken down into two further categories, due to the problems and the rarities of using fuel tank trucks to transport water and vice versa. For water, 1 liter = 1 kilogram of weight.

| Old US and Modern NATO Supply Class | Modern US Supply Class | Description |
|---|---|---|
| I | I | Subsistence, including rations and gratuitous health and welfare items. |
| II | II | Clothing, individual equipment, tentage, tool sets and kits, administrative and housekeeping supplies and equipment; includes all equipment, other than principal items, prescribed in authorization/allowance tables and items of supply (not including repair parts). |
| III | III | Petroleum, oil, and lubricants (POL), including fuels of all types, compressed gas, coolants and antifreeze, and solid fuels. |
| IV | IV | Construction materials, including installed equipment and fortification/barrier materials. |
| V | V | Ammunition of all types, including explosives, chemical, radiological, and special weapons; also fuzes, detonators, rockets, pyrotechnics, and related items. |
| I | VI | Personal demand items (nonmilitary sale items), available through a post exchange. |
| II | VII | Major end items; equipment ready for its intended use, such as tanks, artillery pieces, mobile machine shops, vehicles. |
| II | VIII | All medical supplies, including repair parts peculiar to medical users. |
| II | IX | Repair parts and components of all types (except medical), including kits, assemblies, etc., required for maintenance of all equipment. |
| IV | X | Materials for nonmilitary programs such as agricultural and economic development if not included in classes V to IX. |

Sources: US Army, FM 63-3J, *Combat Service Support Operations—Corps* (Washington DC: US Dept of the Army, August 1985), pp. 2-25 and 2-28; US Army FM 105-5-1, *Operational Terms and Symbols* (Washington DC: US Dept of the Army, October 1985), p. 1-14 and Appendix C.

| MODE: | Attack | Pursuit | Reserve |
|---|---|---|---|
| **DIVISION:** | | | |
| **1953 Armored** | 702 total | 351 total | 136 total |
| Subsistence | 43 | 45 | 43 |
| Fuel/POL | 111 | 187 | 46 |
| Ammunition | 401 | 70 | - |
| Other | 147 | 49 | 46 |
| | | | |
| **1953 Infantry** | 589 total | 314 total | 111 total |
| Subsistence | 51 | 53 | 51 |
| Fuel/POL | 74 | 144 | 21 |
| Ammunition | 418 | 73 | - |
| Other | 46 | 44 | 39 |
| | | | |
| **1990 Mechanized** | 2,743 total | 2,079 | 557 |
| Subsistence | 46 | 48 | 46 |
| Fuel/POL | 1401 | 1,746 | 408 |
| Ammunition | 1002 | 175 | - |
| Other | 294 | 110 | 97 |

Sources: US Army FM 101-10; US Army FM-101-1/2 Staff Officers' Field Manual: *Organizational, Technical and Logistical Data Planning Factors* (vol. 2) (Washington DC: US Dept of the Army, Oct 1987), pp. 2-0 to 2-180.

# Testing the TNDM:

## What Happens When the Rate of Fire Goes to Zero

### by Christopher A. Lawrence

As we have discussed elsewhere in this newsletter, TDI is beginning to work on developing a logistics module for the TNDM. It is expected that in its final form, the logistics module will serve as a mechanism to increase or decrease the OLIs. This can be done in one of two ways, either multiply the OLIs by a predetermined factor based upon the amount of ammunition either available or used, or multiply the rate of fire by a predetermined factor based upon the amount of ammunition either available or used. Changing the rate of fire, of course, changes the OLIs. To see the impact of this was on the model, TDI conducted eight different TNDM runs. One was of a WWII–era, theoretical US reinforced armored division attacking a German panzer division. This was the standard US "light" armored division, with three attached battalions (not unusual), one of self–propelled tank destroyers, one antiaircraft artillery automatic weapons battalion, and one cavalry squadron. The opposing panzer division was a typical Wermacht panzer division at authorized strength. See Dave Bongard's attached explanation for more detail.

Next the same two units were used, except the rates of fire of all the weapons of the panzer division were set at zero, under the assumption that this would be the result of running out of ammunition. In the third run, the rate of fire of the panzer division was doubled to measure the defensive impact of an abundance of ammunition. Finally, the rate of ammunition of the US armored division was doubled, to measure the offensive impact of an abundance of ammunition.

As a result of reviewing those runs, we conducted another four runs, this time of a reinforced US infantry division attacking a German infantry division. This was done primarily to test the results without a preponderance of armor on either side. Again the same four runs were made.

This model was never designed or validated to operate in this mode. It must be stressed that this is simply a test to see what the outcome of such a change to the model architecture would be in the extreme cases.

As can be seen from "LOGSTC1", the US armored division defeats the German panzer division as a result of developing a combat power advantage of 1.731 to 1. This results in the US division advancing 9 kilometers per day, and suffering over 230 casualties and 18 tanks. The Germans lose over 560 people and 15 tanks. At the end of the day, the combat power ratio between the two forces has increased to over 2 to 1, meaning that if the battle continues in its current form, the German division will be driven further back and continue to suffer an unfavorable casualty exchange loss rate.

In the second test, the rates of fire of the panzer division were reduced to zero. This effectively reduced its armor OLI to half, its infantry OLI to one–fifth, and the rest to zero. The combat ratio for this engagement is 5.5 to 1 and results in the US armored division advancing almost 43 kilometers, while losing less then 70 people and 3 or 4 tanks. The German panzer division loses a little over 400 people and 15 tanks. While this is not an unrealistic result, it may only be indicative of the quirks within the model. The model was not designed to function with rates of fire of zero. The only reason the panzer division has any significant combat power is that reducing the firepower of a tank to zero results in it maintaining half of its combat strength. This is probably not a justifiable outcome.

In the third test, the rates of fire of the German panzer division were doubled. This effectively doubled the firepower scores of all the German weapons except for the armor and infantry scores, which only went up 40% for the armor and around 80% for the infantry. This changes the combat power ratio to 1.35 to 1 in favor of the Germans, stopping all US advance and resulting in around 420 casualties for the US and around 480 for the Germans. The US armor losses were 38 and the German armor losses were 11.

Finally, we did a fourth test of this scenario in which the rates of fire of the US armored division were doubled. This effectively doubled the firepower scores of all the US weapons except for armor and infantry. The armor went up only 35%, while the infantry went up only 55%. Overall, the US OLIs went up a little over 50%. This increased the combat power ratio to 3.263 to 1 in favor of the US, resulting in a US advance of almost 22 kilometers, with around 90 casualties for the US and around 350 casualties for the Germans.

This effect on the OLIs is summarized in the brief piece by Dave Bongard "TNDM OBs for WWII Division Engagement: Logistical Analysis." It became clear from this analysis that any attempt to adjust the OLIs by changing the rate of fire was going to force a redesign of the way that armor is calculated. While this is a major hindrance to using this methodology to measure the impact on logistics, I still didn't feel that I had properly "crash–tested" the model. Therefore we did the same procedure using a WWII US infantry division versus a 1944 German infantry division.

The US infantry division is reinforced with a towed tank destroyer battalion. All other conditions were the same as in the previous test, except Road Quality was Mediocre instead of Good. See Dave Bongard's analysis "Order of Battle: US Infantry Division vs German Infantry Division" for details as to what each side had.

As can be seen from "LOGSTCA", the US infantry division does not defeat the German infantry division. The German infantry division has a combat power advantage of 1.1 to 1 over the US division. This results in the US division not advancing, and suffering over 500 casualties and 5 "tanks" (meaning AFVs, including armored cars and half–tracks). The Germans lose over 450 people and two "tanks."

In the second test, the rates of fire of the German division were reduced to zero. This effectively reduced its total OLI to one sixtieth of its previous value. The combat ratio for this engagement is over 15 to 1 and results in the US division advancing almost 20 kilometers while losing less then 110 people and no "tanks." The German division loses a little over 650 people and 4 "tanks."

In the third test, the rates of fire of the German division were doubled. This effectively doubled the firepower scores of all the German weapons except for the armor scores, which only went up only 30%. Overall, the unit's OLI is effectively doubled. This changes the combat power ratio to 3.249 to 1 in favor of the Germans, stopping all US advance and resulting in around 800 casualties for the US and around 300 for the Germans. The US armor losses were 11 "tanks" and the German armor losses were one "tank."

Finally, we ran a fourth test of this scenario wherein the rates of fire of the US division were doubled. This effectively doubled the firepower scores of all the US weapons except for Armor, which only went up around 35%. Overall the US OLIs effectively doubled. This increased the combat power ratio to 2.892 to 1 in favor of the US, resulting in a US advance of almost 8 kilometers, with around 300 casualties for the US and around 680 casualties for the Germans.

The table below contains a summary:

As a result of these tests, I concluded that modifying the rate of fire shortfalls and abundance of munitions is not the correct way to proceed. I was already biased against this approach before I started, but wanted to look at it anyway. There were three basic reasons for this bias. First, during an ammunition shortage, a unit will not uniformly reduce rates of fire, or ammunition expenditure. Instead, a unit will reduce spurious and harassing fire, and instead try to conserve its ammo for the more critical situations. During those critical situations, like when they are about to overrun, they will fire those guns at the highest practical rate.

Second, in battle, a gun rarely fires at its sustained rate of fire for any extended period of time. It will fire at its rate of fire for brief periods of time at critical moments in the battle. At other times, especially with harassing fire, it will fire briefly at whatever rate that they wish. Usually, most guns in battle are silent throughout most of the day. An abundance in ammunition will mean more harassing, blind fire, recon by fire and other missions, which do not have the highest combat utility.

Therefore, directly modifying the rates of fire upward or downward provides a linear effect to the shortage or surplus of ammunition that is not there.

The third reason, which will be discussed in more depth in a future issue, is that I have some reservations about the rate of fire calculations used to create the OLIs. In fact, I have doubts that the basic firepower construct used in many combat models of *Rate of Fire x Effect of a Single Round = Firepower* is correct. I will discuss this argument in more depth in a future issue, but suffice it to say that if I modify rate of fire to show the impact on logistics, I do not believe I am modifying the correct factor.

Finally, this analysis created a fourth reason, which is if I do modify the rates of fire to reflect the impact of ammunition shortages and abundances, then I have to change the way armored vehicles are calculated. This complicates my life.

Therefore, unless someone can make a compelling argument otherwise, I intend to have the logistics module modify the OLIs of the weapons, instead of changing the Rates of Fire.

| Scenario | US vs German Ratio | US Losses | German Losses | Rate of Advance | Remarks |
|---|---|---|---|---|---|
| 1 | 1.7 to 1 | 240 | 570 | 9 | Base Case |
| 2 | 5.5 to 1 | 70 | 410 | 43 | German ROF = 0 |
| 3 | 1 to 1.4 | 420 | 480 | 0 | German ROF x2 |
| 4 | 3.3 to 1 | 90 | 350 | 22 | US ROF x2 |
| | | | | | |
| 5 | 1 to 1.1 | 510 | 460 | 0 | Base Case |
| 6 | 15.7 to 1 | 110 | 650 | 20 | German ROF = 0 |
| 7 | 1 to 3.2 | 800 | 310 | 0 | German ROF x2 |
| 8 | 2.0 to 1 | 300 | 680 | 8 | US ROF x2 |

# TNDM OBs for WWII Divisional Engagement:

## Logistical Analysis

**by Dave Bongard**

At Chris' behest I have researched OLIs for standard World War II weapons with the standard TNDM Rates of Fire (RsOF), with a ROF of 0, and with a doubled ROF. For anything aside from AFVs, which have an OLI derived from both onboard weapons and punishment factor, a ROF of 0 gives a weapon an OLI of 0, while a doubled ROF doubles a weapon's OLI. In the case of AFVs it's a little more complicated, but the general trend is there.

| AFV | Normal | 0 ROF | x2 ROF |
|---|---|---|---|
| SdKfz-250 | 14 | 11 | 15 |
| SdKfz-251 | 21 | 18 | 22 |
| SdKfz-250/9 | 42 | 14 | 58 |
| SdKfz-234/1 | 132 | 72 | 179 |
| SdKfz-234/3 | 264 | 69 | 379 |
| PzKw-IVH | 219 | 94 | 316 |
| PzKw-VG | 392 | 241 | 511 |
| JgPz-38(t) | 125 | 37 | 179 |
| JgPz-IV(k) | 180 | 76 | 260 |
| JgPz-IV(l) | 183 | 77 | 263 |
| StuG-IIIG | 152 | 65 | 204 |
| HT 75 AG, 251/9 | 145 | 22 | 256 |
| | | | |
| M-3A1 HT | 31 | 28 | 32 |
| M-8 | 101 | 32 | 147 |
| M-20 Scout | 28 | 26 | 30 |
| M-4A2 | 292 | 167 | 390 |
| M-4(76) | 319 | 167 | 422 |
| M-4(105) | 380 | 165 | 510 |
| M-5A1 | 86 | 50 | 112 |
| M-8 HMC | 191 | 64 | 287 |
| M-10 GMC TD | 335 | 178 | 444 |
| M-36 GMC TD | 400 | 179 | 556 |

# Order of Battle:
# US Reinforced Armored Division vs German Panzer Division

Essentially, no German panzer division followed exactly the same TO&E, although the general pattern was similar. For the sake of argument, this scenario assumes an up–to–snuff German Army (not SS) panzer division, with a personnel strength of 14,300 and the usual assortment of weapon and vehicles. The US force is a standard "light" armored division, with three attached battalions: one of self–propelled TDs, one of antiaircraft automatic weapons, and one non–divisional cavalry squadron.

| Item | German | US | Attached | Total |
|---|---|---|---|---|
| Personnel | **14,300** | 10,608 | 2,141 | **12,749** |
| Rifles | **8,104** | 2,036 | 860 | **2,896** |
| Carbines/ARs | **1,182** | 5,228 | 816 | **6,044** |
| SMGs | **1,624** | 2,803 | 333 | **3,136** |
| BARs/LMGs | **1,157** | 69 | | **69** |
| MMGs | **64** | 396 | 104 | **500** |
| .50cal HMGs | | 404 | 87 | **491** |
| 60mm Mortars | | 63 | 27 | **90** |
| 81mm Mortars +SP | **40 + 6** | 30 + 18 | + 3 | **30 + 21** |
| 120mm Mortars | **16** | | | |
| Bazookas/PzSchreck | **200** | 607 | 93 | **700** |
| Panzerfausts | **500** | | | |
| 57mm/75mm AT Guns | **12** | 30 | | **30** |
| M-3 / SdKfz-251 HT | **45** | 451 | 48 | **499** |
| SdKfz-250 Lt HT | **115** | | | |
| M-8 / SdKfz-234/1 | **13** | 54 | 46 | **100** |
| M-20 / SdKfz-250/9 | **13** | | 30 | **30** |
| M-8 H / SdKfz-234/3 | **3** | 17 | 6 | **23** |
| M5A1 Lt Tank | | 77 | 17 | **94** |
| M-7 / Wespe | **12** | 54 | | **54** |
| Hummel | **6** | | | |
| sIG T +SP | **6 + 6** | | | |
| SdKfz-251/9 SP 75How | **15** | | | |
| T 105mm How | **12** | | | |
| T 150mm How | **8** | | | |
| T 105mm FG | **4** | | | |
| M-4A2 / PzKw IVH | **52** | 132 | | **132** |
| M-4(76) / PzKw VG | **51** | 36 | | **36** |
| M-4(105) | | 18 | | **18** |
| M-10 / JgPz IV (1) | **21** | | 36 | **36** |
| M-15 / 20mmx4 SPAA | **6** | | 16 | **16** |
| M-16 / 20mm SPAA | **12** | | 16 | **16** |
| T 20mm AA | **37** | | | |
| 37mm SPAA | **8** | | | |
| 88mm AA | **8** | | | |
| Other tracked | **8** | 33 | 6 | **39** |
| Motor vehicles | **2,328** | 1,134 | 241 | **1,375** |
| Motorcycles | **480** | | | |

# Order of Battle:
# US Reinforced Infantry Division vs German Infantry Division

The US infantry division portrayed here is a standard full–strength infantry division in the ETO, organized under the July 1943 TO&E. It is reinforced by a single standard towed TD battalion. Their German opposition comprises a putatively full–strength infantery division Type 44.

| Item | German | US | Attached | Total |
|---|---|---|---|---|
| Personnel | **12,352** | 14,253 | 797 | **15,050** |
| Rifles | **8,040** | 6,349 | 117 | **6,466** |
| Carbines/ARs | **1,029** | 5,204 | 360 | **5,564** |
| SMGs | **1,503** | 90 | 298 | **388** |
| BARs/LMGs | **556** | 405 | | **405** |
| MMGs | **90** | 211 | 104 | **315** |
| .50cal HMGs | | 250 | 87 | **337** |
| 60mm Mortars | | 90 | 27 | **117** |
| 81mm Mortars | **48** | 54 | | **54** |
| 120mm Mortars | **28** | | | |
| Bazookas/PzSchreck | **108** | 558 | 93 | **651** |
| Panzerfausts | **324** | | | |
| 57mm AT Guns | | 57 | | **57** |
| 75mm / 76.2mm AT Guns | **21** | | 36 | **36** |
| Hetzer SP AT | **14** | | | |
| M-3 / SdKfz-251 HT | | 5 | 36 | **41** |
| M-8 | | 13 | 4 | **17** |
| M-20 | | | 10 | **10** |
| sIG 150mm Towed | **6** | | | |
| leIG 75mm Towed | **18** | | | |
| T 105mm Inf How | | 18 | | **18** |
| T 105mm How | **36** | 36 | | **36** |
| T 150mm/155mm How | **12** | 12 | | **12** |
| 37mm Towed AA | **12** | | | |
| Other tracked | | 3 | | **3** |
| Motor Vehicles | **615** | 1362 | 89 | **1,451** |
| H-DR vehicles | **1,466** | | 11 | **11** |
| Motorcycles | **168** | | | |
| Bicycles | **162** | | | |
| | | | | |
| | | | | |

As with the Armored/Panzer division logisitics scenarios, there will be four engagements: US attacking with doubled ROF vs German standard, and US standard attacking German ROF=0, standard, and ROF x2.

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                           Compiled 12 March 1995
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                                09/10/1996


                  ENGAGEMENT FILENAME:  LOGSTC1     ANALYST: D L Bongard
               ENGAGEMENT DESCRIPTION:  U.S. Lt Armd Div (+) attack on
                German std PzD, nominal conditions
          STARTING DATE OF ENGAGEMENT:  09/15/1944
          STARTING TIME OF ENGAGEMENT:  0700
                               ATTACKER:  WW2 Lt Armd Div (+)
                               DEFENDER:  WW2 std PzD
     ATTACKER'S STARTING POINT (X, Y):     0.00,    0.00
          ATTACKER'S OBJECTIVE (X, Y):    20.00,    0.00

                                RESULTS SUMMARY

                                     ATTACKER       DEFENDER

             COMBAT POWER RATIO         1.731          0.578
                         WINNER        XXXXXX
              DISTANCE ADVANCED         8.976
          ADVANCE RATE (KM/DAY)         8.976
                     CASUALTIES       238.162        565.536
               % CASUALTIES/DAY         1.868          3.955
                    TANK LOSSES        24.945         14.640
              % TANK LOSSES/DAY         5.319          8.714

     PROGRAM-CONTROL VARIABLES
                 TIME STEP FOR ATTRITION CALCULATION:   24.0000 HOURS
                  TIME STEP FOR PRINT OUT OF RESULTS:   24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:   24.000 HOURS
           INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT


                                    INPUT DATA

     ENVIRONMENTAL VARIABLES
             LIGHTING LEVEL:  24-HOUR PERIOD
               TERRAIN TYPE:  ROLLING-GENTLE-MIXED
          WEATHER CONDITION:  DRY-OVERCAST-TEMPERATE
     CLIMATE/SEASON OF YEAR:  TEMPERATE
               ROAD QUALITY:  GOOD ROADS
               ROAD DENSITY:  EUROPEAN STANDARD


     OPERATIONAL VARIABLES
               ATTACKER'S MISSION:  ATTACK (NORMAL)
               DEFENDER'S MISSION:  HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION:  US
DEFENDER'S WEAPONS SOPHISTICATION:  GERMAN/SWEDISH/S. KOREA
                       FORCE TYPE:  ARMORED
NEITHER SIDE HAS AIR SUPERIORITY
                    SURPRISE LEVEL:  NO SURPRISE
  PRIOR DAYS OF COMBAT - ATTACKER:   0.00
  PRIOR DAYS OF COMBAT - DEFENDER:   0.00
               Shoreline Vulnerability not applied


           EQUATION MODIFIERS      ATTACKER       DEFENDER

                 COMBAT POWER:         1.000          1.000
               ATTRITION RATE:         1.000          1.000
         TOWED ARTILLERY RATE:         1.000          1.000
            SP ARTILLERY RATE:         1.000          1.000
                 ADVANCE RATE:         1.000
            SET PIECE FACTORS:         1.000          1.000
```

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Light AD (+) of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 std Army PzD of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 12749 | 14300 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 469 | 168 | 92665.000 | 40270.000 |
| Infantry..... | 13803 | 12354 | 30227.465 | 13510.834 |
| Anti-Tank..... | 730 | 712 | 17350.000 | 6857.500 |
| Towed Artillery..... | 0 | 30 | 0.000 | 6938.000 |
| Self-Propelled Artillery..... | 54 | 24 | 12042.000 | 5694.000 |
| Anti-Air..... | 32 | 71 | 942.960 | 3361.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 153227 | 76631 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks..... | 1375 | 2328 | | |
| Tracked Vehicles..... | 93 | 24 | | |
| Fixed-Wing Aircraft..... | 0 | 0 | | |
| Rotary-Wing Aircraft..... | 0 | 0 | | |
| Motorcycles..... | 0 | 480 | | |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| | | |
|---|---|---|
| FORCE STRENGTHS | | |
| FORCE STRENGTHS..... | 138630.005 | 63757.796 |
| FORCE RATIO..... | 2.174 | 0.460 |
| POWER POTENTIAL | | |
| COMBAT POWER (P)..... | 153336.040 | 88562.246 |
| P/P RATIO..... | 1.731 | 0.578 |
| TIME AND SPACE | | |
| ADVANCE RATE (km/day): | 8.976 | |
| LOCATION (x, y): | 8.976 | 0.000 |
| TOTAL DISTANCE (km): | 8.976 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 12511 | 13734 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 444 | 153 | 87736.365 | 36760.713 |
| Infantry..... | 13545 | 11865 | 29662.791 | 12976.508 |
| Anti-Tank..... | 716 | 684 | 17025.888 | 6586.300 |
| Towed Artillery..... | 0 | 30 | 0.000 | 6882.234 |
| Self-Propelled Artillery..... | 53 | 24 | 11928.993 | 5580.271 |
| Anti-Air..... | 31 | 68 | 925.345 | 3228.079 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 147279 | 72014 |
| NUMBERS OF MOBILITY ELEMENTS | | | | |
| Trucks..... | 1362 | 2282 | | |
| Tracked Vehicles..... | 88 | 22 | | |
| Fixed-Wing Aircraft..... | 0 | 0 | | |
| Rotary-Wing Aircraft..... | 0 | 0 | | |
| Motorcycles..... | 0 | 471 | | |

**********
* End of report *
**********

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                                  09/10/1996


                   ENGAGEMENT FILENAME:  LOGSTC2     ANALYST: D L Bongard
                 ENGAGEMENT DESCRIPTION:  U.S. Lt Armd Div (+) attack on
                  German std PzD w/ROF=0, other conditions nominal
            STARTING DATE OF ENGAGEMENT:  09/15/1944
            STARTING TIME OF ENGAGEMENT:  0700
                               ATTACKER:  WW2 Lt Armd Div (+)
                               DEFENDER:  WW2 std PzD
     ATTACKER'S STARTING POINT (X, Y):     0.00,    0.00
          ATTACKER'S OBJECTIVE (X, Y):    20.00,    0.00

                                  RESULTS SUMMARY

                                       ATTACKER       DEFENDER

              COMBAT POWER RATIO          5.507          0.182
                          WINNER         XXXXXX
               DISTANCE ADVANCED         42.840
           ADVANCE RATE (KM/DAY)         42.840
                      CASUALTIES         67.030        414.633
               % CASUALTIES/DAY          0.526          2.900
                    TANK LOSSES          7.021         15.062
              % TANK LOSSES/DAY          1.497          8.965

     PROGRAM-CONTROL VARIABLES
                  TIME STEP FOR ATTRITION CALCULATION:   24.0000 HOURS
                   TIME STEP FOR PRINT OUT OF RESULTS:   24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:   24.000 HOURS
           INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT


                                    INPUT DATA

     ENVIRONMENTAL VARIABLES
             LIGHTING LEVEL:  24-HOUR PERIOD
               TERRAIN TYPE:  ROLLING-GENTLE-MIXED
          WEATHER CONDITION:  DRY-OVERCAST-TEMPERATE
     CLIMATE/SEASON OF YEAR:  TEMPERATE
               ROAD QUALITY:  GOOD ROADS
               ROAD DENSITY:  EUROPEAN STANDARD


     OPERATIONAL VARIABLES
               ATTACKER'S MISSION:  ATTACK (NORMAL)
               DEFENDER'S MISSION:  HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION:  US
DEFENDER'S WEAPONS SOPHISTICATION:  GERMAN/SWEDISH/S. KOREA
                       FORCE TYPE:  ARMORED
NEITHER SIDE HAS AIR SUPERIORITY
                    SURPRISE LEVEL:  NO SURPRISE
  PRIOR DAYS OF COMBAT - ATTACKER:   0.00
  PRIOR DAYS OF COMBAT - DEFENDER:   0.00
               Shoreline Vulnerability not applied


            EQUATION MODIFIERS      ATTACKER       DEFENDER

                  COMBAT POWER:         1.000          1.000
                ATTRITION RATE:         1.000          1.000
          TOWED ARTILLERY RATE:         1.000          1.000
             SP ARTILLERY RATE:         1.000          1.000
                  ADVANCE RATE:         1.000
              SET PIECE FACTORS:         1.000          1.000
```

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Light AD (+) of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 std Army PzD w/ROFs=0 of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 12749 | 14300 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 469 | 168 | 92665.000 | 20451.000 |
| Infantry..... | 13803 | 12354 | 30227.465 | 2565.000 |
| Anti-Tank..... | 730 | 712 | 17350.000 | 0.000 |
| Towed Artillery..... | 0 | 30 | 0.000 | 0.000 |
| Self-Propelled Artillery..... | 54 | 24 | 12042.000 | 0.000 |
| Anti-Air..... | 32 | 71 | 942.960 | 0.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 153227 | 23016 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1375 | 2328 |
| Tracked Vehicles..... | 93 | 24 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 480 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 138630.005 | 19691.850 |
| FORCE RATIO..... | 7.040 | 0.142 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 298002.722 | 20841.104 |
| P/P RATIO..... | 14.299 | 0.070 |
| P'/P' IMBALANCE..... | 5.507 | 0.182 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 42.840 | |
| LOCATION (x, y): | 42.840 | 0.000 |
| TOTAL DISTANCE (km): | 42.840 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 12682 | 13885 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 462 | 153 | 91277.855 | 18617.468 |
| Infantry..... | 13730 | 11996 | 30068.540 | 2490.627 |
| Anti-Tank..... | 726 | 691 | 17258.780 | 0.000 |
| Towed Artillery..... | 0 | 30 | 0.000 | 0.000 |
| Self-Propelled Artillery..... | 54 | 24 | 12010.302 | 0.000 |
| Anti-Air..... | 32 | 69 | 938.002 | 0.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 151553 | 21108 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1371 | 2294 |
| Tracked Vehicles..... | 92 | 22 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 473 |

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* End of report *
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                  ENGAGEMENT FILENAME:  LOGSTC3     ANALYST: D L Bongard
               ENGAGEMENT DESCRIPTION:  U.S. Lt Armd Div (+) attack on
                German std PzD w/ROFs x2; other cndtns nominal
           STARTING DATE OF ENGAGEMENT:  09/15/1944
           STARTING TIME OF ENGAGEMENT:  0700
                               ATTACKER:  WW2 Lt Armd Div (+)
                               DEFENDER:  WW2 std PzD
      ATTACKER'S STARTING POINT (X, Y):     0.00,    0.00
           ATTACKER'S OBJECTIVE (X, Y):    20.00,    0.00

                                RESULTS SUMMARY

                                     ATTACKER       DEFENDER

             COMBAT POWER RATIO         0.739          1.353
                         WINNER                       XXXXXX
              DISTANCE ADVANCED         0.000
           ADVANCE RATE (KM/DAY)        0.000
                     CASUALTIES       418.997        479.093
              % CASUALTIES/DAY          3.287          3.350
                   TANK LOSSES        43.886         10.510
             % TANK LOSSES/DAY          9.357          6.256

     PROGRAM-CONTROL VARIABLES
                 TIME STEP FOR ATTRITION CALCULATION:   24.0000 HOURS
                  TIME STEP FOR PRINT OUT OF RESULTS:   24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:   24.000 HOURS
          INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT


                                    INPUT DATA

     ENVIRONMENTAL VARIABLES
             LIGHTING LEVEL:  24-HOUR PERIOD
               TERRAIN TYPE:  ROLLING-GENTLE-MIXED
          WEATHER CONDITION:  DRY-OVERCAST-TEMPERATE
     CLIMATE/SEASON OF YEAR:  TEMPERATE
               ROAD QUALITY:  GOOD ROADS
               ROAD DENSITY:  EUROPEAN STANDARD


     OPERATIONAL VARIABLES
               ATTACKER'S MISSION:  ATTACK (NORMAL)
               DEFENDER'S MISSION:  HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION:  US
DEFENDER'S WEAPONS SOPHISTICATION:  GERMAN/SWEDISH/S. KOREA
                       FORCE TYPE:  ARMORED
NEITHER SIDE HAS AIR SUPERIORITY
                    SURPRISE LEVEL:  NO SURPRISE
  PRIOR DAYS OF COMBAT - ATTACKER:   0.00
  PRIOR DAYS OF COMBAT - DEFENDER:   0.00
               Shoreline Vulnerability not applied


           EQUATION MODIFIERS      ATTACKER       DEFENDER

                 COMBAT POWER:         1.000          1.000
              ATTRITION RATE:          1.000          1.000
         TOWED ARTILLERY RATE:         1.000          1.000
            SP ARTILLERY RATE:         1.000          1.000
                 ADVANCE RATE:         1.000
            SET PIECE FACTORS:         1.000          1.000
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ATTACKER'S ORDER OF BATTLE

1.000 WW2 Light AD (+) of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 std Army PzD w/ROF x2 of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 12749 | 14300 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 469 | 168 | 92665.000 | 56074.000 |
| Infantry..... | 13803 | 12354 | 30227.465 | 24136.668 |
| Anti-Tank..... | 730 | 712 | 17350.000 | 13715.000 |
| Towed Artillery..... | 0 | 30 | 0.000 | 13876.000 |
| Self-Propelled Artillery..... | 54 | 24 | 12042.000 | 11388.000 |
| Anti-Air..... | 32 | 71 | 942.960 | 6722.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 153227 | 125912 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1375 | 2328 |
| Tracked Vehicles..... | 93 | 24 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 480 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 138630.005 | 104122.991 |
| FORCE RATIO..... | 1.331 | 0.751 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 118999.978 | 160952.599 |
| P/P RATIO..... | 0.739 | 1.353 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 0.000 | |
| LOCATION (x, y): | 0.000 | 0.000 |
| TOTAL DISTANCE (km): | 0.000 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 12330 | 13821 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 425 | 157 | 83994.082 | 52565.926 |
| Infantry..... | 13349 | 11940 | 29234.038 | 23328.016 |
| Anti-Tank..... | 706 | 688 | 16779.791 | 13255.506 |
| Towed Artillery..... | 0 | 30 | 0.000 | 13781.751 |
| Self-Propelled Artillery..... | 53 | 24 | 11842.466 | 11195.609 |
| Anti-Air..... | 31 | 69 | 911.970 | 6496.793 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 142762 | 120624 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1352 | 2289 |
| Tracked Vehicles..... | 84 | 22 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 472 |

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ENGAGEMENT FILENAME: LOGSTC4 ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: U.S. Lt Armd Div w/ROFx2 attack on German std PzD, other conditions nominal
STARTING DATE OF ENGAGEMENT: 09/15/1944
STARTING TIME OF ENGAGEMENT: 0700
ATTACKER: WW2 Lt Armd Div (+)
DEFENDER: WW2 std PzD
ATTACKER'S STARTING POINT (X, Y): 0.00, 0.00
ATTACKER'S OBJECTIVE (X, Y): 20.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 3.263 | 0.306 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 21.930 | |
| ADVANCE RATE (KM/DAY) | 21.930 | |
| CASUALTIES | 92.503 | 345.476 |
| % CASUALTIES/DAY | 0.726 | 2.416 |
| TANK LOSSES | 9.689 | 10.761 |
| % TANK LOSSES/DAY | 2.066 | 6.405 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 24.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 24.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-MIXED
WEATHER CONDITION: DRY-OVERCAST-TEMPERATE
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: GOOD ROADS
ROAD DENSITY: EUROPEAN STANDARD

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: US
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: ARMORED
NEITHER SIDE HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Light AD (+) of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 std Army PzD of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 12749 | 14300 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 469 | 168 | 124565.000 | 40270.000 |
| Infantry..... | 13803 | 12354 | 46906.930 | 13510.834 |
| Anti-Tank..... | 730 | 712 | 34700.000 | 6857.500 |
| Towed Artillery..... | 0 | 30 | 0.000 | 6938.000 |
| Self-Propelled Artillery..... | 54 | 24 | 24084.000 | 5694.000 |
| Anti-Air..... | 32 | 71 | 1885.920 | 3361.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 232142 | 76631 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1375 | 2328 |
| Tracked Vehicles..... | 93 | 24 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 480 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 209284.539 | 63757.796 |
| FORCE RATIO..... | 3.282 | 0.305 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 302701.586 | 84174.173 |
| P/P RATIO..... | 3.596 | 0.278 |
| P'/P' IMBALANCE..... | 3.263 | 0.306 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 21.930 | |
| LOCATION (x, y): | 21.930 | 0.000 |
| TOTAL DISTANCE (km): | 21.930 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 12656 | 13955 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 459 | 157 | 121991.685 | 37690.651 |
| Infantry..... | 13703 | 12056 | 46566.585 | 13184.424 |
| Anti-Tank..... | 725 | 695 | 34448.226 | 6691.829 |
| Towed Artillery..... | 0 | 30 | 0.000 | 6904.148 |
| Self-Propelled Artillery..... | 54 | 24 | 23996.467 | 5624.798 |
| Anti-Air..... | 32 | 69 | 1872.236 | 3279.801 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 228875 | 73376 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1370 | 2300 |
| Tracked Vehicles..... | 91 | 22 |
| Fixed-Wing Aircraft..... | 0 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 0 | 474 |

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* End of report *
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                   ENGAGEMENT FILENAME:  LOGSTCA     ANALYST: D L Bongard
                 ENGAGEMENT DESCRIPTION:  Attack by U.S. Inf Div against
                  German Typ-44 Inf Div; all nominal conditions
            STARTING DATE OF ENGAGEMENT:  09/10/1944
            STARTING TIME OF ENGAGEMENT:  0600
                               ATTACKER:  U.S. WW2 Inf Div (+)
                               DEFENDER:  Ger WW2 T-44 Inf Div
       ATTACKER'S STARTING POINT (X, Y):     0.00,    0.00
            ATTACKER'S OBJECTIVE (X, Y):    15.00,    0.00

                                  RESULTS SUMMARY

                                       ATTACKER       DEFENDER

               COMBAT POWER RATIO         0.909          1.100
                           WINNER                XXXXXX
                DISTANCE ADVANCED         0.000
            ADVANCE RATE (KM/DAY)         0.000
                      CASUALTIES       509.295        458.307
                   % CASUALTIES/DAY         3.384          3.710
                        TANK LOSSES         5.443          1.461
                % TANK LOSSES/DAY        20.160         10.435

       PROGRAM-CONTROL VARIABLES
                    TIME STEP FOR ATTRITION CALCULATION:   24.0000 HOURS
                     TIME STEP FOR PRINT OUT OF RESULTS:   24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:   24.000 HOURS
             INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT


                                       INPUT DATA

       ENVIRONMENTAL VARIABLES
                LIGHTING LEVEL:  24-HOUR PERIOD
                  TERRAIN TYPE:  ROLLING-GENTLE-MIXED
               WEATHER CONDITION:  DRY-OVERCAST-TEMPERATE
       CLIMATE/SEASON OF YEAR:  TEMPERATE
                  ROAD QUALITY:  MEDIOCRE ROADS
                  ROAD DENSITY:  EUROPEAN STANDARD


       OPERATIONAL VARIABLES
                  ATTACKER'S MISSION:  ATTACK (NORMAL)
                  DEFENDER'S MISSION:  HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION:  US
DEFENDER'S WEAPONS SOPHISTICATION:  GERMAN/SWEDISH/S. KOREA
                        FORCE TYPE:  INFANTRY
ATTACKER HAS AIR SUPERIORITY
                     SURPRISE LEVEL:  NO SURPRISE
  PRIOR DAYS OF COMBAT - ATTACKER:   0.00
  PRIOR DAYS OF COMBAT - DEFENDER:   0.00
                  Shoreline Vulnerability not applied
                         DEFENDER CEV:  1.200


            EQUATION MODIFIERS      ATTACKER       DEFENDER

                    COMBAT POWER:         1.000          1.000
                  ATTRITION RATE:         1.000          1.000
              TOWED ARTILLERY RATE:         1.000          1.000
                 SP ARTILLERY RATE:         1.000          1.000
                      ADVANCE RATE:         1.000
                SET PIECE FACTORS:         1.000          1.000
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ATTACKER'S ORDER OF BATTLE

1.000 WW2 Inf Div w/twd TD bn of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 Typ-44 Inf Div of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 15050 | 12352 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 27 | 14 | 2082.000 | 1946.000 |
| Infantry..... | 13660 | 11294 | 15828.015 | 12588.812 |
| Anti-Tank..... | 651 | 453 | 20589.000 | 5429.268 |
| Towed Artillery..... | 66 | 72 | 14478.000 | 13314.000 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 852.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 52977 | 34130 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1451 | 1348 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 168 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 39843.011 | 25835.107 |
| FORCE RATIO..... | 1.542 | 0.648 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 33102.267 | 36404.758 |
| P/P RATIO..... | 0.909 | 1.100 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 0.000 | |
| LOCATION (x, y): | 0.000 | 0.000 |
| TOTAL DISTANCE (km): | 0.000 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 14541 | 11894 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 22 | 13 | 1662.265 | 1742.926 |
| Infantry..... | 13198 | 10875 | 15292.392 | 12121.719 |
| Anti-Tank..... | 629 | 436 | 19892.264 | 5227.821 |
| Towed Artillery..... | 65 | 71 | 14358.872 | 13213.700 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 820.388 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 51206 | 33127 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1426 | 1323 |
| Tracked Vehicles..... | 2 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 165 |

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ENGAGEMENT FILENAME: LOGSTCB ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by U.S. Inf Div against
German Typ-44 Inf Div w/ROF = 0
STARTING DATE OF ENGAGEMENT: 09/10/1944
STARTING TIME OF ENGAGEMENT: 0600
ATTACKER: U.S. WW2 Inf Div (+)
DEFENDER: Ger WW2 T-44 Inf Div
ATTACKER'S STARTING POINT (X, Y): 0.00, 0.00
ATTACKER'S OBJECTIVE (X, Y): 15.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 15.694 | 0.064 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 19.584 | |
| ADVANCE RATE (KM/DAY) | 19.584 | |
| CASUALTIES | 107.767 | 652.514 |
| % CASUALTIES/DAY | 0.716 | 5.283 |
| TANK LOSSES | 0.696 | 2.080 |
| % TANK LOSSES/DAY | 2.578 | 14.857 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 24.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 24.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-MIXED
WEATHER CONDITION: DRY-OVERCAST-TEMPERATE
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: MEDIOCRE ROADS
ROAD DENSITY: EUROPEAN STANDARD

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: US
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
ATTACKER HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied
DEFENDER CEV: 1.200

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Inf Div w/twd TD bn of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 Typ-44 Inf Div of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 15050 | 12352 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 27 | 14 | 2082.000 | 546.000 |
| Infantry..... | 13660 | 11294 | 15828.015 | 0.000 |
| Anti-Tank..... | 651 | 453 | 20589.000 | 0.000 |
| Towed Artillery..... | 66 | 72 | 14478.000 | 0.000 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 0.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 52977 | 546 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1451 | 1348 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 168 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 39213.011 | 464.100 |
| FORCE RATIO..... | 84.493 | 0.012 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 107031.732 | 564.717 |
| P/P RATIO..... | 189.532 | 0.005 |
| P'/P' IMBALANCE..... | 15.694 | 0.064 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 19.584 | |
| LOCATION (x, y): | 19.584 | 0.000 |
| TOTAL DISTANCE (km): | 19.584 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 14942 | 11699 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 26 | 12 | 2028.330 | 464.878 |
| Infantry..... | 13562 | 10697 | 15714.677 | 0.000 |
| Anti-Tank..... | 646 | 429 | 20441.571 | 0.000 |
| Towed Artillery..... | 66 | 71 | 14453.051 | 0.000 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 11 | 0.000 | 0.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 52638 | 465 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1446 | 1312 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 164 |

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* End of report *
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                TACTICAL NUMERICAL DETERMINISTIC MODEL (TNDM)
                            Compiled 12 March 1995
              Version:  1.85 Copyright (c) 1990-1995 T. N. Dupuy
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                                 09/18/1996


                  ENGAGEMENT FILENAME:  LOGSTC-C     ANALYST: D L Bongard
               ENGAGEMENT DESCRIPTION:  Attack by U.S. Inf Div against
                German Typ-44 Inf Div, w/ROF x 2
          STARTING DATE OF ENGAGEMENT:  09/10/1944
          STARTING TIME OF ENGAGEMENT:  0600
                               ATTACKER:  U.S. WW2 Inf Div (+)
                               DEFENDER:  Ger WW2 T-44 Inf Div
     ATTACKER'S STARTING POINT (X, Y):     0.00,    0.00
          ATTACKER'S OBJECTIVE (X, Y):    15.00,    0.00

                                  RESULTS SUMMARY

                                       ATTACKER       DEFENDER

             COMBAT POWER RATIO           0.308          3.249
                         WINNER                         XXXXXX
              DISTANCE ADVANCED           0.000
          ADVANCE RATE (KM/DAY)           0.000
                     CASUALTIES         803.722        305.954
               % CASUALTIES/DAY           5.340          2.477
                    TANK LOSSES          10.803          0.903
              % TANK LOSSES/DAY          40.012          6.450

     PROGRAM-CONTROL VARIABLES
                  TIME STEP FOR ATTRITION CALCULATION:   24.0000 HOURS
                   TIME STEP FOR PRINT OUT OF RESULTS:   24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT:   24.000 HOURS
           INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT


                                    INPUT DATA

     ENVIRONMENTAL VARIABLES
             LIGHTING LEVEL:  24-HOUR PERIOD
               TERRAIN TYPE:  ROLLING-GENTLE-MIXED
          WEATHER CONDITION:  DRY-OVERCAST-TEMPERATE
     CLIMATE/SEASON OF YEAR:  TEMPERATE
               ROAD QUALITY:  MEDIOCRE ROADS
               ROAD DENSITY:  EUROPEAN STANDARD


     OPERATIONAL VARIABLES
               ATTACKER'S MISSION:  ATTACK (NORMAL)
               DEFENDER'S MISSION:  HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION:  US
DEFENDER'S WEAPONS SOPHISTICATION:  GERMAN/SWEDISH/S. KOREA
                       FORCE TYPE:  INFANTRY
ATTACKER HAS AIR SUPERIORITY
                    SURPRISE LEVEL:  NO SURPRISE
  PRIOR DAYS OF COMBAT - ATTACKER:   0.00
  PRIOR DAYS OF COMBAT - DEFENDER:   0.00
               Shoreline Vulnerability not applied
                     DEFENDER CEV:  1.200


           EQUATION MODIFIERS      ATTACKER       DEFENDER

                 COMBAT POWER:         1.000          1.000
               ATTRITION RATE:         1.000          1.000
          TOWED ARTILLERY RATE:         1.000          1.000
             SP ARTILLERY RATE:         1.000          1.000
                  ADVANCE RATE:         1.000
            SET PIECE FACTORS:          1.000          1.000
```

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Inf Div w/twd TD bn of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 Typ-44 Inf Div of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 15050 | 12352 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 27 | 14 | 2082.000 | 2548.000 |
| Infantry..... | 13660 | 11294 | 15828.015 | 25177.624 |
| Anti-Tank..... | 651 | 453 | 20589.000 | 10858.536 |
| Towed Artillery..... | 66 | 72 | 14478.000 | 26628.000 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 1704.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 52977 | 66916 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1451 | 1348 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 168 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 40113.911 | 49590.915 |
| FORCE RATIO..... | 0.809 | 1.236 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 24505.852 | 87225.975 |
| P/P RATIO..... | 0.281 | 3.559 |
| P'/P' IMBALANCE..... | 0.308 | 3.249 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 0.000 | |
| LOCATION (x, y): | 0.000 | 0.000 |
| TOTAL DISTANCE (km): | 0.000 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 14246 | 12046 | | |
| | | | ATTACKER | DEFENDER |
| NUMBERS OF COMBAT SYSTEMS | | | SCORES | |
| Armor..... | 16 | 13 | 1248.945 | 2383.659 |
| Infantry..... | 12931 | 11014 | 14982.745 | 24553.984 |
| Anti-Tank..... | 616 | 442 | 19489.477 | 10589.574 |
| Towed Artillery..... | 65 | 72 | 14288.550 | 26494.760 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 1661.793 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 50010 | 65684 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1412 | 1331 |
| Tracked Vehicles..... | 2 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 166 |

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* End of report *
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TACTICAL NUMERICAL DETERMINISTIC MODEL (TNDM)
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09/18/1996

ENGAGEMENT FILENAME: LOGSTCD ANALYST: D L Bongard
ENGAGEMENT DESCRIPTION: Attack by U.S. Inf Div w/ROF x 2, vs. German Typ-44 Inf Div
STARTING DATE OF ENGAGEMENT: 09/10/1944
STARTING TIME OF ENGAGEMENT: 0600
ATTACKER: U.S. WW2 Inf Div (+)
DEFENDER: Ger WW2 T-44 Inf Div
ATTACKER'S STARTING POINT (X, Y): 0.00, 0.00
ATTACKER'S OBJECTIVE (X, Y): 15.00, 0.00

RESULTS SUMMARY

| | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER RATIO | 2.892 | 0.346 |
| WINNER | XXXXXX | |
| DISTANCE ADVANCED | 7.964 | |
| ADVANCE RATE (KM/DAY) | 7.964 | |
| CASUALTIES | 295.945 | 683.043 |
| % CASUALTIES/DAY | 1.966 | 5.530 |
| TANK LOSSES | 2.812 | 2.177 |
| % TANK LOSSES/DAY | 10.416 | 15.553 |

PROGRAM-CONTROL VARIABLES
TIME STEP FOR ATTRITION CALCULATION: 24.0000 HOURS
TIME STEP FOR PRINT OUT OF RESULTS: 24.0000 HOURS
MAXIMUM ELAPSED TIME FOR SIMULATED COMBAT ENGAGEMENT: 24.000 HOURS
INTERMEDIATE RESULTS WILL NOT BE PRINTED OUT

INPUT DATA

ENVIRONMENTAL VARIABLES
LIGHTING LEVEL: 24-HOUR PERIOD
TERRAIN TYPE: ROLLING-GENTLE-MIXED
WEATHER CONDITION: DRY-OVERCAST-TEMPERATE
CLIMATE/SEASON OF YEAR: TEMPERATE
ROAD QUALITY: MEDIOCRE ROADS
ROAD DENSITY: EUROPEAN STANDARD

OPERATIONAL VARIABLES
ATTACKER'S MISSION: ATTACK (NORMAL)
DEFENDER'S MISSION: HASTY DEFENSE
ATTACKER'S WEAPONS SOPHISTICATION: US
DEFENDER'S WEAPONS SOPHISTICATION: GERMAN/SWEDISH/S. KOREA
FORCE TYPE: INFANTRY
ATTACKER HAS AIR SUPERIORITY
SURPRISE LEVEL: NO SURPRISE
PRIOR DAYS OF COMBAT - ATTACKER: 0.00
PRIOR DAYS OF COMBAT - DEFENDER: 0.00
Shoreline Vulnerability not applied
DEFENDER CEV: 1.200

| EQUATION MODIFIERS | ATTACKER | DEFENDER |
|---|---|---|
| COMBAT POWER: | 1.000 | 1.000 |
| ATTRITION RATE: | 1.000 | 1.000 |
| TOWED ARTILLERY RATE: | 1.000 | 1.000 |
| SP ARTILLERY RATE: | 1.000 | 1.000 |
| ADVANCE RATE: | 1.000 | |
| SET PIECE FACTORS: | 1.000 | 1.000 |

ATTACKER'S ORDER OF BATTLE

1.000 WW2 Inf Div w/twd TD bn of USA

DEFENDER'S ORDER OF BATTLE

1.000 WW2 Typ-44 Inf Div of GERMANY

| FORCE & EQUIPMENT INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL..... | 15050 | 12352 | | |
| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER SCORES |
| Armor..... | 27 | 14 | 2799.000 | 1946.000 |
| Infantry..... | 13660 | 11294 | 31656.030 | 12588.812 |
| Anti-Tank..... | 651 | 453 | 41178.000 | 5429.268 |
| Towed Artillery..... | 66 | 72 | 28956.000 | 13314.000 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 12 | 0.000 | 852.000 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 104589 | 34130 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1451 | 1348 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 168 |

SNAPSHOT OF BATTLEFIELD OUTCOME AFTER 24.000 HOURS OF COMBAT
( 1 TIME STEP OF CALCULATION)

| FORCE STRENGTHS | | |
|---|---|---|
| FORCE STRENGTHS..... | 77603.661 | 26157.757 |
| FORCE RATIO..... | 2.967 | 0.337 |

| POWER POTENTIAL | | |
|---|---|---|
| COMBAT POWER (P)..... | 104594.412 | 36169.387 |
| P/P RATIO..... | 2.892 | 0.346 |

| TIME AND SPACE | | |
|---|---|---|
| ADVANCE RATE (km/day): | 7.964 | |
| LOCATION (x, y): | 7.964 | 0.000 |
| TOTAL DISTANCE (km): | 7.964 | |

| FINAL INVENTORY | ATTACKER | DEFENDER | | |
|---|---|---|---|---|
| NUMBER OF PERSONNEL | 14754 | 11669 | | |
| NUMBERS OF COMBAT SYSTEMS | | | ATTACKER SCORES | DEFENDER SCORES |
| Armor..... | 24 | 12 | 2507.446 | 1643.346 |
| Infantry..... | 13391 | 10669 | 31033.542 | 11892.674 |
| Anti-Tank..... | 638 | 428 | 40368.271 | 5129.039 |
| Towed Artillery..... | 66 | 71 | 28818.312 | 13163.383 |
| Self-Propelled Artillery..... | 0 | 0 | 0.000 | 0.000 |
| Anti-Air..... | 0 | 11 | 0.000 | 804.886 |
| Fixed-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| Rotary-Wing Aircraft..... | 0 | 0 | 0.000 | 0.000 |
| TOTAL OLI | | | 102728 | 32633 |

| NUMBERS OF MOBILITY ELEMENTS | | |
|---|---|---|
| Trucks..... | 1437 | 1311 |
| Tracked Vehicles..... | 3 | 0 |
| Fixed-Wing Aircraft..... | 10 | 0 |
| Rotary-Wing Aircraft..... | 0 | 0 |
| Motorcycles..... | 11 | 163 |

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* End of report *
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# Validation of the TNDM at Battalion Level

**by Christopher A. Lawrence**

The original QJM (Quantified Judgement Model) was created and validated using primarily division–level engagements from WWII and the 1967 and 1973 Mid–East Wars. For a number of reasons, we are now using the TNDM for analyzing more lower level engagements. We expect, with the changed environment in the world, this trend to continue.

The model, while designed to handle battalion–level engagements, was never validated for those size engagements. There were only 16 engagements in the original QJM Database with less than 5,000 people on one side, and only one with less than 2,000 people on a side. The sixteen smallest engagements are:

| | | | | |
|---|---|---|---|---|
| 1973 Mid-East | Mt. Hermon I | 2,692 | 1,583 | * |
| 1973 Mid-East | Canal Assault (S) | 22,850 | 3,020 | |
| WWII (1943) | Monte Maggiore | 5,551 | 3,288 | * |
| WWII (1943) | Monte Camino III | 20,744 | 3,288 | |
| 1967 Mid-East | Bir Gifgafa | 3,600 | 3,500 | * |
| 1973 Mid-East | Kuneitra | 17,750 | 3,630 | |
| WWII (1944) | Il Giogo Pass | 15,721 | 3,700 | |
| WWII (1943) | Port of Salerno | 12,917 | 4,250 | |
| WWII (1943) | Amphitheater | 12,917 | 4,250 | |
| 1967 Mid-East | Rawiyeh | 5,350 | 4,350 | |
| 1973 Mid-East | Canal Assault (N) | 29,490 | 4,455 | |
| WWII (1944) | Carrocetto | 26,490 | 4,515 | |
| WWII (1944) | Monte Grande | 13,095 | 4,563 | |
| 1973 Mid-East | Mt. Hermon II | 5,700 | 4,750 | |
| 1973 Mid-East | Mt. Hermon III | 11,400 | 4,750 | |
| 1973 Mid-East | Rafid | 19,525 | 4,958 | |

While it is not unusual in the operations research community to use unvalidated models of combat, it is a very poor practice. As TDI is starting to use this model for battalion–level engagements, it is time it was formally validated for that use. A model that is validated at one level of combat is not validated to represent sizes, types and forms of combat to which it has not been tested.

TDI is undertaking a battalion–level validation effort for the TNDM. We intend to publish the material used and the results of the validation in the International TNDM Newsletter. As part of this battalion–level validation we will also be looking at a number of company–level engagements. Right now, my intention is to simply just throw all the engagements into the same hopper and see what comes out.

By battalion–level, I mean any operation consisting of the equivalent of two or less reinforced battalions on one side. Three or more battalions imply a regiment or brigade–level operation. A battalion in combat can range widely in strength, but that usually does not have an authorized strength in excess of 900. Therefore, the upper limit for a battalion–level engagement is 2,000 people, while its lower limit can easily go below 500 people. Only one engagement in the original QJM Database fits that definition of a battalion–level engagement. But the companies of HERO, DMSI, TND & Associates, and TDI (all companies founded by Trevor N. Dupuy) have examined a number of small engagements over the years. HERO assembled 23 WWI engagements for the Land Warfare Database (LWDB), TDI has done 15 WWII small unit actions for the Suppression contract and Dave Bongard has assembled four others from that period for the Pacific, DMSI did 14 battalion-level engagements from Vietnam for a study on low intensity conflict 10 years ago, and Dave Bongard has been independently looking into the Falkland Islands War and other post–WWII sources to locate 10 more engagements, and we have three engagements that Trevor N. Dupuy did for South Africa. We added two other World War II engagements and the three smallest engagements from the list to the left (those marked with an asterisk). This gives us a list of 74 additional engagements that can be used to test the TNDM.

The smallest of these engagements is 220 people on both sides (100 vs 120), while the largest engagement on this list is 5,336 versus 3,270 or 8,679 vs 725. These 74 engagements consist of 23 engagements from WWI, 22 from WWII, and 29 post–1945 engagements. There are three engagements where both sides have over 3,000 men and 3 more where both sides are above 2,000 men. In the other 68 engagements, at least one side is below 2,000, while in 50 of the engagements, both sides are below 2,000.

This leaves the following force sizes to be tested:

| | |
|---|---|
| 0 - 199 | 19 |
| 200 - 499 | 25 |
| 500 - 999 | 41 |
| 1000 - 1499 | 14 |
| 1500 - 1999 | 19 |
| 2000 - 2499 | 4 |
| 2500 - 2999 | 8 |
| 3000 - 3499 | 4 |
| 3500 - 3999 | 4 |
| 4000 - 4999 | 4 |
| 5000 - 5999 | 5 |
| 6000 - 9000 | 1 |

These engagements have been "randomly" selected in the sense that the researchers grabbed whatever had been done and whatever else was conveniently available. It is not a proper random selection, in the sense that every war in this century was analyzed and a representative number of engagements was taken from each conflict. This is not practical, so we settle for less than perfect data selection. Furthermore, as many of these conflicts are with countries that do not have open archives (and in many cases limited unit records) some of the opposing forces strength and losses had to be estimated. This is especially true with the Viet Nam engagements. It is hoped that the errors in estimation deviate equally on both sides of the norm, but there is no way of knowing that until countries like the People's Republic of China and Vietnam open up their archives for free independent research.

TDI intends to continue to look for battalion–level and smaller engagements for analysis, and may add to this data base over time. If some of our readers have any other data assembled, we would be interested in seeing it. In the next issue we will publish the preliminary results of our validation.

## Battalion Level Engagements

| Name | Date | Attacker | Att N | A Cas | Defender | Def N | D Cas | Source |
|---|---|---|---|---|---|---|---|---|
| ***World War I*** | | | | | | | | |
| Yvonne-Odette | 13-14 Apr 1918 | *StGr Grethe* | 3702 | 71 | I&L/9 IRgt | 650 | 71 | n |
| Cantigny | 28 May 1918 | 28th IRgt | 8679 | 300 | *II/272 IR* | 725 | 386 | n |
| Hill 142 | 6 Jun 1918 | 5 Mar Rgt- | 2913 | 383 | *II/273 IR+* | 2458 | 471 | n |
| West Wd I | 6 Jun 1918 | 3/5 Mar (-) | 1740 | 361 | *I/461 IR* | 1121 | 54 | n |
| Bourschs I | 6 Jun 1918 | 6 Mar Rgt- | 2753 | 343 | *II/461 IR* | 1352 | 186 | n |
| West Wd II | 11 Jun 1918 | 2/5 Mar (+) | 3349 | 279 | *I/461 IR+* | 1798 | 541 | n |
| N Wood I | 12 Jun 1918 | 3/5 Mar (+) | 1747 | 167 | *II/110 GrR* | 1952 | 293 | n |
| Bourschs II | 13 Jun 1918 | *109 IR -/+* | 3690 | 138 | 3/5 Mar (+) | 2629 | 107 | n |
| N Wood II | 21 Jun 1918 | 1/7 IR | 1697 | 192 | *III/347 IR+* | 1428 | 18 | n |
| N Wood III | 23 Jun 1918 | 3/5 Mar (+) | 1256 | 133 | *I/347 IR* | 1565 | 19 | n |
| N Wood IV | 25 Jun 1918 | 3/5 Mar (+) | 1453 | 273 | *I/347 IR* | 1546 | 437 | n |
| St. Amand F | 18 Jul 1918 | 2/28 IR (+) | 1150 Tk | 120 | *II/396 IRgt* | 400 | 400 | n |
| Beaupre F | 18 Jul 1918 | 2/23 IR (+) | 4480 LT | 125 | *III/219 IR* | 565 | 181 | n |
| Chaudun | 18 Jul 1918 | 3/18 IR (+) | 1611 | 130 | *II/109 BGrR+* | 800 | 500 | n |
| Berzy le Sec | 21 Jul 1918 | 28 IR +/- | 4000 | 210 | *109 IR +/-* | 350 | 116 | n |
| Bouzancy Rdg | 21 Jul 1918 | 18 IR +/- | 5300 | 350 | *II/52 JgrR* | 554 | 276 | n |
| Medeah Far | 3 Oct 1918 | 2/9 IRgt | 1921 LT | 247 | *I/235 ResIR* | 155 | 83 | n |
| Essen Hook | 3 Oct 1918 | 1/5 Mar (+) | 1420 LT | 140 | *2/KolnLSAbt* | 216 | 120 | n |
| Exermont-M | 4 Oct 1918 | 18 IR (+) | 5336 LT | 352 | *elm 3 GdIR+* | 3270 | 196 | n |
| Mayache Rv | 4 Oct 1918 | 26 IR (+) | 5427 LT | 376 | *II/170 IR+* | 1899 | 114 | n |
| Le Neuville | 4 Oct 1918 | 28 IR (+) | 5365 | 340 | *I/111 IR+* | 1940 | 61 | n |
| Remy-Aillicourt | 6-7 Nov 1918 | 1/16 IR | 1210 | 25 | *6 ResJgrBn+* | 296 | 30 | n |
| Hill 252 | 7 Nov 1918 | 16 IR -/+ | 1989 | 110 | *14 Res ID-* | 1655 | 182 | n |
| | | | | | | | | |
| ***World War II*** | | | | | | | | |
| Wake II | 23 Dec 1941 | *SNLF (+)* | 1500 | ? | det 1 MDBn | 430 | ? | n |
| Makin Raid | 25 Aug 1942 | 2 MarRdrBn+ | 221 | 40? | *1 co (-)* | 83 | 70 | T |
| Tenaru River | 18 Aug 1942 | *Ichiki Force* | 770 | 700 | 1&2/1st Mar | 1600 | 80 | T |
| Edson's Ridge | 13 Sep 1942 | *Kawaguchi F* | 4000 | 1200 | 1 MarRBn+ | 980 | 200 | T |
| Chouigi Pass | 26 Nov 1942 | *190 Pz Bn* | 465 Tk | 40 | elms 1 AD | 188 | 15 | n |
| Mte Maggio | 2-3 Dec 1943 | 36 Inf Div - | 5551 | | *15 PGD & 29 PD* | 3288 | | Q |
| Engebi Is | 18 Feb 1944 | 22 MarRgt - | 4125 | 303 | *1st AmBde-* | 1276 | 1240 | T |
| Eniwetok | 17 Dec 1944 | 106 IRgt -/+ | 2600 | 202 | *1st AmBde-* | 1350 | 450 | T |
| Lausdell XRds | 20 Feb 1944 | *KG Müller* | *3300* | 400 | 1/9 Inf (+) | 600 | 400 | T |
| Assenois | 26 Dec 1944 | CCB/4 AD | 1796 Tk | 80 | *FusAbt 26+* | 614 | 470 | T |
| VER 7BWx | 8 Feb 1945 | 7 BW/51 ID | 800 | 33 | 1 co/84 ID | 150 | 10 | T |
| VER 57Gx | 8 Feb 1945 | 5/7 Gordons | 800 | 35 | 1.5 cos/84 ID | 220 | 12 | T |
| VER 1BWx | 8 Feb 1945 | 1 Black W | 800 | 22 | 1.5 cos/84 ID | 220 | 20 | T |
| VER HLIx | 8 Feb 1945 | 1 HLI/53 ID | 800 | 14 | 1 F Co/84 ID | 150 | 15 | T |
| VER 4RWx | 8 Feb 1945 | 4 R Wel Fus | 800 | 20 | 1 F Co/84 ID | 150 | 15 | T |
| VER 10Bx | 8 Feb 1945 | 1 Ox&Bucks | 800 | 11 | 1 F Co/84 ID | 150 | 15 | T |
| VER 2GHx | 8 Feb 1945 | 2 GH/15 ID | 800 | 21 | 1 F Co/84 ID | 150 | 10 | T |
| VER 9Cx | 8 Feb 1945 | 9 Camerons | 800 | 41 | 1 F Co/84 ID | 300 | 20 | T |
| VER 2ASx | 8 Feb 1945 | 2 A&S Hldrs | 800 | 46 | 2.5 cos/84 ID | 370 | 32 | T |
| VER XHLx | 8 Feb 1945 | 10 HLI | 800 | 42 | 2.5 cos R/84 ID | 380 | 32 | T |
| VER RDMx | 8 Feb 1945 | RdM/2d C ID | 800 | 20 | 1 co/84 ID | 150 | 15 | T |
| VER CHx | 8 Feb 1945 | Cal Hldrs | 800 | 44 | 3 cos/84 ID | 450 | 40 | T |

Note that in the above table, for World War II, German, Japanese, and Axis forces are listed in italics, while US, British, and Allied forces are listed in regular typeface. Also, in the VERITABLE engagements, the 5/7th Gordons' action continues the assault of the 7th Black Watch, and that the 9th Cameronians assumed the attack begun by the 2d Gordon Highlanders.

| Name | Date | Attacker | Att N | A Cas | Defender | Def N | D Cas | Source |
|---|---|---|---|---|---|---|---|---|
| ***Post-1945*** | | | | | | | | |
| Tu-Vu | 9 Sep 1951 | 312 VMD -/+ | 5000 | 1200 | 2 Mor cos + | 420 | 250 | T |
| Ninh Binh | 29 Jun 1954 | elms GM.2 | 850 | 20 | VM bn TF | 475 | 285 | Q+ |
| Cau Lanh | 28 Aug 1963 | AR/CIDG TF | 500 | 3 | VC company - | 60 | 36 | Q+ |
| Cai Nuoc | 10 Sep 1963 | VC 306 IBn | 500 | 16 | ARVN co TF | 150 | 60 | Q+ |
| ZDB050.. | 10 Sep 1963 | Sct/42 IR | 100 | 0 | VC company | 120 | 49 | Q+ |
| Mapu | 27 Apr 1966 | Indo. Bn | 200 | 53 | B/2/Para | 75 | 7 | Q+ |
| Long Tan | 18 Aug 1966 | VC Force | 1500 | 700 | 6 RoyAusRgt+ | 900 | 39 | Q+ |
| Hill 450 | 10 Nov 1966 | 2/502 IBn | 850 | 20 | NVA 5/95 IRgt | 214 | 131 | Q+ |
| PrekKlok 1 | 28 Feb 1967 | VC Bn TF | 500 | 292 | B/1/6 | 164 | 53 | Q+ |
| PrekKlok 2 | 10 Mar 1967 | VC 272 IR- | 1000 | 354 | 2/2+, 1 ID | 1600 | 41 | Q+ |
| Buell II | 10 Mar 1967 | NVA 273 IR | 2800 | 553 | 3/22-, 25 ID | 400 | 27 | Q+ |
| ApBauBang 2 | 1 Mar 1967 | VS 2726 IR | 900 | 403 | A/3/5Cav | 150 | 66 | Q+ |
| Bir Gigafa | 8 Jun 1967 | Eg 4 ArmD | 3600 | | Is Tal Div | 3500 | | Q |
| Lo Giang 1 | 2 Feb 1968 | NVA co TF | 350 | 136 | B/1/6 | 120 | 32 | Q+ |
| Lo Giang 2 | 3 Feb 1968 | 1/6 Amcl ID | 500 | 47 | NVA bn TF | 800 | 403 | Q+ |
| Nui Ba Den | 18 Aug 1968 | VC Force | 400 | 32 | elm 25 ID | 180 | 28 | Q+ |
| Mt Hermon I | 8 Oct 1973 | S Para Bde | 2692 | | Is 1 Inf Bde | 1683 | | Q |
| Goose Grn | 28 May 1982 | 2/Para Regt | 550 | 51 | 12 IRgt (+) | 1300 | 200 | T |
| Mt Harriet | 11 Jun 1982 | 42 RMCdo | 600 | 12 | elms Arg Ar | 400+ | 100 | n |
| Two Sisters | 11 Jun 1982 | 45 RMCdo | 600 | 14 | elms Arg Ar | 300? | 20 | n |
| Mt Longdon | 11 Jun 1982 | 3/Para Rgt | 550 | 70 | 7 IRgt (+) | 800? | 120+ | n |
| Tumbledown | 12 Jun 1982 | 2/Scots Gds | 700 | 42 | elm 5 MBn+ | 300 | 100? | n |
| Wireless R | 12 Jun 1982 | 2/Para Rgt | 660 | 14 | Arg Inf R | 650 | 60 | T |
| Salinas | 25-26 Oct 1983 | US Rangers | 900 | ? | Cubans/GARM | 300 | 20? | n |
| Pearls AF | 25 Oct 1983 | USMC BLT | 850+ | 2 | Gren mil co. | 30 | 5 | T |
| Lomba | 10 Mar 1987 | 61 MczBn | 1199 | 9 | FAPLA 47 Bde | 2284 | 120 | T |
| Cuatir R. | 13 Jan 1988 | RSA 20 Bde | 2706 | 23 | FAPLA 21 Bde | 2329 | 150 | T |
| Lipanda | 14 Feb 1988 | 4 SAI Rgt | 1212 | 2 | FAPLA 59 Bde | 2263 | 300 | T |
| TF Bayonet | 20 Dec 1989 | 5 MczD TF | ? | ? | Pan NG | 400 | ? | n |

Tu-Vu is described in some detail in Fall's *Street Without Joy* (pp. 51–53). The remaining Indochina/SE Asia engagements listed here are drawn from a QJM–based analysis of low–intensity operations (HERO Report 124, Feb 1988).

The coding for source and validation status, on the extreme right of each engagement line in the ***D Cas*** column, is as follows:

- n indicates an engagement which has not been employed for validation, but for which good data exists for both sides (35 total).
- Q indicates an engagement which was part of the original QJM database (3 total).
- Q+ indicates an engagement which was analyzed as part of the QJM low–intensity combat study in 1988 (14 total).
- T indicates an engagement analyzed with the TNDM (20 total).

# Validation of the Quantified Judgement Model (QJM)

**by Christopher A. Lawrence**

The original QJM came about from a study funded in 1969 by the US Air Force on exploring the use of historical data in evaluating military effectiveness. While that study was underway, the British Defence Operational Analysis Establishment (DOAE) asked HERO to analyze the relationship of tactical air support to land combat. This analysis focused entirely on 60 division–sized engagements in the Amercian 5th Army Area in Italy from September 1943 to June 1944. From this data, HERO developed the weapons values and assigned values for the combat variable effects by using a Delphic process. These factors were then related to each other so as to match the outcomes of the campaign. This generated the Quantified Judgement Method of Analysis of Historical Combat Data (QJMA). It was designed as a method of analyzing the impact of the air campaign on the ground, and it was from that point that it developed into a model of combat. This model, now known as the QJM (Quantified Judgement Model) was developed from a curve–fitting exercise to fit 60 division–level engagments in one small theater of WWII. This model was in it first form by the end of 1971.

In comparison, in 1971, a officer in Strategic Analysis Group (STAG) feed the compiled data into the Army's theater–level model, ATLAS, and came up with a considerably worse correlation in the outcomes. Of course, at this point, the QJM, designed from 60 battles, was self–validating when tested to those same 60 battles. But, in 1972 and 1973, HERO did two additional studies, one on advance rates in combat and on the effectiveness of barriers in combat. This resulted in data being generated in 21 additional engagements. These 21 engagements, mostly from France 1944, were then used to validate the model, with similar, but not quite as good results as were obtained from the initial 60 engagements.

As of mid–1973, the QJM existed as a model that could be used with reasonable comfort for predicting the outcomes of combat of US and British forces versus Germans in WWII. There was also some reason to believe that it was a reasonable predictor of Eastern Front operations, but the lack of access to primary source Soviet data did not allow one much confidence in the data. In 1973–74, HERO was asked to develop the OLIs it was using for its WWII combat model to the present (1970s era) weapons. This was done, and they also extended them to the past. They also used these values to conduct theoretical NATO versus Warsaw Pact engagements. As a result of this work, additional improvements were made to the model, including revised weather effects tables.

Meanwhile, the Yom Kippur war occurred in the Middle East in October 1973. In the fall of 1975, Trevor N. Dupuy and colleagues attended a series of symposia in Israel and Egypt on the war. From this, Trevor developed an extensive collection of contacts in the middle east in Israel, Syria, Jordan and Egypt. This included friendships with a number of Eqyptian generals and publishing their books on the war by HERO books. It was also during this time that Trevor met then Lt. Col. Nicholas Krawciw, who was attached to the UN Truce Supervision Organization during the 1973 War. General Krawciw now heads the Dupuy Institute.

As a result of these contacts, Trevor and his research team assembled and estimated data for 20 1967 division–level engagements and 33 1973 division–level engagements. Additional work on this was funded by the US government in 1975 and 1976. These additional 53 engagements were then used to validate the model as a tool for predicting modern combat. At this point, the model validation data base consisted of 134 battles: the 60 originally used to design the model and the 74 used to validate it in two different iterations. Model improvements did continue throughout this process as a result of additional lessons learned.

At this point, the QJM developed a some attention and respect from certain members of the US defense department operations research community. This was primarly as a result of its ability to predict the outcome of the 1973 Arab–Israeli battle, something that many other models in the operations research community were having a problem doing. But a significant portion of the community continued (and have continued) to oppose it, mostly based upon strongly–felt convictions on the theory of how combat models should be developed and concerns over the relevence of historical data.

Finally, during the 1970s some additional battles were developed and analyzed, including selected engagements from the Napoleonic Wars, Civil Wars, World War I, the Korean War, and a few additional Wold War II engagements to result in a QJM Database of 149 division–level engagements. The engagements that made up this QJM Data Base* are listed in the table on the next page.

In 1977, the model, data and methodology were assembled into a book called *Numbers, Predictions, and War* and published. It was reprinted in 1985, unchanged

*The QJM Database consists of those battles that were used to test and validate the QJM. There also exists the less detailed Land Warfare Database of over 600 battles from the 30 Years War to present.

except to add in an analysis of the 1982 fight in the Bekaa Valley. In 1978, the results of his research into the Middle East Wars were published in his book *Elusive Victory*. This effectively completed the public presentation of the model, its validation, and the data used for it.

In 1979 the improved QJM was revalidated to 66 engagements from the QJM Database. This included 35 of the 81 World War II engagements, 5 new engagements from World War II, and 26 from the 1973 Middle East War. This new validation effort considered four outputs: success/failure, movement rates, personnel casualties, and tank losses. The QJM predicted success/failure correctly for 85% of the engagements, movement rates with a 15% error, and personnel attrition with a 40% error or less. The error rate for tank losses was around 80%, with the model consistently underestimating tank losses because of the input being AFVs while the output (losses) was tanks (oops!). This was corrected.

In the early 1980s the model was programmed into BASIC to be used on a PC by José Perez. It was then reprogrammed into Pascal in 1987–88 by one of the customers at their expense. Finally, Trevor's book *Understanding War* on his theory of combat was published in 1987. This book analyzed combat using both the QJM and the Land Warfare Database. In the back of this book, he published the summary of the reuslts of 94 World War II battles and 52 engagments from the Arab–Israeli Wars. Six more World War II battles had been added to the QJM database and one removed from the Arab–Israeli listing. Furthermore, the outputs had changed some for most battles from the outputs published in 1977. This

| *War* | *Campaign* | *Opposing Forces* | *# of Battles* |
|---|---|---|---|
| Napoleonic | | French vs Allies | 2 |
| | | | |
| Amer. Civil War | | Union vs Confederate | 2 |
| | | | |
| WWI | Somme 1918 | UK vs German | 2 |
| | Megiddo 1918 | UK vs Turkey | 1 |
| | | | |
| WWII | France 1940 | French vs German | 1 |
| | Russian 1941 | USSR vs German | 1 |
| | Malayan 1941 | UK vs Japan | 1 |
| | Russian 1943 | USSR vs German | 3 |
| | Italian 1943-44 | US/UK vs German | 61 |
| | France 1944 | US vs German | 20 |
| | Manchuria 1945 | USSR vs Japan | 1 |
| | | | |
| Korea | Korea 1950 | NKPA vs ROK | 1 |
| | | | |
| 1967 Mideast | Egyptian Front | Israel vs Egypt | 10 |
| | Egyptian Front | Israel vs PLO | 1 |
| | Jordanian Front | Israel vs Jordan | 5 |
| | Golan Heights | Israel vs Syria | 4 |
| | | | |
| 1973 Mideast | Egyptian Front | Israel vs Egypt | 16 |
| | Golan Heights | Israel vs Syria | 14 |
| | Golan Heights | Israel vs Iraq | 2 |
| | Golan Heights | Israel vs Jordan | 1 |

means, without any such announcement of such, that Trevor had retested all the battles and re–validated the changes to the model to the original battle data. I am not aware that this was done as a formal process, but suspect it was done over time as "a matter of course."

Model evolution on the QJM stopped when Trevor left DMSI in 1990. He then created the TNDM, using the work on Lanchester equations done by Dr. James Taylor of the Naval Post–Graduate School and a revised AFV scoring system developed by W. "Chip" Sayers. The model was programmed in Turbo Pascal by José Perez.

# The Velocity Attrition Factor

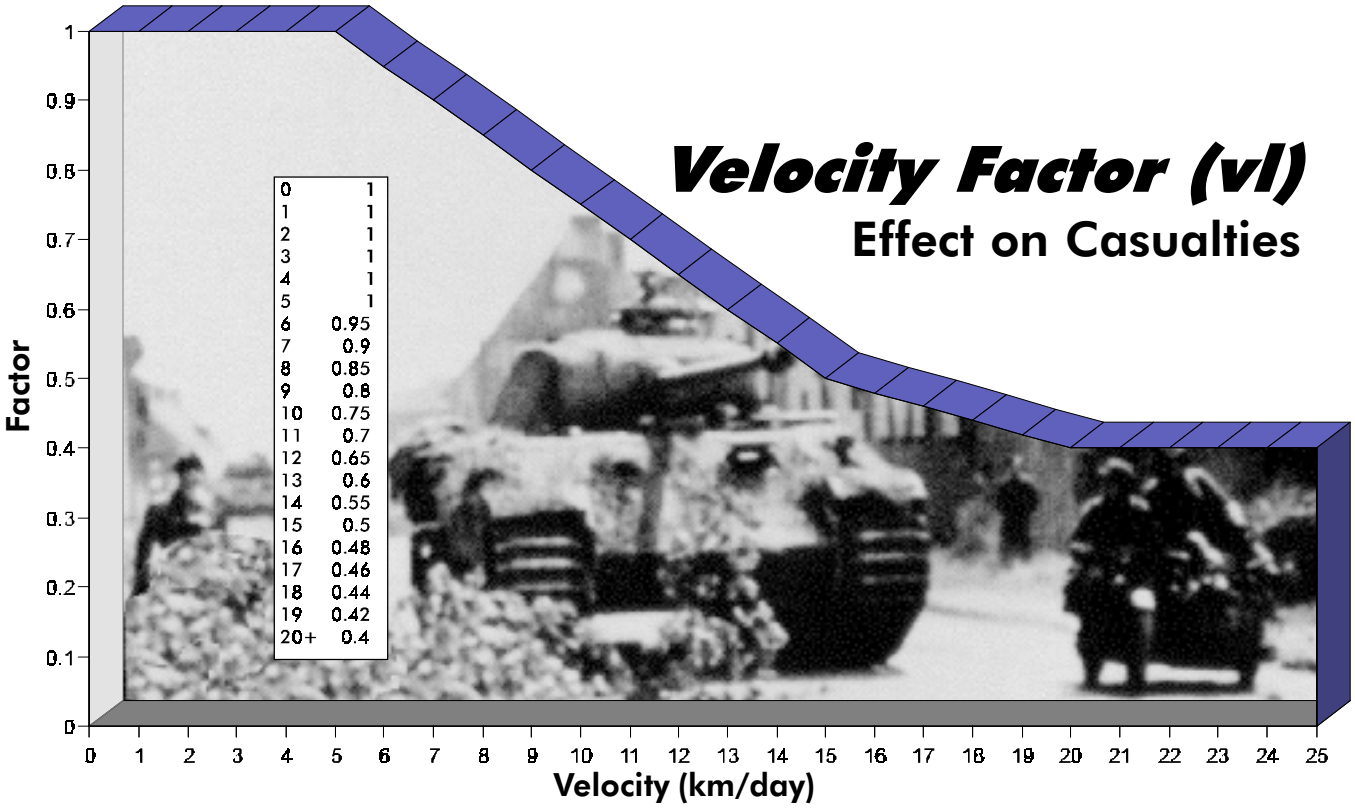
**by Christopher A. Lawrence**

In April of this year, I was assembling a list of validated models. One of the people that I called on was Dr. Brian McCue, formally of the Congressional Office of Technology Assesment. In particular, I was trying to locate the phone number of Dr. Joshua Epstein to find out what validation efforts was done with his model. Brian said to me at the time that there were many interesting elements in the "much–maligned Joshua Epstein model." One element, which Brian claimed to have seen in no other mode, was that the defender recieved some benefit from retreating, which was reduced casualties. He claimed that he knew of no other model that did that. Retreat was simply an output in these models, like casualties, winner/loser, and equipment lost. I opined at the time that the TNDM did that, but when I went into *Numbers, Predictions, and War* to prove it, I could not find any such effect. This puzzled me, as I instinctually knew that casualties went down as the defender retreated, assuming no units were isolated or broken through and though that Trevor had included that in the model.

Last month, after Dave Bongard ran a series of runs for me, I realized that this effect was showing up in the results of the runs (see my article on "What Happens When the Rate of Fire Goes to Zero" for copies of those runs). This caused me to look back into *Numbers, Predictions, and War*, and again no luck. I then had Dave look into José Perez's list of model changes to the TNDM that was included in the last newsletter, and there under TNDM v. 0.2 was listed that "The Velocity Attrition Factor was added to the Personnel Loss Rate calculation." Sure enough, a look into the TNDM manuals produced the table attached to this article.

As I said in the last issue, I am constantly surprised by the degree of sophistication I keep finding in this relatively simple model. Unfortunately, I do not know when this change was inserted into the model, as documented changes to the old QJM are filed who knows where, but I suspect the change was placed into the QJM sometime between 1978 and 1986. This relationship between casualties and advance rates is not discussed in Trevor's book *Understanding War* in 1987, but from looking at his chapter "Advance Rates in combat," it does appear that he had looked at this subject by the time he published, even if he neglected to write about the relationship. I do not know the basis for the factors chosen, but I can only assume that it was "reasonable judgement" based upon measured outcomes.

Therefore, Brian, here is the second model where the defender gains something from retreating. For that matter, so does the attacker.



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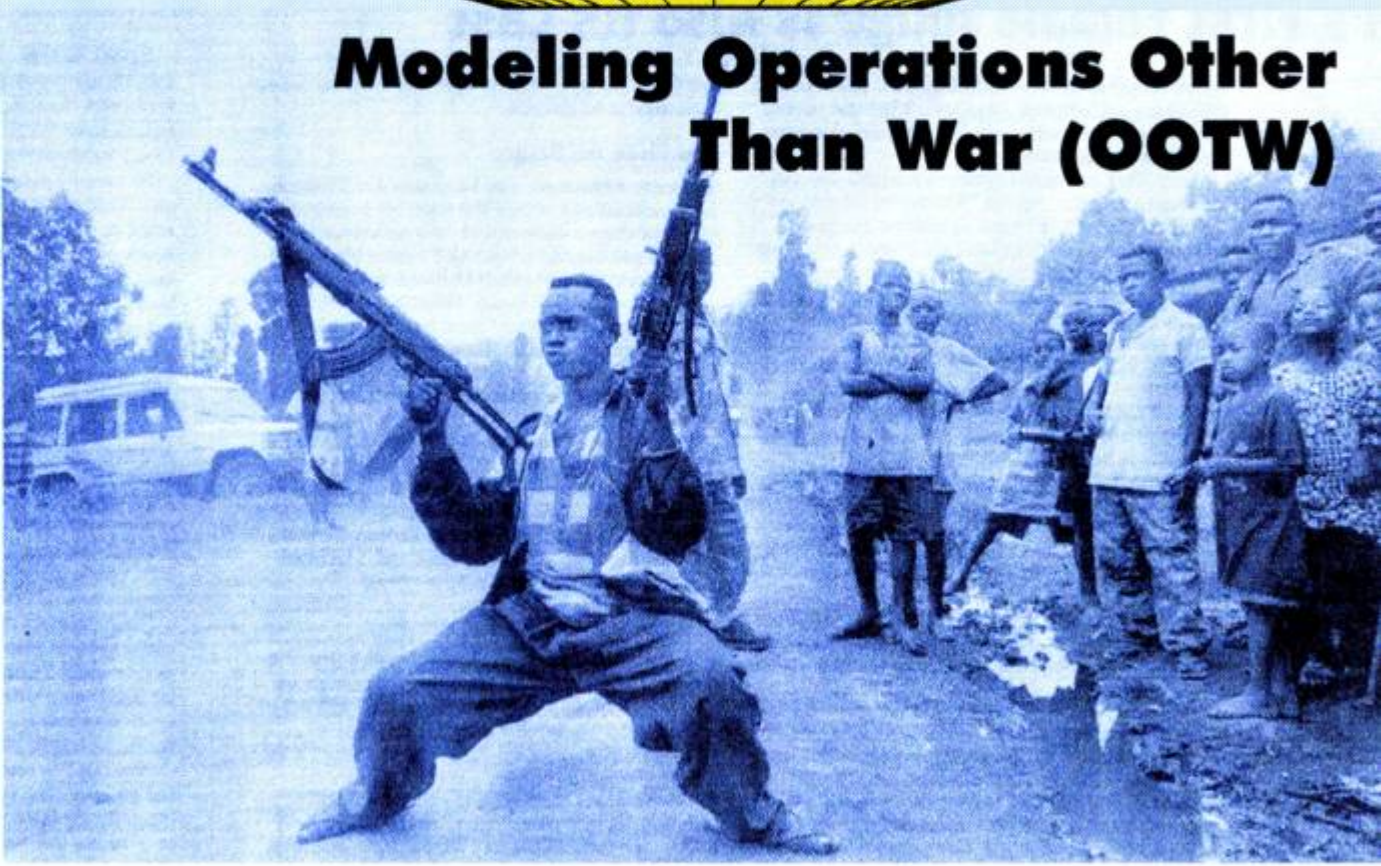

## Modeling Operations Other Than War (OOTW)

Also in this issue:

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- The Butterfly Effect in History
- Dispersion Is Not Played in the TNDM
- The Effect of Dispersion on Combat

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*Publisher*
The Dupuy Institute

*Editor*
Christopher A. Lawrence

*Production Manager*
Jay Karamales
Olórin Press

*Contributing Editors*
Richard C. Anderson
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

*Founder*
Col. Trevor N. Dupuy

*President*
Gen. Nicholas Krawciw

*Executive Director*
Christopher A. Lawrence

*Board of Directors*
Dr. George A. Daoust, chairman
Frances B. Kapper
John D. Kettelle
Nicholas Krawciw
James C. Pfautz
Abraham Wolf

*Administrative Offices*
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
NikatTDI@aol.com

# From the Editor...

For those of you who have an annual support contract with us, you will be receiving in a couple of weeks the latest version of the TNDM, version 1.86. It incorporates the first changes to the TNDM done without the involvement of Trevor Dupuy. They are all minor changes. See the article at the end of this newsletter for a more detailed description. We are still planning an improvement to the TNDM in 1997 to include a logistics module.

We suffered from a unique problem in this issue: we had too many articles. As a result of our battalion–level validation effort, I had developed a considerable mass of data and graphs. I had planned to publish all of these in this issue, but my plan went by the wayside when I called up Jay Karamales and asked him how long would it take to draw up 99 graphs. Therefore, we slimmed down the issue to a more manageable size and will publish the work we've been doing on the battalion–level validation in the next issue. This may bump the articles we've been preparing on the DACM (Dupuy Air Combat Model), but I suspect not.

In this issue I carry the burden of writing most of the articles. These articles came about from our attempts to use the TNDM beyond its validated design. There are two articles related to Operations Other Than War (OOTW—I really do dislike this term). These came out of our attempt to estimate casualties in Bosnia and a trip I made out to the Naval Post–Graduate School and RAND a few months ago. The battalion–level validation and modeling operations other than war are interrelated, as I believe that making predictions for many of our future operations is going to require the use of a battalion–level model. The QJM was fundamentally a division–level model, and we hope that we can validate (or change) the TNDM to be used as a battalion–level combat model. All this came about because of my concerns about using the TNDM for making casualty estimates for the Bosnia operation back in November of 1995. While the use of the TNDM was only a small part of that study (and that part was published in the first issue of the newsletter), I became concerned that we were using a model outside of its designed and tested parameters. Even though Col. Dupuy had designed and tested the model to do battalion–level combat, he had never validated it for such.

We recently examined using the TNDM to test the battle of Gettysburg. This led to the articles on dispersion and calculating attrition. Our ongoing battalion–level validation effort has caused to me look into areas where the model may give us some problems with accurate forecasts. This generated the articles on time and the TNDM and José Perez's article on unit size.

For the sake of stylistic variety, we have included an article by Richard Anderson. When Rich suggested the idea to me, all I could think of was the afternoon I wasted pigeon–holed by a guy at a party who insisted on explaining to me all the intricacies of chaos theory. For those who were so lucky as to miss chaos theory, it is fashionably presented in the film ***Jurassic Park***. Obviously, the movie provides clear validation of the theory. In this issue, we provide our own contribution to the development of chaos theory with Rich's article, "The Butterfly Effect in History." For those few who might have missed ***Jurassic Park***, the "butterfly effect" refers to the effect created in air currents by one butterfly flapping its wings. This change in the air currents could set of a series of small changes in the atmosphere that eventually could build up to a full scale hurricane elsewhere in the world. Personally, I always think about the butterfly that the time traveler stepped on in Ray Bradbury's short story "A Sound of Thunder." It is amazing how much impact a butterfly can have. Just to show that we are on the cutting edge of western intellectual thought, we have identified our own butterfly effect in history, where the actions of one insignificant colonial militia major, our very own G. Washington, plunges the world into 200 years of chaos and darkness. Pretty frightening. I am sure a lot of butterflies were disturbed in the process.

As José Perez is the programmer who wrote the code for the TNDM and code for the original computerized version of the QJM, it is now time to introduce him. Again,

*(cont.)*

when it came time to get a portrait, like Mr. Bongard, Mr. Perez just wouldn't ante one up, so we felt free to substitute our own, in this case that of Blaise Pascal, father of modern computing.

Finally, we have updates on our improvement program for the TNDM. In the next issue, we will provide an update on our battalion–level validation effort.

The next issue will also contain an article on our initial attempts to create a model of the Air Campaign. We will be publishing the results of our validation of the TNDM as a battalion–level model and a series of support articles. We may include the article on the use of the Lanchester Equations in the TNDM, but I would not be surprised if it slides out to a later issue.

The fifth issue will focus on the modeling of tanks and armored warfare. This will include the article on the use of mines and fortifications at Kursk. We also have a set of tables prepared by Richard Anderson on the effects of artillery on tanks. They are quite startling. Also, we hope to have a cover article by Jay Karamales from his tank/antitank studies. His new book *Against the Panzers*, a study of eight World War II battles in which American infantry defended against German tank attacks, is available through NOVA Publications.

The sixth issue will include an article written by Trevor N. Dupuy that has never been published called "Technology and the Human Factor in War."

Finally, Niklas Zetterling of the Swedish War College has volunteered to prepare as article on re–calculating CEVs for the World War II battles in Italy. He told me that the article would imply criticism of some of Trevor Dupuy's work and research. This is not a problem. In fact, at the suggestion and encouragement of Dr. Paul Berenson, Scientific Advisor to TRADOC, I encourage anyone receiving this newsletter to write up their criticisms of the QJM/TNDM, no matter how condemning. Quite simply, over the years, I have heard many complaints about the model. Far too many of them have been general condemnations ("The model is just wrong," "the model is a fraud," or my personal favorite "Trevor Dupuy just makes up his data."). I have **never** seen a thoughtful criticism of the model. I would love to see a written criticism and promise to publish such a criticism no matter how derogatory it is of the model, of Trevor, or for that matter, of me. So please, if you have some suggestions for improvement, constructive criticisms, or even vicious critical analysis, please send it in.

This is not to imply that I (or TDI) worships at the alter of the TNDM. I am well aware of its shortcomings and faults. This is part of the reason why I am validating it for battalion–level use and why I have a listed program of improvements. The purpose of this newsletter is not be a slick advertising medium. It is to be an open forum for discussion on how the model works and how to make it better.

That is all for now. If you have any questions, please contact me. Addresses, E-mail addresses, and phone numbers are in the masthead.

# Modeling Operations Other Than War (OOTW)


**by Christopher A. Lawrence**

How war is fought is a subject that has been seriously studied for the last 200 years, was first analyzed well over 2000 years ago, and has been studied in great detail by the analytic community for the last 50+ years. Yet, we are still struggling to come up with force–on–force combat models in which everyone has confidence. Furthermore, in sthe US, most combat models were basically designed to analyze a potential Soviet attack on Europe.

Direct conflict with Russia in a conventional war in Europe is highly unlikely anytime in the near or even more distant future. The US is entering a phase in its history where the pattern and nature of conflicts in which it will be involved will be mostly small insurgencies, minor contingency operations, and peacekeeping operations.

Ignoring nuclear war, it is possible for the US to end up in three different types of conflict. First is a conventional war (e.g., Korea 1950–1953 and the Persian Gulf War 1991), probably with opponents from the third world. The second is a full–scale guerilla war (e.g., Vietnam). This is not a very likely scenario due to the lack of a Cold War to fuel such a conflict at the levels of intensity that we have seen in the past. The third would be a "low–intensity" conflict, ranging from peacekeeping to small insurgencies. Note that I clearly differentiate between large insurgencies (e.g. Vietnam, Afghanistan, Greek Civil War, Algeria) and the smaller efforts that are often intertwined with other types of operations (including peacekeeping).

While the current models are designed to simulate a hot war, often at an aggregation of division vs division, there is no real set of models, methodologies, or procedures to predict the type of conflicts in which we will be primarily involved over the next 20 to 50 years. This became obvious to TDI when we were called upon to provide an estimate of US losses in Bosnia for JCS. Not only was our estimate very much on the mark, but rumor has it, we were the only organization even in the ball park. According to the rumor I heard, nobody else had na estimate of less than 100 killed. I would be interested if anyone out there could confirm or refute this rumor.

This Bosnia work has led to me consider what is needed to really predict casualties for all US operations in the future. Such a program must have a model to predict conventional combat outcome (we at TDI, of course, feel we have a perfectly good model for that in the TNDM). We also must have a model that can predict a full–scale guerilla war. Both of these models must take into account the differences in training, experience, and motivation of the forces involved.

Then I believe another model will be needed that can be used to predict lower levels of intensity of combat. This model will also need to have some mechanism for considering "activity levels" and "propensity to resort to violence." In most of these operations other than war, the potential combat power available is not an accurate measurement of the actual combat power used. The peacekeeping operation in Bosnia is a perfect example of that, where the IFOR was inserted between three very well armed forces, yet little actual conflict occurred.

This leads to the necessity of developing a model that will predict the possibilities of the "indigenous" forces partaking in violence and the degree of such violence to which they partake. Similar work was done in the 1960s, trying to measure the likelihood of rebellion or the probability of political violence. It may be time to blow the dust off the work by Dr. Ted Gurr, Drs. Feierhabend, the infamous Project Camelot, and other such work, and use this as a starting point for new models on predicting political violence.

Oddly enough, I know of no model that will predict disease and non–battle injuries (DNBI). In the casualty–sensitive environment in the US, these predictions are important, and in a number of operations, like Bosnia, make up the majority of losses. This is a relatively simply task and needs to be done. Also, as some of these operations are political ly sensitive, some form of model or methodology for estimating collateral losses, including civilian casualties, needs to be done. It somehow needs to address the rules of engagement, as this can change the possibility of civilian losses. If one does not think that civilian casualties are a major issue or problem in these contingency operations, I only have to remind people that one of the ten bloodiest air disasters in history occurred when the *USS Vincennes* accidently shot down an Iranian airliner during our naval deployment in the Gulf in 1988.

Finally, not all armies are equal. I think the Gulf War clearly proved this point. Therefore, there must be some systematic method of measuring how good an army will be. This is not the difference in weapons. Currently at TDI we estimate what these differences are based upon past performance and judgement, but we have no systematic methodology for making such a prediction. Since much of the US combat modeling community has not even at-

tempted to address this need, there is no methodology of measuring the relative performance between armies. In most combat models in the US, any untrained conscript or militia force is treated as the equal to the US career–oriented professional forces. This is absurd.

I have assembled a list of the forms of models and constructs that would be needed to address most of the questions asked in terms of expected casualties on a given operation.

**I. Conventional War Model**
- A. Must consider air
- B. Must consider combat performance differences
- C. Must address future technology

**II. Guerilla War Model**
- A. Will probably need a Bn-level combat model
  - 1. Must consider combat performance differences
- B. Must consider "activity levels"
- C. Must address future technology

**III. Low Intensity Combat Model**
- A. May need a Bn-level combat model
  - 1. Must consider combat performance differences
- B. Must consider "activity levels"
- C. Must consider "propensity to resort to violence"
- D. Must address future technology

**IV. Indigenous Forces Model**
- A. Propensity to rebel
- B. Propensity to activity
- C. Propensity to resort to violence

**V. Other Losses Model**
- A. Accidents and DNBI
- B. Friendly fire
- C. Must address future technologies

**VI. Collateral Losses Model**
- A. Civilian losses
- B. Damage to terrain
- C. Must address rules of engagement
- D. Must address future technologies

**VII. Combat Performance model**
- A. Methodology for measuring combat performance as a dependent variable.
- B. Development of measurement of independent variables.
- C. Product would be a rating of all current armies.

# The Modern Contingency Operations Database (MCODB)

## by Christopher A. Lawrence

The Modern Contingency Operations Database (MCODB) was created in October and November of 1995 by The Dupuy Institute for the express purpose of helping estimate of US casualties in the projected Bosnia peacekeeping operation. It consists of 45 fields that track such data as strength, losses, tanks, weather, means of insertion, length of operations, type of operation, etc. It currently consists of 144 contingencies and minor insurgencies. It contains data on 92 different operations, 14 different campaigns within those operations, 35 engagements, and three "incidents." All data is from military operations that occurred after WWII. Much of the data originally came from a 1985 Historical Evaluation Research Organization (HERO) report called *Casualty Estimates for Contingency Operations (CEC)*. As we were specifically looking at a peace–keeping operation in Bosnia, TDI also gathered the data for all the UN peace-keeping operations. Additional data and operations were added from other readily available sources.

The database specifically excludes 12 major wars and insurgencies that have occurred since WWII. The excluded wars are the Chinese Civil War, the Korean War, the French Indo–China War, the Algerian War of Independence, the three Arab–Israeli Wars (1956, 1967 and 1973), two India–Pakistan Wars (1965 and 1971), the Vietnam War (1965–1973), the Iran–Iraq War and the Persian Gulf War of 1991. In essence, we excluded any large conventional wars and large well–developed guerilla wars (with conventional elements) much beyond the size and scope of the Bosnian peacekeeping effort. Large guerilla wars, like Afghanistan and the Greek Civil War, were included in the database.

In the actual Bosnia study we analyzed 90 operations. These included:

- All 38 UN Peacekeeping Operations
- 4 Other Peacekeeping Operations (all in Lebanon)
- 16 Interventions (including Hungary, 1956)
- 10 Insurgencies (including Afghanistan)
- 10 Evacuation and Rescue Operations
- 4 Military Assistance Efforts (including Vietnam, 1961–1964)
- 4 Police Actions (including Northern Ireland)
- 3 Raids
- 1 Conventional War (Falklands)

The operations chosen for analysis were not randomly selected. We selected those operations for which data were quickly and easily available. Since 1945 there have been well over 300 wars, minor contingencies, extended insurgencies, and peacekeeping operations. This is certainly a representative sampling, although it could be slightly skewed.

The database was quickly assembled from mostly secondary sources under a tight schedule so as to meet JCS requirements. TDI thinks that this database is a very useful research tool and would like to expand it to make it more comprehensive, and would like to do more extensive research into the operations already in the database. TDI would like to develop a complete database on all military operations since WWII.

It is now possible, by using an update to our Modern Contingency Operations Database and some basic statistical and regression analysis, to create an expert system for PCs to provide a casualty estimate for contingency operations.

# The Butterfly Effect in History

## (or How George Washington Triggered Two Centuries of Warfare)

### by Richard Anderson

On 31 October 1753 Robert Dinwiddie, the Governor of Virginia—alarmed by the growing influx of French colonists into the Ohio River Valley—sent Major George Washington on a mission to deliver a demand that the French withdraw from the region. The French refused the demand and accused the twenty-one year-old major of being responsible for the murder of some of their men.

Governor Dinwiddie ordered the newly promoted Lieutenant Colonel Washington to lead a military expedition to establish a British presence at the confluence of the Monongahela and the Allegheny rivers. Unfortunately the French had stolen a march on the colonists, building Fort Dusquesne (present day Pittsburgh) at the site. Washington decided to build his own refuge nearby at Great Meadows which he called Fort Necessity (a clear indication of his frame of mind). The French resolved to drive him out of what they had—at least by squatter's rights—firmly established as their own territory. Washington decided to open hostilities with the French rather than withdrawing. He was initially successful, defeating the French on 28 May, but was then forced to seek refuge in Fort Necessity, which he surrendered on 3 July 1754. This minor event, precipitated by the rashness of a young and inexperienced militia officer, catapulted the world into two centuries of conflict, resulting in the deaths of millions.

The sequence of events that resulted from Washington's actions are—in outline—something like this:

**1754** – George Washington's decision to begin open hostilities with the French colonists in North America—an action that probably exceeded his orders from Governor Dinwiddie—precipitated a *de facto* state of war between Britain and France. The French King was rightfully offended by the attack on his forces by Washington's Virginians and was concerned for the safety of his subjects in America. As a result France dispatched troops to reinforce the garrison of French Canada. The convoy was intercepted and—without provocation—attacked by the British Navy. In retaliation the French attacked and seized Majorca from the British. The final result was a declaration of war between France and England, which rapidly embroiled their allies and various opportunistic minor monarchs, such as Frederick the Great of Prussia, in what came to be known as the Seven Years War.

**1763** – The Seven Years War ended with little result except for the ceding of Canada by France to England. However, France was left with a burning desire to revenge itself upon Britain. Both nations were left with a crippling war debt. In an effort to reduce their debt the British Crown made the request that the American Colonies pay a fair share of the cost of their own protection. The colonists did not like this.

**1775** – Ongoing disputes between the Crown and the Colonies over the cost of defending the colonists erupted into open rebellion in New England. By 1778 the French sensed an opportunity to get back at their old enemy and openly sided with the Americans, supplying vast sums of money, arms, troops, and ships to the war.

**1783** – The American Revolution ended with little result except for the establishment of a new, weak, and debt-ridden nation in America. France had succeeded in humbling its old enemy—and had bankrupted itself at the same time.

**1789** – The French economy, unable to stand the strain of being at war for fifteen of the preceding twenty-six years, collapsed. Revolutionaries, inspired by the example of the American colonists, overthrew and then executed the French King. This antagonized the other crowned heads of Europe who set to work to crush the rebellion.

**1805** – The crowned heads of Europe united to defeat Napoleon Bonaparte, who had the gall to promote himself as a crowned head of Europe by declaring himself Emperor of the French. Napoleon responded by crushing the other crowned heads in battle and remaking the map of Europe. He dismantled the Holy Roman Empire and created new kingdoms in Germany by unifying the crazy-quilt of minor principalities into a new Confederation of the Rhine. Napoleon's growing influ-

ence in Germany led to war with Prussia—which was swiftly humiliated by Napoleon. As a result, a burning desire for revenge began to grow in Prussia. "Burning Desires for Revenge" became a major theme in Franco-Prussian relations for the next 134 years.

**1814** – Prussia, as part of an allied coalition, participated in the humiliation of France. The French monarchy was reestablished, but remained unpopular. Prussia seized most of Napoleon's Confederation of the Rhine, threatening the control by Austria of German politics. Prussia's increased power and prestige spurred by a growing Prussian nationalism combined to lead to the rise of a unified German State.

**1830** – Periodic "Jacobin" revolutions swept through Europe, culminating in the Revolutions of 1848. The revolutionaries were inspired by the American and French examples and had strong democratic and socialistic overtones. The tumult of these two decades directly influenced the work of Karl Marx and Frederich Engels, leading to the rise of the communist idealogy.

**1866** – The long simmering dispute over control of Germany between Prussia and Austria erupted into open war. Austria was crushed. France became alarmed by the new Prussian strength and the popinjay Emperor Napoleon III (grandnephew of Napoleon) hoped for an opportunity to reestablish French prestige in Europe.

**1870** – Napoleon III's military pretensions lost him his crown to the Prussians. Kaiser Wilhelm I then took the opportunity to establish a German Empire under Prussian control. A burning desire for revenge began to grow France.

**1914** – World War I began in part due to the growing animosity between France and Prussia and the maze of alliances that they had created. The results again devastated Europe, humbled Germany, and sparked the Bolshevik Revolution in Russia. A burning desire for revenge began to grow in Germany.

**1939** – The Germans' burning desire for revenge, continuing economic hardship in much of Europe caused by the devastation of the war and its aftermath, and fear of Bolshevism again caused the outbreak of war.

**1945** – Germany was crushed by the Allied nations of Europe. The Soviet Union established a group of puppet states on its borders with Europe as a defensive buffer. This and other exhibitions of paranoia and repressive control on the part of the Soviet State and its leaders alienated the Soviets erstwhile Western Allies, leading to the first Cold War.

**1991** – The Soviet Union's economy collapsed, precipitating a reunification of Germany. The United States became the sole international superpower. George Washington's actions in 1754 continued to drive world events.

Thus, it can easily be demonstrated that George Washington, the "Father of His Country," was also the father of over two centuries of European and world conflict...or perhaps it was all Robert Dinwiddie's fault.

# Dispersion is Not Played in the TNDM


**by Christopher A. Lawrence**

The TNDM does not play dispersion. When the analyst is asked in the OLI menu to pick a period, this action has no effect on the model's output. Dispersion exists only in the model as a theoretical construct and explanation, but does not actually change any results of the model.

The user encounters the request to set the dispersion in the OLI menu. Weapons effects are measured by TLIs (Theoretical Lethality Indices). It is a numerical value that measures the theoretical number of people that would be killed in a 100 yard by 100 yard box of people, each person occupying 1 square yard. The OLI (Operational Lethality Index) is created by dividing that number by a value to represent the appropriate historical period. When the user pulls up the OLI menu, the user is asked to select the historical period in which that battle occurred. This process has led many people to assume that the model was adjusting casualties depending on historical period. It does not, and there is no mechanism currently within the model that does this.

Quite simply, casualty calculations, advance rates, and who wins or loses are determined by other factors. One of these factors is the force ratio. The force ratio is determined by comparing the cumulative relevant OLIs from one side to the opposing side. As both sides are divided by the same dispersion factor, then there is no mathematical effect on the ratios, as both sides have the same denominator. One can test this by pulling up any modern era battle they have already run, calculate the OLIs using the dispersion value from a different historical period, and rerun the engagement. The result will be the same. The only differences will be caused by the rounding of numbers, as modern weapons have very large TLIs, and if they are not divided by modern dispersion factors, can result in large OLIs. The TNDM can be run based upon TLIs with no impact in the results.

So, while Col. Dupuy talked a lot about dispersion rates, they had no impact on the model results. This means that there will no difference in the rate of casualties from WWI, to WWII, to the Arab–Israeli Wars, to now. This would be true if the rate that dispersion has increased is equal to the rate of the increase in lethality. This appears to be the case from WWII to the present. It does appear to have been the case with WWI. The battalion–level validation we are conducting will determine if this creates a problem as roughly 1/3 of the battles are from WWI, 1/3 from WWII, and 1/3 post–WWII.

We could modify the model to delete the mention of dispersion entirely. My suspicion is that it was to play a significant role in the original version of the model, including calculations of frontage and depth of the battlefield (see pages 28–30 in *Numbers, Predictions, and War*), but evolution of the model has left it a useless appendage.

# How Attrition is Calculated in the QJM vs the TNDM


## by Christopher A. Lawrence

There are two different attrition calculations in the QJM, one for post–1900 battles and one for pre–1900 battles. For post–1900 battles, the QJM methodology from *Numbers, Predictions, and War* was basically:

(Standard rate in percent*) x (factor based on force size) x (factor based upon mission) x (opposition factor based on force ratios) x (day/night) x (special conditions**) = percent losses.

* Different for attacker (2.8%) and defender (1.5%)
** WWI and certain forces in WWII and Korea

For the attacker the highest this percent can be in one day is 13.44% not counting the special conditions, and the highest it can be for the defender is 5.76%.

The current TNDM methodology is:

(Standard personnel loss factor*) x (number of people) x (factor based upon posture/mission) x (CEV of opponent, up to 1.5) x (factor for surprise) x (opposition factor based on force ratios) x (factor based on force size) x (factor based on terrain) x (factor based upon weather) x (factor based upon season) x (factor based upon rate of advance) x (factor based upon amphibious and river crossings) x (day/night) x (factor based upon daily fatigue) = Number of casualties

* Different for attacker (.04) and defender (.06)

The special conditions mentioned in *Numbers, Predictions, and War* are not accounted for here, although it is possible to insert them, if required.

All these tables have been revised and refined from *Numbers, Predictions, and War.*

In *Numbers, Predictions, and War*, the highest multiplier for size was 2.0, and this was for forces of less than 5,000 men. From 5,000 to 10,000 is 1.5 and from 10,000 to 20,000 is 1.0. This formulation certainly fit the data to which the model was validated. The current model has the following table for values below 15,000 men (which is 1.0):

| | | | |
|---|---|---|---|
| 12,500 - 15,000: | 1.1 | 2,000 - 4,000: | 2.5 |
| 10,000 - 12,500: | 1.15 | 1,000 - 2,000: | 5 |
| 8,000 - 10,000: | 1.2 | 500 - 1,000: | 8 |
| 6,000 - 8,000: | 1.4 | Fewer than 500: | 20 |
| 4,000 - 6,000: | 1.8 | | |

The highest percent losses the attacker can suffer in a force of greater than 15,000 men in one day is "over" 100%. If one leaves out three large multipliers for special conditions—surprise, amphibious assault, and CEV—then the maximum percent losses is 18%. The multiplier for complete surprise is 2.5 (although this degraded by historical period), 2.00 for amphibious attack across a beach, and 1.5 for enemy having a noticeable superior CEVs. In the case of the defender, leaving out these three factors, the maximum percent casualties is 21.6% a day.

This means at force strengths of less than 2,000 it would be possible for units to suffer 100% losses without adding in conditions like surprise.

The following tables have been modified from the originals in *Numbers, Predictions, and War* to include a casualty factor, among other modifications:

| | |
|---|---|
| Table 1/"2": | Terrain Factors |
| Table 2/"3": | Weather Factors |
| Table 3/"4": | Season Factors |
| Table 5/"6": | Posture Factors |
| Table 6/"9": | Shoreline Vulnerability |
| Table 9/"11": | Surprise |

The following tables have also been modified from the original QJM as outlined in *Numbers, Predictions, and War*:

| | |
|---|---|
| Table "1": | OLI's |
| Table "13": | Advance Rates |
| Table "16": | Opposition Factor |
| Table "17": | Strength/Size Attrition Factors |
| Table "20": | Maximum Depth Factor |

The following tables have remained the same:

| | |
|---|---|
| Table 4/"5": | Effects of Air Superiority |
| Table 7/"12": | Morale Factors |
| Table 8/"19": | Mission Accomplishment |
| Table "14": | Road Quality Factors |
| Table "15": | River or Stream Factor |

The following new tables have been added:

| | |
|---|---|
| Table "7": | Qualitative Significance of Quantity |
| Table "8": | Weapons Sophistication |
| Table "10": | Fatigue Factors |
| Table "18": | Velocity Factor |
| Table "20": | Maximum Depth Factor |

*(cont.)*

The following tables has been deleted and the effect subsumed into another table:

| | |
|---|---|
| unnumbered: | Mission Factor |
| unnumbered: | Minefield Factors |

The table numbers in quotes are the TNDM table numbers, the other table numbers are the numbers from *Numbers, Predictions, and War*.

As far as I can tell, Table 20 "Maximum Depth Factor" has a very limited impact on the model outcomes. Table 1, "OLIs," has no impact on model outcomes.

I have developed a bad habit, if I want to understand or know something about the TNDM, to grab my copy of *Numbers, Predictions, and War* for reference. As shown by these attrition calculations, the model has developed enough from its original form that the book is no longer a good description of the model. The TNDM has added in an additional level of sophistication that was not in the QJM.

The TNDM does not have any procedure for calculating combat from before 1900. In fact, the TNDM is not intended to be used in its current form for any combat before WWII.

# How Historical Attrition is Calculated by the QJM


**by Christopher A. Lawrence**

Curt Johnson, formerly the vice–president of HERO, suggested that we could use the TNDM to test the Hunt versus Hancock controversy over the use of Union artillery to stop Pickett's charge during the Battle of Gettysburg. This led Dave Bongard and me to do a "quickie" test of Picket's charge using the TNDM. This is what led us to analyze how the attrition results were used and how dispersion affected the casualties recorded by the model. This in turn led me to look at how the QJM modeled pre–1900 combat. The TNDM does not model combat before 1900 (really, it is not designed for use before WWII).

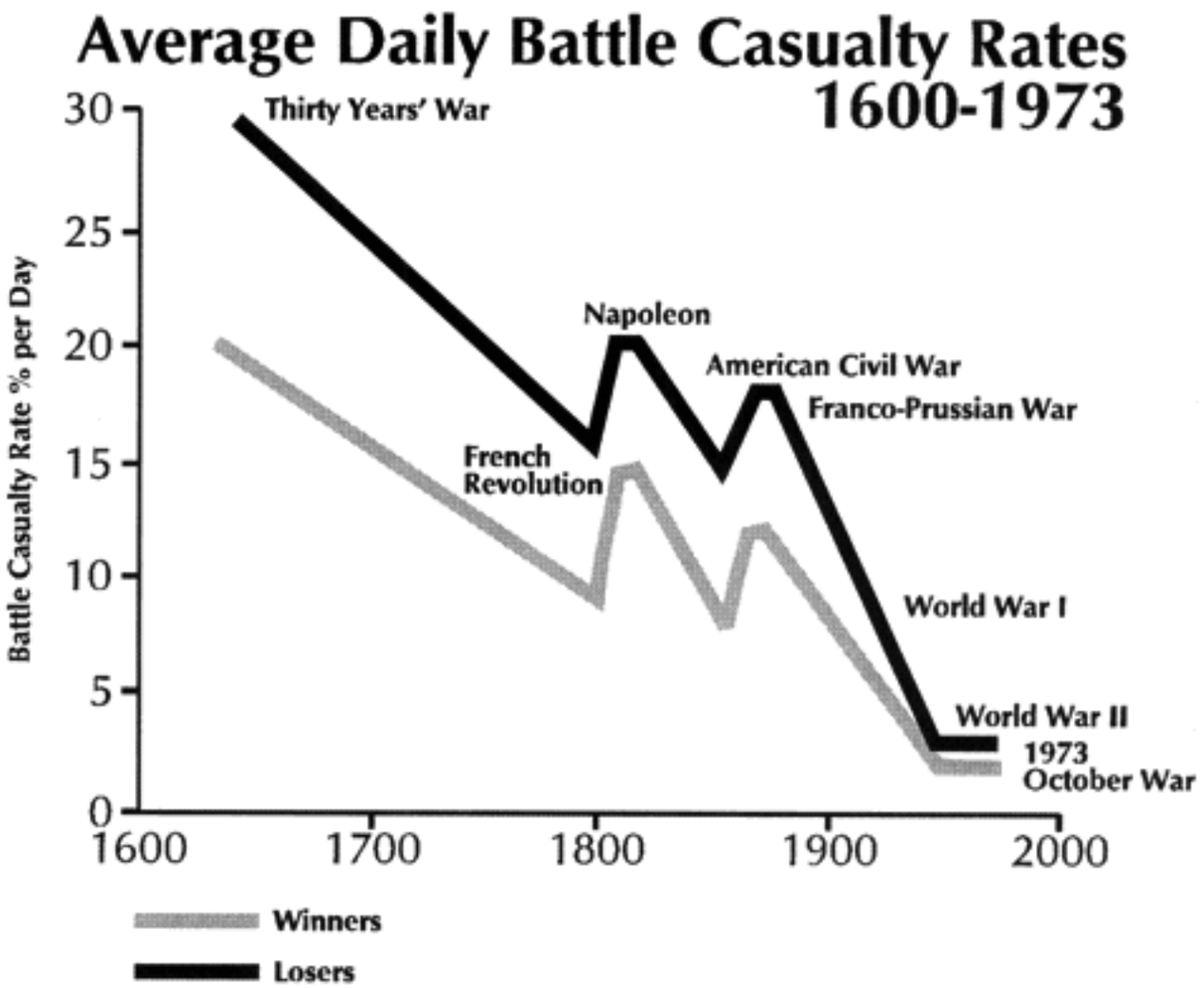
For actions before 1900, the QJM was only validated to two Napoleonic and two Civil War battles (and only three WWI battles). Everything else was after 1900. For the pre–1900 battles, the *Numbers, Predictions, and War* attrition methodology was basically:

(Standard rate in percent for year for either winner or loser) x (force size) = percent losses.

In effect there are only three variables: year, force size, and winner/loser. The calculations of force ratio (modified by all the other factors) only determines who wins or loses, not what the losses are. Therefore, the Confederates in Pickett's charge would suffer the same losses whether the Union had a large amount of effective artillery or none at all, as long as the Confederates lost the battle. Only if they won would they suffer less losses.

While the pre–1900 calculations fit the eight data points (remember there are two results for each battle, one for each side), I do not consider this sufficient validation to be comfortable with using the model before 1900. I know of no changes or improvements made to this methodology, unlike what has been done with the post–1900 methodology.

I do not feel comfortable with any of the TNDM results from before WWI. I think there would be value in testing and properly developing the TNDM to pre–1900 battles, with the American Civil war being my first choice, but this is not currently on my list of model improvements.



# Time and the TNDM

## by Christopher A. Lawrence

Combat models are designed to operate within their design parameters, but sometimes we forget what those are. A model can only be expected to perform well in those areas for which it was designed in and those areas where it has been tested (meaning validated). Since most of the combat models used in the US Department of Defense have not been validated, this leaves open the question as to what their parameters might be. In the case of the TNDM, if the model is not giving a reasonable result, then you must ask, is it because the model is being operated outside of its parameters? The parameters of the model are pretty well defined by the 149 engagements of the QJM Database to which it was validated.

One of the areas where there is a problem with the TNDM is that while the analyst is capable of running a battle over any time period, the model was fundamentally validated to run 1 to 3 days engagements. This means that there should be a reduced confidence in the results of any engagement of less than 24 hours or over three days. The actual number of days used for each engagement in the original QJM data base is shown below:

**Original 60 Italian Campaign Engagements:**

| LENGTH | NUMBER |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 5 |
| 36 - 60 hours (2 days) | 25 |
| 60 - 84 hours (3 days) | 23 |
| 4 days | 4 |
| 5 days | 2 |
| 6 days | 1 |

**21 Additional WWII engagements**

| | |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 3 |
| 36 - 60 hours (2 days) | 7 |
| 60 - 84 hours (3 days) | 5 |
| 4 days | 2 |
| 5 days | 1 |
| 6 days | 1 |
| 7 days | 0 |
| 8 days | 1 |
| 9 days | 1 |

**8 Additional WWII engagements**

| | |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 1 |
| 36 - 60 hours (2 days) | 1 |
| 60 - 84 hours (3 days) | 3 |
| 4 days | 0 |
| 5 days | 1 |
| 6 days | 0 |
| 7 days | 1 |
| 8 days | 1 |

**7 Pre-WWII engagements**

| | |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 3 |
| 36 - 60 hours (2 days) | 1 |
| 60 - 84 hours (3 days) | 1 |
| 4 days | 0 |
| 5 days | 0 |
| 6 days | 1 |
| 7 days | 0 |
| 8 days | 0 |
| 9 days | 1 |

**53 1967/1973 Arab-Israeli Wars**

| | |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 27 |
| 36 - 60 hours (2 days) | 20 |
| 60 - 84 hours (3 days) | 5 |
| 4 days | 1 |

**SUMMATION (149 engagements):**

| | |
|---|---|
| less than 6 hours | 0 |
| less than 12 hours | 0 |
| less than 18 hours | 0 |
| 18 - 36 hours (1 day) | 39 |
| 36 - 60 hours (2 days) | 54 |
| 60 - 84 hours (3 days) | 37 |
| 4 days | 7 |
| 5 days | 4 |
| 6 days | 3 |
| 7 days | 1 |
| 8 days | 2 |
| 9 days | 2 |

By comparison, the 75 battalion level engagements that we are using to validate the TNDM for battalion–level engagements occur over the following time periods:

**WWI Battalion-level engagements:**

| | |
|---|---|
| less than 6 hours | 11 |
| less than 12 hours | 5 |
| less than 18 hours | 7 |
| 18 - 36 hours (1 day) | 0 |
| 36 - 60 hours (2 days) | 0 |

**WWII Battalion-level engagements:**

| | |
|---|---|
| less than 6 hours | 3 |
| less than 12 hours | 8 |
| less than 18 hours | 9 |
| 18 - 36 hours (1 day) | 2 |
| 36 - 60 hours (2 days) | 1 |

**Post-WWII Battalion-level engagements:**

| | |
|---|---|
| less than 6 hours | 13 |
| less than 12 hours | 8 |
| less than 18 hours | 4 |
| 18 - 36 hours (1 day) | 3 |
| 36 - 60 hours (2 days) | 1 |

**SUMMATION AND COMPARISON:**

| | Battalion-level | QJM |
|---|---|---|
| less than 6 hours | 27 | 0 |
| less than 12 hours | 21 | 0 |
| less than 18 hours | 20 | 0 |
| 18 - 36 hours (1 day) | 5 | 39 |
| 36 - 60 hours (2 days) | 2 | 54 |
| 60 - 84 hours (3 days) | 0 | 37 |
| 4 days | 0 | 7 |
| 5 days | 0 | 4 |
| 6 days | 0 | 3 |
| 7 days | 0 | 1 |
| 8 days | 0 | 2 |
| 9 days | 0 | 2 |
| | -- | --- |
| | 75 | 149 |

Three of the engagements used in the battalion–level validation are from the QJM database.

We did run sample engagements of 24 hours, 12 hours, 6 hours and 3 hours. The results of the 12–hour run was literally ½ the casualties and ½ of the advance for the 24–hour run. The same straight dividing effect was true for the 3– and 6–hour runs. For increments less than 24 hours the model just divided the results by the number of hours. As Dave Bongard pointed out to me, there are various lighting choices, including daylight and night, and these could vary the results some if used. But the impact for daylight would be 1.1 additional casualties and the reduction for night is .7 or .8.

The problem is that briefer battles will result in higher casualties per hour than extended battles. Also, in any extended battle, there are intense periods and un–intense periods, with the model giving the average result of those periods. For battles of less than 24 hours, there tends to be only intense periods. Therefore, it should be expected that battles lasting 3 hours should have more than 1/6 the losses of a 24 hours battle. This will be tested during the battalion–level validation.

For battles in excess of one day, there is a table in the TNDM that reduces the overall casualties and advance rate over time to account for fatigue.

# The Effects of Dispersion on Combat

by Christopher A. Lawrence

The TNDM does not play dispersion. But it is clear that dispersion has continued to increase over time, and this must have some effect on combat. This effect was identified by Trevor N. Dupuy in his various writings, starting with the *Evolution of Weapons and Warfare*. His graph in *Understanding War* of the battle casualties trends over time is presented here as Figure 1. As dispersion changes over time (dramatically), one would expect the casualties would change over time. I therefore went back to the Land Warfare Database (the 605 engagement version) and proceeded to look at casualties over time and dispersion from every angle that I could.

**Figure 1: Average Daily Battle Casualty Rates 1600-1973**


I eventually realized that I was going to need some better definition of the time periods I was measuring to, as measuring by years scattered the data, measuring by century assembled the data in too gross a manner, and measuring by war left a confusing picture due to the number of small wars with only two or three battles in them in the Land Warfare Database. I eventually defined the wars into 14 categories, so I could fit them onto one readable graphs:

| Category | Years | # Examples | # Major Battles (Clodfelter) |
|---|---|---|---|
| Thirty Years' War | 1618-1648 | 18 | 20 |
| English Civil War | 1642-1652 | 9 | 15 |
| Other Wars | 1600-1699* | 21 | 12+ |
| Other Wars | 1700-1755 | 15 | 46+ |
| Seven Years' War | 1756-1763 | 18 | 48 |
| American Revolutionary Wars | 1775-1783 | 14 | 43 |
| French Revolutionary Wars | 1792-1802 | 23 | 51 |
| Napoleonic Wars | 1803-1815 | 33 | 140 |
| Other Wars | 1816-1859 | 19 | 63+ |
| American Civil War | 1861-1865 | 49 | 143 |
| Other Wars | 1860-1905 | 30 | 123+ |
| WWI | 1912-1920** | 131 | 68++ |
| WWII | 1937-1945*** | 172 | 92+++ |
| Arab-Israeli Wars | 1967, 1968, 1973 | 53 | 0++ |
| Other Post-WWII**** | | | 44+ |

To give some idea of how representative the battles listed in the LWDB were for covering the period, I have included a count of the number of battles listed in Michael Clodfelter's two–volume book *Warfare and Armed Conflict, 1618–1991.* In the case of WWI, WWII and later, battles tend to be defined as a divisional–level engagement, and there were literally tens of thousands of those.

I then tested my data again looking at the 14 wars that I defined:

- Average Strength by War (Figure 2)
- Average Losses by War (Figure 3)
- PercentLosses Per Day By War (Figure 4)
- Average People Per Km By War (Figure 5)
- Losses per Kilometer of Front by War (Figure 6)
- Strength and Losses Per Km of Front By War (Figure 7)
- Ratio of Strength and Losses per Km of Front by War (Figure 8)
- Ratio of Strength and Losses per Km of Front by Century (Figure 9)

A review of average strengths over time by century and by war showed no surprises (see Figure 2). Up through around 1900, battles were easy to define: they were one– to three–day affairs between clearly defined forces at a locale. The forces had a clear left flank and right flank that was not bounded by other friendly forces. After 1900 (and in a few cases before), warfare was fought on continuous fronts

**Figure 2: Average Strengths by War**


with a 'battle' often being a large multi–corps operations. It is no longer clearly understood what is meant by a battle, as the forces, area covered, and duration can vary widely. For the LWDB, each battle was defined as the analyst wished. In the case of WWI, there are a lot of very large battles which drive

* Includes 1 battle before 1650

** Includes Balkan Wars and Russo-Polish War

*** Includes 1 Spanish Civil War Battle and several Russo-Japanese engagements

**** The only post-WWII battles the LWDB looks at is the Arab-Israeli Wars from 1967-1973. It leaves out the Korean War and the Vietnam War.

the average battle size up. In the case of the WWII, there are a lot of division–level battles, which bring the average down. In the case of the Arab–Israeli Wars, there are nothing but division and brigade–level battles, which bring the average down.

The interesting point to notice is that the average attacker strength in the 16th and 17th century is lower than the average defender strength. Later it is higher. This may be due to anomalies in our data selection.

Average losses by war (see Figure 3) suffers from the same battle definition problem.

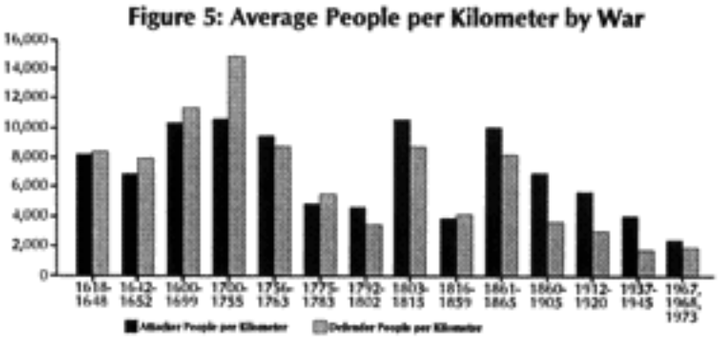
**Figure 3: Average Losses by War**


Percent losses per day (see Figure 4) is a useful comparison through the end of the 19th Century. After that, the battles get longer and the definition of a duration of the battle is up to the analyst. Note the very clear and definite downward pattern of percent losses per day from the Napoleonic Wars through the Arab–Israeli Wars. Here is a very clear indication of the effects of dispersion. It would appear that from the 1600s to the 1800s the pattern was effectively constant and level, then declines in a very systematic pattern. This partially contradicts Trevor Dupuy's writings and graphs (see Figure 1). It does appear that after this period of decline, that the percent losses per day are being set at a new, much lower plateau. Percent losses per day by war is attached.

**Figure 4: Percent Losses per Day by War**


Looking at the actual subject of dispersion, the dispersion of people (measured in people per kilometer of front) remained relatively constant from 1600 through the American Civil War (see Figure 5). Trevor Dupuy defined dispersion as the number of people in a box–like area. Unfortunately, I do not know how to measure that. I can clearly identify the left and right of a unit, but it is more difficult to tell how deep it is. Furthermore, density of occupation of this box is far from uniform, with a very forward bias. By the same token, fired delivered into this box is also not uniform, with a very forward bias. Therefore, I am quite comfortable measuring dispersion based upon unit frontage, more so than by front multiplied by depth.

**Figure 5: Average People per Kilometer by War**




Note, when comparing the Napoleonic Wars to the American Civil War, that the dispersion remains about the same. Yet, if you look at the average casualties (Figure 3) and the average percent casualties per day (Figure 4), it is clear that the rate of casualty accumulation is lower in the American Civil War (this again partially contradicts Dupuy's writings). There is no question that with the advent of the Minié ball, allowing for rapid–fire rifled muskets, the ability to deliver accurate firepower increased.

As you will also note, the average people per linear km between WWI an WWII differs by a factor of a little over 1.5 to 1. Yet the actual difference in casualties (see Figure 4) is much greater. While one can just postulate that the difference is the change in dispersion squared (basically Dupuy's approach), this does not seem to explain the complete difference, especially the difference between the Napoleonic Wars and the Civil Wars.

Instead of discussing dispersion, we should be discussing "casualty reduction efforts." This basically consists of three elements:

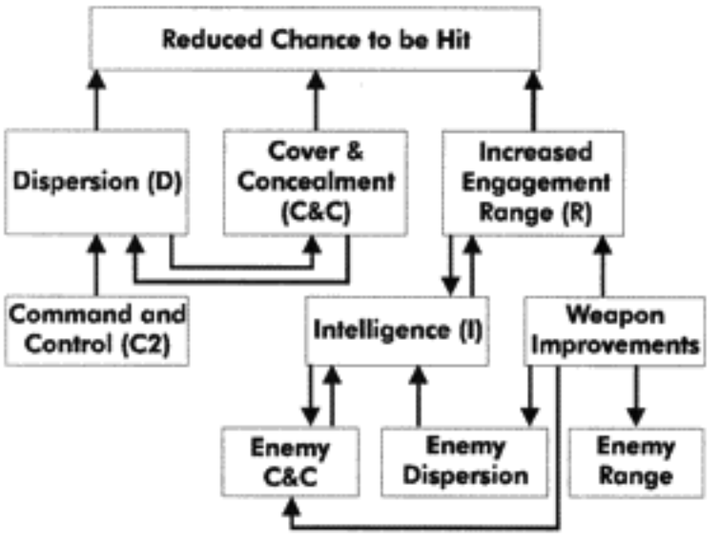
- Dispersion (D)
- Increased engagement ranges (R)
- More individual use of cover and concealment (C&C).

These three factors together, result in the reduced chance to hit. They are also partially interrelated, as one cannot make more individual use of cover and concealment unless one is allowed to disperse. So, therefore, the need for cover and concealment increases the desire to disperse and the process of dispersing allows one to use more cover and concealment.

Command and control are integrated into this construct as being something that allows dispersion, and dispersion creates the need for better command control. Therefore, improved command and control in this construct does not operate as a force modifier, but enables a force to disperse.

Intelligence becomes more necessary as the opposing forces use cover and concealment and the ranges of engagement increase. By the same token, improved intelligence allows you to increase the range of engagement and forces the enemy to use better concealment.

This whole construct could be represented by the diagram at the top of the next page.




Now, I may have said the obvious here, but this construct is probably provable in each individual element, and the overall outcome is measurable. Each individual connection between these boxes may also be measurable.

Therefore, to measure the effects of reduced chance to hit, one would need to measure the following formulae (assuming these formulae are close to being correct):

$$(K * \Delta D) + (K * \Delta C\&C) + (K * \Delta R) = H$$

$$(K * \Delta C2) = \Delta D$$

$$(K * \Delta D) = \Delta C\&C$$

$$(K * \Delta W) + (K * \Delta I) = \Delta R$$

K = a constant
Δ = the change in..... (alias "Delta")
D = dispersion
C&C = Cover & Concealment
R = Engagement Range
W = Weapon's Characteristics

Also, certain actions lead to a desire for certain technological and system improvements. This includes effect of increased dispersion leading to a need for better C&C and increased range leading to a need for better intelligence. I am not sure these are measurable.

I have also shown in the diagram how the enemy impacts upon this. There is also an interrelated mirror image of this construct for the other side.

I am focusing on this because I really want to come up with some means of measuring the effects of a "revolution in warfare." The last 400 years of human history have given us more revolutionary inventions impacting war than we can reasonably expect to see in the next 100 years. In particular, I would like to measure the impact of increased weapon accuracy, improved intelligence, and improved C2 on combat.

For the purposes of the TNDM, I would very specifically like to work out an attrition multiplier for battles before WWII (and theoretically after WWII) based upon reduced chance to be hit ("dispersion"). For example, Dave Bongard is currently using an attrition multiplier of 4 for his WWI engagements that he is running for the battalion–level validation data base. No one can point to a piece of paper saying this is the value that should be used. Dave picked this value based upon experience and familiarity with the period.

**Figure 6: Losses per Kilometer of Front by War**

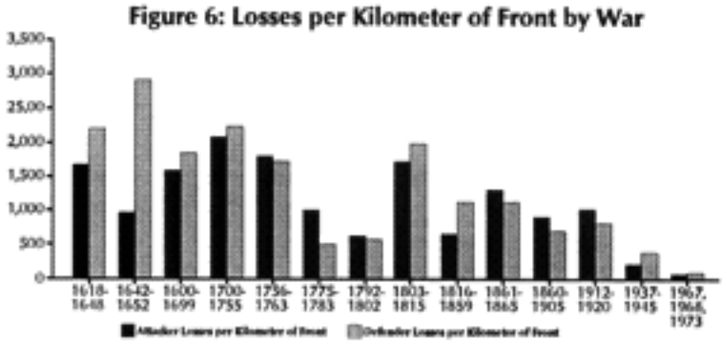
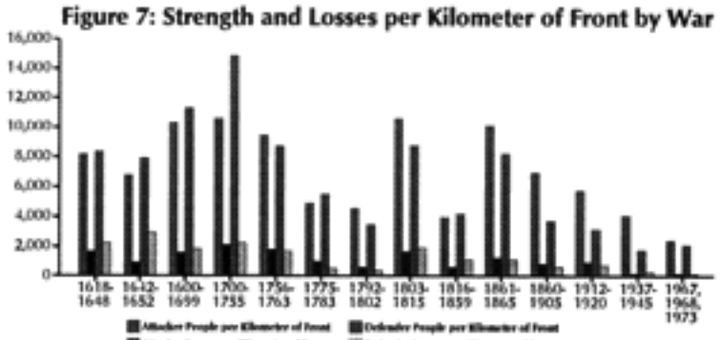



**Figure 7: Strength and Losses per Kilometer of Front by War**




I have also attached Average Losses per Kilometer of Front by War (see Figure 6 above), and a summary chart showing the two on the same chart (see Figure 7 above). The values from these charts are:

| | | | | | |
|---|---|---|---|---|---|
| 1618 A | 8,148 | 1,649 | 4.9 | 2.8 | 12.8 |
| 1618 D | 8,329 | 2,193 | 3.8 | 2.8 | 12.8 |
| 1642 A | 6,765 | 942 | 7.2 | 2.5 | 12.8 |
| 1642 D | 7,902 | 2,903 | 2.7 | 2.5 | 12.8 |
| 1699 A | 10,324 | 1,573 | 6.6 | 3.6 | 11.3 |
| 1699 D | 11,341 | 1,830 | 6.2 | 3.6 | 11.3 |
| 1755 A | 10,629 | 2,063 | 5.2 | 4.3 | 14.3 |
| 1755 D | 14,866 | 2,222 | 6.7 | 4.3 | 14.3 |
| 1756 A | 9,511 | 1,785 | 5.3 | 3.1 | 11.6 |
| 1756 D | 8,747 | 1,702 | 5.1 | 3.1 | 11.6 |
| 1775 A | 4,851 | 977 | 5.0 | 1.7 | 4.9 |
| 1775 D | 5,506 | 487 | 11.3 | 1.7 | 4.9 |
| 1792 A | 463 | 605 | 7.7 | 1.4 | 3.9 |
| 1792 D | 3,471 | 563 | 6.2 | 1.4 | 3.9 |
| 1803 A | 10,644 | 1,683 | 6.3 | 3.2 | 12.1 |
| 1803 D | 8,798 | 1,959 | 4.5 | 3.2 | 12.1 |
| 1859 A | 3,965 | 637 | 6.2 | 1.4 | 5.8 |
| 1859 D | 4,223 | 1,111 | 3.8 | 1.4 | 5.8 |
| 1861 A | 10,135 | 1,282 | 7.9 | 3.1 | 8.0 |
| 1861 D | 8,266 | 1,111 | 7.4 | 3.1 | 8.0 |
| 1905 A | 6,991 | 885 | 7.9 | 1.8 | 5.2 |
| 1905 D | 3,755 | 689 | 5.4 | 1.8 | 5.2 |
| 1912 A | 5,784 | 1,009 | 5.7 | 1.5 | 6.1 |
| 1912 D | 3,165 | 814 | 3.9 | 1.5 | 6.1 |
| 1937 A | 4,169 | 214 | 19.5 | 1.0 | 1.0 |
| 1937 D | 1,814 | 386 | 4.7 | 1.0 | 1.0 |
| 1967 A | 2,533 | 67 | 37.8 | 0.76 | 0.52 |
| 1967 D | 2,019 | 89 | 22.7 | 0.76 | 5.2 |

The TNDM sets WWII dispersion factor at 3,000 (which I gather translates into 30,000 men per square kilometer). The above data shows a linear dispersion per kilometer of 2,992 men, so this number parallels Dupuy's figures.

The final chart I have included is the Ratio of Strength and Losses per Km of Front by War (Figure 8). Each line on the bar graph measures the average ratio of strength over casualties for either the attacker or defender. Being a ratio, unusual outcomes resulted in some really unusually high ratios. I took the liberty of taking out six

**Figure 8: Ratio of Strength and Losses per Kilometer of Front by War**


data points because they appeared unusually lop–sided. Three of these points are from the English Civil War and were way out of line with everything else. These were the three Scottish battles where you had a small group of mostly sword–armed troops defeating a "modern" army. Also, Walcourt (1689), Front Royal (1862), and Calbritto (1943) were removed. I also have included the same chart, except by century (Figure 9).

**Figure 9: Ratio of Strength and Losses per Kilometer of Front by Century**


Again, one sees a consistency in results in over 300+ years of war, in this case going all the way through WWI, then sees an entirely different pattern with WWII and the Arab–Israeli Wars.

A very tentative set of conclusions from all this is:

1. Dispersion has been relatively constant and driven by factors other than firepower from 1600–1815.
2. Since the Napoleonic Wars, units have increasingly dispersed (found ways to reduce their chance to be hit) in response to increased lethality of weapons.
3. As a result of this increased dispersion, casualties in a given space have declined.
4. The ratio of this decline in casualties over area have been roughly proportional to the strength over an area from 1600 through WWI. Starting with WWII, it appears that people have dispersed faster than weapons lethality, and this trend has continued.
5. In effect, people dispersed in direct relation to increased firepower from 1815 through 1920, and then after that time dispersed faster than the increase in lethality.
6. It appears that since WWII, people have gone back to dispersing (reducing their chance to be hit) at the same rate that firepower is increasing.
7. Effectively, there are four patterns of casualties in modern war:

**Period 1 (1600 - 1815): Period of Stability**
Short battles
Short frontages
High attrition per day
Constant dispersion
Dispersion decreasing slightly after late 1700s
Attrition decreasing slightly after mid–1700s.

**Period 2 (1816 - 1905): Period of Adjustment**
Longer battles
Longer frontages
Lower attrition per day
Increasing dispersion
Dispersion increasing slightly faster than lethality

**Period 3 (1912 - 1920): Period of Transition**
Long Battles
Continuous Frontages
Lower attrition per day
Increasing dispersion
Relative lethality per km similar to past, but lower
Dispersion increasing slightly faster than lethality

**Period 4 (1937 - present): Modern Warfare**
Long Battles
Continuous Frontages
Low Attrition per day
High dispersion (perhaps constant?)
Relatively lethality per km much lower than the past
Dispersion increased much faster than lethality going into the period.
Dispersion increased at the same rate as lethality within the period.

So the question is whether warfare of the next 50 years will see a new "period of adjustment," where the rate of dispersion (and other factors) adjusts in direct proportion to increased lethality, or will there be a significant change in the nature of war?

Note that when I use the word "dispersion" above, I often mean "reduced chance to be hit," which consists of dispersion, increased engagement ranges, and use of cover & concealment.

One of the reasons I wandered into this subject was to see if the TNDM can be used for predicting combat before WWII. I then spent the next few days attempting to find some correlation between dispersion and casualties. Using the data on historical dispersion provided above, I created a mathematical formulation and tested that against

the actual historical data points, and could not get any type of fit.

I then looked at the length of battles over time, at one-day battles, and attempted to find a pattern. I could find none. I also looked at other permutations, but did not keep a record of my attempts. I then looked through the work done by Dean Hartley (Oakridge) with the LWDB and called Paul Davis (RAND) to see if there was anyone who had found any correlation between dispersion and casualties, and they had not noted any.

It became clear to me that if there is any such correlation, it is buried so deep in the data that it cannot be found by any casual search. I suspect that I can find a mathematical correlation between weapon lethality, reduced chance to hit (including dispersion), and casualties. This would require some improvement to the data, some systematic measure of weapons lethality, and some serious regression analysis. I unfortunately cannot pursue this at this time.

Finally, for reference, I have attached two charts showing the duration of the battles in the LWDB in days (Figure 10, Duration of Battles over Time and Figure 11, A Count of the Duration of Battles by War).

**Figure 10: Duration of Battles Over Time**

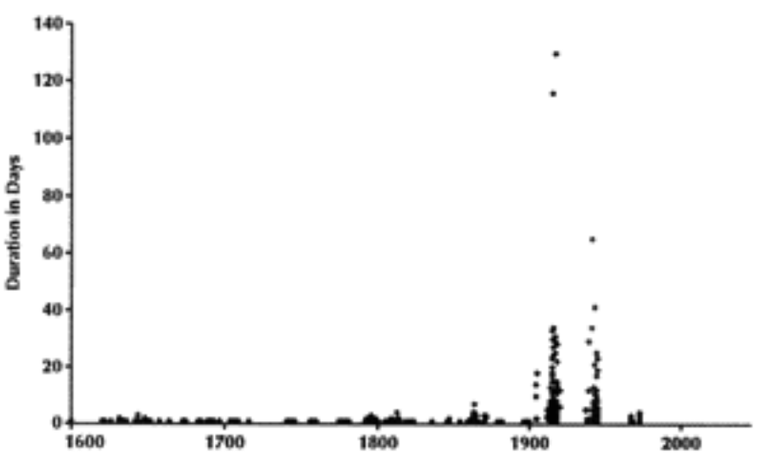
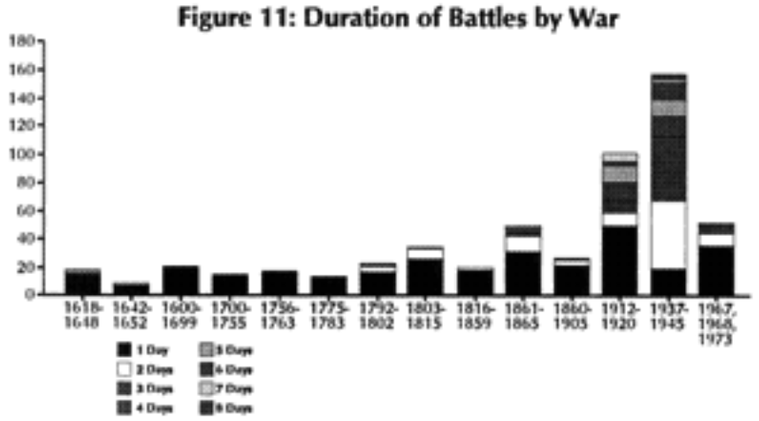



**Figure 11: Duration of Battles by War**



# TDI Profile: José Perez

José M. Perez received a BS in Political Science from the Massachusetts Institute of Technology in June 1979 and a MS in Political Science from MIT in February 1983. For both of his Political Science degrees, Mr. Perez concentrated on Defense and Arms Control. His undergraduate thesis was "Defense Planning: An Analysis of the Taft White Paper on Defense" and his master's thesis was "War Games as a Military Decision–making Tool in Operations and Planning."

Mr. Perez worked for Data Memory Systems, Inc. (DMSi) from November 1984 through December 1985. At the time, DMSi was a research and consulting firm owned and operated by Col. Trevor N. Dupuy. While at DMSi, Mr. Perez worked with Col. Dupuy to enhance and refine the QJM software. Initially, the software was written in BASIC, running on an Apple II. During the summer of 1985, it was converted to run on the IBM PC.

After his departure from DMSi, Mr. Perez continued to perform the maintenance and enhancement of the QJM software. After Col. Dupuy left DMSi to found T. N. Dupuy Associates, which then became The Dupuy Institute (TDI), Mr. Perez became involved in the development of The Numerical Deterministic Model (TNDM) software. The original concept software was written by Dr. James Taylor; it was converted into Pascal by Mr. Perez. Mr. Perez is one of the owners of the TNDM.

Mr. Perez has continued to work with improvements to the model made by the Dupuy Institute and was involved in the installation of the model at the Korean Institute for Defense Analysis (KIDA).

Mr. Perez currently lives in Massachusetts and his work on the development of the TNDM continues on a consultant basis and as a labor of love. He currently works as a network administrator for a relocation consulting company.

# Exactly How the Unit Size Modifiers Are Calculated

**by José Perez**

As noted in my first column, many changes have been made to the TNDM since its inception. Some of those changes were not well documented and do not appear in the revision history (TNDM Newsletter, vol. 1, no. 1). One of these undocumented changes involves the Strength/Size Factor.

The Personnel Strength/Size factor as documented in the *Rules and Procedures Manual* is a table containing ranges of personnel and the factor value associated with each range. However, in the summer of 1991, Col. Dupuy expressed some dissatisfaction with this since it meant that a minor change in the number of personnel could result in a large change in the factor value. For example, the value for the range of 500–1,000 is 8; the value for 1,000–2,000 is 5 (from Table 17, Strength/Size Factors, *The TNDM Manual of Rules and Procedures*, February 1991). If personnel strength for one side was changed from 999 to 1,000, that side's Personnel Strength/Size factor would change from 8 to 5.

Some research on small unit engagements had also revealed that the values for smaller units (less than 5,000) produced casualty rates that were too low. The table was revised to increase the factor values for small units. A by-product of this work was that a graph of the new values was smoother (see columns A and B in the table below) than the old values.

Col. Dupuy then asked Dr. James Taylor to develop an equation that would duplicate the table but give values for any personnel strength. The result was the following equation:

**tz = 20**, when Personnel < 500
**tz = (9501.9/Personnel) - 0.00375**, when 500 <= Personnel <= 400,000
**tz = 0.2**, when Personnel > 400,000

However, the results generated by the equation did not match the table exactly (see column C for the error). But since it generated a graph that has the same shape as the table, the next step was to develop a method to correct the results.

The simplest way to do this was to create an equation that calculates the error adjustment between each range (500–533, 533–567, 567–600, etc.). The new equation is:

**tz = 20**, when Personnel < 500
**tz = (9501.9/Personnel) - 0.00375 - (M * Personnel + B)**, when 500 <= Personnel <= 400,000
**tz = 0.2**, when Personnel > 400,000

where M and B are found in the table on the next page.

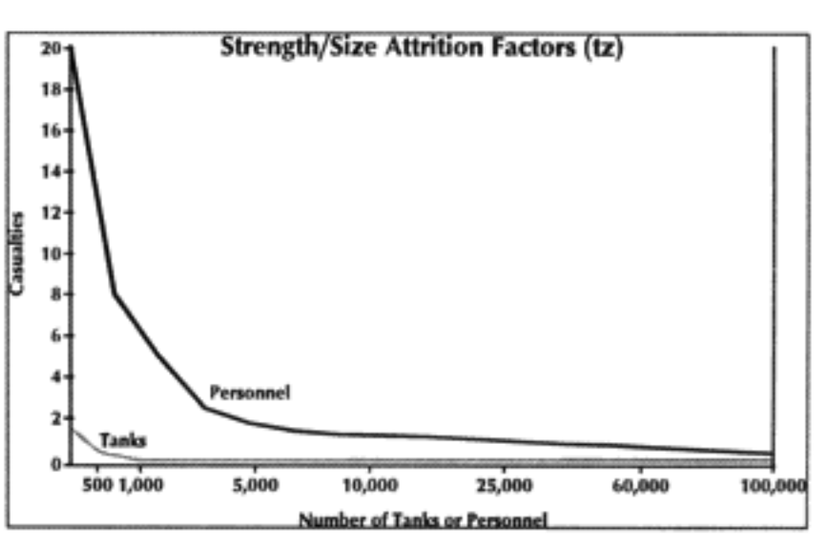
M and B were derived using basic algebra:

Given two points (x1, y1) and (x2, y2), the equation for a line between them is

$$y = (M * x) + B,$$

where

x1 and x2 are personnel strengths;
y1 and y2 are the errors between the equation and the table;
M = (y2 - y1) / (x2 - x1) and
B = y1 - (M * x1) = y2 - (M * x2).



| Personnel | Factor (tz) | Error between formula and tz | Formula | M | B |
|---|---|---|---|---|---|
| <500 | 20 | | 20 | | |
| 500 | 19 | 0.00005 | 19.00005 | -0.00535138 | 2.67574 |
| 533 | 18 | -0.17655 | 17.82346 | -0.00202951 | 0.90518 |
| 567 | 17 | -0.24555 | 16.75445 | 0.0023727 | -1.59087 |
| 600 | 16 | -0.16725 | 15.83275 | 0.00528486 | -3.33817 |
| 633 | 15 | 0.00715 | 15.00715 | 0.00690667 | -4.36477 |
| 667 | 14 | 0.24198 | 14.24198 | 0.00995199 | -6.396 |
| 700 | 13 | 0.57039 | 13.57039 | 0.00190114 | -0.76041 |
| 750 | 12 | 0.66545 | 12.66545 | 0.0041635 | -2.45718 |
| 800 | 11 | 0.87363 | 11.87363 | 0.00602662 | -3.94767 |
| 850 | 10 | 1.17496 | 11.17496 | 0.00757922 | -5.26738 |
| 900 | 9 | 1.55392 | 10.55392 | 0.00888667 | -6.44408 |
| 950 | 8 | 1.99825 | 9.99825 | 0.009998 | -7.49985 |
| 1,000 | 7 | 2.49815 | 9.49815 | -0.00363809 | 6.13624 |
| 1,100 | 6.5 | 2.13434 | 8.63434 | -0.00219841 | 4.55259 |
| 1,200 | 6 | 1.9145 | 7.9145 | -0.00359096 | 6.22365 |
| 1,300 | 5.75 | 1.5554 | 7.3054 | -0.00272082 | 5.09248 |
| 1,400 | 5.5 | 1.28332 | 6.78332 | -0.00202471 | 4.11792 |
| 1,500 | 5.25 | 1.08085 | 6.33085 | -0.00145913 | 3.26954 |
| 1,600 | 5 | 0.93494 | 5.93494 | -0.00099335 | 2.52429 |
| 1,700 | 4.75 | 0.8356 | 5.5856 | -0.0006052 | 1.86444 |
| 1,800 | 4.5 | 0.77508 | 5.27508 | -0.00013942 | 1.02603 |
| 2,000 | 4 | 0.7472 | 4.7472 | -0.00115952 | 3.06625 |
| 2,200 | 3.8 | 0.5153 | 4.3153 | -0.0007996 | 2.27442 |
| 2,400 | 3.6 | 0.35538 | 3.95538 | -0.00052274 | 1.60995 |
| 2,600 | 3.4 | 0.25083 | 3.65083 | -0.00030521 | 1.04436 |
| 2,800 | 3.2 | 0.18979 | 3.38979 | -0.00013118 | 0.55709 |
| 3,000 | 3 | 0.16355 | 3.16355 | 0.00001022 | 0.13289 |
| 3,200 | 2.8 | 0.16559 | 2.96559 | 0.00012666 | -0.23973 |
| 3,400 | 2.6 | 0.19093 | 2.79093 | -0.0002763 | 1.13034 |
| 3,600 | 2.5 | 0.13567 | 2.63567 | -0.00019458 | 0.83617 |
| 3,800 | 2.4 | 0.09675 | 2.49675 | -0.00012513 | 0.57223 |
| 4,000 | 2.3 | 0.07173 | 2.37173 | -0.00006559 | 0.33408 |
| 4,200 | 2.2 | 0.05861 | 2.25861 | -0.00001417 | 0.11813 |
| 4,400 | 2.1 | 0.05577 | 2.15577 | 0.00003054 | -0.0786 |
| 4,600 | 2 | 0.06188 | 2.06188 | 0.00006966 | -0.25856 |
| 4,800 | 1.9 | 0.07581 | 1.97581 | 0.00010409 | -0.42381 |
| 5,000 | 1.8 | 0.09663 | 1.89663 | -0.00014552 | 0.82425 |
| 5,500 | 1.7 | 0.02387 | 1.72387 | -0.00008794 | 0.50752 |
| 6,000 | 1.6 | -0.0201 | 1.5799 | -0.00004364 | 0.24173 |
| 6,500 | 1.5 | -0.04192 | 1.45808 | -0.00000883 | 0.0155 |
| 7,000 | 1.4 | -0.04634 | 1.35366 | -0.00006968 | 0.4414 |
| 8,000 | 1.3 | -0.11601 | 1.18399 | -0.00009197 | 0.61975 |
| 9,000 | 1.26 | -0.20798 | 1.05202 | -0.00007558 | 0.47221 |
| 10,000 | 1.23 | -0.28356 | 0.94644 | -0.00005638 | 0.28025 |
| 11,000 | 1.2 | -0.33994 | 0.86006 | -0.00004198 | 0.12188 |
| 12,000 | 1.17 | -0.38193 | 0.78808 | -0.00003091 | -0.01101 |
| 13,000 | 1.14 | -0.41283 | 0.72717 | -0.00003221 | 0.00587 |
| 14,000 | 1.12 | -0.44504 | 0.67496 | -0.00002525 | -0.09158 |
| 15,000 | 1.1 | -0.47029 | 0.62971 | -0.00001959 | -0.17642 |
| 16,000 | 1.08 | -0.48988 | 0.59012 | -0.00001493 | -0.25095 |
| 17,000 | 1.06 | -0.50481 | 0.55519 | -0.00001105 | -0.31693 |
| 18,000 | 1.04 | -0.51587 | 0.52413 | -0.00000778 | -0.37577 |
| 19,000 | 1.02 | -0.52365 | 0.49635 | -0.00000501 | -0.42855 |
| 20,000 | 1 | -0.52866 | 0.47135 | -0.00001262 | -0.27618 |
| 21,000 | 0.99 | -0.54128 | 0.44872 | -0.00001057 | -0.31937 |
| 22,000 | 0.98 | -0.55185 | 0.42815 | -0.00000878 | -0.35872 |
| 23,000 | 0.97 | -0.56062 | 0.40938 | -0.00000721 | -0.39471 |
| 24,000 | 0.96 | -0.56784 | 0.39216 | -0.00000584 | -0.42776 |
| 25,000 | 0.95 | -0.57367 | 0.37633 | -0.00000462 | -0.45822 |
| 26,000 | 0.94 | -0.57829 | 0.36171 | -0.00000354 | -0.48637 |
| 27,000 | 0.93 | -0.58183 | 0.34817 | -0.00000257 | -0.51247 |
| 28,000 | 0.92 | -0.5844 | 0.3356 | -0.0000017 | -0.53674 |
| 29,000 | 0.91 | -0.5861 | 0.3239 | -0.00000092 | -0.55937 |
| 30,000 | 0.9 | -0.58702 | 0.31298 | -0.00000022 | -0.58051 |
| 31,000 | 0.89 | -0.58724 | 0.30276 | 0.00000042 | -0.6003 |
| 32,000 | 0.88 | -0.58682 | 0.29318 | 0.000001 | -0.61888 |
| 33,000 | 0.87 | -0.58581 | 0.28419 | 0.00000153 | -0.63635 |
| 34,000 | 0.86 | -0.58428 | 0.27572 | 0.00000202 | -0.6528 |
| 35,000 | 0.85 | -0.58227 | 0.26773 | -0.00000254 | -0.49333 |
| 36,000 | 0.845 | -0.58481 | 0.26019 | -0.00000213 | -0.508 |
| 37,000 | 0.84 | -0.58694 | 0.25306 | -0.00000176 | -0.52189 |

# An Update: Planned Improvements to the TNDM


## by Christopher A. Lawrence

TDI has decided that there are sufficient changes to warrant creating an interim version of the TNDM. This will be version 1.86.

We will be making a major improvement to the TNDM to address logistics but this will not take place until early 1997. As part of that improvement effort, I intended to make a number of minor changes to the model. We decided to make those minor changes now. The new features in version 1.86 are:

- Show only the defender's missions in the list of Defender's Missions.
- Make it possible to delete an engagement.
- Make saving an engagement optional.
- Print out a one–page result sheet
- Correct an error in the velocity attrition table.
- Correct the Find/Search functions in the OLI DB Menu.
- Allow user to change own dispersion factor.

I have listed below the changes that I am currently planning on implementing in the next revision of the model, which I expect to come out sometime in spring of 1997. It consists of the changes required for the logistics module. The lists after that consist of all the easy changes that are high priority and then the ones that are of lower priority. Then I list all the major changes that I would like see made to the model, both high priority and low priority. The "Future Changes" lists was not changed from the previous newsletter.

**CHANGES INTENDED FOR THE LOGISTICS MODULE REVISION (Version 2.0):**

1. Develop a draft logistics package.
2. Make is possible to counterattack.
3. Allow user to create forces with both horses and motor vehicles.
4. When CEV is an initial input, that value should be considered when calculating new CEV.

**ALSO UNDERWAY**: Validate model for battalion-level use.

*FUTURE CHANGES:*

**MINOR TASKS (High priority):**

1. Re-validate the model to the QJM Database.
2. Store engagements in a database.

**MINOR TASKS (Low priority):**

1. The vulnerability formulae need to be reviewed.
2. Audit the software to the model design.
3. Determine whether the model under–predicts high casualty days and over–predicts low casualty days.
4. Review and integrate the Swedish arctic values into the model.
5. Add a stealth factor to show the impact of stealth on weapons, especially AFVs, planes, and helicopters (adjust size?).
6. Make a more comprehensive help file.
7. Track individual unit strengths during an engagement.
8. Modify model to run in Windows.
9. Address fanaticism.
10. Develop guidance on terrain and weather values.

**MAJOR TASKS (High priority):**

1. Address battalion-level combat.
2. Develop graphics package, including mapping functions.
3. Add functions to allow the model to be used as a training tool.
4. Address low intensity combat.
5. Develop rules for battle termination.
6. Provide user guidance for CEVs.
7. Add a tank/antitank loop, including:
   - Eliminate use of firepower scores (OLI's)
   - Account for relative differences in weapon performance.
   - Add tank breakdowns, destroyed vs damaged differentiation, and recovery and repair calculations for multi–day battles.

**MAJOR TASKS (Low Priority):**

1. Update documentation.
2. Develop an air campaign module.
3. Add an electronic warfare subroutine.
4. Allow user to show trends in military affairs.
5. Make the model mathematically coherent
6. Add sector/theater modeling capability.

Volume 1, Number 4 February 1997

# THE INTERNATIONAL TNDM NEWSLETTER

## Verification, Validation, and Accreditation (VVA)

Also in this issue:

- Military History and Validation of Combat Models
- 76 & 112 Battalion–Level Battles
- Casualties, Time, Winners and Losers Using BLODB
- How to Run TNDM from Windows 3.1 and Win95

# INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this fourth issue of our newsletter Christopher Lawrence, Dave Bongard, Richard Anderson, and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically–based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

(1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;

(2) Training, cultural and psychological profiles, and flow of information;

(3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in–house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically–based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.

# CONTENTS



IN HONOR OF THE MEMORY OF THE LATE

**Trevor N. Dupuy**

Col., USA, Rtd.

**International TNDM Newsletter**

*Publisher*
The Dupuy Institute

*Editor*
Christopher A. Lawrence

*Production Manager*
Jay Karamales
Olórin Press

*Contributing Editors*
Richard C. Anderson
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

*Founder*
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*President*
Maj. Gen. Nicholas Krawciw

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Maj. Gen. Nicholas Krawciw
Maj. Gen. James C. Pfautz
Dr. Abraham Wolf

*Administrative Offices*
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
NikatTDI@aol.com

# From the Editor...

This issue is a hodgepodge of articles. A few months ago, I carefully laid out plans for all the future issues, starting with this issue, to be organized around definite themes. The previous issue was also intended to be slightly thematic, except that I had to reduce the number of graphs (meaning the number of articles) so as to get the issue out sometime in 1996. This issue was intended to be built around the Dupuy Air Campaign Model (DACM), but several things occurred that worked against this plan. First, I was left with a collection of articles intended for the last newsletter ("article overflow") that I wanted to print. Second, and more significantly, an informal memo I wrote in 1994 suddenly got widely distributed within the US Army combat modeling community. This memo was intended for my future thematic issue on model validation (carefully planned to be the October 1997 issue), but the memo and issue are current now, so the thematic issue plans are temporarily reshuffled and we are going to talk about model validation in this issue.

Model validation has been discussed in the industry for over 20 years. In this decade, there was been some progress towards validation of models in the US Army, but from my point of view, not nearly enough. My experience with validation is as a "hands–on" expert. I was the program manager for two validation databases, the Ardennes Campaign Simulation Data Base (ACSDB) and the Kursk Data Base (KDB). In addition, I have directed the creation of the Battalion-Level Operations Database (BLODB). The real worker on that is Dave Bongard. I have then used that database to start a validation of the TNDM for battalion–level combat. This means that I have been involved in some way with three validation efforts, so I feel as qualified as anyone to discuss validation issues.

Enclosed in this issue is a letter from Paul Berenson of the US Army Training and Doctrine Command (TRADOC) to the "whole world" asking if validation is being done. This came about because of a phone conversation we had in December 1996 in which I stated in passing that "of course, none of these models has been validated." Dr. Berenson asked me if I had something I could send him on that, and indeed I did have a two old memos that I had written two years earlier to Dr. Brian McCue when he was at the Office of Technology Assessment (OTA) and to Trevor Dupuy. I then attached a cover letter to it and faxed it to him. After reading them, he asked me if it was okay to send them out, and I said it was. In January, I realized that they had been sent to the "whole world."

Upon re-reading them, I would have to say that the tone is a little harsher than I would like to take in a public letter, but then they were written as private letters. Hopefully no one was offended by the tone. Regardless of how sweet and sugary I might rewrite them, the basic ideas presented would be the same.

In my first memo, I state that I had no comment on the subject of accreditation. This is no longer the case. I have therefore enclosed an article on accreditation to clarify my position, or perhaps just my understanding, of this issue. I have also included an article on validation addressing the problems of validating models to other models, test data, or range data. This is in direct response to a statement in Dr. Berenson's memo. I have enclosed the late Trevor N. Dupuy's paper on validation that he presented at a MORS mini-symposium. We did not edit this paper, and it is included as is. I actually find he overstates the "fuzziness" of historical combat data. With proper research and selection of the battles, it isn't very fuzzy at all. I can certainly get figures like strengths and casualties to within 20%.

Also enclosed in this issue is the work we are doing on the battalion-level validation. The original data for the 74 battalion–level combats were assembled by Dave Bongard from secondary sources. I, as much as anyone, am aware that we should use primary source wherever possible, but since primary source research is expensive, and no one has budgeted for us to do this, we either had to use secondary sources or do nothing. I chose to do something.

After Mr. Bongard had assembled the battles, I put them in a database format so I could look at and test the data. Initially I just wanted to see if the data that we were getting from the battalion–level battles behaved significantly different than what we had gotten from division–level data. I got a little carried away with these tests and the four articles in

*(cont.)*

this newsletter are the result. Hopefully there is much of interest there. A note of warning: the data on some of the engagements have not been finalized, and for the validation some of the data have been corrected. I do not believe this makes any significant difference in my analysis of the data.

In the meantime, Mr. Bongard ran these engagements through the TNDM to see how they would come out. In the process, we added two more engagements, as we had situations in Tenaru River and Bir Gifgafa in which the defender made a significant counterattack with reinforcements during the battle. Instead of running it as one battle, Dave chose to break it into two separate engagements. This resulted in our having 76 engagements. I am now comparing the results of these 76 runs with the historical outcomes. Our conclusions will be printed in the next issue.

We have therefore included a revised listing of the 76 battles used in the validation effort. This is an update from the list in Volume 1, Number 2 of this newsletter. Also, as we suspect that we will be making some changes to the TNDM as a result of this validation effort, we have started preparing a second collection of 112 battalion–level engagements with which to recheck our revised model. This list is also included in the newsletter. You will note a number of obscure and unusual engagements. I believe if you test something, you should test it like you are trying to make it fail, so we let Mr. Bongard pick any engagements he desired. I may regret this.

For the Programmer's Cubicle, we have an article from José about using the TNDM in Windows 3.1 and Windows 95. Only those who have version 1.86 of the TNDM can access it in Windows 95. We have looked at making the model run with a Windows–type interface, but that change is a little more difficult.

For "Who is TDI" we have uncovered some background on Richard Anderson, who provided the article in the last issue on the Butterfly Effect. Again, pictures of historians are rare, but if you look at the cover of this issue you will see a picture of one of his workstations.

The next issue will contain the article on our initial attempts to create a model of the Air Campaign. We will be publishing the results of our validation of the TNDM as a battalion–level model.

The sixth issue will focus on the modeling of tanks and armored warfare. This will include the article on the use of mines and fortifications at Kursk. We also have a set of tables prepared by Richard Anderson on the effects of artillery on tanks. They are quite startling. Also, we hope to have a cover article by Jay Karamales from his tank/antitank studies. His new book *Against the Panzers* is now a featured selection for the Military Book Club.

The first issue of the second year of publication will include an article written by Trevor N. Dupuy that was never before published called "Technology and the Human Factors in War".

I am still awaiting articles from outside TDI and eagerly check my mailbox in hope of finding one. I also haven't yet seen any well–considered criticism of the model. I will publish any that I see. I am also looking for any suggestions for improvement.

That is all for now. If you have any questions, please contact me. Addresses and phone numbers are in the masthead.

**DEPARTMENT OF THE ARMY**
**HEADQUARTERS UNITED STATES ARMY TRAINING AND DOCTRINE COMMAND**
**OFFICE OF THE COMMANDING GENERAL**
**FORT MONROE, VIRGINIA 23651-5000**

REPLY TO ATTENTION OF

ATCG-S

21 Jan 97

MEMORANDUM FOR

Mike Bauman, Director, TRADOC Analysis Center
Edgar Vandiver III, Director, USA Concepts Analysis Agency
John McCarthy, Director, US Army Materiel Systems Analysis Activity

SUBJECT: Validation

Enclosure states that "Validation of models is not being done, regardless of what the regulations say." If the statement is true, it seriously limits the applications of such models.

The enclosure discusses why this statement is made, so I won't repeat the supporting rationale. You may be aware of the arguments in the enclosure.

I understood that validation was required for all models, as it should be. If validation through comparisons with properly validated models, or combat, NTC, or test data is not being done, how do we ensure that users are aware of the limitations of the models, and how it is appropriate to use each model? The argument that models are implicitly validated by widespread use isn't valid.

Do we need to change the policy governing model validation? Should we ask MORS to review the status of validations, and make recommendations for improvement?

Would appreciate a response.

Paul

Enclosure

PAUL J. BERENSON
Scientific Advisor to the CG

DISTRIBUTION:
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Mr Hollis
Dr Davis
Dr Fallin
Mr Fisette
Mr Hartman
Mr Riente
Mr Fox
Mr LaRocque
Mr Resnick

8 December 1996

To: Dr. Paul Berenson, TRADOC
From: Chris Lawrence
Subject: Validation

Dear Dr. Berenson,

Back in the middle of 1994, I was involved in the issues of Validation, Verification and Assurance (VVA), partially because of my work with the Congressional Office of Technology Assessment (OTA) and partially because of my role as the creator of two historical validation databases. Although my opinions have changed slightly (but only slightly) on the subject, I will forward to you the material I generated at that time. They include:

1. Letter to Dr. Brian McCue (OTA) dated 22 June 1994 of 5 pages.
2. Internal memorandum to Trevor Dupuy dated 28 July 1994 of 2 pages addressing some of his disagreements with my letter to Dr. Brian McCue.

According to what I know, only the following validations have been done:

1. Atlas (using 1940 Campaign in the West)
2. Vector (using undocumented turning runs)
3. QJM (by HERO using WWII and middle-east data)
4. Dr. Janice Fain's model (using HERO data)
5. CEM (by CAA using Ardennes Data Base)
6. SIMNET/JANUS (by IDA using 73 Easting data)
7. By Dr. Ralph Tom using exercises
8. FTLM (by Martin-Marietta/Oak Ridge)
9. TWISP (Korean data)

I am being polite in calling some of these validations. The only two validations I put a lot of credence in is the QJM validation in the 1970's and the CEM validation using Ardennes data that was completed last year. The Atlas validation of the France 1940 campaign is rumored to have resulted in the France winning and the analysts concluded that history has no relevance for modern combat. I don't know how valid this rumor is. The Vector validation used undocumented tuning runs to make sure the data fit according to Dr. James Taylor of the Naval Post–Graduate school. He has the documentation on that. The SIMNET/JANUS test is very strange because in the battle they choose, one side could not see or hit the other side. This results in the battle being a one–sided live fire exercise. Even then, my conclusion from reading the report was that the model was not validated, but indeed was sorely in error on such basic items as SSPKs and ammunition expenditure. FTLM has not been validated at all, but was simply a verification that was decreed to be a validation in the introduction of the report, even though the body of the report says otherwise. I forget who and what is the background on TWISP, but of course, one cannot get accurate Korean War data for the opposing side. I need to research this one better. Dr. Janice Fain also did some validation effort on a combat model she was working on some time in the 70s and also Dr. Ralph Tom's validated his model of man–to–man combat in defending a nuclear storage facility by conducting a series of field exercises.

I did bounce this list by Paul Davis of RAND several months ago, and his was not able to add any other validations to the list. I know that certain major models have never been validated. This includes JTLS (Joint Theater Level Simulation), that is used down in your neck of the woods by the Joint Warfare Center. You may want to wander over there and check this out for yourself. Validation of models is not being done, regardless of what the regulations say. This requirement will not be followed until such time as it is enforced by a policeman with a very big stick.

If you have any more questions, please call me at (703) 356-1151.

Sincerely,
Christopher A. Lawrence
Executive Director

---

22 June 1994

Dear Brian,

Thank you for the opportunity to attend the OTA review committee. I found the discussions on VVA to be particularly interesting. I found it frustrating that the panelists, who in some cases had clearly divergent views on the subject, neither stressed these views or debated the different points. There was actually nothing I would have liked to do more than leap into these discussions. As it would have been inappropriate for me to so, I remained quiet. But, over time, my thinking on the subject of VVA and the scientific process of combat modeling have clearly crystallized into a strong opinion that I would like to take this opportunity to express in writing for the first time.

**Verification, Validation and Assurance (VVA):**

1. VVA = QA. (Validation, verification and assurance equals quality assurance). In any production facility working on a government deliverable (say for example, General Dynamics Convair Division working on the cruise missiles), QA is an independent discipline with a very specific function. There are people specially trained for it, they are in a department under a separate vice-president, quite independent from the production and program personnel, and usually have some authority to review, approve, or reject the products being produced by the rest of the company. This QA function in large facilities is further supplemented hy an in-house DCAS representative who is also a QA spe-

cialist representing the government. One estimate I heard was that QA usually made up 15 of the cost of an engineering project.

The Verification part of VVA is simply that QA step, which currently does not systematically exist for modeling. Verification should be planned as a on-going effort in any major modeling project, should be done by personnel independent of the project, and should have adequate money set aside to conduct the verification. While there is no need to place a hard and fast budget figure for VVA nor certify VVA engineers, the Defense Department needs to establish the habit (culture?) of conducting an independent verification is for every major modeling effort. The requirement to do this and certain minimum goals or standards should be clearly spelled out in internal DOD regulations. As there is no use in having a rule without an enforcer, some office should be assigned responsibility to make sure that VVA is conducted for every major modeling effort.

2. Validation needs to be done for all major models that are used in any predictive mode. This certainly includes JANUS, CEM, JTLS etc. Models used to develop "intellectual insights" do not need to be validated, but should not be used for any other purpose. I cannot think of a single model that is used simply to develop "intellectual insight." Certainly any model that will be predicting war outcomes, or forecasting ammunition expenditures needs to be validated.

3. Validation must be done by or with the help of an independent organization. This organization's independence is more important for validation than it is for verification. During a verification effort, at least the "verifier" and the project personnel will usually have a common goal of making sure the work was done correctly. In a validation effort, there may be no common ground and widely different perceptions of what is correct.

4. For models forecasting combat results (casualties, ammunition expenditures, or whatever), they must be able to be validated to history in addition to any other validation tests that may be appropriate.

Amid all the discussions of high tech weapons, what is often overlooked is that most of the weapons currently used are either updated WWII type weapons, or linear descendants of such. The organizations employing those weapons are structurally and doctrinally linear descendants of the WWII US Army organizations, and the personnel using them are similar (and in some case direct descendants) of the people who used them in WWII. When doing a simulation of modern combat, the majority of the elements employed are similar and directly descendent from those elements used in WWII. As such, any model for future combat, if the high tech weapons are stripped out, should be an entirely adequate model of WWII combat. If such a model cannot model WWII combat with is low-tech weapons, then one must question its ability to model any combat. While being able to model the past does not prove that it can model the future, not being able to model the past raises serious question whether the model can model anything.

The other main objection I hear to using historical data for validation is that combat is stochastic and that a battle represents just one point on the curve of possibilities. This is a semantic argument that is not looking deep enough into the subject.

Let us assume for a moment that the actions of any one person is unpredictable. If these people behave with any patterns, any norms or any societal conditioning, then there will be norms and patterns of behavior that will appear across most groups of people. Combat is conducted with groups of these people. If I have 10,000 people in a unit, these groups of people should behave in some definable patterns. Even if the patterns are weak, the sheer size of the samples should provide a bell-curve of possible results, and a range of expected results. If I have 10,000 of these unpredictable people engage 1,000 opposing unpredictable people, the difference in the ratios should alone produce a result that is different than pure chance.

If I give these people a little training, a little target practice, organize them in units, provide them with a doctrine, then their unpredictability declines considerably. If fact, I would expect that while I still could not predict the actions of individuals, nor those of their commanders, if a placed them in combat against 10,000 untrained unpredictable people, I would more often than not get an expected result.

While one cannot rule out the role of the individual in combat, especially as a commander, and while one cannot rule out the occasionally significant and unpredictable events, on most days with most units, you can expect a predictable result from combat. With large numbers of individuals, combat is deterministic with stochastic elements. This is considerably different than considering combat stochastic.

As you know, I have been in charge of assembling one data base of the Ardennes Campaign for the US Army Concepts Analysis Agency and am currently program manager for the second campaign data base to be assembled for them on the Battle of Kursk. In your viewgraphs presented today, you summarized the stochastic argument against validation as "N=l." As best as I can understand the argument (and in all honestly, I neither understand nor appreciate this argument), there is no value in validating a model to a historical campaign because there is only one known outcome out of many possible ones. I can only project from this argument that the person would only find a historical validation useful if we validated the model to a statistically significant sample of hundreds of campaigns.

But, an engagement consists of large numbers of men involved on each side. This aggregated data (the engagement) is repeated multiple times in a division in a day. This probably makes the division versus division battles somewhat deterministic. In the campaign data bases I have assembled, the division has been the basic unit that is "tracked" in the data base. In the case of the Ardennes Campaign Simulation Data Base, there are 79 divisions involved

ing combat over 30 days. Assuming that one division faces its equivalent to two-sided combat, then the data base has around 2,200 division days of combat to build the "probability curve" out of. This creates a number far larger than "N=l". For the Kursk data base, I estimate when it is complete there will be another 1,000 division days to work from, in addition to a large number of independent regiments and brigades. There are also other historical data bases to draw from besides these two. So in addition to validating the model to the data base, you also validate it to the individual combats, the aggregated combats and the means and modes of selected combats under selected conditions. In the case of the two campaigns, they were both fairly one sided. I would be surprised if any model would have the Germans roaring across the Meuse and on towards Brussels or the Germans slicing through the mass of Soviet units and penetrating to Oboyan, let alone all the way to Kursk. In both of these campaigns, the "N=l" result that came about was pretty much what you would expect given the starting forces.

5. Finally, probably the best way to execute effective VVA is to establish a separate agency within DOD (or each service) in charge of assisting in VVA efforts for all major models in the armed forces (or its individual service). This agency should be manned with people knowledgeable in the field and should be organizationally separate from any command producing or relying on models.

One of the problems involved in validating any model is that considerable time is required to learn the model, and some time is required to run it. As the experts are the people who designed it, and often they are the only ones knowledgeable to run it, than all VVA efforts should be a cooperative effort using a mixed staff of people from the VVA agency and the actual modelers who designed it. Needless to say, the report or analysis of the validation effort should be produced by the VVA Agency, vice the operating agency.

I doubt anything less than this will produce effective validation. The issue of validation has been discussed in the industry now for at least 20 years. To date, I only know of two validation efforts (both US Army). One appears seriously flawed and the other one I do not have the ability to validate (even though it used the Ardennes Data Base that I helped to assemble). Neither were done by an independent agency from the model's regular user. There is a point that to get anything done, one must quit discussing the details of how it should be done, and simply assign someone to do it, and give them the authority and resources to go forward.

6. I have no comments on the subject of assurance.

**THE SCIENTIFIC METHOD AND MODELING:**

1. The fundamental problem with the models being built for the purpose of forecasting is that no one has ever systematically assembled and analyzed the data on combat. Therefore, we don't know what really happens and what is really true. Even "sciences" as soft as economics have a "Law of Supply and Demand" (although it is certainly not a "law"). Military science does not know for certain if morale is to material as three is to one. Although most serious students realize this is probably true, it has neither been proven nor measured. The same for "defense is the stronger form of combat", the effects of suppression, the causes of breakpoints, the degradation effects of the combat environment, etc. None of the basic pieces that make up a model have been systematically proven or measured.

2. The models therefore are not built upon any established, accepted and provable pieces of data. In effect, all models are simply somebody's assumptions, guesses and judgements, that have been quantified and buried in computer code.

3. There is no lack of data to work from. It is complex, hard to assemble, and time-consuming to assemble and analyze (read "expensive"). But data does exist on combat, combat operations and the effects of combat, and exists in large amounts, although not always in the form that the user desires.

4. Combat data is difficult to analyze. It has a wide range of variability, has stochastic elements to it, has a very high number of significant independent variables, and those "independent" variables often cross correlate with each other. It is a very complex problem, probably more difficult to solve than sending a man to the moon.

5. To develop a base from which to build combat models from requires some form of understood norms, hypotheses and theories established and supported by data. To attempt to build a model without such a base is nothing less than quantifying opinion.

6. To build such a base requires "pure research" or "pure science". In the practical world, these means that some agency needs to fund one or more groups to assemble the large amount of data required to analyze this complex problem. This data needs to then be analyzed by one or more groups (the same or different groups) to identify patterns and norms. They may even be able to support such notions as "moral is to material as 2.76 is to 1".

7. To conduct such research required a steady multi-year funding effort among one or more research groups for the purpose of having them discover anything that is discoverable from this data. This large effort would eventually over time and repeated testing, determine what is knowable. What is then knowable could be incorporated in the model designs, reducing the judgement and increasing the quality.

Sincerely,
Chris Lawrence

28 July 1994

To: Trevor
From: Chris
Subject: VVA

1. Thanks for taking a look over my write-up. I will probably have one on John Kettelle's paper, which I found very interesting, in a couple of more days.

2. To clarify a point, I do not feel that validation is more important than verification. I just realize that the resistance to validation in the community will be much higher than the resistance to verification. In fact, I suspect most organizations will set up a verification program, label it "VVA" and claim that they have taken care of all validation, verification and assurance.

3. There is considerable resistance to validation within the community. I have encountered it in CAA and heard similar arguments put forward at the OTA meeting. While there may be some intellectual validity to their arguments (although I have yet to see any), and they may sincerely believe in what they say, the result of their arguments is to torpedo any validation efforts.

4. There are already software quality assurance (QA) procedures, software documentation standards, and software configuration management standards. These, if properly implemented, make it possible to do the verification of the software within the models. Any really good software QA process should also determine whether or not the software does what it was written to do. This is the essence of verification. The problems of verification can be solved by using established industry QA procedures. I suspect, as many of these models are made by "paper shops" and FFRDC's, they are not used to operating under a formal QA system the same way as hardware manufacturers are, and therefore this is not being done.

5. If an organization has a good internal, aggressive, independent QA organization, then verification should not be a problem. It is in the long term interest of the program managers, model designers, and the QA people to conduct the verification properly. Of course, it may not be in their short-term interest (schedule and budget!). But validation must be conducted by an outside and independent agency, for if the model is really bad, it is not in interest of the using or designing organization to confirm this.

6. So, it is not that I consider validation more important, but it is just that the only way to get a proper validation program going will be to create an independent agency for such. Socrates' "gadfly" as it is. An independent agency to do verification is not necessary, although it would be helpful. The real danger is that these organizations will set up verification efforts disguised as VVA and effectively bury the very necessary validation efforts that should be done.

7. As for Brian, I would recommend that you write him. I believe Dr. McCue is already aware of my opinions. I think I discussed it with him several years ago. I suspect he also knows your position. Finally, I suspect that his position is not far from ours, if he is not already in agreement. The real question for him is whether an OTA report is the proper forum to raise this issue. My recommendation to him would be to add an appendix to the OTA report (perhaps to Linda Voss' paper) detailing the reasons, recommendations, and how a truly independent VVA agency would be established. If OTA wishes to pursue such an recommendation, than it would probably be useful to obtain support and signatures from other people within the community.

8. If an OTA report is not the proper forum, than perhaps you should prepare an independent "report" for Congress, obtaining support and signatures from other major names in the community.

9. I'll probably provide a copy of this memo to Brian and Linda Voss.

# Military History and Validation of Combat Models

## *A Presentation at MORS Mini–Symposium on Validation, 16 Oct 1990*

**by Trevor N. Dupuy**

In the operations research community there is some confusion as to the respective meanings of the words "validation" and "verification." My definition of validation is as follows:

"To confirm or prove that the output or outputs of a model are consistent with the real-world functioning or operation of the process, procedure, or activity which the model is intended to represent or replicate."

In this paper the word "validation" with respect to combat models is assumed to mean assurance that a model realistically and reliably represents the real world of combat. Or, in other words, given a set of inputs which reflect the anticipated forces and weapons in a combat encounter between two opponents under a given set of circumstances, the model is validated if we can demonstrate that its outputs are likely to represent what would actually happen in a real-world encounter between these forces under those circumstances.

Thus, in this paper, the word "validation" has nothing to do with the correctness of computer code, or the apparent internal consistency or logic of relationships of model components, or with the soundness of the mathematical relationships or algorithms, or with satisfying the military judgment or experience of one individual.

True validation of combat models is not possible without testing them against modern historical combat experience. And so, in my opinion, a model is validated only when it will consistently replicate a number of military history battle outcomes in terms of: (a) Success-failure; (b) Attrition rates; and (c) Advance rates.

"Why," you may ask, "use imprecise, doubtful, and outdated history to validate a modern, scientific process? Field tests, experiments, and field exercises can provide data that is often instrumented, and certainly more reliable than any historical data."

I recognize that military history is imprecise; it is only an approximate, often biased and/or distorted, and frequently inconsistent reflection of what actually happened on historical battlefields. Records are contradictory. I also recognize that there is an element of chance or randomness in hurnan combat which can produce different results in otherwise apparently identical circumstances. I further recognize that history is retrospective, telling us only what has happened in the past. It cannot predict, if only because combat in the future will be fought with different weapons and equipment than were used in historical combat.

Despite these undoubted problems, military history provides more, and more accurate, information about the real world of combat, and how human beings behave and perform under varying circumstances of combat, than is possible to derive or compile from any other source. Despite some discrepancies, patterns are unmistakable and consistent. There is always a logical explanation for any individual deviations from the patterns. Historical examples that are inconsistent, or that are counter-intuitive, must be viewed with suspicion as possibly being poor or false history.

Of course absolute prediction of a future event is practically impossible, although not necessarily so theoretically. Any speculations which we make from tests or experiments must have some basis in terms of projections from past experience.

Training or demonstration exercises, proving ground tests, field experiments, all lack the one most pervasive and most important component of combat: Fear in a lethal environment. There is no way in peacetime, or non-battlefield, exercises, tests, or experiments to be sure that the results are consistent with what would have been the behavior or performance of individuals or units or formations facing hostile firepower on a real battlefield.

We know from the writings of the ancients (for instance Sun Tze—pronounced Sun Dzuh—and Thuycidides) that have survived to this day that human nature has not changed since the dawn of history. The human factor the way in which humans respond to stimuli or circumstnces is the most important basis for speculation and prediction. What about the "scientific" approach of those who insist that we can have no confidence in the accuracy or reliability of historical data, that it is therefore unscientific, and therefore that it should be ignored? These people insist that only "scientific" data should be used in modeling.

In fact, every model is based upon fundamental assumptions that are intuitive and unprovable. The first step in the creation of a model is a step away from scientific reality in seeking a basis for an unreal representation of a real phenomenon. I have shown that the unreality is perpetuated when we use other imitations of reality as the basis for representing reality. History is less than perfect, but to ignore it, and to use only data that is bound to be wrong, assures that we will not be able to represent human behavior in real combat.

At the risk of repetition, and even of protesting too much, let me assure you that I am well aware of the shortcomings of military history:

The record which is available to us, which is history, only approximately reflects what actually happened. It is incomplete. It is often biased, it is often distorted. Even when it is accurate, it may be reflecting chance rather than normal processes. It is neither precise nor consistent. But, it provides more, and more accurate, information on the real world of battle than is available from the most thoroughly documented field exercises, proving ground tests, or laboratory or field experiments.

Military history is imperfect. At best it reflects the actions and interactions of unpredictable human beings. We must always realize that a single historical example can be misleading for either of two reasons: (1) The data may be inaccurate, or (2) The data may be accurate, but untypical.

Nevertheless, histoy is indispensable. I repeat that the most pervasive characteristic of combat is fear in a lethal environment. For all of its imperfections, military history and only military history represents what happens under the environmental condition of fear.

Unfortunately, and somewhat unfairly, the reported findings of S.L.A. Marshall about human behavior in combat, which he reported in *Men Against Fire*, have been recently discounted by revisonist historians who assert that he never could have physically performed the research on which the book's findings were supposedly based. This has raised doubts about Marshall's assertion that 85% of infantry soldiers didn't fire their weapons in combat in World War II. That dramatic and surprising assertion was first challenged in a New Zealand study which found, on the basis of painstaking interviews, that most New Zealanders fired their weapons in combat. Thus, either Americans were different from New Zealanders, or Marshall was wrong. And now American historians have demonstrated that Marshall had had neither the time nor the opportunity to conduct his battlefield interviews which he claimed were the basis for his findings.

I knew Marshall, moderately well. I was fully as aware of his weaknesses as of his strengths. He was not a historian. I deplored the imprecision and lack of documentation in *Men Against Fire*. But the revisionist historians have underestimated the shrewd journalistic assessment capability of "SLAM" Marshall. His observations may not have been scientifically precise, but they were generally sound, and his assessment has been shared by many American infantry officers whose judgements I also respect. As to the New Zealand study, how many people will, after the war, admit that they didn't fire their weapons?

Perhaps most important, however, in judging the assessments of SLAM Marshall, is a recent study by a highly-respected British operations research analyst, David Rowland. Using impeccable OR methods Rowland has demonstrated that Marshall's assessment of the inefficient performance, or non-performance, of most soldiers in combat was essentially correct. An unclassified version of Rowland s study, "Assessments of Combat Degradation" appeared in the June 1986 issue of the *Royal United Services Institution Journal*.

Rowland was led to his investigations by the fact that soldier performance in field training exercises, using the British version of MILES technology, was not consistent with historical experience. Even after allowances for degradation from theoretical proving ground capability of weapons, defensive rifle fire almost invariably stopped any attack in these field trials. But history showed that attacks were often in fact, usually successfu1. He therefore began a study in which he made both imaginative and scientific use of historical data from over 100 small unit battles in the Boer War and the two World Wars. He demonstrated that when troops are under fire in actual combat, there is an additional degradation of performance by a factor ranging between 10 and 7. A degradation virtually of an order of magnitude! And this, mind you, on top of a comparable built-in degradation to allow for the difference between field conditions and proving ground conditions.

Not only does Rowland's study corroborate SLAM Marshall's observations, it showed conclusively that field exercises, training competitions and demonstrations, give results so different from real battlefield performance as to render them useless for validation purposes.

Which brings us back to military history. For all of the imprecision, internal contradictions, and inaccuracies inherent in historical data, at worst the deviations are generally far less than a factor of 2.0. This is at least four times more reliable than field test or exercise results.

I do not believe that history can ever repeat itself. The conditions of an event at one time can never be precisely duplicated later. But, bolstered by the Rowland study, I am confident that history paraphrases itself.

If large bodies of historical data are compiled, the patterns are clear and unmistakable, even if slightly fuzzy around the edges. Behavior in accordance with this pattern is therefore typical. As we have already agreed, sometimes behavior can be different from the pattern, but we know that it is untypical, and we can then seek for the reason, which invariably can be discovered.

This permits what I call an actuarial approach to data analysis. We can never predict precisely what will happen under any circumstances. But the actuarial approach, with ample data, provides confidence that the patterns reveal what is to happen under those circumstances, even if the actual results in individual instances vary to some extent from this "norm" (to use the Soviet military historical expression.).

It is relatively easy to take into account the differences in performance resulting from new weapons and equipment. The characteristics of the historical weapons and the current (or projected) weapons can be readily compared, and adjustments made accordingly in the validation procedure.

In the early 1960s an effort was made at SHAPE Headquarters to test the ATLAS Model against World War II data for the German invasion of Western Europe in May, 1940. The first excursion had the Allies ending up on the Rhine River. This was apparently quite reasonable: the Allies substantially outnumbered the Germans, they had more tanks, and their tanks were better. However, despite these

Allied advantages, the actual events in 1940 had not matched what ATLAS was now predicting. So the analysts did a little "fine tuning," (a splendid term for fudging). After the so-called adjustments, they tried again, and ran another excursion. This time the model had the Allies ending up in Berlin. The analysts (may the Lord forgive them!) were quite satisfied with the ability of ATLAS to represent modern combat. (Or at least they said so.) Their official conclusion was that the historical example was worthless, since weapons and equipment had changed so much in the preceding 20 years!

As I demonstrated in my book, *Options of Command*, the problem was that the model was unable to represent the German strategy, or to reflect the relative combat effectiveness of the opponents. The analysts should have reached a different conclusion. ATLAS had failed validation because a model that cannot with reasonable faithfulness and consistency replicate historical combat experience, certainly will be unable validly to reflect current or future combat.

How then, do we account for what I have said about the fuzziness of patterns, and the fact that individual historical examples may not fit the patterns? I will give you my rules of thumb:

a. The battle outcome should reflect historical success-failure experience about four times out of five.

b. For attrition rates, the model average of five historical scenarios should be consistent with the historical average within a factor of about 1.5.

c. For the advance rates, the model average of five historical scenarios should be consistent with the historical average within a factor of about 1.5.

Just as the heavens are the laboratory of the astronomer, so military history is the laboratory of the soldier and the military operations research analyst. The scientific basis for both astronomy and military science is the recording of the movements and relationships of bodies, and then analysis of those movements. (In the one case the bodies are heavenly, in the other they are very terrestrial.)

I repeat: Military history is the laboratory of the soldier. Failure of the analyst to use this laboratory will doom him to live with the scientific equivalent of Ptolomean astronomy, whereas he could use the evidence available in his laboratory to progress to the military science equivalent of Copernican astronomy.

# The Problems of Validating Models to Other Models or to Test Data

**by Christopher A. Lawrence**

In his letter, Dr. Berenson refers to "...validation through comparisons with properly validated models, or combat, NTC or test data..." Obviously the best thing to validate a model to is current combat data. For many reasons, this is often not possible or practical. Therefore, people have looked at validating models by other methods. These other methods have problems that are often overlooked or not fully appreciated. They include validating to a properly validated model, NTC, or test data. Dr. Berenson very correctly states that the "argument that models are implicitly validated by widespread use isn't valid." I had heard rumors that people have seriously proposed this idea in MORS meetings. I assume the idea has died a natural and deserved death.

Let me preface my comments with the statement that my intersection with the modeling community is only in the area of force–on–force models. Much of what I say may not be relevant for other types of models.

Validating a model to another model makes little sense except as an expedient to save time and money. If I have validated the "properly validated model" to data, then why not just use that same data to validate the next model? An intermediary is not needed and could only serve to confuse the issue. We can probably assume that no combat model will ever validate perfectly. It will never match combat data point by point. This means there will be a certain amount of random error compared to the real world, and most likely there will be areas in which the model will tend to under–predict and areas in which the model will tend to over–predict. But if it is in the ball park, then it is validated. But when you validate one model to another, it may make errors in the same direction as those your baseline model is making, indicating a higher degree of fit to the real world data than actually exists. It may also make errors in the opposite direction. In the case where the validated model was over–predicting and the model to be validated was under–predicting (or vice versa), both models could be in the ball park, but the validation would show the second model significantly in error to the first.

Furthermore, some models certainly make counterbalancing errors, where the over–prediction in one error is countered by the under–prediction in another, resulting in a good final output. A good validation effort needs to be more than a simply pass/fail test. If the model to be validated to is being compared to other parts of the other model (say a tactical model is being compared to the tactical part of a model that does tactical and operational combat), then this can also cause problems with the veracity of the validation.

Finally, of course, if the model you are trying to validate is differing from the data being validated to, the problem can always be with the validation data. If you are validating to another model, then you are left with no choice but to go back to the original data anyway.

I personally know of no models that have been validated to other models. I would be interested in knowing of anyone who has done this, why they did this, and why they didn't use the original validation data.

While validation of a combat model to National Training Center (NTC) data may look reasonable on the surface, is not always the best. Training is not combat. In combat, the primary goal of many of the soldiers is to survive the experience. In training, surviving the experience is not an issue. Quite simply, you do not lose much if you "die" during a training exercise. This is very different from the real world. In combat, people will be far more cautious, for more concerned that they are covered and concealed, far less willing to advance, hastier in some actions, in some cases panicky. Training exercises will have higher rates of fire, more accurate fire, faster movement, quicker combat resolution and many other differences from real combat. As discussed in the work of David Rowland, these differences can be by a factor as much as 7 to 10 times to what would occur in a true combat environment. As such, any model validated to a training exercise is likely to produce casualties and advance rates that are simply too high by an order of magnitude.

I do know of one validation to a "training" exercise. Dr. Ralph Toms, formerly of Lawrence Livermore Laboratory, was developing a model of man–to–man combat to determine the minimum and optimum number of people to defend a storage facility. The number of defenders was 20 people or less. To validate his model, he actually took a recently evacuated facility that still had its standard guard team, and had it assaulted multiple times by a small special forces team. As a result of this validation exercise, he revised the model to serve as a better tool for his analysis. An interesting outcome of this validation is that the model as designed moved everyone about twice as fast as they did in the real world. This was because people within a model don't loiter, peek around corners, stop and adjust the straps on their packs, or slow to a walk when not moving in the open.

For the intended use of the model, which was to compare different defensive arrangements of storage facilities, this a good validation for the limited purposes for which the model is to be used. If one started to mutate this model into some form of small unit combat model, then it would have to be validated to some combat data. Ideally, this model should have been validated to combat data, but it would be extremely difficult to get the second–by–second combat data

that would be needed for such a model. But it could be tested to a well–documented commando operation at a more macro–level, like the raid on St. Nazaire, looking at the raid in 15 minute snapshots.

One interesting aspect of the validation is that by using field exercises, he was able to do multiple iterations of the "battle" to compare to the multiple iterations of the model. Of course, as a field exercise is still only a model of a battle, then you are basically still comparing a model to a model, albeit with a model that is clearly closer to the real world of combat.

Validating a combat model to test data has all the problems of validating a model to a training exercise, plus some. At least in a training exercise some of Clausewitz's friction in warfare appears (although not all). In a test environment, most of the friction in warfare will disappear. Unless the model is being used for some limited weapons comparison purposes, you are now validating a model against data that is only peripherally connected to the real world of combat.

Models designed from test data have even a greater potential for error from real world casualty rates. This means that for the model to be used for forecasting (and yes, Virginia, many models are used for forecasting), some type of severe dampening effect has to be designed into the model. I gather that many of the US Army models designed from AMSAA data have embedded this dampening effect somewhere in their code or design. How this dampening effect was derived, from what studies it came, and how it has been quantitatively measured, remain a mystery to me. I gather it is based on "expert" judgement.

Since receiving Paul Berenson's letter, two other validations methods have been brought to my attention. One is validation to expert judgement. My first thought is that if the experts could produce such great judgement, then why not just ask the experts to start with, and dispense with the models. It would certainly save a lot of money. But again, if one were using the models for training, and the goal and the use of the model was to create a realistic training environment, then an expert (meaning a combat veteran) would certainly be the person that could provide confirmation that it "feels right." Beyond that use, I am a little mystified as to when you would ever want to use "expert" judgement for validation. The other danger of expert validation is that the experts are simply brought in to sprinkle holy water on the effort without getting into the actual details of the model. Validation by expert judgement doesn't sound much different than "...models are implicitly validated by widespread use..."

The final and most intriguing validation methodology is the rumor I've heard that the SOTACA model was validated to the commercial wargame *Desert Fox*.

# "Model Creep" and Model Accreditation


## by Christopher A. Lawrence

In 1994, when I was preparing my memo on validation, I had never been involved in an accreditation issue, so I had no understanding nor interest in the subject. This has changed as a result of our using the TNDM for the Bosnia study.

As part of our forecast of potential US casualties in Bosnia, we modeled a deployment scenario and estimated the casualties based upon this scenario. This effort was headed by John Kettelle. Some of the scenarios that we were considering were up to brigade–level attacks on US positions. For our combat resolution, we used the TNDM. The TNDM had been used for battalion–level and company–level combat before, but this was the first time I had been involved in its use for such. After a discussion with Richard Anderson, I began to worry that we were using the model beyond it designed parameters. This led me to look into the use of the TNDM as a battalion–level model.

The TNDM was designed to model battalion– and company–level combat, but it was never tested or validated for such. In effect, it could do it, but we had no basis for knowing if it could do it right. The model had been validated to divisional–level combat and its use at a much lower level of combat had never been systematically tested (although it was not entirely untested). Fundamentally, this is the accreditation issue.

The danger here is "model creep," which is something like mission creep. A group of smart people design a model for a specific purpose, assemble data for that effort, test it, maybe even validate it, use it, and eventually get comfortable with it. They then start finding other subjects that the model can address until the model starts being used for something other than what it was originally designed for. As this can occur over a period of time, and often long after the original designers have moved onto greener pastures, the model may be creeping out of its validated use without the real awareness of the users. I can honestly state that this was what we were starting to do with the TNDM. I know that this has occurred elsewhere.

I believe the official definition of accreditation is "an official determination by management that an M&S is acceptable for a specific purpose." In the real world, especially in the commercial part of the real world, a significant part of the manager's job is to sell the organization's next job. As you must sell to eat, and usually eating takes priority over more mundane issues like the intellectual validity of your work, then "model creep" can become a major issue.

I particularly worry about it in the context of distributed interactive systems. The industry is starting to cobble together complex simulations using unrelated component parts to do new and better things. While these unrelated parts may indeed all be validated (although this is not always the case), the sum total of this effort, and the new purposes for which it is used for, also need to validated.

# The 76 Battalion–Level Engagements

## by Dave Bongard

The concept of "battalion–level engagement" has been employed relatively loosely here. As far as this list is concerned, a battalion–level engagement involves a force of no more than one reinforced battalion on one side, and a roughly comparable force on the other (ranging from a minimum of one company (+/-) to a maximum of one brigade/regiment). Broadly speaking, this produces manpower totals of 150 to 6,000.

The winning side or force is in italic boldface. An engagement with no indicated winner is a draw.

## *World War I*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Adv | Sc |
|---|---|---|---|---|---|---|---|---|---|---|
| Yvonne-Odette | 4/13/18 | StGr Grethe | 3072 | 71 | I&L/9 IRgt | 650 | 71 | 3.5 | 0.00 | T |
| Cantigny | 5/28/18 | ***28th Irgt*** | 8679 | 300 | II/272 IR | 725 | 386 | 2 | 1.60 | T |
| Hill 142 | 6/6/18 | ***5 Mar Rgt (-)*** | 2913 | 383 | II/273 IR (+) | 2458 | 471 | 8 | 0.90 | T |
| West Wd I | 6/6/18 | 3/5 Mar (-) | 1740 | 361 | ***I/461 IR*** | 1121 | 54 | 6 | 0.00 | T |
| Bourschs I | 6/6/18 | 6 Mar Rgt (-) | 2753 | 343 | II/461 IR | 1352 | 186 | 6 | 1.00 | T |
| West Wd II | 6/11/18 | ***2/5 Mar (+)*** | 3349 | 279 | I/461 IR (+) | 1798 | 541 | 12 | 1.60 | T |
| N Wood I | 6/12/18 | ***3/5 Mar (+)*** | 1740 | 167 | II/110 GrR | 1952 | 293 | 12 | 0.80 | T |
| Bourschs II | 6/13/18 | 109 IR (-/+) | 3690 | 138 | ***3/5 Mar (+)*** | 2629 | 107 | 3 | 0.00 | T |
| N Wood II | 6/21/18 | 1/7 IR | 1697 | 192 | ***III/347 IR (+)*** | 1428 | 18 | 4.5 | 0.00 | T |
| N Wood III | 6/23/18 | 3/5 Mar (+) | 1256 | 133 | ***I/347 IR*** | 1565 | 19 | 4 | 0.00 | T |
| N Wood IV | 6/25/18 | ***3/5 Mar (+)*** | 4453 | 273 | I/347 IR | 1546 | 437 | 11 | 0.70 | T |
| St. Amand F | 7/18/18 | ***2/28 IR (+)*** | 1150 | 120 | II/396 IRgt | 400 | 400 | 2 | 2.00 | T |
| Beaurpre F | 7/18/18 | ***2/23 IR (+)*** | 4480 | 125 | III/219 IR | 565 | 181 | 4 | 2.50 | T |
| Chaudun | 7/18/18 | ***3/18 IR (+)*** | 1611 | 130 | II/109 BGrR (+) | 800 | 500 | 12 | 3.50 | T |
| Berzy le Sec | 7/21/18 | ***28 IR (-/+)*** | 4000 | 210 | 109 IR (-/+) | 325 | 116 | 3.75 | 3.50 | T |
| Bouzancy Rdg | 7/21/18 | ***18 IR (-/+)*** | 5300 | 350 | II/52 JgrR | 554 | 276 | 4 | 1.50 | T |
| Medeah Far | 10/3/18 | ***2/9 IRgt*** | 1921 | 247 | I/235 ResIR | 155 | 83 | 2 | 3.10 | T |
| Essen Hook | 10/3/18 | ***1/5 Mar (+)*** | 1420 | 140 | 2/KolnLSAbt | 216 | 120 | 5 | 0.10 | T |
| Exermont-M | 10/4/18 | ***18 IR (+)*** | 5336 | 352 | elm 3 GdIR (+) | 3270 | 193 | 14 | 2.10 | T |
| Mayache R | 10/4/18 | ***26 IR (+)*** | 5427 | 376 | II/170 IR (+) | 1899 | 114 | 14 | 1.30 | T |
| La Neuville | 10/4/18 | ***28 IR (+)*** | 5365 | 340 | I/111 IR (+) | 1940 | 61 | 12 | 1.60 | T |
| Remilly-Aillicourt | 11/6/18 | ***1/16 IR*** | 1210 | 25 | 6 ResJgrBn (+) | 296 | 30 | 12 | 1.00 | T |
| Hill 252 | 11/7/18 | ***16 IR (-/+)*** | 1989 | 110 | 14 Res ID (-) | 1655 | 182 | 8 | 2.90 | T |

## *World War II*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Adv | Sc |
|---|---|---|---|---|---|---|---|---|---|---|
| Wake II | 12/23/41 | ***SNLF (+)*** | 1500 | 120 | det 1 MDBn | 430 | 85 | 7 | 1.25 | T |
| Makin Raid | 8/17/42 | ***2 MarRdrBn (-*** | 221 | 40 | 1 co (-) | 90 | 83 | 4 | 2.50 | T |
| Tenaru R I | 8/25/42 | Ichiki Force | 910 | 250 | ***2/1st Mar*** | 920 | 60 | 9 | 0.00 | T |
| Tenaru R 2 | 8/25/42 | ***1&2/1st Mar*** | 1823 | 48 | Ichiki Force | 664 | 541 | 8.5 | 3.60 | T |
| Edson's Rdg | 9/13/42 | Kawaguchi Frc | 3500 | 600 | 1 MarRBn (+) | 920 | 263 | 12 | 2.00 | T |
| Chouigui Pass | 11/26/42 | 190 Pz Bn | 465 | 30 | ***1/1/1 AD*** | 188 | 24 | 6 | 0.00 | T |
| Mte Maggio | 12/2/43 | ***36 Inf Div (-)*** | 5551 | 40 | 15 PGD & 29 PzD | 3288 | 15 | 48 | 2.40 | Q |
| Engebi Is | 2/18/44 | ***22 MarRgt (-)*** | 4125 | 303 | 1st AmBde (-) | 1276 | 1240 | 24 | 2.80 | T |
| Eniwetok | 2/19/44 | ***106 IRgt (-/+)*** | 2605 | 202 | 1st AmBde (-) | 1350 | 449 | 23 | 1.10 | T |
| Lausdell XRds | 12/17/44 | KG Müller | 3300 | 550 | 1/9 Inf (+) | 600 | 400 | 5.75 | 0.75 | T |
| Assenois | 12/26/44 | ***CCB/4 AD*** | 1800 | 80 | FusAbt 26 (+) | 650 | 470 | 5 | 8.50 | T |
| VER7BWx | 2/8/45 | ***7 BW/51 ID*** | 850 | 33 | 1 co/84 ID | 150 | 12 | 6 | 1.00 | T |
| VER57Gx | 2/8/45 | ***5/7 Gordons*** | 740 | 35 | 1.5 cos/84 ID | 200 | 12 | 6 | 1.70 | T |
| VER1BWx | 2/8/45 | ***1 Black Watc*** | 740 | 22 | 1.5 cos/84 ID | 220 | 18 | 12 | 2.75 | T |
| VER1HLx | 2/8/45 | ***1 HLI/53 ID*** | 740 | 14 | 1 F Co/84 ID | 150 | 15 | 12 | 5.70 | T |
| VER4RWx | 2/8/45 | ***4 R Welch Fu*** | 740 | 20 | 1 F Co/84 ID | 150 | 10 | 12 | 4.00 | T |
| VER1OBx | 2/8/45 | ***1 Ox&Bucks*** | 740 | 11 | 1 F Co/84 ID | 150 | 12 | 12 | 9.00 | T |
| VER1GHx | 2/8/45 | ***1 GH/15 ID*** | 740 | 21 | 1 F Co/84 ID | 150 | 12 | 6 | 12.90 | T |
| VER9Cx | 2/8/45 | ***9 Cameronian*** | 722 | 41 | 2 F Cos/84 ID | 154 | 12 | 6 | 12.25 | T |
| VER2ASx | 2/8/45 | ***2 A&S Hlndrs*** | 740 | 46 | 2.5 F Cos/84 ID | 370 | 26 | 12 | 5.30 | T |
| VERXHLx | 2/8/45 | ***10 HLI*** | 740 | 42 | 2.5 F Cos/84 ID | 370 | 25 | 12 | 9.20 | T |
| VERRDMx | 2/8/45 | ***RdM/2d C ID*** | 740 | 20 | 1 F Co/84 ID | 130 | 12 | 12 | 5.40 | T |
| VERCHx | 2/8/45 | ***Cal Hlndrs*** | 740 | 88 | 3 F cos/84 ID | 400 | 58 | 12 | 4.80 | T |

*see notes, next page*

## *Post-1945*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Adv | Sc |
|---|---|---|---|---|---|---|---|---|---|---|
| Tu-Vu | 12/9/51 | ***312 VMD (-/+)*** | 7000 | 1200 | 2 Mor cos (+) | 420 | 250 | 12 | 2.80 | T |
| Ninh Binh | 6/29/54 | ***elms GM.2*** | 850 | 26 | VM bn TF | 475 | 283 | 6 | 3.00 | Q+ |
| Cau Lanh | 8/28/63 | ***AR/CIDG TF*** | 500 | 3 | VC company (-) | 60 | 36 | 8 | 1.50 | Q+ |
| Cai Nuoc | 9/10/63 | ***VC 306 IBn*** | 500 | 16 | ARVN co TF | 150 | 60 | 1 | 1.25 | Q+ |
| ZDB050 | 9/10/63 | ***Sct/42 IR*** | 100 | 1 | VC company | 120 | 49 | 1 | 1.00 | Q+ |
| Mapu | 4/27/66 | Indo. Bn | 200 | 53 | ***B/2/Para*** | 75 | 7 | 2 | 0.00 | Q+ |
| Long Tan | 8/18/66 | VC force | 1500 | 700 | ***6 RoyAusRgt (+)*** | 900 | 39 | 6 | 0.00 | Q+ |
| Hill 450 | 11/10/66 | ***2/502 IBn*** | 850 | 51 | NVA 5/95 IRgt | 214 | 142 | 12 | 2.50 | Q+ |
| PrekKlok 1 | 2/28/67 | VC Bn TF | 500 | 292 | ***B/1/6th Inf*** | 164 | 53 | 4 | 0.00 | Q+ |
| PrekKlok 2 | 3/10/67 | VC 272 IR (-) | 1000 | 354 | ***2/2 (+), 1 ID*** | 1600 | 41 | 3 | 0.00 | Q+ |
| Buell II | 3/10/67 | NVA 273 IR | 2800 | 553 | ***3/22 (-), 25 ID*** | 400 | 27 | 3 | 0.00 | Q+ |
| ApBauBang 2 | 3/19/67 | VC 2726 IR | 900 | 403 | ***A/3/5 Cav*** | 150 | 66 | 8 | 0.00 | Q+ |
| Bir Gifgafa 1 | 6/8/67 | ***Eg 4 ArmdD*** | 3500 | 150 | Is Tal Div | 2000 | 50 | 2 | 1.50 | Q |
| Bir Gifgafa 2 | 6/8/87 | ***elm Tal Div*** | 3030 | 10 | Eg 4 Armd Div | 3350 | 300 | 1 | 3.00 | Q |
| Lo Giang 1 | 2/2/68 | NVA co TF | 350 | 136 | ***B/1/6th Inf*** | 120 | 32 | 1 | 0.00 | Q+ |
| Lo Giang 2 | 2/3/68 | ***1/6 Amcl ID*** | 500 | 47 | NVA bn TF | 800 | 403 | 4 | 2.50 | Q+ |
| Nui Ba Den | 8/18/68 | VC force | 400 | 32 | ***elm 25 ID*** | 180 | 28 | 2 | 0.00 | Q+ |
| Mt Hermon I | 10/8/73 | Is Gol. Bde | 2697 | 50 | ***Syr Para Bde*** | 1583 | 100 | 20 | 0.00 | Q |
| Goose Green | 5/28/82 | ***2/Para Rgt*** | 548 | 51 | 12 IRgt (+) | 1324 | 200 | 15 | 10.50 | T |
| Mt Harriet | 6/11/82 | ***42 RMCdo*** | 660 | 12 | 4th IR (-) | 400 | 325 | 8 | 3.50 | T |
| Two Sisters | 6/11/82 | ***45 RMCdo*** | 711 | 14 | B, Svc/4th IR | 400 | 53 | 4 | 3.00 | T |
| Mt Longdon | 6/11/82 | ***3/Para Rgt*** | 560 | 70 | B/7 IRgt (+) | 300 | 200 | 9 | 2.80 | T |
| Tumbledown | 6/13/82 | ***2/Scots Gds*** | 696 | 52 | 5th Mar Bn (+) | 900 | 100 | 11.25 | 3.50 | T |
| Wireless R | 6/13/82 | ***2/Para Rgt*** | 660 | 14 | 7th Inf R (-) | 650 | 60 | 8 | 3.50 | T |
| Salinas | 10/25/83 | ***US Rangers*** | 600 | 20 | Cubans/GARM | 754 | 220 | 12 | 4.00 | T |
| Pearls AF | 10/25/83 | ***USMC BLT*** | 500 | 2 | Gren Militia | 35 | 5 | 4.5 | 3.60 | T |
| Lomba | 3/10/87 | ***61 Mcz Bn*** | 1199 | 9 | FAPLA 47 Bde | 2264 | 120 | 24 | 0.50 | T |
| Cuatir River | 1/13/88 | ***RSA 20 Bde*** | 2706 | 23 | FAPLA 21 Bde | 2329 | 150 | 26 | 2.00 | T |
| Lipanda | 2/14/88 | ***4 SAI Rgt*** | 1213 | 2 | FAPLA 59 Bde | 2263 | 300 | 6 | 16.00 | T |
| TF Bayonet | 12/20/89 | ***5 Mcz Div TF*** | 3620 | 70 | Panama NG | 2300 | 94 | 45 | 3.00 | T |

Tu-Vu is described in some detail in Fall's *Street Without Joy* (pp. 51–53). The remaining Indochina/SE Asia engagements listed here are drawn from a QJM–based analysis of low–intensity operations (HERO Report 124, Feb, 1988).

The engagements listed here comprise 23 from World War I, 23 from World Was II, and 30 post–1945 battles, for a grand total of 76 engagements.

The coding for source and validation status, on the extreme right of each engagement line, is as follows. A "Q" (3 total) indicates an engagement which was part of the original QJM database, while a "Q+" (14 total) mark engagements which were analyzed as part of the QJM low–intensity combat study in 1988, and have recently been re–run with the TNDM. Finally, a "T" marks an engagement analyzed solely with the TNDM (57 total).

# The 112 Battalion–Level Engagements

## by Dave Bongard

The engagements listed below are "candidates" for TNDM analysis for validation of the TNDM for battalion-level actions.

This list (so far) provides 17 engagements from World War I, 7 interwar engagements, 20 from World war II, and 69 post-1945. The "Nicaraguan" engagements from the late 1920s involve 1–3 companies on each side, including both Marines and Nicaraguan government forces for the "good guys."

### *World War I era*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Front | Advance |
|---|---|---|---|---|---|---|---|---|---|---|
| Nuatja, T | 8/27/14 | Anglo-Fr | 750 | 73 | Schutzpolizei | 150 | 6 | 4 | 1.2 | 0.0 |
| Nsanakang K | 8/31/14 | Kam Schutzpn | 400 | 35 | Brit WA Regt | 236 | 144 | 3 | 1.0 | 1.0 |
| Sandfontein | 9/26/14 | SWA Schutzpn | 550 | 60 | SA/UK trps | 305 | 62 | 10 | 2.4 | 0.0 |
| Tanga 1 | 11/3/14 | Force B (-) | 3000 | 300 | Schutzpn | 450 | 25 | 12 | 1.6 | 1.0 |
| Longido | 11/3/14 | Kraut Schutzpn | 680 | 12 | Rhodesian trps | 1500 | 52 | 10 | 3.0 | 4.0 |
| Tanga 2 | 11/4/14 | Force B | 7700 | 517 | Schutzpn | 1150 | 123 | 12 | 2.4 | 0.0 |
| Yasimi | 1/18/15 | SchTr elms | 2000 | | BEA gar trps | 1000 | 200 | 10 | 3.5 | 2.0 |
| Bare, K. | 3/3/15 | GC Regt (+) | 800 | 148 | Kam Schutzpn | 500 | 104 | 5 | 1.6 | br |
| Trekkopjes | 4/26/15 | SWA Schutzpn | 710 | 41 | UK/SA Force | 650 | 42 | 5 | 1.2 | 0.0 |
| Bayo, K. | 11/4/15 | UK bde (-) | 1100 | 65 | Kam Schutzpn | 430 | 40 | 49 | 2.2 | 1.2 |
| Salaita Hill | 2/23/16 | SA Bde | 5820 | 452 | SchTr elms | 1270 | 53 | 10 | 6.0 | 0.0 |
| Lokisale | 4/5/16 | SA Mtd Bde | 1200 | 70 | Feldkompanie 28 | 180 | 150 | 5 | 1.2 | 2.0 |
| Makinda | 6/24/16 | UK bde (-) | 850 | 46 | Kraut gruppe | 500 | 87 | 1.5 | 3.5 | 1.6 |
| Narungombe | 7/19/17 | KAR & GCR | 1600 | 120 | 8x Feldkompanie | 2000 | 106 | 11 | 4.5 | 0.4 |
| Mahiwa | 11/17/17 | Beves' col. | 4900 | 2700 | 5x Feldkompanie | 1500 | 517 | 37 | 7.0 | 0.0 |
| The Rovuma | 11/25/17 | Schutztrpn | 1200 | 20 | Portugese Askari | 1000 | 620 | 3 | 3.0 | 3.0 |
| Nhamacurra | 7/1/18 | Schutztrpn | 2000 | 45 | Angol-Portugese | 1600 | 650 | 5 | 3.0 | 3.0 |

### *1919–1939*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Front | Advance |
|---|---|---|---|---|---|---|---|---|---|---|
| Ocotal | 7/16/27 | Sandino forces | 500 | 100 | Hatfield Cmd | 77 | 7 | 19 | 0.50 | 0.5 |
| Quilali 1 | 12/21/27 | Sandino forces | 350 | 20 | Livingston Col | 157 | 28 | 5 | 0.50 | 0.0 |
| Quilali 2 | 12/21/27 | Sandino forces | 200 | 12 | Richal Col | 60 | 10 | 40 | 0.25 | 0.0 |
| Nva Segovia | 2/27/28 | Sandino Gp | 20 | 15 | USMC patrol | 50 | 13 | 1.5 | 0.25 | 0.0 |
| Pingarron | 2/27/37 | AL bn/XV InfBn | 550 | 300 | Nat 4 Bde | 2000 | 400 | 20 | 2.00 | 0.2 |
| Jarama | 3/14/37 | Natnlst Bde | 600 | 100 | AL & Brit bn | 350 | 22 | 4 | 1.50 | 0.0 |
| Qunts Ebro | 8/24/37 | XV Int'l Bde | 2200 | 91 | Natnlst Bde | 2000 | 810 | 40 | 5.00 | 3.0 |

### *World War II*

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Front | Advance |
|---|---|---|---|---|---|---|---|---|---|---|
| Binalonan | 12/24/41 | 47th Inf (+) | 3000 | 600 | 26th Cav (+) | 900 | 350 | 14.5 | 3.00 | 2.50 |
| Quinauan 1 | 1/23/42 | 3d/1 Const. | 450 | 20 | bulk 2/20 IR | 600 | 12 | 8 | 1.00 | 0.30 |
| Quinauan 2 | 1/24/42 | 3d/1 Const. | 430 | 20 | bulk 2/20 IR | 588 | 12 | 10 | 0.85 | 0.02 |
| Lngskwyn 1 | 1/25/42 | Bridget USN bn | 580 | 30 | elm 2/20 IR | 300 | 12 | 8 | 0.50 | 0.00 |
| Lngskwyn 2 | 1/27/42 | Bridget bn (+) | 600 | 40 | elm 2/20 IR | 288 | 15 | 9 | 0.50 | 0.01 |
| Lngskwyn 3 | 1/28/42 | 2/57 PS (+) | 600 | 50 | elm 2/20 IR | 273 | 85 | 10 | 0.50 | 0.65 |
| Quinauan 3 | 1/28/42 | 3/45 PS (+) | 650 | 25 | bulk 2/20 IR | 576 | 8 | 10 | 0.85 | 0.09 |
| Lngskwyn 4 | 1/29/42 | 2/57 PS (+) | 550 | 30 | elm 2/20 IR | 178 | 150 | 7 | 0.50 | 0.40 |
| Quinauan 4 | 1/29/42 | 3/45 PS (+) | 725 | 50 | bulk 2/20 IR | 568 | 15 | 10 | 0.85 | 0.02 |
| Quinauan 5 | 1/30/42 | 3/45 PS (+) | 675 | 220 | bulk 2/20 IR | 553 | 140 | 60 | 0.85 | 0.05 |
| Quinauan 6 | 2/2/42 | 3/45 PS (+) | 455 | 70 | bulk 2/20 IR | 413 | 60 | 26 | 0.85 | 0.02 |
| Quinauan 7 | 2/4/42 | 3/45 PS (+) | 455 | 50 | bulk 2/20 IR | 353 | 200 | 9 | 0.80 | 0.30 |
| Corregidor | 5/5/42 | 61 IR (-/+) | 800 | 120 | 4th Mar (-) | 1115 | 200 | 10.5 | 0.40 | 1.28 |
| Arzew | 11/8/42 | 1 Rngr Bn | 550 | 14 | Vichy forces | 520 | 400 | 12 | 2.50 | 6.40 |
| Pte du Hoe | 6/6/44 | 2 & 5 Rngr Bns | 400 | 260 | elms 352 VGD | 400 | 300 | 72 | 4.00 | 5.00 |
| Hosingen | 12/16/44 | elms 26 VGD | 3000 | 85 | K(+)/110th Inf | 303 | 17 | 52 | 1.20 | 2.00 |
| Clervaux | 12/17/44 | elms 2d PzD | 4000 | 60 | HQ/110th Inf (-/+) | 700 | 250 | 15 | 2.40 | 3.00 |
| Wiltz | 12/19/44 | 5 FJD (-), PzLD (-) | 7500 | 186 | elms 28 ID | 1505 | 285 | 10.5 | 4.00 | 4.00 |
| Noville | 12/19/44 | elms 2d PzD | 8000 | 500 | TmC/CCB/10 AD (+) | 1120 | 380 | 20 | 3.00 | 2.00 |
| Parker's XRds | 12/23/44 | elms 2d SS-PzD | 6000 | 30 | elms 589 FABn | 120 | 85 | 2 | 1.20 | 1.50 |

# 1945–Present

| Engagement | Date | Attacker | Att Str | Att Cas | Defender | Def Str | Def Cas | Time | Front | Advance |
|---|---|---|---|---|---|---|---|---|---|---|
| UK Convoy | 3/11/46 | Indo Rebels | 1200 | 200 | 1/Patiala | 850 | 105 | 80 | 5.00 | 4.00 |
| Deskati | 9/24/46 | EAN force | 300 | 70 | GNA co (+) | 135 | 47 | 13 | 1.20 | 1.20 |
| Agrafa-Vini. | 9/18/47 | GNA TF | 1100 | 60 | EAN force | 375 | 40 | 7 | 3.00 | 0.00 |
| Mt. Vermion | 5/26/47 | EAN force | 700 | 20 | GNA Garrison | 400 | 54 | 6 | 1.50 | 0.00 |
| Florina 1 | 5/29/47 | EAN bn TF | 820 | 45 | GNA inf bn | 600 | 12 | 4.5 | 2.00 | 0.00 |
| Grevena | 7/25/47 | EAN lg TF | 1200 | 200 | GNA inf bn (+) | 640 | 34 | 6.5 | 3.00 | 0.00 |
| Kfar Etzion | 5/11/48 | elms Arab Leg (+) | 1500 | 300 | Haganah Garrison | 440 | 400 | 38 | 10.00 | 3.00 |
| Degania | 5/20/48 | Syr 1st Bde | 700 | 50 | Degania Garrison | 300 | 20 | 9 | 2.40 | 0.00 |
| Latrun 1 | 5/25/48 | Isr 7 Bde | 1200 | 300 | elms Arab Legion | 700 | 27 | 9 | 3.50 | 0.00 |
| Latrun 2 | 5/30/48 | Isr 7 Bde | 1900 | 250 | elms Arab Legion | 700 | 35 | 6 | 7.50 | 0.50 |
| Def. Negba | 7/12/48 | Egypt Army trps | 2000 | 200 | Negba Garrison | 140 | 20 | 10 | 1.60 | 0.00 |
| Iraq-el-Mnsh | 10/16/48 | Negev, 8 bdes | 900 | 85 | Egypt Army trps | 500 | 34 | 5.67 | 3.00 | 0.50 |
| Beersheba | 10/21/48 | IDF 8 Bde (-/+) | 2200 | 50 | Egypt Inf bn | 720 | 120 | 5.25 | 6.00 | 2.50 |
| TF Smith | 7/1/50 | NKPA 4th ID | 2400 | 120 | TF Smith (+)/24th ID | 540 | 185 | 7 | 2.20 | 2.50 |
| Alfonso Ridge | 8/15/50 | A/19/24th ID | 160 | 50 | u/i NKPA | 200 | 20 | 2.5 | 0.40 | 0.00 |
| Saga | 9/3/50 | u/i NKPA co | 120 | 45 | A/64 FABn | 130 | 19 | 1 | 0.50 | 0.00 |
| Chongju Pass | 10/29/50 | D/89 TkBn, 3 RAR | 900 | 30 | NKPA mecz TF | 400 | 60 | 3 | 1.50 | 0.70 |
| Chipyong-ni | 2/13/51 | PLA Inf Regt | 2500 | 500 | 2/23 Inf (+) | 920 | 110 | 30 | 1.10 | 0.40 |
| Chichong-ni | 4/23/51 | PLA Inf | 1200 | 400 | 92 AFAB (-/+) | 600 | 15 | 10 | 1.50 | 0.00 |
| Hill 800 | 5/17/51 | PLA Inf | | 4000 | 3/38th Inf | 750 | 30 | 3.8 | | 0.00 |
| MDollar Hill | 8/3/51 | PLA Inf | 400 | 75 | K/5th Inf | 150 | | 7.25 | 0.50 | 0.00 |
| My Coi | 7/1/54 | VM 9 IRgt (-) | 1200 | 110 | S/Gpt B. 2 | 642 | 13 | 5 | 5.00 | 0.00 |
| Kuseima | 10/30/56 | Isr Bn/4 IB | 600 | 26 | Egypt 6th IB (-) | 500 | 100 | 2 | 2.25 | 2.00 |
| Thamad | 10/30/56 | Isr elms 202 PB | 600 | 10 | 2 cos, DesFF | 250 | 25 | 2 | 2.00 | |
| Nakhl | 10/30/56 | Isr elms 202 PB | 400 | 0 | Egypt 2 MtzBdrBn | 200 | 35 | 0.42 | 2.50 | |
| Mitla Pass | 10/31/56 | Egypt 2d IB (-) | 1848 | 711 | Isr 202 PB (-) | 1000 | 188 | 24 | | 6.00 |
| Abu Aweigila | 10/31/56 | Isr 7th AB (-) | 950 | 10 | elm Egypt 6 IB | 600 | 40 | 3.5 | 1.75 | |
| Port Fuad | 11/5/56 | 2d RCP | 991 | 27 | elms Egypt 2d ID | 1000 | 88 | 12 | | 4.00 |
| Gamil Airfield | 11/5/56 | 3d Para Rgt | 780 | 40 | Egypt NG bn | 750 | 100 | 10 | | 5.00 |
| Agounnenda | 5/23/57 | 2d RCP | 700 | 37 | FLN Azedine | 300 | 105 | 60 | | 6.00 |
| Hassi Rhambou | 11/21/57 | 3,4/3d RCP | 300 | 20 | FLN Militia | 100 | 15 | 4 | | 2.00 |
| Jebel Akhdar | 11/26/59 | Sqn, 22d SAS | 200 | 3 | ORM coy | 180 | 25 | 1.75 | 3.00 | |
| N'djilli Airport | 7/13/60 | 2d Co/6 Cdo bn | 80 | 0 | ANC forces | 120 | 10 | 1 | 1.50 | |
| Boende | 7/17/60 | 2d Co (+)/6 Cdo | 225 | 0 | ANC forces | 100 | 5 | 1 | 1.50 | |
| Bunia Airfield | 7/17/60 | 1st/4 Cdo Bn | 150 | 0 | ANC forces | 80 | 4 | 0.25 | 1.20 | |
| Mongbwalu | 7/17/60 | C/1st/4 Cdo Bn | 30 | 4 | ANC roadblocks | 40 | 7 | 1.5 | 0.10 | |
| Niemba | 11/8/60 | Baluba Irr | 100 | 8 | Irish Patrol | 12 | 12 | 2 | | 0.20 |
| Bukavu | 11/15/60 | Nigerian TF | 112 | 0 | ANC force | 200 | 30 | 40 | | 1.00 |
| Bay of Pigs | 4/17/61 | Brig 2506 | 1453 | 1303 | Cuban Army | 3500 | 800 | 78 | 25.00 | 12.00 |
| Rotunda | 4/18/61 | Cuban TF | 2100 | 500 | Oliva's TF | 370 | 70 | 8 | 2.50 | 0.00 |
| San Blas | 4/18/61 | Cuban force | 1200 | 80 | 1 (Para) Bn | 180 | 100 | 54 | 1.00 | 1.75 |
| Sidi Ahmd AB | 7/19/61 | 2d RPIMar | 760 | 28 | Tun Army trps | 500 | 40 | 6 | | 3.00 |
| Bizerta | 7/21/61 | 3d RPIMar (+) | 1715 | 113 | Tun Army | 3000 | 650 | 24 | | 4.50 |
| Ap Bac I | 1/2/63 | ARVN 7 ID (-) | 7000 | 300 | VC elms | 600 | 100 | 8 | 10.00 | 0.00 |
| Tebedu PolS | 4/12/63 | Indo Plat. | 30 | 0 | Sar. Police | 15 | 3 | 0.5 | 0.10 | |
| Gumbang | 4/23/63 | IBT section | 15 | 5 | Pol+C/40 Cdo | 20 | 1 | 1 | 0.10 | |
| Rajang R. | 8/16/63 | TNI Plat (+) | 55 | 6 | patrol 2/8 GuR | 30 | 0 | 0.75 | 1.00 | |
| Rajang R. | 9/2/63 | Indo. Squad | 12 | 5 | plat 1/2 GuR | 35 | 1 | 0.25 | 0.10 | |
| Long Jawail | 9/28/63 | Indo. Coy | 135 | 0 | squad Gur/Po | 14 | 5 | 2 | 0.10 | |
| Long Jawail 2 | 10/2/63 | 11 Pl 1/2 GuR | 35 | 0 | Indo Pl. | 26 | 26 | 1 | 0.20 | |
| Kalabakan | 12/29/63 | Benny, Wyng grp | 72 | 5 | RMR & Police | 85 | 27 | 2.75 | 1.00 | 1.20 |
| nr LongPaSha | 1/23/64 | 2 sqd, 1/RLcst | 20 | 0 | IBT camp | 45 | 6 | 0.25 | 0.20 | |
| Track 6/6A | 3/7/64 | elm A, 2/10 GR | 75 | 2 | pl, TNI regs | 40 | 13 | 3 | 0.30 | |
| Kluah | 3/24/64 | A, 2/10 GuRfl | 140 | 3 | 2 pl TNI camp | 80 | 5 | 4 | 1.00 | |
| Batu Lintang | 6/15/64 | ap pn, 2/2 GR | 35 | 1 | IBT platoon | 50 | 15 | 0.75 | 0.50 | |
| base 1/6GR | 6/21/64 | IBT company | 100 | 7 | 2 pltns, 1/6 GR | 70 | 10 | 4 | 0.20 | |
| Stass ambs | 7/21/64 | 11 pn, 1/GuRfl | 35 | 0 | Ind Reg A pn | 30 | 11 | 0.1 | 0.10 | |
| Dragon Rdge 1 | 11/23/64 | Belg Para Cdo (-) | 600 | 7 | Simba rebels | 800 | 11 | 1.5 | | |
| Dragon Rdge 2 | 11/23/64 | Vandewalle Col | 700 | 12 | Simba rebels | | | 20 | | |
| Dragon Nr | 11/26/64 | Para Cdo Rgt (-) | 400 | 7 | Simba rebels | | | 34.17 | 2.00 | 6.00 |
| Pesiagnan | 1/2/65 | C, 1/2 GurRfl | 130 | 5 | Ind Army co (-) | 50 | 28 | 2 | | 0.30 |
| Duo My | 7/20/66 | 5th RAR (-/+) | 625 | 1 | VC forces | 100 | 6 | 12 | | 3.00 |
| FSB Blmrl 1 | 5/26/68 | VC Inf bn | 700 | 70 | 3d RAR (+) | 900 | 8 | 2 | | 1.50 |
| FSB Blmrl 2 | 5/28/68 | VC Inf bn (+) | 1000 | 120 | 3d RAR (+) | 900 | 9 | 2 | | 2.25 |
| Bhaduria | 12/10/71 | KumaonBn/20MtD | 850 | 300 | Pak Gar. TF | 300 | 120 | 18 | | 4.00 |
| Kolwezi | 5/19/78 | 2d REP (-) | 405 | 13 | CNLF rebels | 1000 | 175 | 5 | | 2.00 |
| Metal Shaba | 5/20/78 | 4/2d REP (+) | 385 | 3 | CNLF garrison | 400 | 80 | 8 | | 1.60 |
| Luilu 1 | 5/24/78 | elms 2d REP | 405 | 3 | CNLF group | 100 | 17 | 1 | | 1.50 |
| Honduras Border | 3/26/86 | elms Hond Army | 800 | | elms Nicarg Army | 1100 | | 24 | 5.00 | |

Notes to charts on previous pages:

* Strength and casualty data for Simba rebel forces for the three "Dragon" engagements in November 1964 will be forthcoming from Leavenworth Paper #14: *Dragon Operations: Hostage Rescue in the Congo, 1964–1965.*

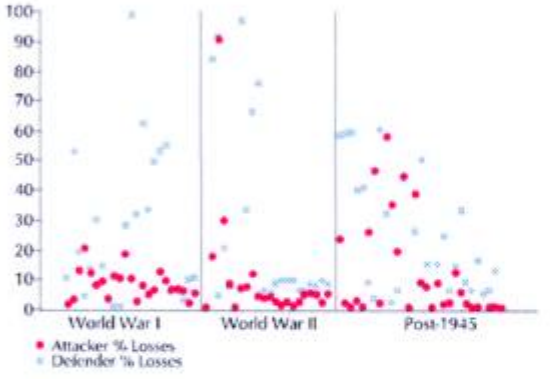
* Casualty figures for the Honduras Border engagement (1986) will require further research.

# Looking at Casualties using the BLODB

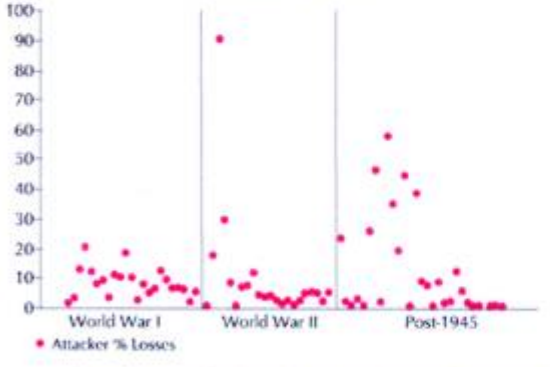

**by Christopher A. Lawrence**

In anticipation of the battalion–level validation, I took Dave Bongard's list of engagements, which in most cases listed the strength and losses for each side, and created the Battalion–Level Operations Data Base (BLODB). This was primarily to test the data to see if it was showing any unusual characteristics. This was from the original collection of 74 engagements, including 23 WWI, 22 WWII and 29 post–WWII engagements. As this was a preliminary look at the data, in some cases we had not completed the data for all these engagements, but all the graphs are assembled from over 140 data points.

Percent Battalion Losses by Period

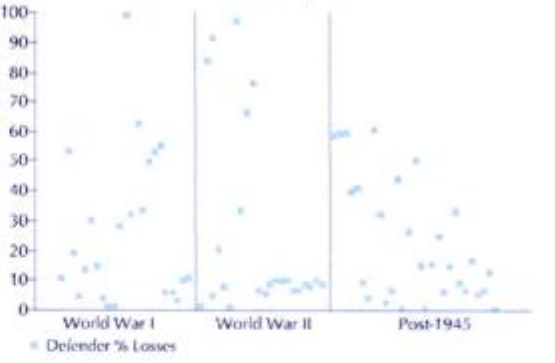



Percent Battalion Losses
Attacker, by Period




The first graph shows the percent losses for around 140 results, both attacker and defender. The second and third graph show the same information, but only showing either the attacker or the defender so any patterns are clearer. As can be seen, there appears to be no significant difference in loss rates from the World War II and modern periods. The

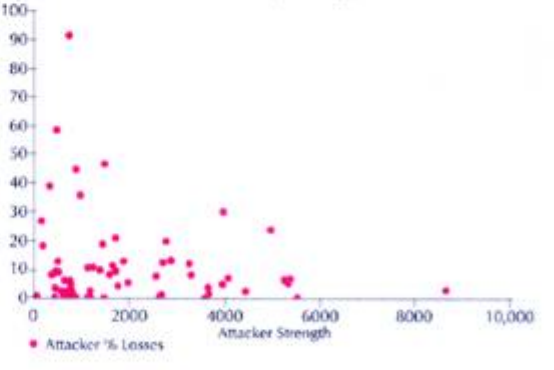
Percent Battalion Losses
Defender, by Period

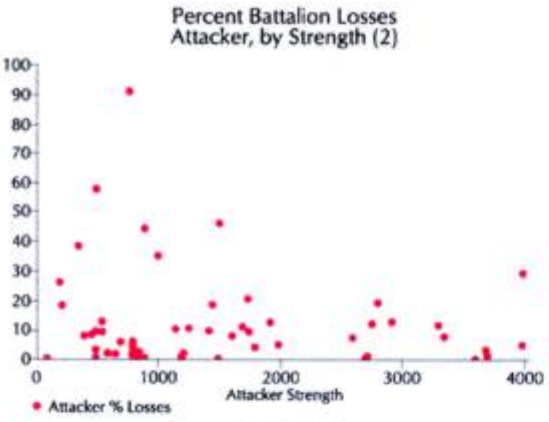


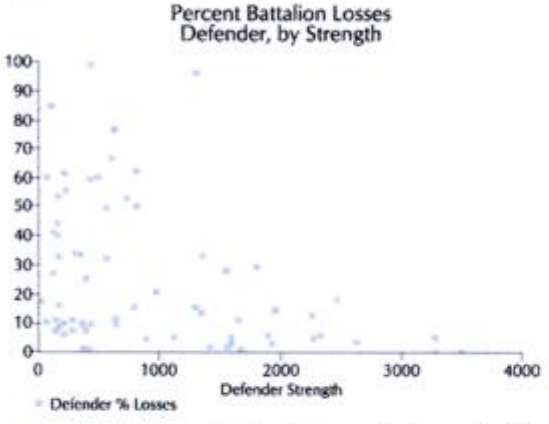

World War I rates do look a little higher. Most of the battles from World War I are larger unit actions, and larger units tend to suffer lower percent losses in combat than small units. This indicates a trend of higher losses in World War I data.

The next three graphs show the percent of losses based upon unit strength. There is a definite trend here, which has shown up in all of Trevor Dupuy's work. As discussed in the previous issue, the TNDM has tables in the model that account for casualties versus unit size (see the article in issue 3: "Exactly How the Unit Size Modifiers Are Calculated").

Percent Battalion Losses
Attacker, by Strength






The data used in the above graphs shows the following characteristics (number in parenthesis is the number of engagements that had good data):

| | WWI | WWII | Post-WWII |
|---|---|---|---|
| No. of Engagements | 23 | 22 (20) | 29 |
| Avg Attacker Strength | 3139 | 1542 | 1170 (28) |
| | | 1344 (20) | 1023 (25) |
| Median Attacker Strength | 2753 | 800 | 775 (28) |
| Avg Attacker Losses | 225 | 166 (20) | 163 (25) |
| Median Attacker Losses | 210 | 40.5 (20) | 32 (25) |
| Percent Avg Losses | 7.2 | 12.4 (20) | 15.9 (25) |
| Avg Defender Strength | 1275 | 602 | 771 |
| | | 477 (20) | 646 (26) |
| Median Defender Strength | 1352 | 335 | 400 |
| Avg Defender Losses | 211 | 158 (20) | 104 (26) |
| Median Defender Losses | 181 | 26 (20) | 60 (26) |
| Percent Avg Loss | 16.5 | 33.1 (20) | 16.1 (26) |

The next eight graphs, printed on the following pages, are:

1. Ratio of Attacker/Defender Strength versus Loss Ratio (Attacker/Defender)
2. Ratio of Attacker/Defender Strength versus Loss Ratio (Attacker/Defender), less 3 data points
3. Ratio of Attacker/Defender Strength versus Percent Loss
4. Ratio of Attacker/Defender Strength versus Percent Loss, less 3 data points
5. Ratio of Attacker/Defender Strength versus Loss Ratio (Defender/Attacker)
6. Ratio of Attacker/Defender Strength versus Loss Ratio (Defender/Attacker), less 5 data points
7. Ratio of Attacker/Defender Strength versus Percent Defender Loss/Percent Attacker Loss
8. Ratio of Attacker/Defender Strength versus Percent Defender Loss/Percent Attacker Loss, less 2 data points

These eights graphs were an attempt to see if there were any trends that could be deduced by comparing the attacker/defender strength ratios to the loss ratios. This was compared in four ways: the ratio of attacker to defender losses, the ratio of the percent of attacker to defender losses, and the inverses of those two ratios (defender to attacker). Basically what we got was noise. This did not surprise me, as when Trevor Dupuy did force ratio comparisons at the division level (see *Understanding War*), he also got noise. This does tend to raise questions about using Lanchester equations at this level of combat.

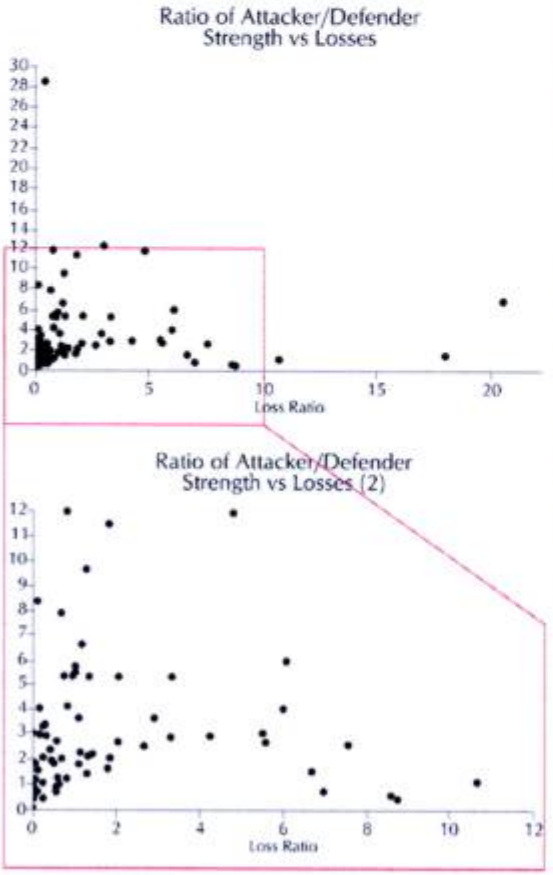
As our battalion–level data includes some fairly large engagements (up to around 3,000 people on one side), I looked at the engagements were we had a lower number engaged. This simply was done by applying a filter to the data base on force size. What we looked at were:

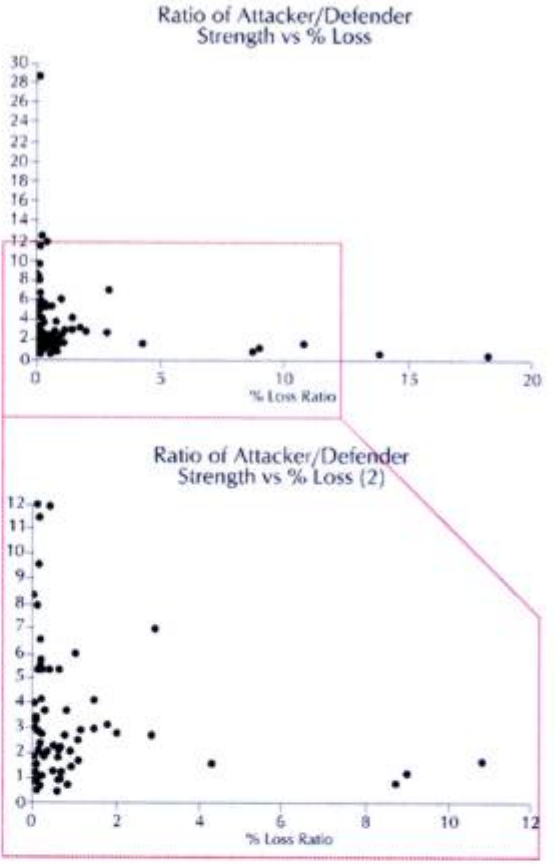
| Conditions | Number of Engagements |
|---|---|
| Both sides less than 2000 | 50 |
| Both sides less than 1600 | 41 |
| Both sides less than 1000 | 32 |
| Both sides less than 800 | 13 |
| Both sides less than 500 | 7 |

This resulted in 20 different graphs. I have not bothered to reprint them here. There was some hint of a pattern in the following graphs:

1. Ratio of Attacker/Defender Strength versus Percent Defender Loss/Percent Attacker Loss (50 cases, attacker and defender < 2,000
2. Ratio of Attacker/Defender Strength versus Loss Ratio (Attacker/Defender) (32 cases, attacker and defender <1,000, no WWI cases).
3. Ratio of Attacker/Defender Strength versus Loss Ratio (Defender/Attacker) (32 cases, attacker and defender <1,000, no WWI cases)
4. Ratio of Attacker/Defender Strength versus Percent Defender Losses/Percent Attacker Losses (32 cases, attacker and defender < 1,000, no WWI cases)
5. Ratio of Attacker/Defender Strength versus Loss Ratio (Defender/Attacker) (13 cases, 2 WWII and 11 post-WWII, attacker and defender <800).
6. Ratio of Attacker/Defender Strength versus Percent Defender Losses/Percent Attacker Losses (13 cases, 2 WWII and 11 post-WWII, attacker and defender <800).

The first graph tended to show an "upward" linear correlation between the Attacker/Defender Ratio and the Defender Percent Loss/Attacker Percent Loss Ratio. The second graph tended to show a linear correlation where the attacker/defender ratios was less than 3. This was an "upward" linear correlation between the Attacker/Defender Ratio and the Loss Ratio (Attacker/Defender). The third graph showed a "downward" linear correlation between the Attacker/Defender Ratio and the Loss Ratio (Defender/Attacker). In light of the previous graph, this is not surprising. The fourth graph shows a "downward" correlation between the Attacker/Defender Ratio and the Percent Defender Losses/Percent Attacker Losses. In the fifth and sixth graphs, we are well below any type of statistically significant number of samples, especially considering the fuzziness of the data. But two graphs showed some pattern. The fifth graph showed a slight "downward" correlation between Attacker/Defender Ratio and Loss Ratio (Defender/Attacker). The sixth chart showed a more noticeable "downward" correlation between Attacker/Defender Ratio and Percent Defender Losses/Percent Attacker Losses. Of note, fourteen of the graphs that I produced showed no discernable pattern that I could detect with my eye (a very precise measuring tool indeed).

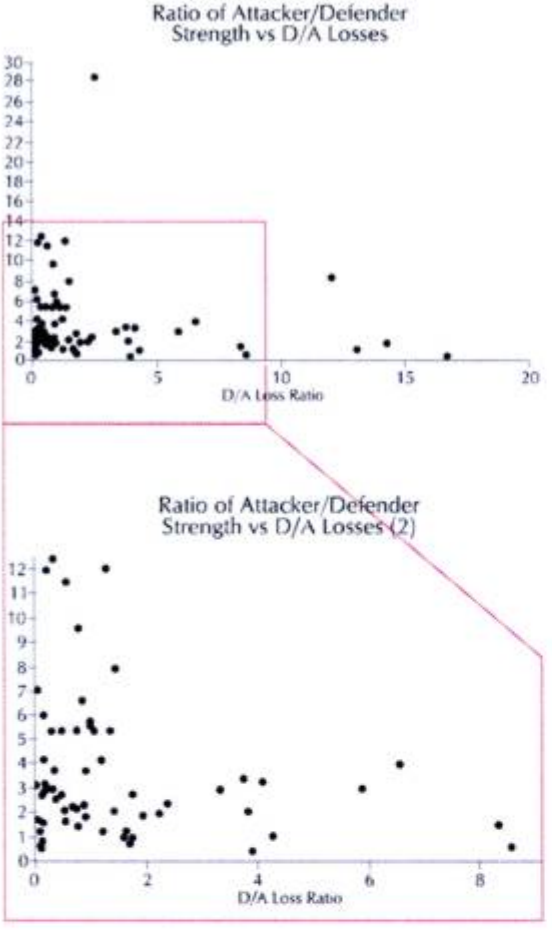


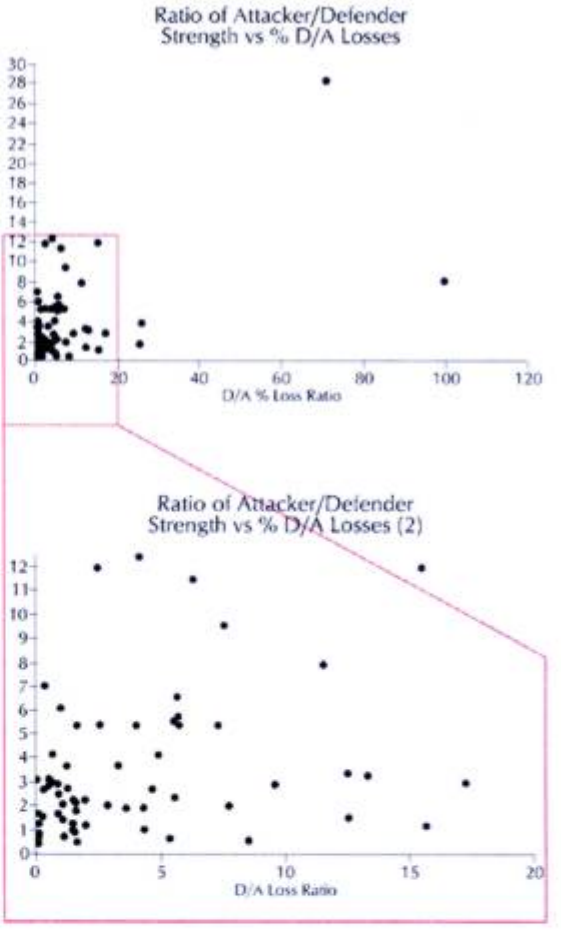




While there is a hint of pattern in the lowest level of the data, and at a statistically insignificant level, this most likely is noise. This could be tested further with considerable more effort that would require additional research. This is not on our corporate agenda at the moment.

What these charts show me is that there is no visible "Lanchesterian" type effects in battalion-level combat. If "Lanchester" effects show up in combat, it is probably at some level well below battalion. It would probably show up if we could test the Gunfight at the OK Corral, but the effect is not visible at any level of combat that we have been able to look at.

When the battalion-level data base is completed with all 188 engagements (giving us 376 data points), I would like to go back and retest this work. I would also like to do a proper statistical analysis and look for mathematical correlations. If time permits, we may also add these engagements to the LWDB.


Ratio of Attacker/Defender
Strength vs D/A Losses
D/A Loss Ratio


Ratio of Attacker/Defender
Strength vs % D/A Losses
D/A % Loss Ratio

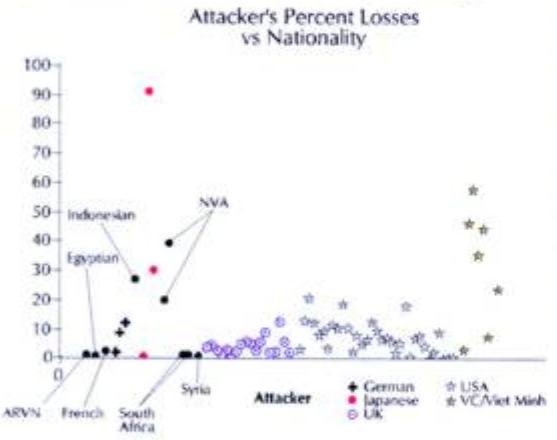

Ratio of Attacker/Defender
Strength vs D/A Losses (2)
D/A Loss Ratio


Ratio of Attacker/Defender
Strength vs % D/A Losses (2)
D/A Loss Ratio

# Looking at Casualties Based Upon Nationality Using the BLODB

by Christopher A. Lawrence

I am afraid this article will open up a Pandora's box of criticism. Everyone is aware that different armies have different doctrines and fight in different styles. Some of this is embedded in training manuals and training systems, but some of it is based upon tradition and culture of the army. But when you hint at the discussion of national differences, people begin getting nervous, especially in our very politically sensitive and politically correct American society. Unfortunately, the field I had to key on in the Battalion-level Operations Data Base (BLODB) was called nationality. I did not have a field for "type of doctrinal system." Therefore, I had a choice of saying nothing or pushing forward and discussing the comparison of casualties by nationality. For better or worse, I choose to say something.

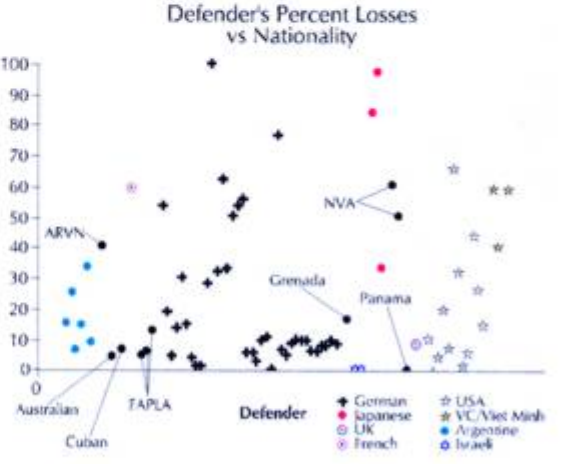



The first chart shows the percent losses of the attacker versus nationality. Note that there is a distinctly different casualty pattern shown by the Indonesians, Japanese, NVA (North Vietnamese Army), VC (Viet Cong), and Viet Minh from that shown by Germany, US and UK.

It appears that the upper threshold for attacker losses for the UK, US and German forces is around 20%. For other forces (unfortunately based upon very few data points), it appears that this threshold for losses is much higher. It certainly went as high as 99% for the Japanese Army in WWII. This is not something that you would ever expect to see in the US, UK, or German armies, unless something truly unusual was occurring.

The intensity and duration of a battle is usually determined by the attacker. The battle ends when the attacker ceases to attack or the defender withdraws. Or...the defender chooses to reverse roles and become the new attacker. As such, if there is a difference in doctrine in the armies, it would be expected to show up in the percent of losses taken by the attacker. Unfortunately, the data is confused somewhat by the fact that the attacking forces taking above 20% losses were often at a notable firepower inferiority compared to their opponents. This is certainly true of the NVA/VC/Viet Minh and is usually the case with the Japanese. But in many of these cases, the units could have broken contact much earlier than they did and minimized their losses. In many of these cases, the increased casualties did not result in an increased chance of winning.

The next chart shows the percent losses of the defender by nationality. Notice that there is still a difference in the pattern of losses in the first group of nations listed from the second group, but the pattern is not as distinct. Obviously, as the attacker determines the intensity and duration of combat, it is quite possible for any defending force to be overrun and destroyed, regardless of doctrine. But, from the few points provided here, it appears that there are a few nations that appear to take higher casualties in the defense than is usually encountered. This appears to be the case with the NVA, VC, Viet Minh and Japanese. This may be entirely due to the opposing attacking force having a significant firepower advantage. Unfortunately, these are also the cases in which we have the least data. More work, with more data, would need to be done before any conclusions could be reached.




Most of the nationalities with high losses have low CEVs (Combat Effectiveness Values). This certainly provides a counter to the argument that by declaring a force to have a low CEV, we are making a criticism of some nation's bravery or manhood. Of course, this does not change the

fact that the low CEV may be providing an implicit criticism of the ability of the nation's armed forces to conduct a battle.

In the TNDM, the CEV is accounted for in three different areas of the model. First and most important, it is used as a divisor of the less capable side's OLIs.

Second, it is used to increase the opposing side's casualties by the multiplier of the side with the larger CEV. This is limited to a multiplier effect of 1.5. The same CEV formulation is used for tank and artillery losses, but the multiplier effect is limited to 2.0. Infantry Weapons, AT Weapons, and General Vehicles use the same formulae, times a scaling factor, as the personnel casualty rate; while APCs are calculated with the tank loss formula, and AA weapons are calculated with the artillery formula.

Third, it is adjusted in the "set–piece" factor, which effectively temporarily increases the CEV of the lower CEV force making a planned attack.

The use of the CEVs to increase opposing losses by 1.5 may sufficiently cover the higher losses displayed by the Japanese, NVA, VC and Viet Minh, but I suspect this will not entirely cover their losses. I have reason to believe that the TNDM will have a problem with the Japanese. If that is the case, then we will seriously need to consider whether there is some other factor that we should be considering (like Dave Bongard's postulated fanaticism).

If indeed, there is a "fanaticism effect" that needs to be displayed in combat modeling, this could be incorporated into a hypothesis for breakpoints. As you may have gathered from reading Trevor N. Dupuy's *Understanding Defeat*, there are multiple causes for breakpoints, and any model of breakpoints is going to have to address these multiple aspects, probably as some form of a decision tree. One of these might be two different sets of postulated breakpoints related to heavy casualties, depending on whether the army fights in a "fanatic" style or not.

# Looking at Time Using the BLODB


**by Christopher A. Lawrence**

The TNDM treats engagements of less than 24 hours as simply a portion of a 24 hour engagement. A unit in a six–hour engagement takes one–fourth the casualties as the unit would in a 24–hour engagement. For various reasons, I am uneasy about that construct as discussed in the article in Issue 3, "Time and the TNDM." I then looked at the data we were getting from the BLODB to determine is if we could discern some casualty patterns from the length of an engagement. I have enclosed three graphs below that show the data.

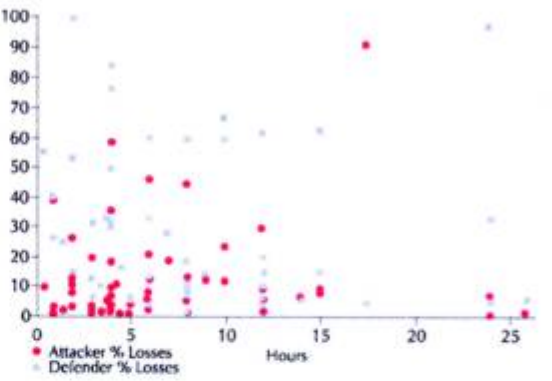
First, I looked at percent losses over time and could see no pattern. I then looked at the total losses over time, and the only pattern that I could see is that casualties tend to be lower for engagements of less than two hours.

This led me to see if larger forces had longer battles. Again, the only pattern that I could discern is based upon the defender's force size:

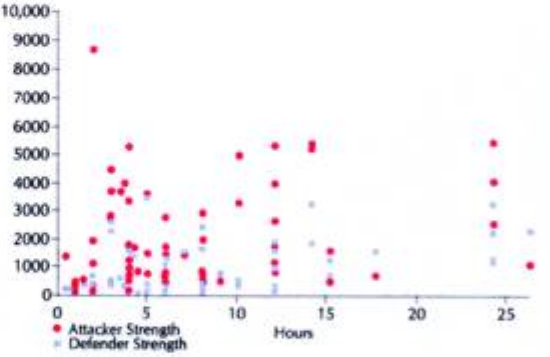
| DEFENDER'S FORCE SIZE | ENGAGEMENT LENGTH |
|---|---|
| > 1,000 | 3 to 24+ hours |
| < 1,000 | .5 to 12 hours (one outlier) |

It is obvious that we need to study more engagements if we are going to see a pattern. As our values for time were obtained from secondary sources, in many cases these were "roughed–in" values. More precise values could be determined if we did further research on these engagements.

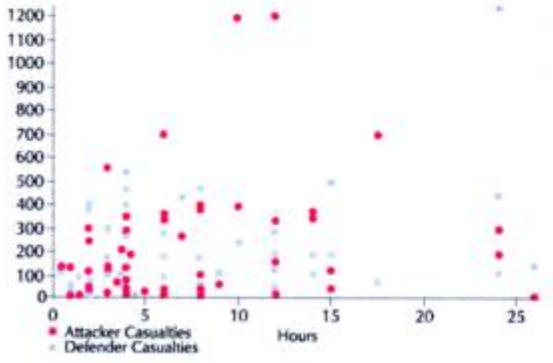
Percent Losses vs Hours of Combat




Force Size vs Hours of Combat




All Losses vs Hours of Combat



# Looking at Winners and Losers Using the BLODB

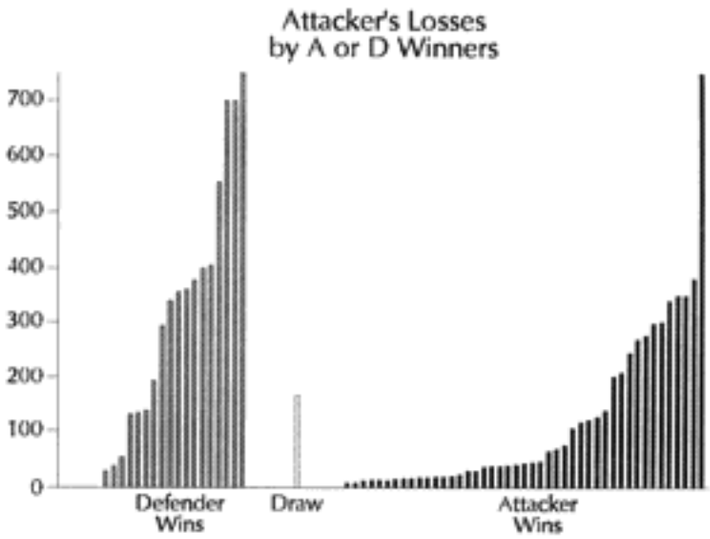

**by Christopher A. Lawrence**

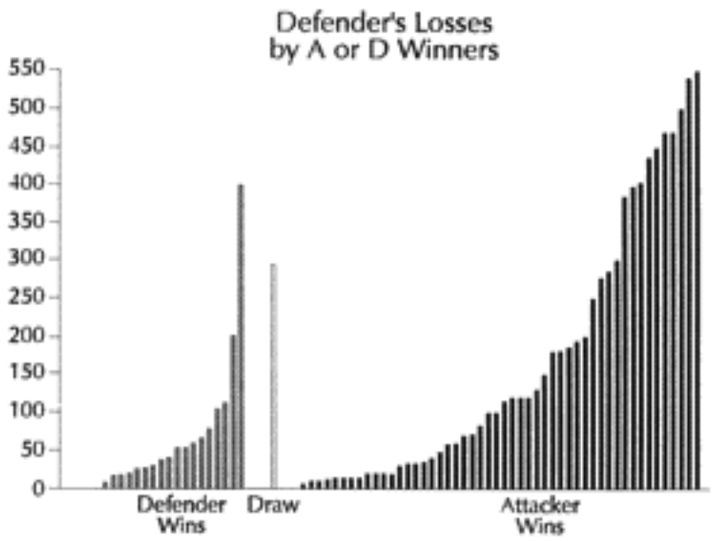
The last element of the data that we looked at before the actually conducting the battalion–level validation was the nature of the battle when compared to who won and who lost.

There is one field for identifying the winner and loser in the data base. If the attacker wins, this field is assigned a value of 1; if the defender wins the field is assigned a value of –1. The one drawn battle in the data base is assigned a value of zero. All the attached charts have been drawn based upon these numerical values, with the defender wins (value of "-1") listed first across the x-axis, the draw listed next (value of "0"), and the attacker listed last (value of "1"). These were laid out in a bar chart format, as that was what was convenient to do with the software I am using. There are probably better ways to display this data.

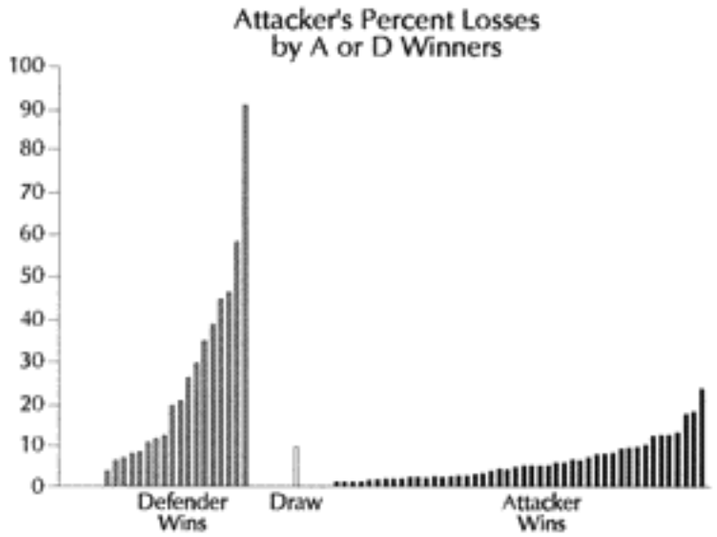
First I looked at whether the battles were longer depending whether the attacker or the defender won. It would appear that on the average, battles where the attacker won are longer. This might be something that needs to be addressed in a battle termination methodology. I suspect that any good battle termination methodology will automatically produce this effect as a by–product. This will not affect the validation as we declare the length of the battle in hours when preparing a TNDM run.


The next two charts show what the attackers or the defenders losses were depending on who won. The very clear pattern here is that the winner of a battle usually suffers reduced casualties. This is a pattern that Trevor Dupuy identified and designed into the TNDM.



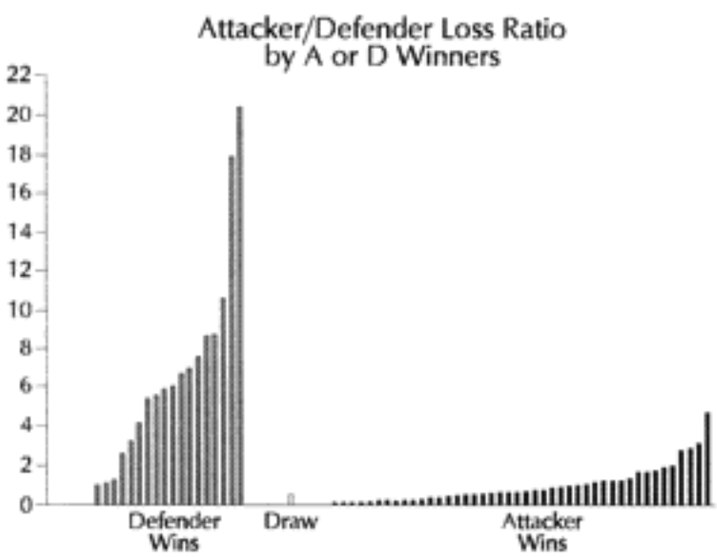



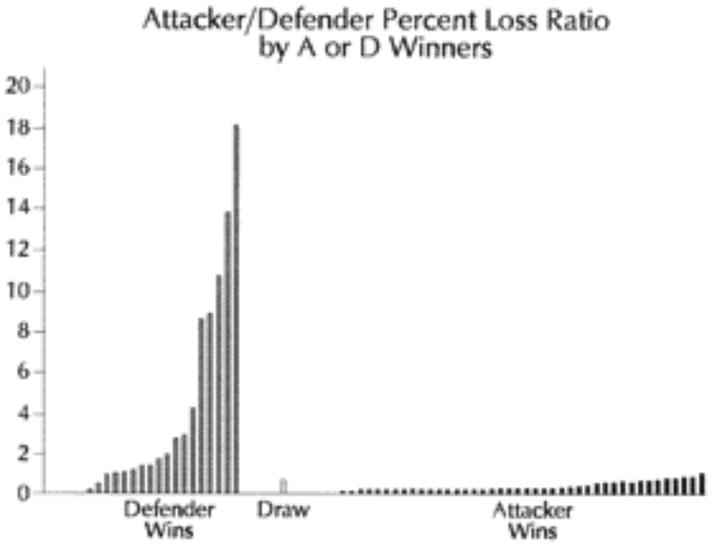
This pattern is even clearer if one looks at the percent losses. This is done in the next two graphs.



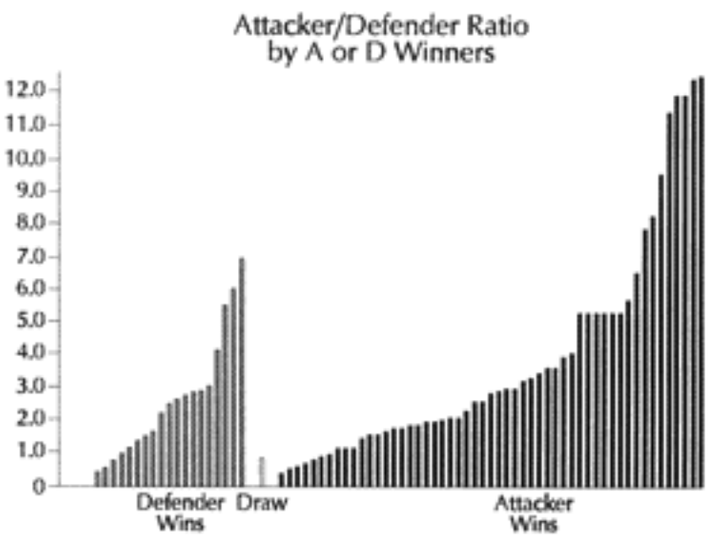


The next two charts simply look at the loss ratios of the attacker to the defender, both in straight numbers and in a percent of unit. This just further clarified the pattern. Failed attacks and failed defenses are costly. Exchange ratios on failed attacks heavily favor the defender. Exchange ratios on successful attacks often still result in the attacker taking higher casualties than the defender.




The last chart looks at the force ratio of attacker vs defender compared to who won. While overwhelming force ratios win, and a higher force ratio helps to win, in many cases the winning attacker has less than a 1–to–1 ratio. This is not unusual and is mostly related to human factors.



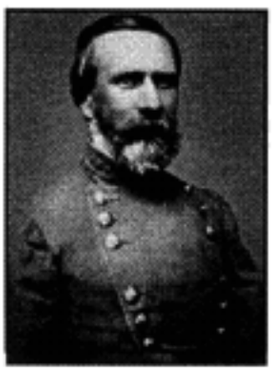

There is nothing in the charts from this article or the previous three articles in this issue that has not been pretty much covered by Trevor N. Dupuy in *Understanding War* using the Land Warfare Database. But it is interesting and instructive to be seeing the same effects in a battalion–level data base. So far, it would appear that except for the higher casualty percents due to the smaller unit sizes, there is a similarity in results from battalion–level battles that parallel the results seen in division–level battles.

# TDI Profile: Richard Anderson

Richard C. Anderson, Jr. received a B.A. in History from George Mason University in 1977. Mr. Anderson concentrated on 19th and 20th Century European and American military history. His plans to continue study with the objective of an advanced degree were curtailed due to a combination of academic *ennui* and financial self–interest (also known as boredom and greed). Mr. Anderson then spent the following ten years working in the Washington area retail sales industry before seeking to return to a career in a history–related field.

Mr. Anderson began working for Data Memory Systems, Inc. in October 1987. DMSi was Colonel Trevor N. Dupuy's previous historically–oriented research and consulting organization. While he was with DMSi, Mr. Anderson worked on several major projects, including the *Breakpoints* study and the *Ardennes Combat Simulation Database*. Mr. Anderson also worked with the predecessor to Colonel Dupuy's TNDM, the QJM, in studies and analyses for various U.S. Government agencies.

Mr. Anderson left DMSi in February 1991 to work with Colonel Dupuy at his new company, TNDA and its non–profit successor, the Dupuy Institute. In the intervening six years he has participated as a contributor to Colonel Dupuy's book *Future Wars*, as an editor and a contributor to the Fourth Edition of the *Harper Encyclopedia of Military History*, and as a co–author, with Colonel Dupuy and David Bongard, of *Hitler's Last Gamble*—a history of the Battle of the Bulge, based upon primary source material. Mr. Anderson's most recent work has been in the development of the *Kursk Database*, a detailed study of the World War II battle considered to be the largest tank battle of history. He has also been involved with studies of casualties in operations other than war, landmine effectiveness, and suppression.



Mr. Anderson has also been co–author, with Curt Johnson, of *Artillery Hell*, an account of the role of artillery in the American Civil War Battle of Antietam. This stems from an ongoing interest in this period of American History. Note that the illustration accompanying this profile is of Civil War Lieutenant General Richard H. Anderson, C.S.A. —no relation to Mr. Anderson, whose Pennsylvanian ancestors included the President of the Borough Council of Gettysburg and a colonel who was killed in action at Spotsylvania. Mr. Anderson insists that he "has no damned rebels" in his family background. In addition to his historical studies and writing, Mr. Anderson enjoys painting military miniature figures, miniature wargames, and attempts to raise three sons (ages fourteen, twelve, and six) without having to resort to the use of whips or chains.

# How to Run the TNDM from Windows 3.1 and Windows 95

**by José Perez**

Setting up the TNDM software to run within Microsoft (MS) Windows 3.1 is a straightforward process, but it does require some understanding of Windows and DOS. Luckily, most of the changes can be made from within Windows.

First, the TNDM software must already be installed. For the purposes of this article, I will assume that it has been installed in C:\TNDM. Next, you need to examine the C:\CONFIG.SYS file. In C:\CONFIG.SYS is a line that reads something like FILES=20. For the TNDM software to run properly, it must be set to at least 25. If your PC was configured properly it was probably set at a higher value (60 or more).

To determine the current setting, go into the Windows Program Manager. Select Main. If you cannot see Main, click on Window in the menu bar and find Main. Click on it. Once Main is open, look for an icon called SysEdit.

## Creating an Icon for SysEdit

If the SysEdit icon is not present, it can be added. Click on File in the menu bar and select New. You will then see a window labeled New Program Object. Select Program Item. Click on the Ok button. In the Program Item Properties windows, enter SysEdit for "Description" and SYSEDIT for "Command Line." Click on the Ok button. You should now see an icon labeled SysEdit. Click on it.

Once SysEdit is running, it will display the contents of several files: WIN.INI, SYSTEM.INI, CONFIG.SYS and AUTOEXEC.BAT. Click on the one labeled CONFIG.SYS. Look for the line that begins FILES= and verify that it is set to a value of at least 25. If it is not, set it to a value between 25 and 60. If any changes were made, click on File in SysEdit's menu bar and then select Exit. You will be asked it the changes should be saved. Click on Yes.

## Creating a Batch File for TNDM

After you have exited from SysEdit, click on the MSDOS icon. A small window with a DOS prompt will appear. At the DOS prompt, enter the command

```
EDIT TNDM.BAT
```

This will start the DOS Edit command. Once the edit screen appears, enter the lines

```
@ECHO OFF
C:\TNDM\TNDM.EXE
```

and then press the Alt key (it should be in the lower right-hand corner of the keyboard). Press F to activate the File menu and then press X to select Exit. You will then be asked if the changes you made are to be saved. Select Yes. When the DOS prompt reappears, enter the command

```
EXIT
```

Once you are back in Windows, select a group to add the TNDM icon to. Once the group is open, click on File in the menu bar and then select New. You will then see a window labeled New Program Object. Select Program Item. Click on the Ok button. In the Program Item Properties windows, enter TNDM for "Description" and TNDM.BAT for "Command Line". Click on the Ok button. You should now see an icon labeled TNDM. Click on it. It should start the TNDM.

Once the TNDM has started, you can adjust its appearance within Windows. If it runs within a window that takes up only a portion of the screen, you can increase the size of the screen that is allocated to TNDM. To do this, find the small box with a dash in it in the upper left-hand corner of the TNDM window. Click on it. A menu will appear. Select Settings. In the Settings for TNDM, change the Display Option from Window to Full Screen.

## Setting up TNDM in Microsoft Windows 95

Setting up the TNDM software for Microsoft Windows 95 is more involved process.

First, version 1.86 of the TNDM software must be installed. Earlier versions of TNDM are incompatible with Windows 95. For the purposes of this article, I will assume that it has been installed in C:\TNDM.

Adding TNDM to the Windows 95 menu:

1. Click on the Start button.
2. Select Settings and then select Taskbar.

3. Click on the tab marked "Start Menu Programs."
4. Click on the Add button.
5. Enter C:\TNDM\TNDM.EXE and click on the Next button.
6. To put it into a folder, select Programs and click on the Next button.
7. Enter TNDM as the shortcut name.
8. Select an icon and then click on Finish.

### Modifying TNDM's Windows 95 Properties

In order for TNDM to run properly in Windows 95, its properties must be changed from the default. To do this:

1. Click on the Start button.
2. Select Settings and then select "Start Menu Programs."
3. Click on the Advanced button.
4. In the window marked "All Folders", click on the + to the left of Programs.
5. Select Programs.
6. On the right-hand side of the screen in "Contents of Programs", find TNDM and select it.
7. In the menu bar, click on File and select Properties.
8. Select the tab marked "Memory".
9. Set Total to 480 and turn off Protected.
10. Click on the OK button to save the changes and click on any other OK buttons until you have exited from "Start Menu Programs."

Volume 1, Number 5

April 1997

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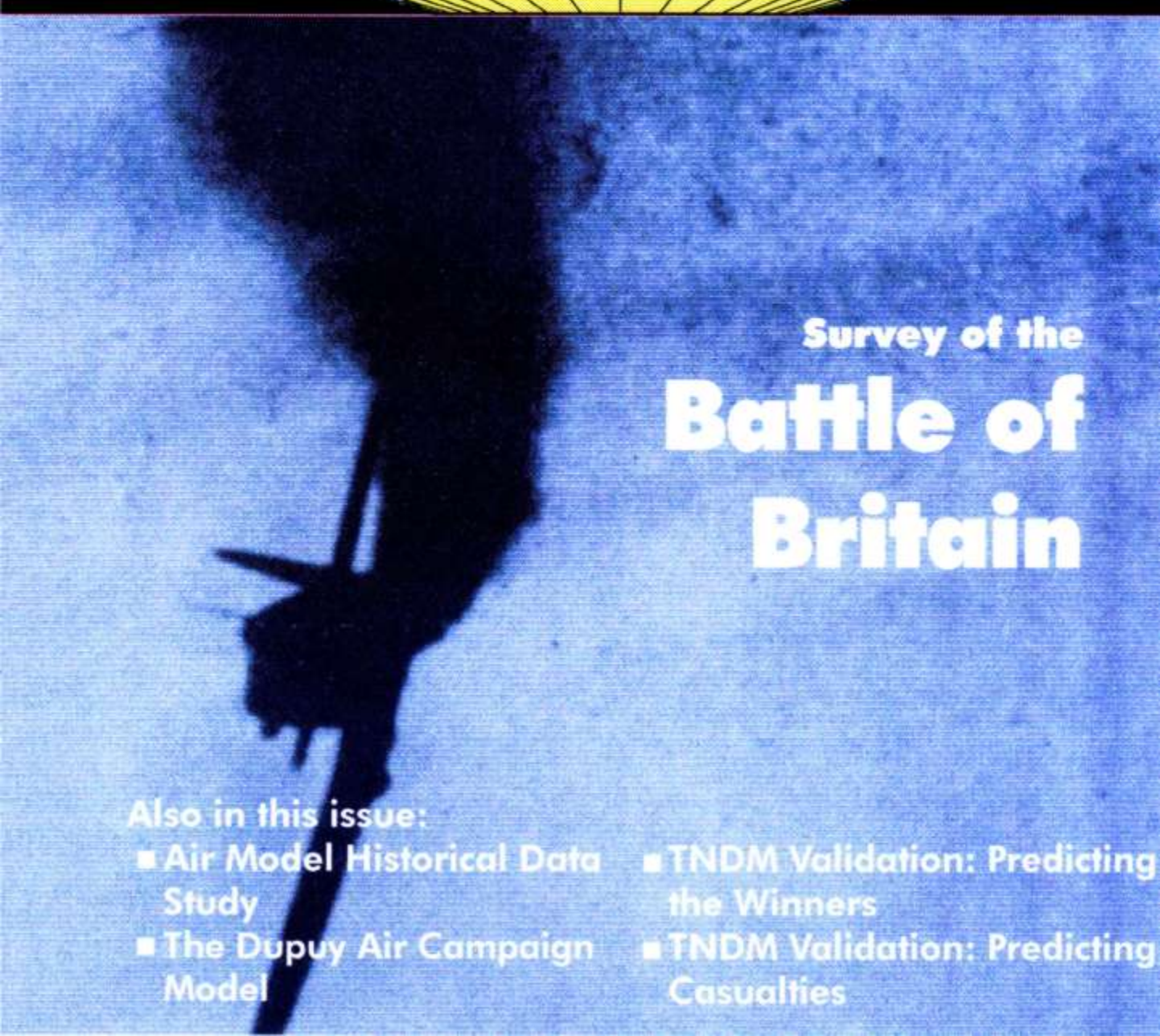
# THE INTERNATIONAL TNDM NEWSLETTER



## Survey of the Battle of Britain

Also in this issue:

- Air Model Historical Data Study
- The Dupuy Air Campaign Model
- TNDM Validation: Predicting the Winners
- TNDM Validation: Predicting Casualties

# INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this fifth issue of our newsletter Christopher Lawrence, Dave Bongard, Richard Anderson, José Perez, Joe Bulger and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically–based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

(1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;

(2) Training, cultural and psychological profiles, and flow of information;

(3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in–house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically–based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.

# CONTENTS



IN HONOR OF THE MEMORY OF THE LATE

**Trevor N. Dupuy**

Col., USA, ret.

**International TNDM Newsletter**

***Publisher***
The Dupuy Institute

***Editor***
Christopher A. Lawrence

***Production Manager***
Jay Karamales
Olórin Press

***Contributing Editors***
Richard C. Anderson
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

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Col. Trevor N. Dupuy

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Maj. Gen. Nicholas Krawciw

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***Administrative Offices***
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
NikatTDI@aol.com

# From the Editor...

Well, we are now back on "theme." This issue includes the material on the Dupuy Air Campaign Model (DACM) that was supposed to be in the last issue. We also have some of the material from the battalion–level validation. We have completed our analysis of the ability of the model to predict winners and the ability of the model to predict casualties. As a result of this validation we will be making some preliminary changes to the model. These are significant changes, and they are the first significant changes not done by Trevor Dupuy. This version it will known be version 2.0. This version should be considered "preliminary," but it will work the same as version 1.86 of the TNDM, except for WWI engagements, engagements of less than 4 hours, and engagements where one side is considered "casualty insensitive." This version is being sent to holders of our support contracts by a separate letter.

We have still to conduct our analysis of the advance rates and a summary conclusion. But we have seen enough to issue this preliminary revision to the model. We consider it a "preliminary" version because we have yet to test it to our second battalion–level validation database. We have assembled the data for 121 battles from 1914 through 1991. We need to program version 2.0 of the TNDM with the changes from the first validation. We then need to do two TNDM runs for each battle (one without CEV and one with). We need to put them in the Battalion–Level Operations Database (BLODB) so we can analyze the results and test the data. We then need to compare the results of the validation runs to the historical runs and write up the results. Finally, as the Battalion–Level Operations Database (BLODB) will now consist of 197 engagements, I would like to go back and perform the same analysis that I did with the 76–engagement database. It would also be useful to add these battles to the Land Warfare Data Base (LWDB).

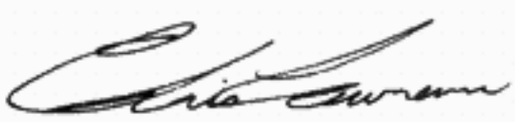
In the Programmer's Cubicle, we have an article on how the data is laid out. This is intended as a supplement to the User's Guide. For "Who is TDI," we have assembled a little background on Col. Joseph Bulger, who took over management of the DACM effort from Trevor Dupuy. We finally got a real picture for a change, although it is not quite current.

The next issue will focus on the modeling of tanks and armored warfare. The cover article will be by Jay Karamales from his Tank/Antitank studies. His new book *Against the Panzers* was the book of the month selection for the Military Book Club. The issue will also include an article on the use of mines and fortifications at Kursk. We have a set of tables prepared by Richard Anderson on the effects of artillery on tanks. They are quite startling. This issue will also contain the rest of our material on the battalion–level validation and another article on measuring combat effectiveness values. We also have on hand our first article from outside the Institute, and we are expecting more. These will be published in the next issue.

We have also, courtesy of Major John Sloan, started our first subscription effort to the newsletter. Our subscription price of $30 a year ($6 an issue) really only covers our reproduction cost. This newsletter was not intended to be a subscription–type magazine and is not intended to be "profit making." It is intended to be part of our support efforts for TNDM users, but we are making the newsletter available to anyone who wishes to subscribe to it.

As a final note, I want to welcome Gene Visco to our board of advisors. Mr. Visco I believe is well known to many of you, as he worked for many years in the office of the Deputy Undersecretary of the Army, Operations Research.

That is all for now. If you have any questions, please contact me. Addresses, e-mail addresses, and phone numbers are in the masthead.



# Air Model Historical Data Study

by Col. Joseph A. Bulger, Jr., USAF, Ret.

The Air Model Historical Study (AMHS) was designed to lead to the development of an air campaign model for use by the Air Command and Staff College (ACSC). This model, never completed, became known as the Dupuy Air Campaign Model (DACM). It was a team effort led by Trevor N. Dupuy and included the active participation of Lt. Col. Joseph Bulger, Gen. Nicholas Krawciw, Chris Lawrence, Dave Bongard, Robert Schmaltz, Robert Shaw, Dr. James Taylor, John Kettelle, Dr. George Daoust and Louis Zocchi, among others. After Dupuy's death, I took over as the project manager.

At the first meeting of the team Dupuy assembled for the study, it became clear that this effort would be a serious challenge. In his own style, Dupuy was careful to provide essential guidance while, at the same time, cultivating a broad investigative approach to the unique demands of modeling for air combat. It would have been no surprise if the initial guidance established a focus on the analytical approach, level of aggregation, and overall philosophy of the QJM and TNDM. It was clear that Trevor had no intention of steering the study into an air combat modeling methodology based directly on QJM/TNDM. To the contrary, he insisted on a rigorous derivation of the factors that would permit the final choice of model methodology.

At the time of Dupuy's death in June 1995, the Air Model Historical Data Study had reached a point where a major decision was needed. The early months of the study had been devoted to developing a consensus among the TDI team members with respect to the factors that needed to be included in the model. The discussions tended to highlight three areas of particular interest—factors that had been included in models currently in use, the limitations of these models, and the need for new factors (and relationships) peculiar to the properties and dynamics of the air campaign. Team members formulated a family of relationships and factors, but the model architecture itself was not investigated beyond the surface considerations.

Despite substantial contributions from team members, including analytical demonstrations of selected factors and air combat relationships, no consensus had been achieved. On the contrary, there was a growing sense of need to abandon traditional modeling approaches in favor of a new application of the "Dupuy Method" based on a solid body of air combat data from WWII.

The Dupuy approach to modeling land combat relied heavily on the ratio of force strengths (largely determined by firepower as modified by other factors). After almost a year of investigations by the AMHDS team, it was beginning to appear that air combat differed in a fundamental way from ground combat. The essence of the difference is that in air combat, the outcome of the maneuver battle for platform position must be determined before the firepower relationships may be brought to bear on the battle outcome.

At the time of Dupuy's death, it was apparent that if the study contract was to yield a meaningful product, an immediate choice of analysis thrust was required. Shortly prior to Dupuy's death, I and other members of the TDI team recommended that we adopt the overall approach, level of aggregation, and analytical complexity that had characterized Dupuy's models of land combat. We also agreed on the time–sequenced predominance of the maneuver phase of air combat. When I was asked to take the analytical lead for the contact in Dupuy's absence, I was reasonably confident that there was overall agreement.

In view of the time available to prepare a deliverable product, it was decided to prepare a model using the air combat data we had been evaluating up to that point—June 1995. Fortunately, Robert Shaw had developed a set of preliminary analysis relationships that could be used in an initial assessment of the maneuver/firepower relationship. In view of the analytical, logistic, contractual, and time factors discussed, we decided to complete the contract effort based on the following analytical thrust:

1. The contract deliverable would be based on the maneuver/firepower analysis approach as currently formulated in Robert Shaw's performance equations;
2. A spreadsheet formulation of outcomes for selected (Battle of Britain) engagements would be presented to the customer in August 1995;
3. To the extent practical, a working model would be provided to the customer with suggestions for further development.

During the following six weeks, the demonstration model was constructed. The model (programmed for a Lotus 1-2-3 style spreadsheet formulation) was developed, mechanized, and demonstrated to ACSC in August 1995. The final report was delivered in September of 1995.

The working model demonstrated to ACSC in August 1995 suggests the following observations:

* A substantial contribution to the understanding of air combat modeling has been achieved.
* While relationships developed in the Dupuy Air Combat Model (DACM) are not fully mature, they are analytically significant.

* The approach embodied in DACM derives its authenticity from the famous "Dupuy Method" thus ensuring its strong correlations with actual combat data.
* Although demonstrated only for air combat in the Battle of Britain, the methodology is fully capable of incorporating modern technology contributions to sensor, command and control, and firepower performance.
* The knowledge base, fundamental performance relationships, and methodology contributions embodied in DACM are worthy of further exploration. They await only the expression of interest and a relatively modest investment to extend the analysis methodology into modern air combat and the engagements anticipated for the 21st Century.

One final observation seems appropriate. The DACM demonstration provided to ACSC in August 1995 should not be dismissed as a perhaps interesting, but largely simplistic approach to air combat modeling. It is a significant contribution to the understanding of air combat relationships that will prevail in the 21st Century. The Dupuy Institute is convinced that further development of DACM makes eminent good sense. An exploitation of the maneuver and firepower relationships already demonstrated in DACM will provide a valid basis for modeling air combat with modern technology sensors, control mechanisms, and weapons. It is appropriate to include the Dupuy name in the title of this latest in a series of distinguished combat models. Trevor would be pleased.


## *AIR MODEL HISTORICAL DATA STUDY*

***August '95***

***NICK KRAWCIW*** ***President, TDI***

***JOE BULGER*** ***Study Director***

**The Dupuy Institute**
**Unit 100, McLean Professional Park**
**1497 Chain Bridge Road, McLean, VA 22101**
**TEL 703-356-1151 FAX 703-356-1152**

062695 TDI1 001

## PURPOSE

- ASSESS IMPACT OF LOSS OF TREVOR DUPUY ON STUDY
- SUMMARIZE PROGRESS AND MAJOR ACCOMPLISHMENTS
- REPORT METHODOLOGY ISSUES
- RECOMMEND AIR CAMPAIGN MODEL DEVELOPMENT THRUST
- DISCUSS / RESOLVE CUSTOMER CONCERNS AND/OR PREFERENCES

## OUTLINE

- STUDY CHRONOLOGY OVERVIEW
- PRELIMINARY MODEL ARCHITECTURE
  - QJM / TNDM OVERVIEW
  - METHODOLOGY ISSUES
  - DUPUY METHOD
- THE TDI AIR-TO-AIR CAMPAIGN MODEL
  - OVERVIEW - METHODOLOGY FLOW
  - SPREADSHEET (LOTUS) MECHANIZATION
  - FACTORS TO BE DERIVED FROM HISTORICAL DATA
- RECOMMENDATIONS FOR FUTURE DEVELOPMENT
  - AIR-TO-AIR CAMPAIGN MODEL CORRELATION
  - COLLATERAL AIR CAMPAIGN DEVELOPMENT
  - INFORMATION WARFARE MODEL DEVELOPMENT

# AMHDS STATEMENT OF WORK - 1 Feb '94

START 15 JUNE '94

- OBJECTIVE
  - PRODUCE EQUATIONS (SPREADSHEET INCORPORATING EQUATIONS) TO
    - ISOLATE & QUANTIFY FACTORS
    - DETERMINE PATTERNS & RELATIONSHIPS
  - FOR COMBAT SITUATIONS
    - AIR TO AIR
    - SURFACE-TO-AIR
    - AIR-TO-SURFACE

- OCTOBER '94 GUIDANCE (SUPPLEMENTED IN JULY '95)
  - FOCUS ON AIR-TO-AIR WARFARE
  - HIGHLY AGGREGATED MODEL DESIRABLE
  - SPREADSHEET MECHANIZATION ATTRACTIVE
  - STUDENT PLANNING / RESEARCH TOOL NEEDED
  - RECOMMEND APPROACH FOR STRATEGIC PARALLEL WARFARE MODEL

STUDY FOCUS AND THRUST HAVE EVOLVED SIGNIFICANTLY

# AMHDS MAJOR TASKS

| TASK | PRINCIPAL CONTRIBUTORS | STATUS |
|---|---|---|
| REVIEW OF CURRENT MODELS & METHODOLOGIES | DUPUY* LAWRENCE SCHMALTZ | COMPLETED PH I REPORT |
| GATHER, PROCESS & ASSESS KURSK & BoB AIR COMBAT DATA | LAWRENCE BONGARD | COMPLETE . . . TO BE DELIVERED MID SEP '95 |
| IDENTIFY AIR TO AIR COMBAT VARIABLES & RELATIONSHIPS | DUPUY* LAWRENCE BONGARD BULGER SCHMALTZ SHAW TAYLOR | COMPLETE . . . TO BE DELIVERED MID SEP '95 |
| TREVOR DEATH JUN 5 '95 | | |
| DEVELOP METHODOLOGY APPROACH AND ARCHITECTURE FOR AIR-TO-AIR MODEL | KRAWCIW LAWRENCE BONGARD BULGER* SHAW SCHMALTZ TAYLOR KETTELLE | AIR-TO-AIR BRIEFED CUSTOMER PREFERENCE FOR FUTURE EFFORT TO BE DETERMINED |

PROFOUND LOSS BUT STRONG TEAM & REAL KNOWLEDGE EMERGING

# OVERVIEW

- **STUDY OVERVIEW**
  - STUDY ON COURSE, AIR-TO-AIR FOCUS
  - TREVOR'S DEATH . . . PROFOUND IMPACT
  - STRONG TEAM ASSEMBLED. . . SIGNIFICANT RESULTS ACHIEVED
- **PELIMINARY MODEL**
- **CURRENT TDI A/A MODEL**
- **RECOMMENDATIONS**

# ORIGINS OF DUPUY AIR SUPERIORITY CAMPAIGN MODEL

(Reference: Dupuy, T.N.: *Understanding War*, Paragon house, New York, p 28-30, 1987.)

- **CLAUSEWITZ THEORY OF COMBAT. . . CONCEPTS**

| | |
|---|---|
| GENIUS | STRENGTH IN DEFENSE |
| DESTRUCTION* OF ENEMY | FRICTION IN WAR |
| SPEED OF MANEUVER | *LAW OF NUMBERS* |

- **DUPUY INTERPRETS CLAUSEWITZ LAW OF NUMBERS**

$$\text{COMBAT POWER} = \left(\text{NUMBERS OF TROOPS}\right) \times \left(\text{QUALITY OF FORCE}\right) \times \left(\text{COMBAT VARIABLES}\right)$$

| NUMBERS OF TROOPS | QUALITY OF FORCE | COMBAT VARIABLES |
|---|---|---|
| Lethality of weapons employed on battlefield | Qualitative human factors influencing performance. | Variable circumstances affecting a combat force in battle. |
| WEAPONS<br>FIGHTING MACHINES | LEADERSHIP<br>MORALE<br>TRAINING | TERRAIN<br>WEATHER<br>COMMUNICATIONS |

$$\text{Force Combat Power} = P = \left(\begin{matrix}\Sigma\,\text{Unit Weapon}\\ \text{Lethalities}\end{matrix}\right)_{(S)} \times \left(\begin{matrix}\text{Composite}\\ \text{Human}\\ \text{Factors}\end{matrix}\right)_{(Q)} \times \left(\begin{matrix}\text{Combat}\\ \text{Operations}\\ \text{Variables}\end{matrix}\right)_{(V)}$$

$$\text{BATTLE OUTCOME} \sim \frac{P_{red}}{P_{blu}}$$

NOTE: BATTLE OUTCOME MEASURED BY SURVIVING COMBAT POWER

**PRELIM TRIALS BASED ON QJM/TNDM WEAPON METHODOLOGY**

# PLATFORM & WEAPON COMBINED STRENGTH

**GERMAN ACFT — AIR TO AIR COMBAT**

**AIRCRAFT SYSTEM CONTRIBUTION TO PERFORMANCE FACTOR**

| ACFT MISSION | WEAPON LETHALITY (OLI) | RANGE .14 | CEILING .14 | CLIMB TO 30 M .16 | CRUISE SPEED .17 | ENDURANCE .03 | WING LOAD .09 | DURABILITY .02 | COMM NAV .13 | FCS/STAB AUGM .07 | WPN DLV AUGM .05 | APF (AIR to AIR) | STRENGTH (S) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR-66C RECON | 0 | .26 | .39 | .53 | .33 | .26 | .71 | .70 | 1.00 | 1.00 | .50 | .54 | 0.00 |
| FW-189A RECON | 1.46 | .34 | .60 | .51 | .54 | .34 | .71 | .70 | 1.00 | 1.00 | .50 | .62 | .90 |
| FW-190F GND ATTK | 7.79 | .19 | .91 | .84 | 1.00 | .19 | .65 | .70 | 1.00 | 1.00 | .50 | .76 | 5.94 |
| HE-111 H BOMBER | 3.34 | .71 | .74 | .33 | .64 | .71 | .51 | 1.00 | 1.00 | 1.00 | .70 | .69 | 2.29 |
| HS-123A GND ATTK | 5.61 | .31 | .78 | .68 | .54 | .31 | 1.00 | 1.00 | 1.00 | 1.00 | .70 | .71 | 3.97 |
| HS-126B RECON | .21 | .21 | .71 | .60 | .56 | .21 | .77 | 1.00 | 1.00 | 1.00 | .70 | .21 | .14 |
| HS-129B2 GND ATTK | 9.02 | .25 | .78 | .50 | .64 | .25 | .41 | 1.00 | 1.00 | 1.00 | .70 | .63 | 5.70 |
| HS-129B2R3 GND ATTK | 7.35 | .25 | .78 | .50 | .64 | .25 | .41 | 1.00 | 1.00 | 1.00 | .70 | .63 | 4.65 |
| JU-52 BOMBER | 0 | .88 | .47 | .27 | .45 | .88 | .40 | .70 | 1.00 | 1.00 | .50 | .61 | 0.00 |
| JU-87D STUKA | .83 | .56 | .63 | .50 | .64 | .56 | .48 | .70 | 1.00 | 1.00 | .50 | .65 | .54 |
| JU-88A BOMBER | 1.65 | 1.00 | .71 | .35 | .71 | 1.00 | .41 | .70 | 1.00 | 1.00 | 1.00 | .75 | 1.23 |
| BF-109G FIGHTER | 3.37 | .33 | 1.00 | 1.00 | .98 | .33 | .74 | .70 | 1.00 | 1.00 | .50 | .83 | 2.79 |

- NUMBER OF FACTORS CAN PROBABLY BE REDUCED / COMBINED
- METHODOLOGY ATTRACTIVE - TRACTABLE - SPREADSHEET SUITABLE

**METHODOLOGY REQUIRES VALIDATION / CORRELATION**


# PLATFORM & WEAPON COMBINED STRENGTH

**GERMAN ACFT — AIR TO AIR COMBAT**

**AIRCRAFT SYSTEM CONTRIBUTION TO PERFORMANCE FACTOR**

| ACFT MISSION | WEAPON LETHALITY (OLI) | RANGE .14 | CEILING .14 | CLIMB TO 30 M .16 | CRUISE SPEED .17 | ENDURANCE .03 | WING LOAD .09 | DURABILITY .02 | COMM NAV .13 | FCS/STAB AUGM .07 | WPN DLV AUGM .05 | APF (AIR to AIR) | STRENGTH (S) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR-66C Recon | 0 | .26 | .39 | .53 | .33 | .26 | .71 | .70 | 1.00 | 1.00 | .50 | .54 | 0.00 |
| FW-189A Recon | 1.46 | .34 | .60 | .51 | .54 | .34 | .71 | .70 | 1.00 | 1.00 | .50 | .62 | .90 |
| FW-190F Gnd Attk | 7.79 | .19 | .91 | .84 | 1.00 | .19 | .65 | .70 | 1.00 | 1.00 | .50 | .76 | 5.94 |
| HE-111H Bomber | 3.34 | .71 | .74 | .33 | .64 | .71 | .51 | 1.00 | 1.00 | 1.00 | .70 | .69 | 2.29 |
| HS-123A Gnd Attk | 5.61 | .31 | .78 | .68 | .54 | .31 | 1.00 | 1.00 | 1.00 | 1.00 | .70 | .71 | 3.97 |
| HS-126B Recon | .21 | .21 | .71 | .60 | .56 | .21 | .77 | 1.00 | 1.00 | 1.00 | .70 | .21 | .14 |
| HS-129B2 Gnd Attk | 9.02 | .25 | .78 | .50 | .64 | .25 | .41 | 1.00 | 1.00 | 1.00 | .70 | .63 | 5.70 |
| HS-129B2R3 Gnd Attk | 7.35 | .25 | .78 | .50 | .64 | .25 | .41 | 1.00 | 1.00 | 1.00 | .70 | .63 | 4.65 |
| JU-52 Bomber | 0 | .88 | .47 | .27 | .45 | .88 | .40 | .70 | 1.00 | 1.00 | .50 | .61 | 0.00 |
| JU-87D Stuka | .83 | .56 | .63 | .50 | .64 | .56 | .48 | .70 | 1.00 | 1.00 | .50 | .65 | .54 |
| JU-88A Bomber | 1.65 | 1.00 | .71 | .35 | .71 | 1.00 | .41 | .70 | 1.00 | 1.00 | 1.00 | .75 | 1.23 |
| BF-109G Fighter | 3.37 | .33 | 1.00 | 1.00 | .98 | .33 | .74 | .70 | 1.00 | 1.00 | .50 | .83 | 2.79 |

- NUMBER OF FACTORS CAN PROBABLY BE REDUCED / COMBINED
- METHODOLOGY ATTRACTIVE - TRACTABLE - SPREADSHEET SUITABLE

**METHODOLOGY REQUIRES VALIDATION/CORRELATION**

## METHODOLOGY ISSUES AND APPROACH

- AIR WARFARE IS NOT AN EXTENSION OF GROUND (WEAPON) RELATIONSHIPS
  PLATFORM (AIRCRAFT) PERFORMANCE DETERMINES WEAPON OPPORTUNITIES
  MUST FOCUS ON AIR COMBAT MANEUVERING EFFECTS
- WILL NOT ABANDON "DUPUY METHOD"
- "DUPUY METHOD" EVOLVED OVER 40 YEARS OF COMBAT ANALYSIS
  1. USE REAL WORLD EXPERIENCE (HISTORY).
  2. USE BEST PROFESSIONAL JUDGEMENT AVAILABLE TO QUANTIFY OTHERWISE UNDETERMINABLE VALUES.
  3. USE RATIONAL CURVE FITTING METHODOLOGY.
  4. VALIDATE AGAINST HISTORICAL DATA WHEREVER POSSIBLE.
- "DUPUY METHOD" CREATED *QJM* AND *TNDM* FOR GROUND WARFARE
- "DUPUY METHOD" WILL CREATE *DACM* FOR AIR WARFARE

**DUPUY LEGACY OF EXCELLENCE WILL BE SUSTAINED**

## OVERVIEW

- STUDY OVERVIEW
  - STUDY ON COURSE, AIR-TO-AIR FOCUS
  - TREVOR'S DEATH . . . PROFOUND IMPACT
  - STRONG TEAM ASSEMBLED. . . SIGNIFICANT RESULTS ACHIEVED
- PELIMINARY MODEL
  - QJM / TNDM DEVELOPED FOR GROUND COMBAT
  - AIR CAMPAIGN DOMINATED BY PLATFORM PERFORMANCE
  - NEW MODEL ARCHITECTURE REQUIRED
- CURRENT TDI A/A MODEL

# AIR TO AIR METHODOLOGY REVISIONS

- **BASIC DUPUY MODEL COMBAT RELATIONSHIP**

$$\text{Force Combat Power} = CP = \left(\sum \text{Unit Weapon Lethalities}\right) \times \left(\text{Composite Human Factors}\right) \times \left(\text{Combat Operations Variables}\right)$$
$$(S) \qquad (Q) \qquad (V)$$

**GROUND COMBAT MODEL**
*(QJM / TNDM)*

- CAMPAIGN AGGREGATED BY PHASES
  MAJOR FORCE REINFORCEMENTS
  OPN'L FACTORS...TERRAIN, WX...
- OUTCOME BASED ON POWER RATIOS
  AGGREGATED FORCE COMBAT POWER
  Σ UNIT LETHALITIES

**AIR COMBAT MODEL**
*(DACM)*

- CAMPAIGN AGGREGATED BY ENGAGEMENT TYPES
  CHANGE IN ACFT TYPES ENGAGED
  MISSIONS...INTERCEPT, ESCORT, SWEEP...
- OUTCOME BASED ON KILLS (RATIO)
  1. MANEUVER (ACFT TYPE DEPENDENT)
  2. WEAPON LETHALITY & TGT SURVIVABILITY

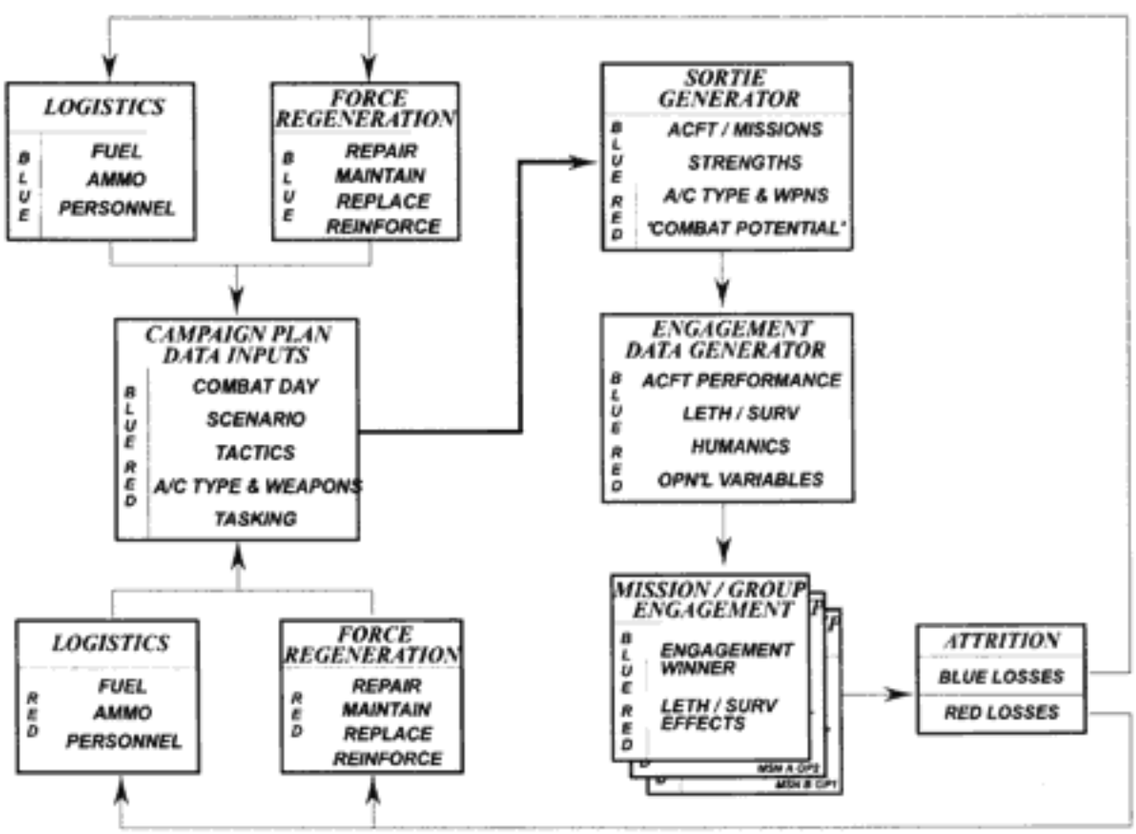
- **DUPUY AIR COMBAT MODEL (DACM) RELATIONSHIP**

$$\text{Kills}_{\text{Blue}} \sim \underbrace{K \times \frac{AP_{\text{Blue}}}{AP_{\text{Red}}} \times \frac{\text{Lethality}_{\text{Blue}}}{\text{Survivability}_{\text{Red}}}}_{(S)} \times \ldots \left(\text{Composite Human Factors}\right) \times \left(\text{Combat Operations Variables}\right)$$
$$(Q) \qquad (V)$$

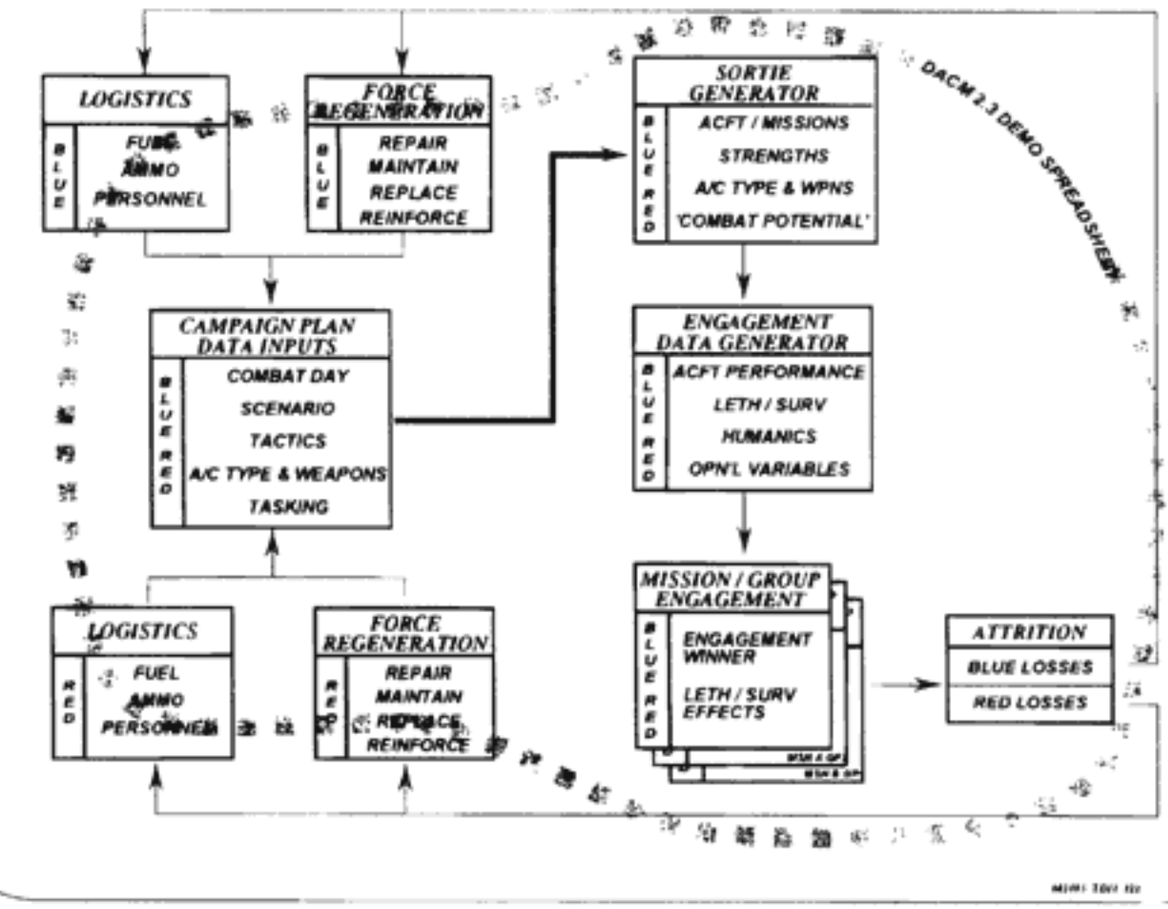
NOTE: K DERIVED FROM HISTORICAL RECORDS

**REVISED METHODOLOGY PRESERVES DUPUY APPROACH**

# PRELIMINARY AIR TO AIR LOGIC FLOW



# SPREADSHEET DEMO. . . DACM2.3




# DACM 2.3 SPREADSHEET DEMO OVERVIEW

PLANNER INPUTS AND ENGAGEMENT SUMMARY

| | ALLOCATE SORTIES (S) | SURV | LETH | APF | KILLS | LOST | ERa | ERf |
|---|---|---|---|---|---|---|---|---|
| b HURRICANES | 0 | 4.60 | 53.0 | 0.93 | 00.0 | 0.0 | na | .51 |
| l SPITFIRES | 8 | 4.46 | 53.0 | 1.01 | 2.3 | 4.6 | .51 | |
| r Bf-109E4 | 8 | 1.63 | 73.6 | .99 | 4.6 | 2.3 | 1.97 | 1.97 |
| e He-111 | 0 | | | | | | | |
| d | | | | | | | | |

TRIAL "K" FACTOR = 0.05

RECORD OF TRIALS TO DETERMINE HISTORICAL (BoB) CORRELATION

| Run # | K | #H | #S | # Bf | Kh | Ks | Lh | Ls | ERh | ERs | ERfb | ERfr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | .05 | 0 | 8 | 8 | 0.0 | 2.3 | 0.0 | 4.6 | na | 0.51 | 0.51 | 1.97 |
| 2A | .05 | 4 | 4 | 8 | 0.6 | 1.6 | 1.7 | 2.3 | 0.32 | 0.72 | 0.55 | 1.82 |
| 3A | .05 | 8 | 0 | 8 | 0.8 | 0.0 | 4.9 | 0.0 | 0.16 | na | 0.16 | 6.20 |

Page 1. PLANNER INPUTS & ENGAGEMENT SUMMARY

Page 2. SCENARIO DESCRIPTION & OPNL FACTORS

Page 3. ACFT & WEAPON CHARACTERISTICS

Page 4. AERO PERFORMANCE FACTOR

Page 5. AIRCRAFT LETHALITY

Page 6. SORTIE PLANNING FACTORS

Page 7. HUMANICS (PILOT EXPERIENCE, TRAINING, & LEADERSHIP)

Page 8. KILLS, KILL RATIOS, EXCHANGE RATIOS

**DACM (2.3) DEMO PROVIDES USEFUL RESEARCH TOOL**

# DACM PAGE 2. SCENARIO & HUMAN FACTORS

TABLE I. SCENARIO DESCRIPTION

| ITEM | UNITS | BLUE | RED |
|---|---|---|---|
| Daily Operating Fraction | nd | 0.5 | 0.5 |
| Distance to Operating Area | nm | 100 | 300 |
| Max Speed for pacing Acft | mph | 300 | 200 |
| Mission Turn-Around Time | hrs | 0.5 | 0.5 |
| Mean Time Before Repair | hrs | 20 | 20 |
| Mean Time to Repair | hrs | 20 | 20 |
| * Sensor Paerformance | nd | 1 | 1 |
| * Avionics Performance | nd | 1 | 1 |
| Weight Factor - Acro Perf | nd | 0.7 | 0.6 |
| Weight Facror - Wpns Performance | nd | 0.3 | 0.4 |
| Weight Factor - Numbers | nd | 0.5 | 0.5 |
| Weight Factor - Tech Quality | nd | 0.5 | 0.5 |

- *MODEL PROVIDES PLANNER WITH DATA SUPPORTING LOGISTICS DECISIONS FOR NEXT ENGAGEMENT*

- *HUMAN FACTORS VERY IMPORTANT IN AIR COMBAT*
- *TABLE II. DEMO DATA PROVIDES GERMAN ADVANTAGE OVER BRITS OF APPROX 2:1*
- *THIS RATIO PROBABLY REALISTIC IN AUG 1940*

TABLE II. HUMAN FACTORS

| ITEM | UNITS | BLUE | RED |
|---|---|---|---|
| PILOT LIMITATIONS | | | |
| Pacing Acft Endurance | hrs | 5 | 10 |
| Max Allowable Fly Hrs per day | hrs | 6 | 12 |
| PILOT EXPERIENCE | | | |
| Relevant Combat Missions | msns | 75 | 150 |
| Relevant Training Missions | msns | 200 | 350 |
| Recency of Combat Experience | mos | 1 | 1 |
| Recency of Training Experience | mos | 6 | 6 |
| Missions in Current Combat Command | msns | 100 | 300 |
| Weight Factor - Combat Experience | nd | 0.3 | 0.3 |
| Weight Facror - Training | nd | 0.2 | 0.2 |
| Weight Factor - Currency | nd | 0.1 | 0.1 |
| Weight Factor - Leadership Quality | nd | 0.1 | 0.1 |
| Weight Factor - Aircrew Quality | nd | 0.3 | 0.3 |

*MODEL UNDERGOING REFINEMENT...SPREADSHEET IS A TOOL*

# DACM PAGE 3. ACFT & WPN CHARACTERISTICS

TABLE III. FORCE COMPOSITION & PERFORMANCE CHARACTERISTICS

| AIRCRAFT | S | Msn # | Vmax mph | Hmax kft | Hend hrs | BHP fp/m | Aw sqf | Acrt sqf | Wt lbs |
|---|---|---|---|---|---|---|---|---|---|
| HURRICANES | 0 | 3 | 311 | 35.0 | 2.0 | 1,030 | 258 | 56.1 | 6,252 |
| SPITFIRES | 8 | 3 | 355 | 37.0 | 2.0 | 1,030 | 242 | 54.2 | 5,481 |
| Bf-109E4 | 8 | 3 | 348 | 35.0 | 2.5 | 1,175 | 174 | 106.6 | 5,205 |
| He-111 | 0 | 1 | 252 | 27.9 | 5.0 | 1,000 | 942 | 550.0 | 19,136 |

TABLE IV. WEAPON CHARACTERISTICS

| AIRCRAFT | WEAPONS # | Type | Fpos nd | Ng nd | Vmuz fps | Wp lbs | RoF rpm | Reff nd |
|---|---|---|---|---|---|---|---|---|
| HURRICANES | 8 | Br .303 | 1.00 | 2.83 | 2,600 | 0.022 | 1,200 | 0.957 |
| SPITFIRES | 8 | Br .303 | 1.00 | 2.83 | 2,600 | 0.022 | 1,200 | 0.957 |
| Bf-109E4 | 2 | MG17 Syn | 1.00 | 1.41 | 2,970 | 0.028 | 1,180 | 1.055 |
| | 2 | MG 20mm | 1.00 | 1.41 | 1,950 | 0.295 | 350 | 3.755 |
| He-111 | 1 | MG 20mm | 1.00 | 1.00 | 1,950 | 0.295 | 350 | 3.755 |
| | 5 | MG15 flex | 0.25 | .24 | 3,000 | 0.028 | 1,000 | 1.056 |

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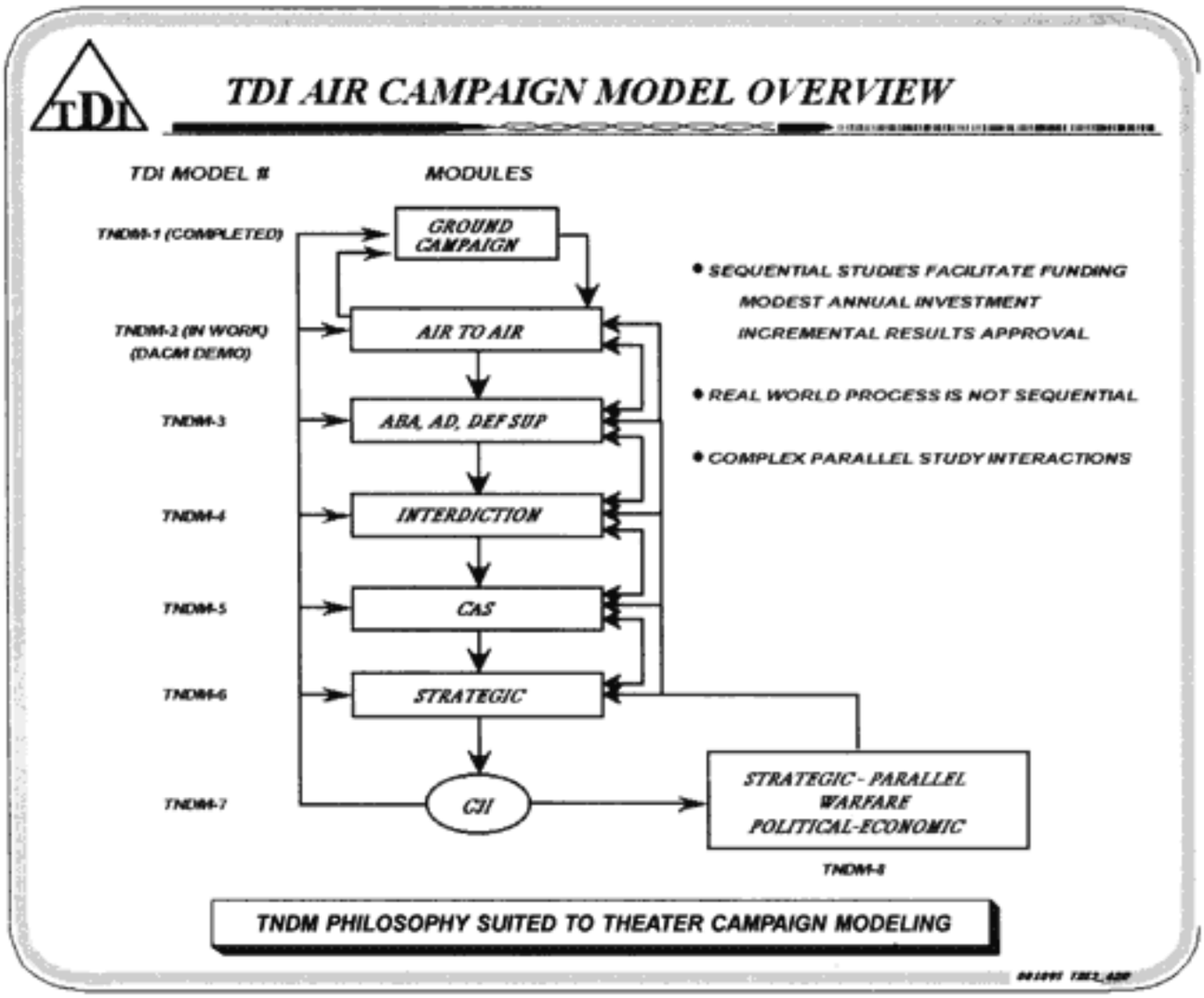
# OVERVIEW

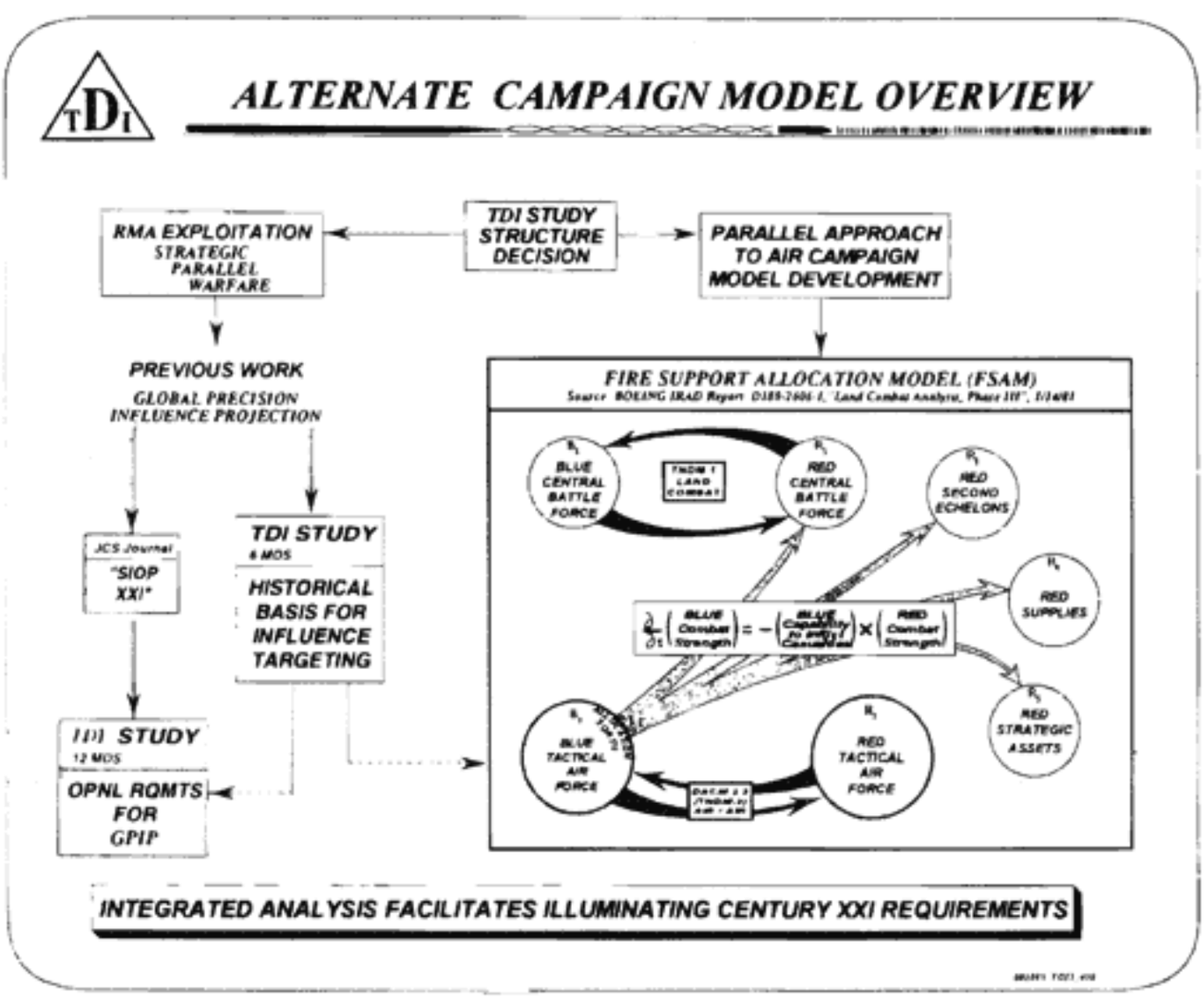
- **STUDY OVERVIEW**
  - STUDY ON COURSE, AIR-TO-AIR FOCUS
  - TREVOR'S DEATH . . . PROFOUND IMPACT
  - STRONG TEAM ASSEMBLED. . . SIGNIFICANT RESULTS ACHIEVED
- **PELIMINARY MODEL**
  - QJM / TNDM DEVELOPED FOR GROUND COMBAT
  - AIR CAMPAIGN DOMINATED BY PLATFORM PERFORMANCE
  - NEW MODEL ARCHITECTURE REQUIRED
- **CURRENT TDI A/A MODEL**
  - AIRCRAFT PERFORMANCE DETERMINES HOW LETHALITY EMPLOYED
  - HISTORICAL CORRELATION MECHANISM INCLUDED
  - SPREADSHEET MECHANZATION PROVIDED USEFUL TOOL
- **RECOMMENDATIONS**

# SUMMARY OBSERVATIONS

- CONFIDENCE GROWING IN DACM METHODOLOGY
- MODEL DERIVATION FROM / CORRELATION WITH HISTORICAL EXPERIENCE SHOULD CONTINUE
- SPREADSHEET DEMO TOOL PERMITS AIR UNIVERSITY PARTICIPATION
  STUDENTS CAN PARTICIPATE IN MODEL IMPROVEMENT
- AIR-TO-AIR MODULE COMPLEMENTS QJM / TNDM GROUND MODEL
- AIR CAMPAIGN MODEL EXPANSION IS VERY COMPLEX

**A GOOD START...NEXT LOOK AT BIG PICTURE**


TDI AIR CAMPAIGN MODEL OVERVIEW
TDI MODEL #
MODULES
TNDM-1 (COMPLETED)
GROUND CAMPAIGN
TNDM-2 (IN WORK) (DACM DEMO)
AIR TO AIR
TNDM-3
ABA, AD, DEF SUP
TNDM-4
INTERDICTION
TNDM-5
CAS
TNDM-6
STRATEGIC
TNDM-7
CJI
STRATEGIC - PARALLEL WARFARE POLITICAL-ECONOMIC
TNDM-8
• SEQUENTIAL STUDIES FACILITATE FUNDING
MODEST ANNUAL INVESTMENT
INCREMENTAL RESULTS APPROVAL
• REAL WORLD PROCESS IS NOT SEQUENTIAL
• COMPLEX PARALLEL STUDY INTERACTIONS
TNDM PHILOSOPHY SUITED TO THEATER CAMPAIGN MODELING


ALTERNATE CAMPAIGN MODEL OVERVIEW
RMA EXPLOITATION
STRATEGIC
PARALLEL
WARFARE
TDI STUDY
STRUCTURE
DECISION
PARALLEL APPROACH
TO AIR CAMPAIGN
MODEL DEVELOPMENT
PREVIOUS WORK
GLOBAL PRECISION
INFLUENCE PROJECTION
JCS Journal
"SIOP XXI"
TDI STUDY
6 MOS
HISTORICAL
BASIS FOR
INFLUENCE
TARGETING
TDI STUDY
12 MOS
OPNL RQMTS
FOR
GPIP
FIRE SUPPORT ALLOCATION MODEL (FSAM)
BLUE CENTRAL BATTLE FORCE
RED CENTRAL BATTLE FORCE
RED SECOND ECHELONS
RED SUPPLIES
RED STRATEGIC ASSETS
BLUE TACTICAL AIR FORCE
RED TACTICAL AIR FORCE
INTEGRATED ANALYSIS FACILITATES ILLUMINATING CENTURY XXI REQUIREMENTS

# INFLUENCE PROJECTION

*INFLUENCE MECHANISM . . .*

AN EVENT, ELEMENT, FACTOR, OR PROCESS WHICH HAS THE POTENTIAL TO CAUSE A DECISIVE CHANGE IN A COMBAT OUTCOME, A TREND IN CRISIS ESCALATION, OR A PATTERN OF NATIONAL BEHAVIOR

EXAMPLES

- LOSS OF PRINCIPAL LEADERSHIP
- FAILURE OF A MAJOR WEAPON SYSTEM
- LOSS OF CONTROL OR COMMAND CAPABILITY
- EXPLOITATION OF A TEMPORARY LOGISTICS VULNERABILITY

*INFLUENCE OPERATIONS . . .*

THE APPLICATION OF SPECIAL "PACKAGES" (WEAPONS, DEVICES, AND/OR FORCES), OFTEN PROJECTED FROM GREAT RANGE; TO EXCITE, INDUCE, OR EXACERBATE ONE OR MORE INFLUENCE MECHANISMS

RESEARCH NEEDED TO VALIDATE EXISTANCE AND TO BETTER DEFINE POTENTIAL INFLUENCE MECHANISMS

# HISTORICAL OVERVIEW

- PRELIMINARY ASSESSMENT PROVIDED BY T. N. DUPUY (COL, USA, RET)

| INFLUENCE CATEGORY | EXAMPLE / EVENT | DATE | NOTES |
|---|---|---|---|
| REMOVAL (LOSS) OF PRINCIPAL LEADERSHIP DURING ENGAGEMENT | JULIAN AT THE TIGRIS | 363 | DECISIVE DEFEAT |
| | HAROLD AT HASTINGS | 1066 | DECISIVE DEFEAT |
| | JOHN TALBOT AT CASTILLON | 1453 | PROB. LOST ANYWAY |
| | TURENNE AT NIEDER-SASBACH | 1675 | DECISIVE DEFEAT |
| | A. S. JOHNSON AT SHILOH | 1862 | PROB. LOST ANYWAY |
| FAILURE OF A MAJOR WEAPON SYSTEM | MACEDONIAN PHALANX AT CYNOSCEPHALAE | 197 BC | |
| | THE LEGION AT ADRIANOPLE | 378 | |
| | ARMORED CAVALRY AT CRECY | 1346 | |
| | CROSSBOW AT CRECY | 1346 | |
| | FRENCH MITRAILLEUSE | 1870 | |
| | GERMAN MAGNETIC MINES | 1939 | |
| | GERMAN V-2 | 1944-45 | |
| | IRAQI "SCUD" | 1991 | |
| LOSS OF CONTROL / COMMAND | PRINCE RUPERT AT NAESBY | 1645 | |
| | MCCLELLAND- SEVEN DAYS & ANTIETAM | 1862 | |
| | RUSSIANS AT TANNENBERG | 1914 | |
| | MOLTKE (YOUNGER) AT MARNE CAMPAIGN | 1914 | |
| | BRITISH AT FIRST GAZA | 1917 | |
| | FREDENDALL AT KASSERINE | 1943 | |
| | S. HUSSEIN IN DESERT STORM | 1991 | |

# POTENTIAL CRISIS AREAS


*Projected crises are located by country of origin.*
*Indicated crises are conflicts which have reasonable expectation of evoking a U.S. reaction or response in which military action may be considered.*

Source: DUPUY, T.N.; "Global Trends in Historical Perspective"; Historical Evaluation Research Organization/Dowling, Mar '90

1. BALTIC STATES
2. SOVIET CENTRAL ASIA
3. SLOVENIA
4. TRANSYLVANIA
5. BESSARABIA
6. GIBRALTAR
7. CYPRUS
- PERSIAN GULF

8. BAGHDAD (NUC REACTOR)
9. ISLAMABAD (NUC REACTOR)
10. AZERBAIJAN
- AFGHANISTAN
- ISRAEL
- LEBANON
- MOSLEM COALITION

14. NEPAL
15. BURMA
- KASHMIR
17. SRI LANKA
- CAMBODIA
19. HONG KONG
- SPRATLEY IS.

21. KURILES
- KOREA
23. TAIWAN
- PHILIPPINES
25. NEW CALEDONIA
26. TAHITI
27. FIJI

28. ETHIOPIA
- ERITREA
30. SOMALIA
- ANGOLA
32. ZAIRE
33. MOZAMBIQUE
- SOUTH AFRICA
- LIBYA

35. CUBA
36. HAITI
- EL SALVADOR
38. NICARAGUA
39. PANAMA
- PERU/COLOMBIA
41. BOLIVIA
42. FALKLAND IS.

# STRATEGIC PARALLEL WARFARE

- CONCEPT OF STRATEGIC PARALLEL WARFARE IS CONSISTENT WITH *GLOBAL PRECISION INFLUENCE PROJECTION (GPIP)*
- PREVIOUSLY ACCOMPLISHED ANALYSIS ON GPIP HELPS BUILD STRONG FOUNDATION FOR NEW RESEARCH
  - INITIAL ASSESSMENTS OF INFLUENCE MECHANISMS EMERGING FROM DESERT STORM
  - PRELIMINARY VALIDATION FROM HISTORICAL PRECEDENTS
  - QUANTIFIABLE MEASURE OF TARGET PRIORITIES AND TIME SENSITIVITY
- SUBSTANTIAL DOCUMENTATION EXISTS FOR GPIP
  - EXPANDED EXPOSITORY BRIEFING
    - DR LABERGE. . . AMB KIRKPATRICK STAFF. . . JACKSON SCHOOL AT UW
  - "JOURNAL OF THE JCS" ESSAY CONTEST ON "REVOLUTION IN MILITARY AFFAIRS" (RMA)
    - 5000 WORD ESSAY "SIOP XXI". . . SUBMITTED AUG '95
- *SPW, RMA, GPIP* ARE COMPLEX . . . NO COMPREHENSIVE ANSWERS AVAILABLE

**ATTRACTIVE OPPORTUNITY EXISTS TO BUILD ON PREVIOUS WORK**

# OVERVIEW

| | |
|---|---|
| ● STUDY OVERVIEW | • STUDY ON COURSE, AIR-TO-AIR FOCUS<br>• TREVOR'S DEATH . . . PROFOUND IMPACT<br>• STRONG TEAM ASSEMBLED. . . SIGNIFICANT RESULTS ACHIEVED |
| ● PELIMINARY MODEL | • QJM / TNDM DEVELOPED FOR GROUND COMBAT<br>• AIR CAMPAIGN DOMINATED BY PLATFORM PERFORMANCE<br>• NEW MODEL ARCHITECTURE REQUIRED |
| ● CURRENT TDI A/A MODEL | • AIRCRAFT PERFORMANCE DETERMINES HOW LETHALITY EMPLOYED<br>• SPREADSHEET MECHANZATION PROVIDED USEFUL TOOL<br>• HISTORICAL CORRELATION MECHANISM INCLUDED |
| ● RECOMMENDATIONS | • COMPLETE HISTORICAL CORRELATION FOR AIR-TO-AIR<br>• SUPPORT JOINT PARTICIPATION<br>• EXPAND EFFORT TO BUILD AIR CAMPAIGN MODEL<br>• INITIATE STUDY ON STRATEGIC PARALLEL WARFARE BASED ON GPIP FOUNDATIONS |

# OVERVIEW

- **STUDY OVERVIEW**
  - STUDY ON COURSE, AIR-TO-AIR FOCUS
  - TREVOR'S DEATH . . . PROFOUND IMPACT
  - STRONG TEAM ASSEMBLED. . . SIGNIFICANT RESULTS ACHIEVED
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- **RECOMMENDATIONS**
  - COMPLETE HISTORICAL CORRELATION FOR AIR-TO-AIR
  - SUPPORT JOINT PARTICIPATION
  - EXPAND EFFORT TO BUILD AIR CAMPAIGN MODEL
  - INITIATE STUDY ON STRATEGIC PARALLEL WARFARE BASED ONGPIP FOUNDATIONS

# The Dupuy Air Campaign Model

by Col. Joseph A. Bulger, Jr., USAF, Ret.

The Dupuy Institute, as part of the DACM, created a draft model in a spreadsheet format to show how such a model would calculate attrition. Below are the actual printouts of the "interim methodology demonstration," which shows the types of inputs, outputs, and equations used for the DACM. If anyone has questions about specific details of this effort, the Institute can provide a copy of the final report. The spreadsheet format was created by Col. Bulger, while many of the formulae were the work of Robert Shaw.

DUPUY AIR COMBAT MODEL (DACM)

INTERIM METHODOLOGY DEMONSTRATION

This demo file is loaded with aircraft and weapon data for Hurricane I, Spitfire IA, Bf-109E4, and He-111. Two Blue acft types can engage the Red force composed of variable numbers of Bf-109 acft.

| Step | GOTO | ALT | TABLE | Task |
|---|---|---|---|---|
| 1. | N4 | s | I. | Input scenario data influencing sortie rates. |
| 2. | N24 | h | II. | Input data & weights for human (pilot) factors. |
| | Note: | Tables I & II have been pre-loaded with preliminary data. | | |
| 3. | V3 | a | III. | Check aircraft performance data. |
| | Note: | Disregard number of sorties (#S). Select later. | | |
| 4. | V24 | w | IV. | Ckeck weapon characteristics data. |
| 5. | "Page Down" to go to engagement summary screen & begin runs. | | | |
| 6. | Addl macros... \c > Calc scrn \i > Input | | | |

PLANNER INPUTS AND ENGAGEMENT SUMMARY

| | ALLOCATE SORTIES (S) | | SURV | LETH | APF | KILLS | LOST | ERa | ERf |
|---|---|---|---|---|---|---|---|---|---|
| b | HURRICANES | 0 | 4.60 | 53.0 | 0.93 | 0.0 | 0.0 | na | |
| l | | | | | | | | | 0.51 |
| u | SPITFIRES | 8 | 4.46 | 53.0 | 1.01 | 2.3 | 4.6 | 0.51 | |
| r | Bf-109E4 | 8 | 1.63 | 73.6 | 0.99 | 4.6 | 2.33 | 1.97 | 1.97 |
| e | | | | | | | | | |
| d | He-111 | 0 | | | | | | | |

TRIAL K FACTOR = 0.05

RECORD OF TRIALS TO DETERMINE HISTORICAL (BoB) CORRELATION

| Run # | #H | #S | #Bf | Kh | Ks | Lh | Ls | ERh | ERs | ERfb | ERfr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 0 | 8 | 8 | 0.0 | 2.3 | 0.0 | 4.6 | na | 0.51 | 0.51 | 1.97 |
| 1B | 4 | 4 | 8 | 0.6 | 1.6 | 1.7 | 2.3 | 0.32 | 0.72 | 0.55 | 1.82 |
| 1C | 8 | 0 | 8 | 0.8 | 0.0 | 4.9 | 0.0 | 0.16 | na | 0.16 | 6.20 |

SCENARIO DESCRIPTION Title: Demo 1A,B,C

| ITEM | SYMBOL | UNITS | BLUE | RED |
|---|---|---|---|---|
| Daily Operating Fraction | FRop | nd | 0.5 | 0.5 |
| Distance to Operating Area | DoA | nm | 100 | 300 |
| Max Speed for Pacing Acft | Vmax | mph | 300 | 200 |
| Mission Turn-around Time | Tta | hrs | 0.5 | 0.5 |
| Mean Time Before Failure | MTBF | hrs | 20 | 20 |
| Mean Time to Repair | MTTR | hrs | 20 | 20 |
| *Sensor Performance | SP | nd | 1 | 1 |
| *Avionics Performance | AV | nd | 1 | 1 |
| *Weight Factor...Aero Performance | Wap | nd | 0.7 | 0.6 |
| *Weight Factor...Weapons Performance | Wwp | nd | 0.3 | 0.4 |
| *Weight Factor...Numbers | Wn | nd | 0.5 | 0.5 |
| *Weight Factor...Tech Quality | Wq | nd | 0.5 | 0.5 |

TABLE II. HUMAN FACTORS

| PILOT LIMITATIONS | | | BLUE | RED |
|---|---|---|---|---|
| Pacing Acft max Endurance | ENDmax | hrs | 5 | 10 |
| MAx Allowable Flying Hours per Day | Hmax | hrs | 6 | 12 |
| PILOT EXPERIENCE | | | | |
| Relevant Combat Missions | RCM | msns | 75 | 150 |
| Relevant Training Missions | RTM | msns | 200 | 350 |
| Recency of Combat Experience | RFc | mos | 1 | 1 |
| Recency of training Experience | RFt | mos | 6 | 6 |
| Missions in Current Combat Command | MCC | msns | 100 | 300 |
| HUMANICS WEIGHTING FACTORS | | | | |
| Weight of Combat Experience | Wce | nd | 0.3 | 0.3 |
| Weight of Training | Wt | nd | 0.2 | 0.2 |
| Weight of Currency | Wc | nd | 0.1 | 0.1 |
| Weight of Leadership Quality | Wlq | nd | 0.1 | 0.1 |
| Weight of Aircrew Quality | Waq | nd | 0.3 | 0.3 |

Notes:

TABLE III. FORCE COMPOSITION & PERFORMANCE CHARACTERISTICS

| AIRCRAFT | S # | Msn mph | Vmax kft | Hmax hrs | Hend fp/m | BHP sqf | Aw sqf | Acrt lbs | Wt |
|---|---|---|---|---|---|---|---|---|---|
| Hurri I | 0 | 3 | 311 | 35.0 | 2.0 | 1,030 | 258 | 56.1 | 6,252 |
| Spit IA | 8 | 3 | 355 | 37.0 | 2.0 | 1,030 | 242 | 54.2 | 5,481 |
| Bf-109E4 | 8 | 3 | 348 | 35.0 | 2.5 | 1,175 | 174 | 106.6 | 5,205 |
| He-111 | 0 | 1 | 252 | 27.9 | 5.0 | 1,000 | 942 | 550.0 | 19,136 |

Notes:

TABLE IV. WEAPON CHARACTERISTICS

| AIRCRAFT | WEAPONS # | Type | Fpos nd | Ng nd | Vmuz fps | Wp lbs | RoF rpm | Reff nd |
|---|---|---|---|---|---|---|---|---|
| Hurri I | 8 | Br .303 | 1.00 | 2.83 | 2,600 | 0.022 | 1,200 | 0.957 |
| Spit IA | 8 | Br .303 | 1.00 | 2.83 | 2,600 | 0.022 | 1,200 | 0.957 |
| Bf-109E4 | 2 | MG17syn | 1.00 | 1.41 | 2,970 | 0.028 | 1,180 | 1.055 |
| | 2 | MGFF20MM | 1.00 | 1.41 | 1,950 | 0.295 | 350 | 3.755 |
| He-111 | 1 | MGFF20MM | 1.00 | 1.00 | 1,950 | 0.295 | 350 | 3.755 |
| | 5 | MG15flx | 0.25 | 2.24 | 3,000 | 0.028 | 1,000 | 1.056 |

EQUATIONS FOR CALCULATING RELATIVE EFFECTIVE RANGE (Reff)

$Reff = Wp^{(1/3)} \times \log(Vmuz)$ for machine guns

$Reff = Wp^{(1/3)} \times 23.5 \times [\log(Vmuz) - 3.05]$ for cannon

Notes:

TABLE V. CALCULATION OF AERO PERFORMANCE FACTOR (APF)

| ACFT | Vmax mph | Vmax fps | Hmax kft | Reff | EGY kft | Efac nd | BHP khp | Aw sqf | Wt klb | STR | MSN TYP | APF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hurri I | 311 | 456 | 35.0 | 0.957 | 38.8 | 0.94 | 1.03 | 258 | 6.25 | 0.14 | 3 | 0.93 |
| Spit Ia | 355 | 521 | 37.0 | 0.957 | 41.7 | 1.01 | 1.03 | 242 | 5.48 | 0.16 | 3 | 1.01 |
| Bf-109E4 | 348 | 510 | 35.0 | 3.755 | 41.1 | 0.99 | 1.18 | 174 | 5.21 | 0.15 | 3 | 0.99 |
| He-111 | 252 | 370 | 27.9 | 1.056 | 30.6 | 0.74 | 1.00 | 942 | 19.1 | 0.09 | 1 | 0.74 |

EGY*=avg = 41.4 STR*=avg= 0.1557

EQUATIONS FOR CALCULATING AERO PERFORMANCE

EGY = (Vmax^2 / 2G) + Hmax + 557 x Reff for V in fps

STR = [SQRT(BHP x Aw) / Wt] x 1.75 for prop acft
STR = [SQRT(T x Aw) / Wt] for conventional jet acft
STR = [SQRT(T x Aw) / Wt] x 0.75 for delta-jet acft

APF = AP = Wegy x Efac + Wman x Tfac

Efac = EGY / EGY* where EGY* = average EGY of acft in engagement

Tfac = STR / STR* where STR* = average STR of acft in engagement

Wegy & Wman Factors

| MISSION TYPE | Wegy | Wman |
|---|---|---|
| 1. Interceptors v escorted bombers | .62 | .38 |
| 2. Interceptors v non escorted bombers | .67 | .33 |
| 3. Escort, fighter sweep | .57 | .43 |
| 4. Bomber | 1.00 | 0.00 |
| 5. Fighter-bomber | .57 | .43 |

Notes:
1. For this methodology trial, all acft in same group (intcp, escort, etc) are of same type; EGY* and STR* are input by planner. In revised program, EGY* and STR* will be calculated based on average of all mixed type aircraft within same engagement.

TABLE VI. CALCULATION OF WEAPON BATTERY EFFECTIVENESS (EFF)

| AIRCRAFT | WEAPONS Type | # | Fpos | Vmuz fps | RoF* rpm | EFF / 10^6 | Ng | WE | Wp lbs | DESfac /10^6 |
|---|---|---|---|---|---|---|---|---|---|---|
| Hurri I | Br .303 | 8 | 1.00 | 2,600 | 1,200 | 3.12 | 2.83 | 8.82 | 0.022 | 6.004 |
| Spit Ia | Br .303 | 8 | 1.00 | 2,600 | 1,200 | 3.12 | 2.83 | 8.82 | 0.022 | 6.004 |
| Bf-109E4 | MG17syn | 2 | 1.00 | 2,970 | 944 | 2.80 | 1.41 | 3.97 | 0.028 | 11.39 |
| | MGFF20MM | 2 | 1.00 | 1,950 | 350 | 0.68 | 1.41 | 0.97 | 0.295 | 197.3 |
| He-111 | MGFF20MM | 1 | 1.00 | 1,950 | 350 | 0.68 | 1.00 | 0.68 | 0.295 | 33.96 |
| | MG15flx | 5 | 0.25 | 3,000 | 1000 | 0.75 | 2.24 | 0.42 | 0.028 | 11.73 |

EQUATIONS FOR CALCULATING WEAPON EFFECTIVENESS

EFF is relative capability of single weapon to hit a given target.

EFF = Fpos x Vmuz x RoF*

where RoF diminished by 20% for synch guns

WE is ability of a SET (battery) of weapons to hit target.

WE = Fpos x EFF x Ng*

where Ng* = sqrt (# guns)

DESfac is relative destructive power of a single hit.

DESfac= Wp x Vmuz^3/64.4 (machine guns)

DESfac= Vmuz x Wp x ( Vmuz^2/64.4 + 28.4X10^4) (cannon)

TABLE VII. BATTERY LETHALITY (LETHbat) | TABL VIII. ACFT LETHALITY(LETH)

| AIRCRAFT | WE | DESfac | LETH (bat) | | EFF | | LETH |
|---|---|---|---|---|---|---|---|
| Hurri I | 8.82 | 6.00 | 52.99 | \| | 3.12 | | 52.99 |
| Spit Ia | 8.82 | 6.00 | 52.99 | \| | 3.12 | | 52.99 |
| Bf-109E4 | 3.97 | 11.39 | 45.16 | \| | 2.80 | ) combined | |
| | 0.97 | 197.3 | 190.47 | \| | 0.68 | ) leth | > 73.61 |
| He-111 | 0.68 | 33.97 | 23.18 | \| | 0.68 | ) combined | |
| | 0.42 | 11.74 | 4.92 | | 0.75 | ) leth | > 13.621 |

BATTERY LETHALITY

LETHbat is lethality of battery.

LETHbat = WE x DESfac

AIRCRAFT LETHALITY

LETH is combined lethality of all batteries on one aircraft.

$$LETH = \frac{LETHbat1 \times EFF1 + LETHbat2 \times EFF2 + \ldots}{EFF1 + EFF2 + \ldots}$$

Note: Incorporates Shaw revised Reff>>Eff for LETH eqn.

TABLE V. CALCULATION OF AIRCRAFT SORTIE LIMITS & NUMBERS (N)

| AIRCRAFT | MSN # | MSN TYP | FRop | DoA nm | Vmax kts | MTTR/MTBF | Tta hrs | END hrs | Hmax hrs | Smax ac | Smax crew | Rfac nd | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hurri I | 3 | FTR | 0.50 | 100 | 270 | 1.00 | 0.5 | 5 | 6 | 2.2 | 4.1 | 0.753 | N/A |
| Spit Ia | 3 | FTR | 0.50 | 100 | 308 | 1.00 | 0.5 | 5 | 6 | 2.2 | 4.6 | 0.784 | N/A |
| Bf-109E4 | 3 | ESC | 0.50 | 300 | 302 | 1.00 | 0.5 | 10 | 12 | 1.4 | 3.0 | 0.669 | N/A |
| He-111 | 1 | BMR | 0.50 | 300 | 219 | 1.00 | 0.5 | 10 | 12 | 1.0 | 2.2 | 0.543 | N/A |

EQUATIONS FOR CALCULATING SORTIE LIMITATIONS

MISSION TYPE CODES

CODE MISSION TYPE

1. Interceptor v Escorted Bombers
2. Interceptor v Unescorted Bombers
3. Escort & Fighter Sweep
4. Bomber
5. Fighter-bomber

CONVERSION mph > kts

mph x 5280/6080 = kts

For bombers (strategic attack & interdiction) and fighter escorts;

$$Smax = 1 + \frac{24 \times FRop}{[(2 \times DoA / (.5 \times Vmax)] \times [1 + (MTTR/MTBF)] + Tta}$$

Smax = maximum sorties/day permissable for this type aircraft

For fighters, including sweeps, CAP, intercept, recce, etc;

$$Smax = 1 + \frac{24 \times FRop}{[(.5 \times END)] \times [1 + (MTTR/MTBF)] + Tta}$$

$$Rfac = [(.5 \times Hmax \times Vmax) - (2 \times DoA)] / (.5 \times Hmax \times Vmax)$$

$$N = S \times Rfac \times C3Ifac$$

Notes:

1. C3I factor not yet included in calculations...assumed = 1.0.
2. Number of Blue interceptors is a player input from page 1.
3. Number of Red sorties assumed a player input for demo case.
4. FOR DEMO CASE, N IS NOT CALCULATED...ADDN'L DERIVATION IN WORK.

TABLE VI. CALCULATION OF HUMANICS (H)

| FORCE | Wce | RCM | RFc | Wt | RTM | RFt | AQ | MCC | Wc | LQ | Wlq | Waq | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BLUE | 0.3 | 75 | 1.0 | 0.2 | 200 | 6.0 | 29.2 | 100 | 0.1 | 39 | 0.1 | 0.3 | 12.7 |
| RED | 0.3 | 150 | 1.0 | 0.2 | 350 | 6.0 | 57 | 300 | 0.1 | 87 | 0.1 | 0.3 | 25.7 |

EQUATIONS FOR CALCULATING HUMANICS

Aircrew Quality (AQ) = Wce x RCM/RFc + Wt x (RTM/RFt)

Leadership Quality (LQ) = Wce x RCM/RFc + Wt x (RTM/RFt) +Wc x MCC

Humanics component (H) = Wlq x LQ + Waq x AQ

TABLE VII. CALCULATION OF COMBAT POTENTIALS (CP)

| AIRCRAFT | Wap | AP | Wwp | WE/ 10^6 | Q | Wq | Wn | N | H | CP | CP FORCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hurri I | 0.70 | 0.93 | 0.3 | 3.12 | 1.5 | 0.5 | 0.5 | N/A | 12.67 | 10.1 | |
| | | | | | | | | | | | 20.483 |
| Spit Ia | 0.70 | 1.01 | 0.3 | 3.12 | 1.6 | 0.5 | 0.5 | N/A | 12.67 | 10.4 | |
| Bf-109E3 | 0.60 | 0.99 | 0.4 | 2.80 | 1.7 | 0.5 | 0.5 | N/A | 25.7 | 22.0 | |
| | | | | | | | | | | | 31.173 |
| He-111 | 0.60 | 0.74 | 0.4 | 0.68 | 0.7 | 0.5 | 0.5 | N/A | 25.7 | 9.2 | |

EQUATIONS FOR CALCULATING COMBAT POTENTIALS

Technical Quality = Q = [Wap x AP + Wwp x WE] x SP x AV

Note: Sensor performance (SP) and Avionics (AV) assumed = 1.0 for demo.

Combat Potential = CP = [Wn x N + Wq x Q] x H

Note: CPforce = Sum of CP for sorties within same mission.

Notes:

1. FOR THIS DEMO, COMBAT POTENTIAL NOT USED DIRECTLY...HUMANICS FACTORS SELECTED TO YIELD OVERALL (H) FACTOR FAVORING RED BY APPROX 2:1.

TABLE VIII. CALCULATION OF AIRCRAFT KILLS

| AIRCRAFT | Aw sqf | Acr sqf | SURV nd | LETH nd | APF nd | S | N* | H | KILLS | LOST |
|---|---|---|---|---|---|---|---|---|---|---|
| Hurri I | 258 | 56 | 4.60 | 52.99 | 0.93 | 0 | 0.00 | | 0.0 | 0.0 |
| | | | | | | | | 12.7 | | |
| Spit Ia | 242 | 54 | 4.46 | 52.99 | 1.01 | 8 | 2.83 | | 2.3 | 4.6 |
| Bf-109E4 | 174 | 107 | 1.63 | 73.61 | 0.99 | 8 | 2.83 | | 4.6 | 2.3 |
| | | | | | | | | 25.7 | | |
| He-111 | 942 | 550 | 1.71 | 13.62 | 0.74 | 0 | 0.00 | | | |

EQUATIONS FOR CALCULATING AIRCRAFT KILLS

SURVIVABILITY = SURV = Aw / Acr

BLU KILLS=KILLSb=KxN* x (APFb/APFr) x (LETHb/SURVr) x (Hb/Hr) x N*/N*tot

Where K in a constant of proportionality to be determined by extraction from historical data.

*************
* K =0.05 *
*************

N* is number of ENGAGEMENTS (1v1), a function of sorties (S). Until refined, N* will be sqrt of S, a player input.

TABLE IX. CALCULATION OF FORCE EXCHANGE RATIOS (ER)

| AIRCRAFT | AP nd | LETH nd | SURV nd | H | FORCE EXCHANGE RATIOS BLUE | RED |
|---|---|---|---|---|---|---|
| Hurri I | 0.93 | 52.99 | 4.60 | | | |
| | | | | 12.7 | | |
| Spit Ia | 1.01 | 52.99 | 4.46 | | 0.51 | |
| Bf-109E3 | 0.99 | 73.61 | 1.63 | | | 1.97 |
| | | | | 25.7 | | |
| He-111 | 0.74 | 0.00 | 1.71 | | | |

ERb = (APFb/APFr)^2 x (LETHb/LETHr) x (Hb/Hr)^2 / (SURVr/SURVb)

ERr = 1 / ERb

Notes:
For calculation of blue losses in Table VIII, use red kill equation for each blue aircraft type, then sum blue losses to total red kills.

The Battle of Britain was the first "pure" air campaign, meaning that there were no concurrent land or naval actions which affected, or were affected by, aerial operations. There is some dissension concerning the precise start and end dates for the campaign, but most historians and writers accept a start date of 13 August 1940 (known as *Adlertag* or "Eagle Day" to the Luftwaffe) and an end date of 19 September 1940. This yields a campaign length of 37 days.

In basic terms, the Battle of Britain was an unsuccessful attempt by the German Luftwaffe's *Luftflotte* (Air Fleet, equivalent to U.S. numbered Air Forces) *2.*, headquartered at Brussels and operating from airfields in Belgium and far northeastern France, and *Luftflotte 3.*, headquartered at Paris and divided into three operational branches: Bomber Command, Coastal Command, and Fighter Command. Bomber Command controlled most bomber aircraft in Britain, while Coastal Command controlled an assortment of bomber, fighter, and reconnaissance aircraft tasked with operations over the sea areas around the British Isles. Fighter Command, of greatest import for the Battle of Britain, controlled most fighter aircraft in Britain, along with a network of radar sites and ground-based observers laid out to provide an integrated air defense system. This system was directed from Fighter Command headquarters at Stanmore, an RAF airfield some 45 km northwest of central London.

Operationally, Fighter Command was divided into

total of 49 serviceable and 7 non-serviceable Hurricanes.

During the 39 days of the Battle of Britain, RAF Fighter Command lost 602 aircraft in combat, including 4 (0.66%) to British antiaircraft fire and 9 (plus one plane damaged, or 1.58%) to other RAF aircraft. The Luftwaffe lost 868 aircraft over the same period, of which 16 (1.84%) were downed by other German planes, and 37 (4.26%) fell to British antiaircraft fire. RAF Spitfires shot down an average of 3.88 German aircraft per 100 sorties, while Hurricanes downed 3.50 Germans, Blenheims downed barely 0.5 planes per 100 sorties, and the much-lamented Boulton-Paul Defiant downed an astonishing 11.2 German aircraft per 100 sorties. To put this last statistic into proper perspective, there were only 67 Defiant sorties during the entire period, and the Defiants lost 20.15 aircraft per 100 sorties. The Spitfire loss rate was 3.19 per 100 sorties, that for Hurricanes was 2.37 per 100 sorties, and that for the Blenheims (operating largely at night) was barely 0.3 per 100 sorties.

The Germans exhibited a rather different kill-rate and loss-rate picture. The Bf-109E, generally accounted the best fighter of the era, downed 4.79 RAF aircraft per 100 sorties, and lost 3.54 Bf-109Es per 100 sorties. The much-vaunted Bf-110Cs fared much worse, downing a respectable 2.72 RAF planes per 100 sorties, but losing an astonishing 6.52 *zerstörers* per 100 sorties. In that light, it is no great surprise that by early September, Luftwaffe commanders had been directed to screen Bf-110C missions with Bf-109Es, escorting their fighters with fighters!

German bombers, unfortunately for the Luftwaffe, suffered similarly. Although the slow, clumsy Ju-87 Stukas downed 1.49 RAF planes per 100 sorties while losing 4.91 of their own, the larger twin-engine bombers shot down 0.83 RAF planes per 100 sorties, and lost an appalling 3.09 of their own planes per 100 sorties. Especially for the bombers, the Germans lost the attrition struggle.

This loss imbalance occurred for several reasons. Primary among these was that when an RAF plane went down in the combat zone, its pilot was usually able to land safely on British soil, and rejoin his squadron within hours or (at most) a few days. For German aircrew, the situation was different. Even if they managed to escape the battle zone without destruction, they stood only about an even chance of reaching a German airfield safely. German aircrew that landed in the Channel were often picked up by the British, despite the determined and gallant efforts of the handful of German air-sea rescue units.

Second, the British had a major advantage in their integrated air defense system, coordinating radar early warning, ground observer confirmation, fighter interception, and antiaircraft fire. Although the British were sometimes outfoxed by the Germans (who twice staged dummy bombing raids, which turned back before reaching the British coast, to draw British fighters out into ambush by German fighter sweeps), in general they were able to attack every German raid, and claim a plane or two at the very least.

Third, the Germans had not conceived of a long-term campaign where replacement aircrew and aircraft would become an important factor, were ill-prepared for this, and after a few weeks, units had to stand down for a period to integrate new pilots and planes. The RAF, on the other hand, had created a comprehensive system to keep a steady stream of new pilots and aircraft flowing to the operational squadrons. In fact, as heavy as Fighter Command's losses were during the period (they lost almost 90% of their initial pool of serviceable aircraft), the serviceable aircraft totals in Fighter Command generally rose during the 39-day campaign, fed by steady production from Britain's aircraft factories.

Fourth, and most important from the German point of view, was a failure to recognize Fighter Command's points of vulnerability. Although the Germans directed a number of raids against the coastal radar sites, they had little indication of the success of these attacks, and (more important yet) did not comprehend how crucial these sites were to Fighter Command's resistance. Linked to this was a general failure by the Luftwaffe to coordinate and orchestrate its target selection: the Germans sent only one strike at Stanmore, and few raids at the regional Group headquarters (Uxbridge for No. 11 Group, and Box for No. 10).

The German failure to recognize the most important targets in Britain was ultimately very costly to them, since their considerable offensive effort was dissipated, directed against a variety of targets of varying importance, and leaving the vital command-and-control infrastructure of RAF Fighter Command essentially intact.

The data availability for the Battle of Britain is extraordinary. Not only are operational records for British forces intact, but considerable German material is available also, despite efforts by G÷ring and the senior Luftwaffe leadership to destroy the service's records at the end of the war. Moreover, there is an ongoing archaeological effort to identify and catalog the wrecked aircraft from the battle, scattered around the countryside of southern England, and in the shallow waters immediately offshore. As a result of years of effort, most of it by dedicated amateurs, nearly all of these wrecked planes have been identified by unit, crew, and (most of them) aircraft serial number. Consequently, it is possible for even modest secondary sources to provide an accurate minute-by-minute account of the principal actions.

There are some problems, not least the fact that the British were operating under Double Daylight Saving Time, so that British times are two hours off from German times. This must be borne in mind when reconstructing actions. Further, some minor mysteries remain, like planes lost at night over water and never recovered.

# Numerical Adjustment of CEV Results: Averages and Means

by Christopher A. Lawrence and David L. Bongard

As part of the battalion–level validation effort, we made two runs with the model—one without CEV incorporated and one with the CEV incorporated. The printout of a TNDM run will have three CEV figures for each side: $CEV_t$, $CEV_l$ and $CEV_{ad}$. $CEV_t$ shows the CEV as calculated on the basis of battlefield results as an ratio of the performance of side a versus side b. It measures performance based upon three factors: mission accomplishment, advance, and casualty effectiveness. $CEV_t$ is calculated according to the following formula:

$CEV_a = (R_a/R_d)/(P'_a/P'_d)$

$R_a = Mf_a + Esp_a + Ecas_a$ a = attacker

$R_d = Mf_d + Esp_d + Ecas_d$ d = defender

MF = Mission Factor
Assigned by judgement with a value ranging from 1 through 10 for each side.

Esp = Calculated spatial effectiveness factor
$Esp_a = \sqrt{[(S_a \times us_a)/(S_d \times us_d)]} \times (4Q + D_d)/3D_a$
$Esp_d$ = as above, exchange "d" for "a"
S = Strength (total OLI)
us = is taken from Table 6 (Posture Factor for Force Strength)
Q = distance advanced
D = depth in kilometers occupied the troops of each side (see table 20).

Ecas = Calculated casualty effectiveness factor
$Ecas_a = v_d^2 \times \sqrt{[(Cas_d \times us_a/S_d)/(Cas_a \times us_d/S_a) - \sqrt{100\ Cas_a/N_a}]}$
$Ecas_d$ = as above, exchange "d" for "a".
v = Vulnerability score. $v_d$ is calculated:

$v_d = 1 - (V_d/S_d)$

$v_d = N_d(uv/ru) \times S_a/S_d \times yv \times rv$

yv = Air superiority effect
rv = Shoreline vulnerability effect
Cas = Number of casualties
N = Number of Personnel

P' = Refined Combat Power Ratio (sum of the modified OLIs). The ' in P' indicates that this ratio has been "refined" (modified) by two behavioral values already, this is the factor for Surprise and the Set Piece Factor.

$CEV_d = 1/CEV_a$ (the reciprocal)

In effect the formula is relative results times modified combat power ratio. This is basically the formulation that was used for the QJM.

In the TNDM Manual, there is an alternate CEV method based upon comparative effective lethality. This methodology has the advantage that the user doesn't have to evaluate mission accomplishment on a ten point scale. The CEVl calculated according to the following formula:

$CEV_l = \sqrt{(L_a/L_d)}$

$L_a = K_a/(us_a \times ru_a \times hu_a \times zu_a \times (\sqrt{sz_a}))$
$L_d$ = as above, exchange "d" for "a"
ru = terrain factor
hu = weather factor
zu = season factor
sz = size

In effect, $CEV_t$ is a measurement of the difference in predicted results from actual results based upon three different factor (mission success, advance rates, and casualties), while $CEV_l$ is a measurement of the difference in predicted casualties from actual casualties. The $CEV_t$ and the $CEV_l$ of the defender is the reciprocal of the one for the attacker.

Now the problem comes in when one creates the $CEV_{ad}$, which is the average of the two CEVs above. I simply do not know why it was decided to create a alternate CEV calculation from the old QJM method, and then average the two, but this is what is currently being done in the model. This averaging results in a revised CEV for the attacker and for the defender that are not reciprocals of each other, unless the $CEV_t$ and the $CEV_l$ were the same. We even have some cases where both sides had a $CEV_{ad}$ of greater than one. Also, by averaging the two, we have heavily weighted casualty effectiveness relative to mission effectiveness and mission accomplishment.

What was done in these cases (again based more on tradition or habit, and not on any specific rule) was:

1. If $CEV_{ad}$ are reciprocals, then use as is.

2. If one CEV is greater than one while the other is less than 1, then add the higher CEV to the value of the reciprocal of the lower CEV (1/X) and divide by two. This result is the CEV for the superior force, and its reciprocal is the CEV for the inferior force.
3. If both CEVs are above zero, then we divide the larger $CEV_{ad}$ value by the smaller, and use its result as the superior force's CEV.

$CEV_{ad}$ value by the smaller, and use its result as the superior force's CEV.

In the case of point three, this methodology usually results in a slightly higher CEV for the attacker side than if we used the average of the reciprocal (usually .1 or .2 higher). While the mathematical and logical consistency of the procedure bothered me, the logic used for the different procedure in point three was that the model was clearly having a problem with predicting the engagement to start with, but that in most cases when this happened before (meaning before the validation), a higher CEV usually produced a better fit than a lower one. As this is what was done before, I accepted it as is, especially if one looks at the example of Mediah Farm. If one averages the reciprocal with the US's CEV of 8.065, one would get a CEV of 4.13. By this methodology, one comes up with a more reasonable US CEV of 1.58.

The interesting aspect is that the rules manual explains how $CEV_t$, $CEV_l$ and $CEV_{ad}$ are calculated, but never is it explained which $CEV_{ad}$ (attacker or defender) you should use. This is the first explanation of this process, and was based upon the "traditions" used at TDI. There is a strong argument to merge the two CEVs into one formulation. I am open to another methodology for calculating CEV. I am not satisfied with how CEV is calculated in the TNDM and intend to look into this further. Expect another article on this subject in the next issue.

# The First Test of the TNDM Battalion–Level Validations: Predicting the Winners

by Christopher A. Lawrence

In the basic concept of the TNDM battalion–level validation, we decided to collect data from battles from three periods: WWI, WWII and Post–WWII. We then made a TNDM run of each battle exactly as the battle was laid out, with both sides having the same CEV. The results of that run indicated what the CEV should have been for the battle, and we then made a second run using that CEV. That was all we did. We wanted to make sure that there was no "tweaking" of the model for the validation, so we stuck rigidly to this procedure. We then evaluated each run for its fit in three areas:

1. Predicting the winner/loser
2. Predicting the casualties
3. Predicting the advance rate

We did end up changing two engagements around. We had a similar situation with one WWII engagement (Tenaru River) and one modern period engagement (Bir Gifgafa), where part–way through the battle the defender received reinforcements and counterattacked. In both cases we decided to run them as two separate battles (adding two more battles to our database), with the conditions from the first engagement being the starting strength, plus the reinforcements, for the second engagement. Based on our previous experience with running Goose Green, for all the Falklands Island battles we counted the Milans and Carl Gustavs as infantry weapons. That is the only "tweaking" we did that affected the battle outcome in the model. We also put in a casualty multiplier of 4 for WWI engagements, but that is discussed in the article on casualties.

This is the analysis of the first test, predicting the winner/loser. Basically, if the attacker won historically, we assigned it a value of 1, a draw was 0, and a defender win was -1. In the TNDM results summary, it has a column called "winner" which records either an attacker win, a draw, or a defender win. We compared these two results. If they were the same, this is a "correct" result. If they are "off by one," this means the model predicted an attacker win or loss, where the actual result was a draw, or the model predicted a draw, where the actual result was a win or loss. If they are "off by two" then the model simply missed and predicted the wrong winner.

The results are (the envelope please....):

| | 1st Run (CEV = 1.0) | 2nd Run (CEV adjusted) |
|---|---|---|
| ***WWI*** | | |
| Correct | 13 | 18 |
| Off by one | 5 | 1 |
| Off by two | 5 | 4 |
| ***WWII*** | | |
| Correct | 17 | 17 |
| Off by one | 2 | 5 |
| Off by two | 4 | 1 |
| ***Modern*** | | |
| Correct | 22 | 29 |
| Off by one | 3 | 0 |
| Off by two | 5 | 1 |

| | % Correct 1st Run | % Correct 2nd Run |
|---|---|---|
| ***WWI*** | 57 | 78 |
| ***WWII*** | 74 | 74 |
| ***Modern*** | 73 | 97 |
| ***TOTAL*** | **68** | **84** |

It is hard to determine a good predictability from a bad one. Obviously, the initial WWI prediction of 57% right is not very good, while the Modern second run result of 97% is quite good. What I would really like to do is compare these outputs to some other model (like TACWAR) to see if they get a closer fit. I have reason to believe that they will not do better.

Most cases in which the model was "off by 1" were easily correctable by accounting for the different personnel capabilities of the army. Therefore, just to look where the model really failed, let's just look at where it simply got the wrong winner:

| | % Dead Wrong 1st Run | % Dead Wrong 2nd Run |
|---|---|---|
| ***WWI*** | 22 | 17 |
| ***WWII*** | 17 | 4 |
| ***Modern*** | 17 | 3 |
| ***TOTAL*** | **18** | **8** |

The TNDM is not designed or tested for WWI battles. It is basically designed to predict combat between 1939 and the present. The total percentages without the WWI data in it are:

| | Less WWI |
|---|---|
| Percent Correct, 1st Run | 74 |
| Percent Correct, 2nd Run | 87 |
| Percent Dead Wrong, 1st Run | 17 |
| Percent Dead Wrong, 2nd Run | 4 |

Overall, based upon this data I would be willing to claim that the model can predict the correct winner 75% of the time without accounting for human factors and 90% of the time if it does.

**CEVs:** Quite simply a user of the TNDM must develop a CEV to get a good prediction. In this particular case, the CEVs were developed from the first run. This means that in the second run, the numbers have been juggled (by changing the CEV) to get a better result. This would make this effort meaningless if the CEVs were not fairly consistent over several engagements for one side versus its other side. Therefore, they are listed below in broad groupings so that the reader can determine if the CEVs appear to be basically valid or are simply being used as a "tweak".

Now, let's look where it went wrong. The following battles were not predicted correctly:

| Off by One 1st Run | Off by Two 1st Run | Off by One 2nd Run | Off by Two 2nd Run |
|---|---|---|---|
| **WWI** | | | |
| Hill 252 | Hill 142 | Mayache | La Neuville |
| West Woods I | North Woods I | | North Woods I |
| Bouresches I | Chaudun | | |
| West Wood II | Medeah Farm | | Medeah Farm |
| Yvonne-Odette | Exermont | | Exermont |
| **WWII** | | | |
| Edson's Ridge | Makin Raid | Edson's Ridge | VER-RDMX |
| Lausdell XRds | | Lausdell XRds | |
| | VER-2ASX | VER-2ASX | |
| | VER-XHLX | | |
| | VER-CHX | VER-CHX | |
| | | VER-9CX | |
| **Modern** | | | |
| Goose Green | Tu-Vu | | Tu-Vu |
| Two Sisters | Mapu | | |
| Cuatir River | Bir Gifgafa II | | |
| | Mt. Langdon | | |
| | Tumbledown | | |

There are 19 night engagements in the data base, five from WWI, three from WWII, and 11 modern. We looked at whether the miss prediction was clustered among night engagements, and that did not seem to be the case. Unable to find a pattern, we examined each engagement to see what the problem was. See the attachments at the end of this article for details.

We did obtain CEVs that showed some consistency. These are shown below. The Marines in World War I record the following CEVs in these WWI battles:

| Battle | Marine Regt | CEV | German Unit |
|---|---|---|---|
| *Hill 142* | *5th Marines* | *1.5* | *273rd Regt* |
| *West Wood I* | *5th Marines* | *0.4* | *461st Regt* |
| *Bouresches I* | *6th Marines* | *0.7* | *461st Regt* |
| *West Wood II* | *5th Marines* | *1.4* | *461st Regt* |
| *North Wood I* | *5th Marines* | *1.5* | *110th Gren Regt* |
| Bouresches II | 5th Marines | 1.2 | 109th Regt |
| North Wood III | 5th Marines | 1 | 347th Regt |
| North Wood IV | 5th Marines | 1.4 | 347th Regt |
| Essen Hook | 5th Marines | 0.9 | 2nd Koeln LS Abt |
| ***Average*** | | ***1.1*** | |
| ***Median*** | | ***1.2*** | |

Compare those figures to the performance of the US Army:

| Battle | Army Regt | CEV | German Unit |
|---|---|---|---|
| *Yvonne-Odette* | *9th Inf* | *0.5* | *Sturmgrp Grethe* |
| Cantigny | 28th Inf | 0.6 or 0.2 | 272nd Regt |
| North Wood II | 7th Inf | 0.7 | 347th Regt |
| St. Amand Farm | 28th Inf | 1.5 | 396th Regt |
| Beaurepaire Farm | 23rd Inf | 1.1 | 219th Regt |
| *Chaudun* | *18th Inf* | *2.5* | *109th Bav Gren Regt* |
| Berzy-le-Sec | 28th Inf | 0.8 | 109th Regt |
| Bunzancy Ridge | 18th Inf | 0.8 | 52nd Jaeger Regt |
| *Medeah Farm* | *9th Inf* | *1.6* | *235th Regt* |
| *Exermont* | *18th Inf* | *0.9* | *3rd Gds Regt* |
| *Mayache Ravine* | *26th Inf* | *0.7* | *170th Regt* |
| *La Neuville* | *28th Inf* | *0.7* | *1111th Regt* |
| Remlyal | 16th Inf | 0.9 | 6th Res Jaeger Bn |
| *Hill 252* | *16th Inf* | *1.5* | *14th Res Inf Div* |
| ***Average*** | | ***1.1*** | |
| ***Average (less high & low)*** | | ***1*** | |
| ***Median*** | | ***0.85*** | |

In the above two and in all following cases, the italicized battles are the ones with which we had prediction problems.

For comparison purposes, the CEVs were recorded in the battles in World War II between the US and Japan:

| Battle | US Unit | CEV | Japanese Unit |
|---|---|---|---|
| Wake | 1st Mar Def Bn | 0.7 | IJN Wake SNLF |
| *Makin* | *2nd Mar Rdr Bn* | *2.4* | *IJA Makin Garrison* |
| Tenaru I | 1st Marine Rgt | 1.4 | IJA Ichiki Det |
| Tenaru II | 1st Marine Rgt | 1.3 | IJA Ichiki Det |
| *Edson Ridge* | *1st Mar Rdr Bn* | *1.5* | *IJA Kawaguchi Force* |
| Engebi | 22nd Marine Rgt | 0.8 | IJA/IJN Engebi Garr |
| Enipar | 106th Inf Rgt | 0.8 | 1st Amph Bde |
| ***Average*** | | ***1.3*** | |
| ***Median*** | | ***1.3*** | |

For comparison purposes, the following CEVs were recorded in Operation Veritable:

| Battle | Britsh Regt | CEV | German Unit |
|---|---|---|---|
| VER7BW | Black Watch | 0.6 | 1062nd Inf Regt |
| VER57G | 7th Gordn Hlndrs | 0.7 | 1062nd Inf Regt |
| VER1BW | Black Watch | 0.9 | 1222nd Inf Regt |
| VER1HL | Highland Light | 0.8 | 84th ID |
| VER4RW | Royal Welch Fus | 0.8 | 84th ID |
| VER10B | Ox & Bucks Lt | 0.9 | 84th ID |
| VER1GH | Glasgow Hlndrs | 0.7 | 84th ID |
| *VER9C* | *Cameronians* | *0.6* | *84th ID* |
| *VER2AS* | *Argyll & Sutherlnd* | *1.3* | *1222nd Inf Regt* |
| *VERXHL* | *Highland Light* | *1.3* | *1222nd Inf Regt* |
| *VERRDM* | *Rgt de Maisonn* | *0.6* | *1222nd Inf Regt* |
| *VERCH* | *Calgary Hlndrs* | *1.3* | *1222nd Inf Regt* |
| ***Average*** | | ***0.9*** | |
| ***Median*** | | ***0.8*** | |

These are the other engagements versus Germans for which CEVs were recorded:

| Battle | Army Division | CEV | German Unit |
|---|---|---|---|
| Chouigui Pass | 1st AR/1st AD | 1.6 | 10th PzD |
| Mte Maggiore | 1st RCT/36th ID | 1 | 15th PzGrD |
| *Lausdell XRds* | *9th Inf/2nd ID* | *1.1* | *KG Mueller/12th SS* |
| Assenois | CCR/4th AD | 1.4 | KG/26th VGD |
| ***Average*** | | ***1.3*** | |
| ***Median*** | | ***1.3*** | |

For comparison purposes, the following CEVs were recorded in the post–WWII battles between Vietnamese forces and their opponents:

| Battle | Opposing Force | CEV | German Unit |
|---|---|---|---|
| *Tu-Vu* | *French Moroccan* | *0.8* | *Vietminh* |
| Bindin | French | 1.2 | Vietminh |
| Longtan | Australian | 1.2 | VC |
| HL450 | US (502nd Abn) | 1.1 | NVA |
| Prek Klok I | US (1st ID) | 1.6 | NVA |
| Prek Klok II | US (2nd Inf Regt) | 1.4 | VC |
| Buell | US (22nd Inf Regt | 2.1 | NVA |
| Ap Bau Bang | US (3/5th Cav) | 3.2 | VC |
| Lo Giang I | US (6th Inf Regt) | 1.5 | VC |
| Lo Giang II | US (6th Inf Regt) | 2 | VC |
| Nui Baden | US (22nd Inf Regt | 1.4 | VC |
| ***Average*** | | ***1.6*** | |
| ***Median*** | | ***1.4*** | |

| Battle | ARVN | CEV | VC |
|---|---|---|---|
| Caolan | ARVN | 0.4 | VC |
| Cainuoc | ARVN | 1.1 | VC |
| ZBO50963 | ARVN | 3.4 | VC |
| ***Average*** | | ***1.6*** | |

Note that the Americans have a average CEV advantage of 1.6 over the NVA (only three cases) while having a 1.8 advantage over the VC (6 cases).

For comparison purposes, the following CEVs were recorded in the battles between the British and Argentines:

| Battle | UK Regt | CEV | Argentine Unit |
|---|---|---|---|
| *Goose Green* | *Para Regt* | *2.4* | *12th Regt* |
| Mt Harriet | 42nd RM Cdo | 2.3 | 4th Regt |
| *Two Sisters* | *45th RM Cdo* | *1.7* | *4th Regt* |
| *Mt Longdon* | *Para Regt* | *2.3* | *7th Regt* |
| *Mt Tumbledown* | *Scots Guard* | *1.9* | *5th Marine Bn* |
| Wireless Ridge | Para | 1.9 | 7th Regt |
| ***Average*** | | ***2.1*** | |
| ***Median*** | | ***2.1*** | |

| Battle | Expected Higher CEV Force | CEV | Expected Lower CEV Force |
|---|---|---|---|
| *Mapu* | *UK* | *2.6* | *Indonesia* |
| Bir Gifgafa I | Israel | 1.5 | Egypt |
| *Bir Gifgafa II* | *Israel* | *3.5* | *Egypt* |
| Hermon I | Israel | 0.8 | Syria |
| Salinas | US (75th Rngrs) | 1.6 | Cuba & Grenada |
| Pearls | US (USMC) | 2.9 | Grenada |
| Lomba | RSA | 3.5 | ANTISA |
| *Cuatir River* | *RSA* | *2.3* | *Angola* |
| Lipanda | RSA | 3.6 | Angola |
| TF Bayonet | US | 1.2 | Panama |
| ***Average*** | | ***2.4*** | |
| ***Median*** | | ***2.5*** | |

**CONCLUSIONS:**

For the WWI battles, the nature of the prediction problems are summarized as:

| Problem Engagement | Definition of Winner | Assign Proper CEV | Unexplained CEV Correction | Problem Result |
|---|---|---|---|---|
| Yvonne-Odette (N) | Y | | | |
| Hill 142 | | Y | | |
| West Wood I | | | Y | |
| Bouresches I (N) | Y | | | |
| West Wood II | | Y | | |
| North Wood I | | Y | | |
| Chaudun | | | Y | |
| Medeah Farm | | | | Y |
| Exermont | | | | Y |
| Mayache Ravine | | | | Y |
| La Neuville | | | | Y |
| Hill 252 | | | Y | |
| | 2 | 3 | 3 | 4 |

**CONCLUSION:** In the case of the WWI runs, five of the problem engagements were due to confusion of defining a winner or a clear CEV existing for a side that should have been predictable. Seven out of the 23 runs have some problems, with three problems resolving themselves by assigning a CEV value to a side that may not have deserved it. One (Medeah Farm) was just off any way you look at it, and three suffered a problems because historically the defenders (Germans) suffered surprisingly low losses. Two had the battle outcome predicted correctly on the first run, and then had the outcome incorrectly predicted after CEV was assigned.

With 5 to 7 clear failures (depending on how you count them), this leads one to conclude that the TNDM can be relied upon to predict the winner in a WWI battalion–level battle in about 70% of the cases.

**WWII (8 cases):**

For the WWII battles, the nature of the prediction problems are summarized as:

**CONCLUSION:** In the case of the WWII runs, three of the

| Problem Engagement | Definition of Winner | Assign Proper CEV | Unexplained CEV Correction | Problem Result |
|---|---|---|---|---|
| Makin Raid | | Y | | |
| Edson's Ridge (N) | Y | | | |
| Lausdell XRds | Y | | | |
| VER-9CX | | | | Y |
| VER-2ASX | | | | Y |
| VER-XHLX | | | Y | |
| VER-RDMX | | | | Y |
| VER-CHX | | | | Y |
| | 2 | 1 | 1 | 4 |

problem engagements were due to confusion of defining a winner or a clear CEV existing for a side that should have been predictable. Four out of the 23 runs suffered a problem because historically the defenders (Germans) suffered surprisingly low losses and one case just simply assigned a possible unjustifiable CEV. This led to the battle outcome being predicted correctly on the first run, then incorrectly predicted after CEV was assigned.

With 3 to 5 clear failures, one can conclude that the TNDM can be relied upon to predict the winner in a WWII battalion–level battle in about 80% of the cases.

**Modern (8 cases):**

For the post–WWII battles, the nature of the prediction problems are summarized as:

| Problem Engagement | Definition of Winner | Assign Proper CEV | Unexplained CEV Correction | Problem Result |
|---|---|---|---|---|
| Tu-Vu | | | | Y |
| Mapu | | Y | | |
| Bir Gifgafa II (N) | | Y | | |
| Goose Green | | Y | | |
| Two Sisters (N) | | Y | | |
| Mt Longdon (N) | | Y | | |
| Tumbledown | | Y | | |
| Cuatir River | | Y | | |
| | | 7 | | 1 |

**CONCLUSION:** In the case of the modern runs, only one result was a problem. In the other seven cases, when the force with superior training is given a reasonable CEV (usually around 2), then the correct outcome is achieved.

With only one clear failure, one can conclude that the TNDM can be relied upon to predict the winner in a modern battalion–level battle in over 90% of the cases.

**FINAL CONCLUSIONS:** In this article, the predictive ability of the model was examined only for its ability to predict the winner/loser. We did not look at the accuracy of the casualty predictions or the accuracy of the rates of advance. That will be done in the next two articles. Nonetheless, we could not help but notice some trends.

First and foremost, while the model was expected to be a reasonably good predictor of WWII combat, it did even better for modern combat. It was noticeably weaker for WWI combat. In the case of the WWI data, all attrition figures were multiplied by 4 ahead of time because we knew that there would be a fit problem otherwise.

**This would strongly imply that there were more significant changes to warfare between 1918 and 1939 than between 1939 and 1989.**

Secondly, the model is a pretty good predictor of winner and loser in WWII and modern. Overall, the model predicted the winner in 68% of the cases on the first run and in 84% of the cases in the run incorporating CEV.

While its predictive powers were not perfect, there were 13 cases where it just wasn't getting a good result (17%). Over half of these were from WWI, only one from the modern period.

In some of these battles it was pretty obvious who was going to win. Therefore, the model needed to do a step better than 50% to be even considered. Historically, in 51 out of 76 cases (67%), the larger side in the battle was the winner. One could predict the winner/loser with a reasonable degree of success by just looking at that rule. But the percent of the time the larger side won varied widely with the period. In WWI the larger side won 74% of the time. In WWII it was 87%. In the modern period it was a counterintuitive 47% of the time, yet the model was best at selecting the winner in the modern period.

The model's ability to predict WWI battles is still questionable. It obviously does a pretty good job with WWII battles and appears to be doing an excellent job in the modern period. We suspect that the difference in prediction rates between WWII and the modern period is caused by the selection of battles, not by any inherit ability of the model.

**RECOMMENDED CHANGES:** While it is too early to settle upon a model improvement program, just looking at the problems of winning and losing, and the ancillary data to that, leads me to three corrections:

*1. Adjust for times of less than 24 hours.* Create a formula so that battles of six hours in length are not ¼ the casualties of a 24–hour battle, but something greater than that (possibly the square root of time). This adjustment should affect both casualties and advance rates.

*2. Adjust advance rates for smaller units* to account for the fact that smaller units move faster than larger units.

*3. Adjust for fanaticism* to account for those armies that continue to fight after most people would have accepted the result, driving up casualties for both sides.

## CASE STUDIES: WHERE AND WHY THE MODEL FAILED CORRECT PREDICTIONS

**World War I (12 cases):**

*Yvonne-Odette (Night)*—On the first prediction, selected the defender as a winner, with the attacker making no advance. The force ratio was 0.5 to 1. The historical results also show the attacker making no advance, but rate the attacker's mission accomplishment score as 6 while the defender is rated as 4. Therefore, this battle was scored as a draw.

On the second run, the Germans (Sturmgruppe Grethe) were assigned a CEV of 1.9 relative to the US 9th Infantry Regiment. This produced a draw with no advance.

This appears to be a result that was corrected by assigning the CEV to the side that would be expected to have that advantage. There is also a problem in defining who is the winner.

*Hill 142*—On the first prediction the defending Germans won, whereas in the real world the attacking Marines won. The Marines are recorded as having a higher CEV in a number of battles, so when this correction is put in the Marines win with a CEV of 1.5. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run to replicate historical results.

Note that while many people would expect the Germans to have the higher CEV, at this juncture in WWI the German regular army was becoming demoralized, while the US Army was highly motivated, trained and fresh. While I did not initially expect to see a superior CEV for the US Marines, when I did see it I was not surprised. I also was not surprised to note that the US army had a lower CEV than the Marine Corps or that the German Sturmgruppe Grethe had a higher CEV than the US side. As shown in the charts below, the US Marines' CEV is usually higher than the German CEV for the engagements of Belleau Wood, although this result is not very consistent in value. But this higher value does track with Marine Corps legend. I personally do not have sufficient expertise on WWI to confirm or deny the validity of the legend.

*West Wood I*—On the first prediction the model rated the battle a draw with minimal advance (.265 km) for the attacker, whereas historically the attackers were stopped cold with a bloody repulse. The second run predicted a very high CEV of 2.3 for the Germans, who stopped the attackers with a bloody repulse. The results are not easily explainable.

*Bouresches I (Night)*—On the first prediction the model recorded an attacker victory with an advance of .5 kms. Historically, the battle was a draw with an attacker advance of one km. The attacker's mission accomplishment score was 5, while the defender's was 6. Historically, this battle could also have been considered an attacker victory. A second run with an increased German CEV to 1.5 records it as a draw with no advance. This appears to be a problem in defining who is the winner.

*West Wood II*—On the first run, the model predicted a draw with an advance of .3 kilometers. Historically, the attackers won and advanced 1.6 kilometers. A second run with a US CEV of 1.4 produced a clear attacker victory. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*North Woods I*—On the first prediction, the model records the defender winning, while historically the attacker won. A second run with a US CEV of 1.5 produced a clear attacker victory. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Chaudun*—On the first prediction, the model predicted the defender winning when historically, the attacker clearly won. A second run with an outrageously high US CEV of 2.5 produced a clear attacker victory. The results are not easily explainable.

*Medeah Farm*—On the first prediction, the model recorded the defender as winning when historically the attacker won with high casualties. The battle consists of a small number of German defenders with lots of artillery defending against a large number of US attackers with little artillery. On the second run, even with a US CEV of 1.6, the German defender won. The model was unable to select a CEV that would get a correct final result yet reflect the correct casualties. The model is clearly having a problem with this engagement.

*Exermont*—On the first prediction, the model recorded the defender as winning when historically the attacker did, with both the attacker's and the defender's mission accomplishment scores being rated at 5. The model did rate the defender's casualties too high, so when it calculated what the CEV should be, it gave the defender a higher CEV so that it could bring down the defender's losses relative to the attackers. Otherwise, this is a normal battle. The second prediction was no better. The model is clearly having a problem with this engagement due to the low defender casualties.

*Mayache Ravine*—The model predicted the winner (the attacker) correctly on the first run, with the attacker having an opposed advance of .8 km. Historically, the attacker had an opposed rate of advance of 1.3 kms. Both sides had a mission accomplishment score of 5. The problem is that the model predicted higher defender casualties that the attacker, while in the actual battle the defender had lower casualties that the attacker. On the second run, therefore, the model put in a German CEV of 1.5, which resulted in a draw with the attacker advancing .3 kms. This brought the casualty estimates more in line, but turned a successful win/loss prediction into one that was "off by one." The model is clearly having a problem with this engagement due to the low defender casualties.

*La Neuville*—The model also predicted the winner (the attacker) correctly here, with the attacker advancing .5 km. In the historical battle they advanced 1.6 kms. But again, the model predicted lower attacker losses than the defender losses, while in the actual battle the defender losses were much lower than the attacker losses. So, again on the second run, the model gave the defender (the Germans) a CEV of 1.4, which turned an accurate win/loss prediction into an

inaccurate one. It still didn't do a very good job on the casualties. The model is clearly having a problem with this engagement due to the low defender casualties.

*Hill 252*—On the first run, the model predicts a draw with a distanced advanced of .2 kms, while the real battle was an attacker victory with an advance of 2.9 kms. The model's casualty predictions are quite good. On the second run, the model correctly predicted an attacker win with a US CEV of 1.5. The distance advanced increases to .6 km, while the casualty prediction degrades noticeably. The model is having some problems with this engagement that are not really explainable, but the results are not far off the mark.

**World War II (8 cases):**

Overall, we got a much better prediction rate with WWII combat. We had eight cases where there was a problem. They are:

*Makin Raid*—On the first run, the model predicted a defender win. Historically, the attackers (US Marines) won with a 2.5 km advance. When the Marine CEV was put in (a hefty 2.4), this produced a reasonable prediction, although the advance rate was too slow. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run in order to replicate historical results.

*Edson's Ridge (Night)*—On the first run, the model predicted a defender win. Historically, the battle must be considered at best a draw, or more probably a defender win, as the mission accomplishment score of the attacker is 3 while the defender in 5.5. The attacker did advance 2 km, but suffered heavy casualties. The second run was done with a US CEV of 1.5. This maintained a defender win and even balanced more in favor of the Marines. This is clearly a problem in defining who is the winner.

*Lausdell X-Roads (Night)*—On the first run, the model predicted an attacker victory with an advance rate of .4 kms. Historically, the German attackers advanced .75 km, but had a mission accomplishment score of 4 versus the defender's mission accomplishment score of 6. A second run was done with a US CEV of 1.1, but this did not significantly change the result. This is clearly a problem in defining who is the winner.

*VER-9CX*—On the first run, the attacker is reported as the winner. Historically this is the case, with the attacker advancing 12 km although suffering higher losses than the defender. On the second run, however, the model predicted that the engagement was a draw. The model assigned the defenders (German) a CEV of 1.3 relative to the attackers in attempt to better reflect the casualty exchange. The model is clearly having a problem with this engagement due to the low defender casualties.

*VER-2ASX*—On the first run, the defender was reported as the winner. Historically, the attacker won. On the second run, the battle was recorded as a draw with the attacker (British) CEV being 1.3. This high CEV for the British is not entirely explainable, although they did fire a massive suppressive bombardment. In this case the model appears to be assigning a CEV bonus to the wrong side in an attempt to adjust a problem run. The model is still clearly having a problem with this engagement due to the low defender casualties.

*VER-XHLX*—On the first run, the model predicted that the defender won. Historically, the attacker won. On the second run, the battle was recorded an attacker win with the attacker (British) CEV being 1.3. This high CEV is not entirely explainable. There is no clear explanation for these model results.

*VER-RDMX*—On the first run, the model predicted that the attacker won. Historically, this is correct. On the second run, the battle recorded that the defender won. This indicates an attempt by the model to get the casualties correct. The model is clearly having a problem with this engagement due to the low defender casualties.

*VER-CHX*—On the first run, the model predicted that the defender won. Historically, the attacker won. On the second run, the battle was recorded as an attacker win with the attacker (Canadian) CEV being 1.3. Again, this high CEV is not entirely explainable. The model appears to be assigning a CEV bonus to the wrong side in an attempt to adjust a problem run. The model is still clearly having a problem with this engagement due to the low defender casualties.

**Modern (8 cases):**

*Tu–Vu*—On the first run, the model predicted a defender win. Historically, the attackers (Viet Minh) won with a 2.8 km advance. When the CEV for the Viet Minh was put in (1.2), the defender still won. The real problem in this case is the horrendous casualties taken by both sides, with the defending Moroccans losing 250 out of 420 people and the attacker losing 1200 out of 7000 people. The model predicted only 140 and 208 respectively. This appears to address a fundamental weakness in the model, which is that if one side is willing to attack (or defend) at all costs, the model simply cannot predict the extreme losses. This happens in some battles with non–first world armies, with the Japanese in WWII, and apparently sometimes with the WWI predictions. In effect, the model needs some mechanism to predict fanaticism that would increase the intensity and casualties of the battle for both sides. In this case, the increased casualties certainly would have resulted in an attacker advance after over half of the defenders were casualties.

*Mapu*—On the first run the model predicted an attacker (Indonesian) win. Historically, the defender (British) won. When the British are given a hefty CEV of 2.6 (as one would expect that they would have), the defender wins, although the casualties are way off for the attacker. This appears to be a case in which the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Bir Gifgafa II (Night)*—On the first run the model predicted a defender (Egyptian) win. Historically the attacker (Israel) won with an advance of three kilometers. When the Israelis are given a hefty CEV of 3.5 (as historically they have tended to have), they win, although their casualties and distance advanced are way off. These errors are probably due to the short duration (one hour) of the model run. This appears to

be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run in order to replicate historical results.

*Goose Green*—On the first run the model predicted a draw. Historically the attacker (British) won. The first run also included the "cheat" of counting the Milans as regular weapons versus AT. When the British are given a hefty CEV of 2.4 (as one could reasonably expect that they would have) they win, although their advance rate is too slow. Casualty prediction is quite good. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Two Sisters (Night)*—On the first run the model predicted a draw. Historically the attacker (British) won yet again. When the British are given a CEV of 1.7 (as one would expect that they would have) the attacker wins, although the advance rate is too slow and the casualties a little low. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Mt. Longdon (Night)*—On the first run the model predicted a defender win. Historically the attacker (British) won as usual. When the British are given a CEV of 2.3 (as one would expect that they should have) the attacker wins, although as usual the advance rate is too slow and the casualties a little low. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Tumbledown*—On the first run the model predicted a defender win. Historically the attacker (British) won as usual. When the British were given a CEV of 1.9 (as one would expect that they should have), the attacker wins, although as usual, the advance rate is too slow and the casualties a little low. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

*Cuatir River*—On the first run the model predicted a draw. Historically, the attacker (The Republic of South Africa) won. When the South African forces were given a CEV of 2.3 (as one would expect that they should have) the attacker wins, with advance rates and casualties being reasonably close. This appears to be a case where the side that would be expected to have the higher CEV needed that CEV input into the combat run.

# The Second Test of the TNDM Battalion–Level Validations: Predicting Casualties

by Christopher A. Lawrence

Actually, I was pretty pleased with the first test of the TNDM, predicting winners and losers. I wasn't too pleased with how it did with WWI, but was quite pleased with its prediction of post–WWII combat. But I knew from our previous analysis that we were going to have some problems with the casualty prediction estimates for WWI, for any battles that the Japanese were involved with, and for shorter engagements.

The problems in prediction of casualties, as related to certain nationalities, were discussed in *Numbers, Predictions, and War*. In the original QJM, as published in *Numbers, Predictions, and War*, three special conditions served as attrition multipliers. These were:

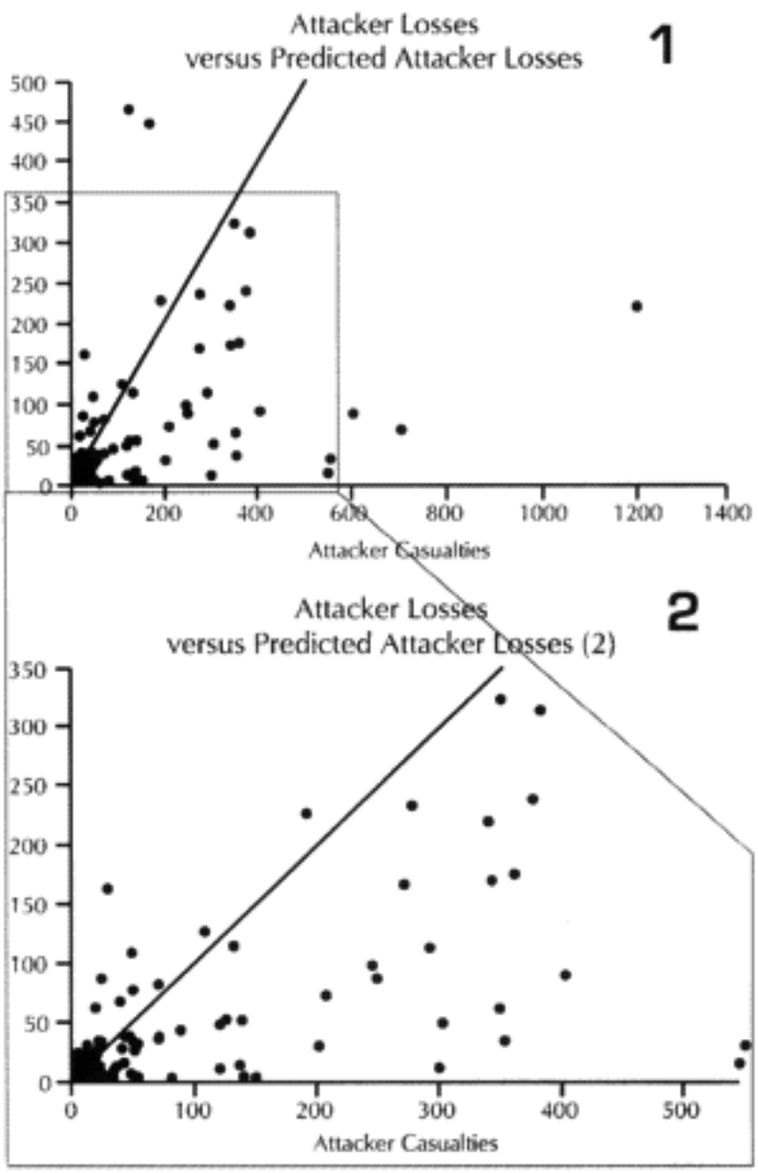
1. For period 1900–1945, Russian and Japanese rates are double those calculated.
2. For period 1914–1918, rates as calculated must be doubled; for Russian, Turkish, and Balkan forces they must be quadrupled.
3. For 1950–1953 rate as calculated will apply for UN forces (other than ROK); for ROK, North Koreans, and Chinese rates are doubled.

The attrition calculation for the TNDM is different from that used in the QJM. Actually the attrition calculations for the later versions of the QJM differ from the earlier versions. The base casualty rates that are used in the original QJM are very different from those used in the TNDM. See my articles in Volume 1, Issue 3. Basically the QJM starts with a based factor of 2.8% for attackers versus 4% for the TNDM, while its base factor for defenders is 1.5% versus 6% for the TNDM.

When Dave Bongard did the first TNDM runs for this validation effort, he automatically added in an attrition multiplier of 4 for all the WWI battles. This undocumented methodology was implemented by Mr. Bongard instinctively because he knew from experience that you need to multiply the attrition rates by 4 for WWI battles. I decided to let it stand and see how it measured up during the validation.

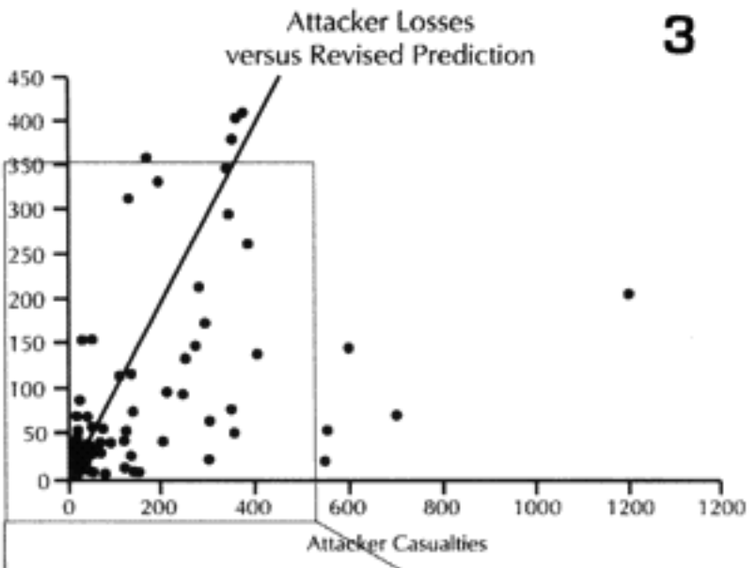
We then made our two model runs for each validation, first without the CEV, and a second run with the CEV incorporated. I believe the CEV results from this methodology are explained in the previous article on winners and losers.

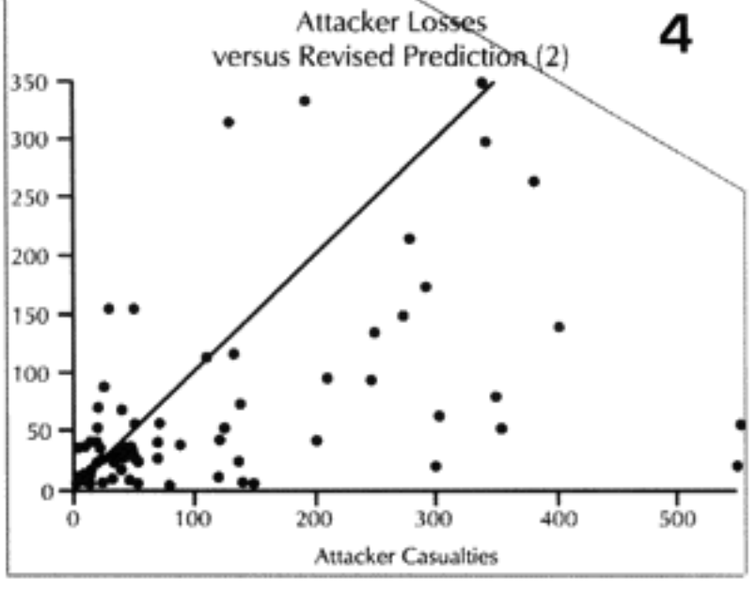
At the top of the next column is a comparison of the attacker losses versus the losses predicted by the model (graphs 1 and 2). This is in two scales, so you can see the details of the data. The diagonal line across these graphs and across the next seven graphs is the "perfect prediction" line, with any point on that line being perfectly predicted. The closer a point is to that line, the better the prediction. Points to the left of that line is where the model over–predicted casualties, while the points to the right is where the model under-predicted.

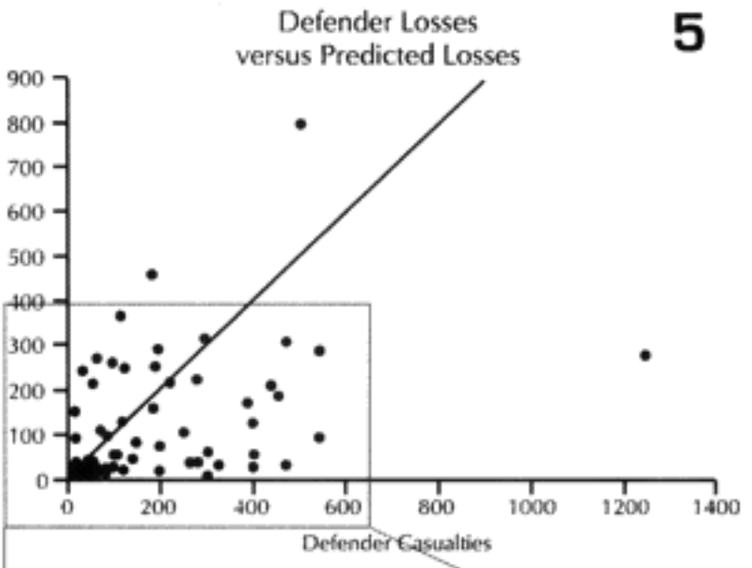


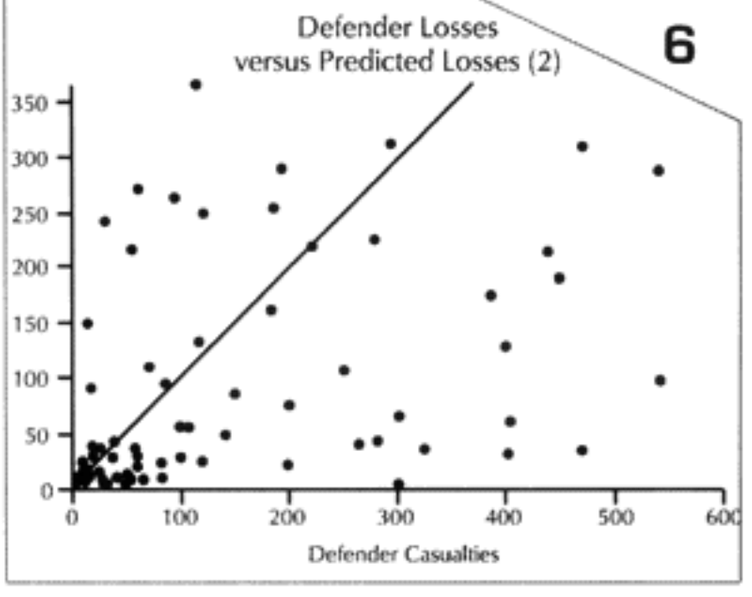

We also ran the model using the CEV as predicted by the model. This "revised prediction" is shown in the next graph (see graphs 3 and 4). We also have done the same comparison of total casualties for the defender (see graphs 5 through 8).

The model is clearly showing a tendency to under-predict. This is shown in the next set of graphs, where we divided the predicted casualties by the actual casualties. Values less than one are under-predictions. That means everything below the horizontal line shown on the graph (graph 9) is under-predicted. The same tests were done the "revised pre-




diction" (meaning with CEV) for the attacker and the both predictions for the defender (graphs 10–12).

I then attempted to do some work using the total casualty figures, followed by a series of meaningless tests of the data based upon force size. Force sizes range widely, and the size of forces committed to battle has a significant impact on the total losses. Therefore, to get anything useful, I really needed to look at percent of losses, not gross losses. These are displayed in the next 6 graphs (graphs 13–18).

Comparing our two outputs (model prediction without CEV incorporated and model prediction with CEV incorporated) to the 76 historical engagements gives the following disappointing results:

| *Attacker Percent Losses* | *Average* | *Std Dev* |
|---|---|---|
| Actual | 9.50 | |
| Predicted | 5.22 | 11.94 |
| Predicted with CEV | 5.75 | 10.73 |
| | | |
| *Defender Percent Losses* | *Average* | *Std Dev* |
| Actual | 26.59 | |
| Predicted | 14.62 | 29.57 |
| Predicted with CEV | 17.93 | 27.49 |

The standard deviation was measured by taking each predicted result, subtracting from it the actual result, squaring it, summing all 76 cases, dividing by 76, and taking the square root. (see sidebar *A Little Basic Statistics* below.)

First and foremost, the model was under–predicting by a factor of almost two. Furthermore it was running high

**A LITTLE BASIC STATISTICS:**

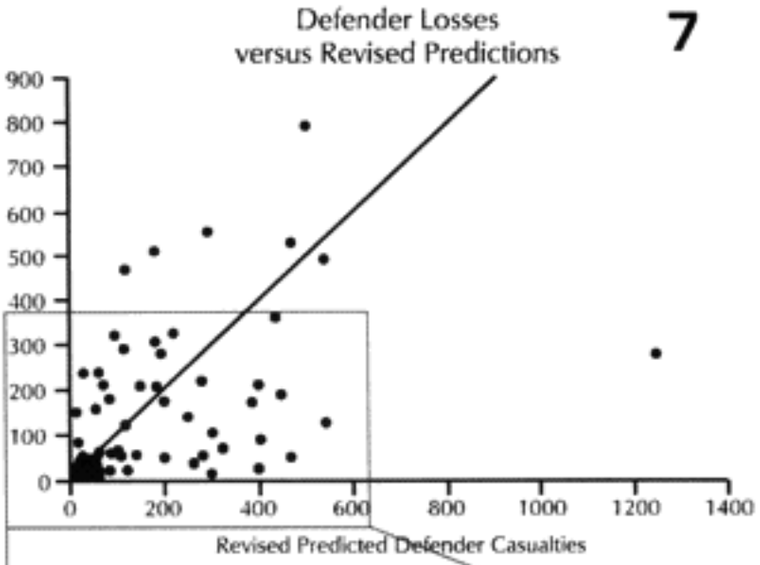
The mean is 5.75 for the attacker and 17.93 for the defender, the standard deviation is 10.73 for the attacker and 27.49 for the defender. The number of examples is 76, the degree of freedom is 75. Therefore the confidence intervals are:

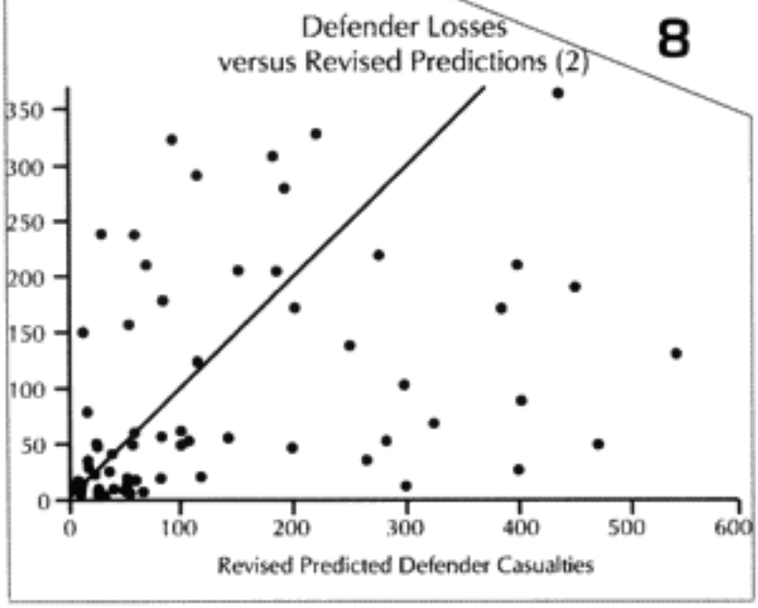
| Attacker | | | | | | Confidence Interval | |
|---|---|---|---|---|---|---|---|
| Confidence Interval | Average | | T-stat | x | 10.73 / 76 | Low | High |
| 80% | 5.75 | +/- | 1.295 | x | 1.231 | 4.16 | 7.34 |
| 85% | 5.75 | +/- | 1.669 | x | 1.231 | 3.70 | 7.80 |
| 90% | 5.75 | +/- | 1.994 | x | 1.231 | 3.30 | 8.20 |

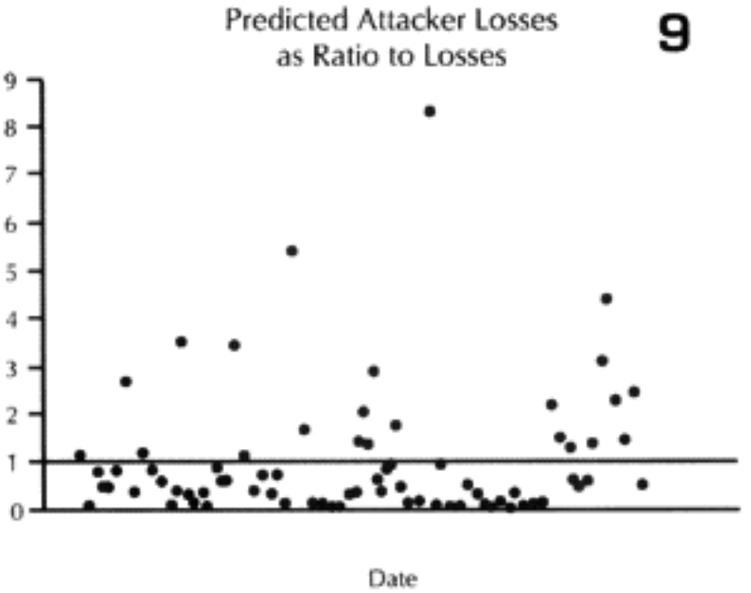
With the actual average being 9.50, we are clearly predicting too low.

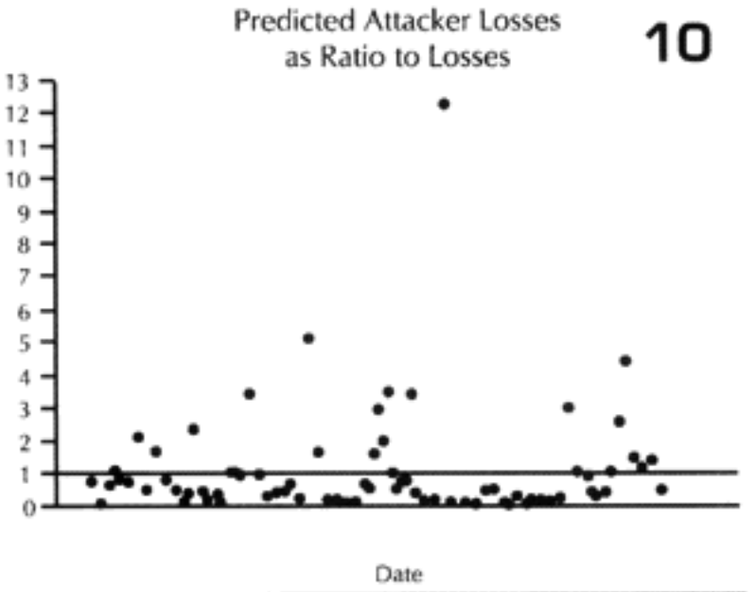
| Defender | | | | | | Confidence Interval | |
|---|---|---|---|---|---|---|---|
| Confidence Interval | Average | | T-stat | x | 27.49 / 76 | Low | High |
| 80% | 17.93 | +/- | 1.295 | x | 3.153 | 13.85 | 22.01 |
| 85% | 17.93 | +/- | 1.669 | x | 3.153 | 12.67 | 23.19 |
| 90% | 17.93 | +/- | 1.994 | x | 3.153 | 11.64 | 24.22 |

With the actual average being 26.59, we are again clearly predicting too low.




standard deviations. This last result did not surprise me considering the nature of the battalion–level combats.

The addition of the CEVs did not significantly change the casualties. This is because in the attrition equations, the conditions of the battlefield play an important part in determining casualties. People in the past have claimed that the CEVs were some type of fudge factor. If that is the case, then it is a damned lousy fudge factor. If the TNDM is getting a good prediction on casualties, it is not because of a CEV "fudge factor."

**TIME AND THE TNDM:**

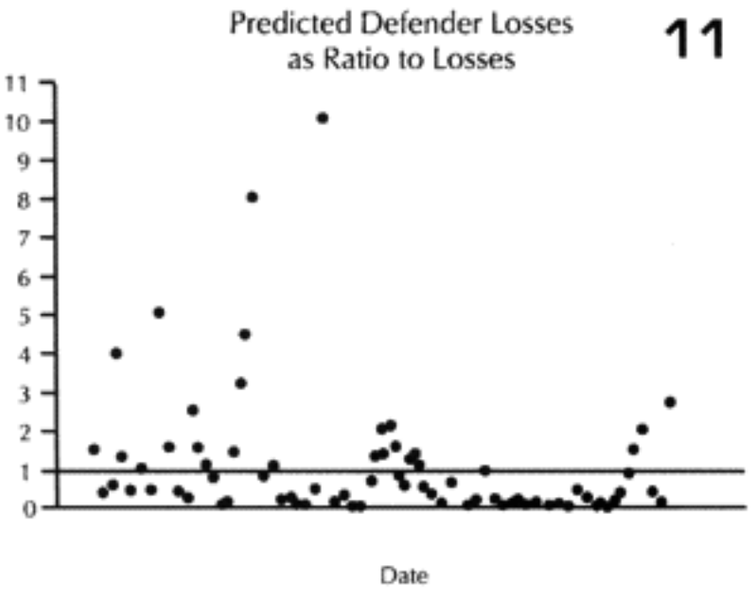
Before this validation was even begun, I knew we were going to have a problem with the fact that most of the engagements were well below 24 hours in length. This problem was discussed in depth in Volume 1, Number 3 of this newsletter. The TNDM considers the casualties for an engagement of less than 24 hours to be reduced in direct proportion to that time. I postulated that the relationship was geometric and came up with a formulation that used the square root of that fraction (i.e., instead of 12 hours being .5 times casualties, it was now .75 times casualties). Being wedded to this idea, I tested this formulation in all ways and for several days. I really wasn't getting a better fit. All I really did was multiply all the points so that the predicted average was closer. The top-level statistics were:

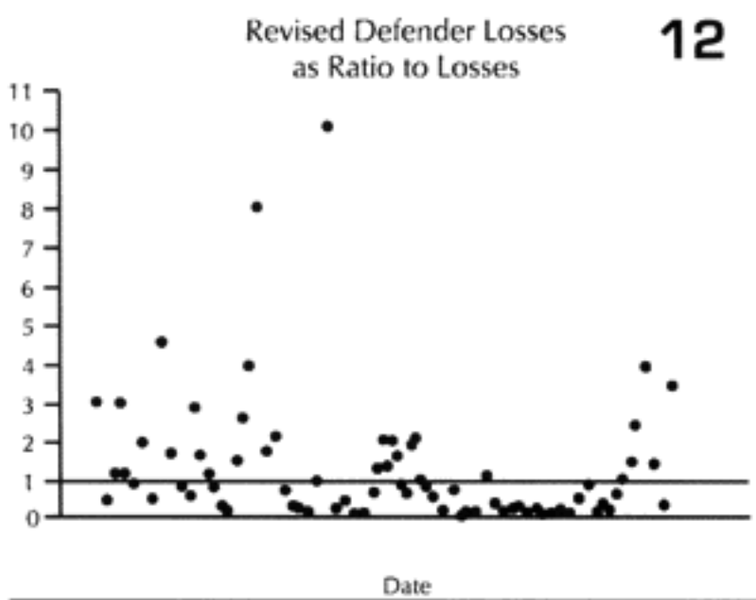
| *Attacker % Losses* | *Average* | *Std Dev* |
|---|---|---|
| Predicted x TF | 9.66 | 12.55 |
| Revised Predicted x TF | 10.95 | 12.17 |
| | | |
| *Defender % Losses* | *Average* | *Std Dev* |
| Predicted x TF | 25.83 | 28.76 |
| Revised Predicted x TF | 30.57 | 29.22 |

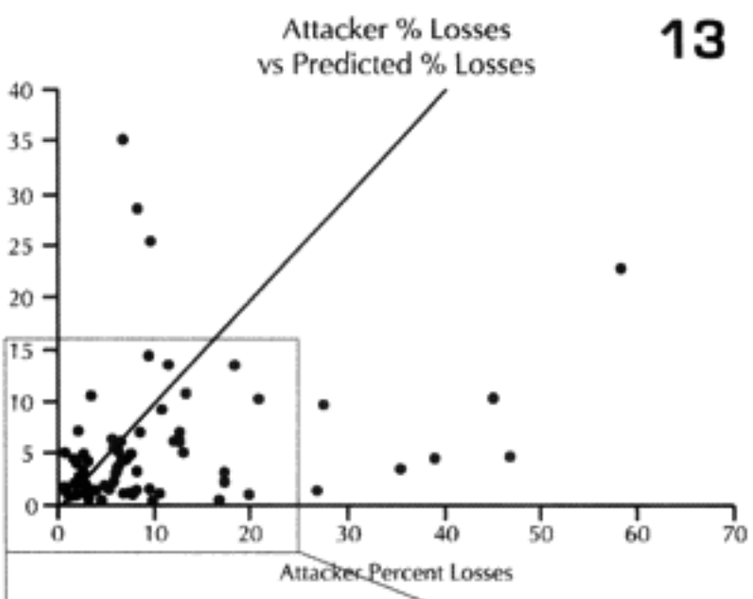
TF = Time Factor

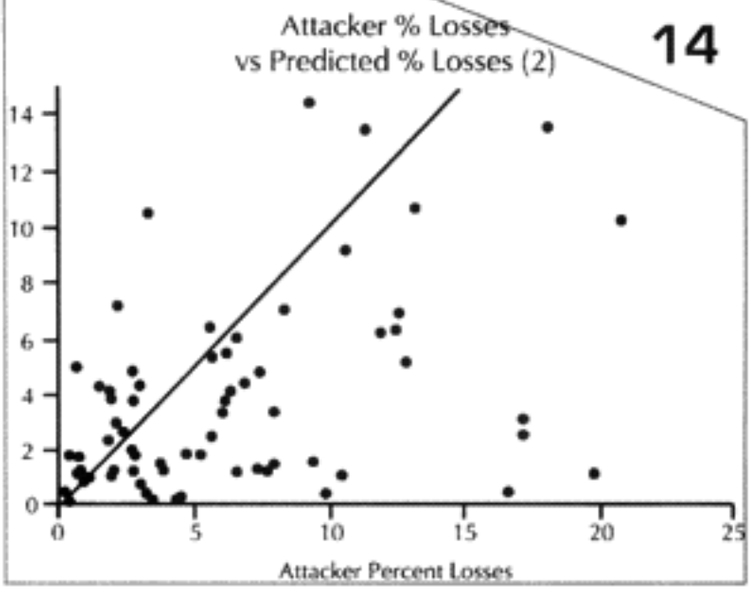
I also looked out how the losses matched up by one of three periods (WWI, WWII, and Post–WWII). When we used the time factor multiplier for the attackers, the WWI engagements average became too high, and the standard deviation increase, same with WWII, while the post–WWII averages were still too low, but the standard deviations got better. For the defender, we got pretty much the same pattern, except now the WWII battles were under–predicting, but the standard deviation was about the same. It was quite clear that all I had with this time factor was noise.

Like any good chef, my failed experiment went right down the disposal. This formulation died a natural death. But looking by period where the model was doing well, and where




it wasn't doing well is pretty telling. The results were:

| Attacker % Losses | WWI | | WWII | | Post-WWII | |
|---|---|---|---|---|---|---|
| | Average | Std Dev | Average | Std Dev | Average | Std Dev |
| ***Actual*** | 8.05 | | 7.36 | | 12.26 | |
| ***Predicted*** | 6.93 | 7.21 | 5.11 | 8.91 | 4.01 | 16.14 |
| ***Revised Predicted*** | 7.45 | 5.42 | 5.62 | 8.49 | 4.55 | 14.63 |

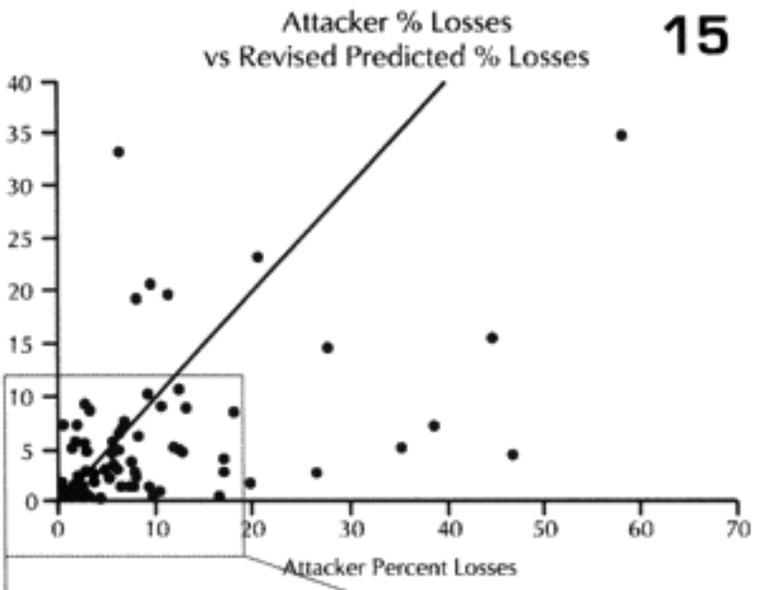
| Defender % Losses | WWI | | WWII | | Post-WWII | |
|---|---|---|---|---|---|---|
| | Average | Std Dev | Average | Std Dev | Average | Std Dev |
| ***Actual*** | 26.29 | | 26.58 | | 26.84 | |
| ***Predicted*** | 25.88 | 29.25 | 11.16 | 32.20 | 8.63 | 27.66 |
| ***Revised Predicted*** | 29.41 | 27.74 | 14.25 | 29.38 | 11.94 | 25.75 |

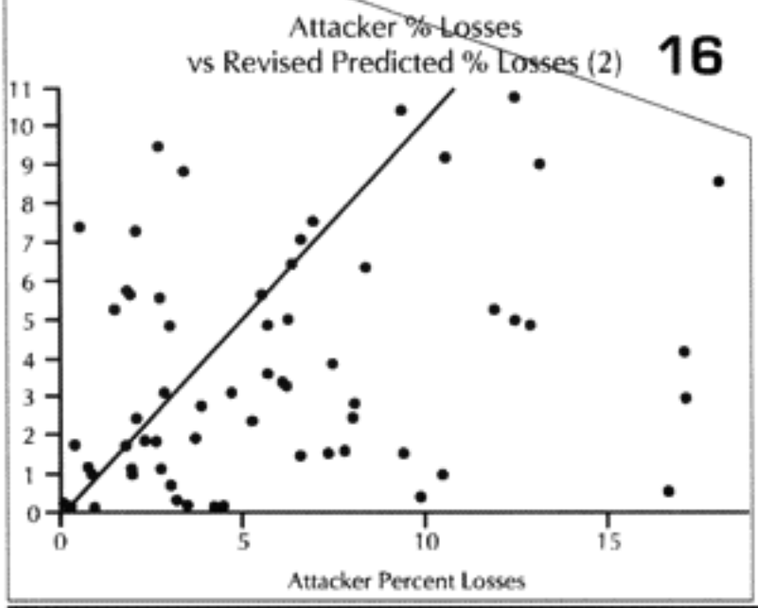
Looking at the basic results, I could see that the model was doing just fine in predicting WWI battles, although its standard deviation for the defenders was still poor. It wasn't doing very well with WWII, and performed quite poorly with modern engagements. This was the exact opposite effect to our test on predicting winners and losers, where the model did best with the post–WWII battles and worst with the WWI battles. Recall that we implemented an attrition multiplier of 4 for the WWI battles. So it was now time to look at each battle, and figure out where were we really off. In this case, I looked at casualty figures that were off by a significant order of magnitude. The reason I looked at significant orders of magnitude instead of percent error, is that making a mistake like predicting 2% instead of 1% is not a very big error, where as predicting 20%, and having the actual casualties 10%, is pretty significant. Both would be off by 100%.

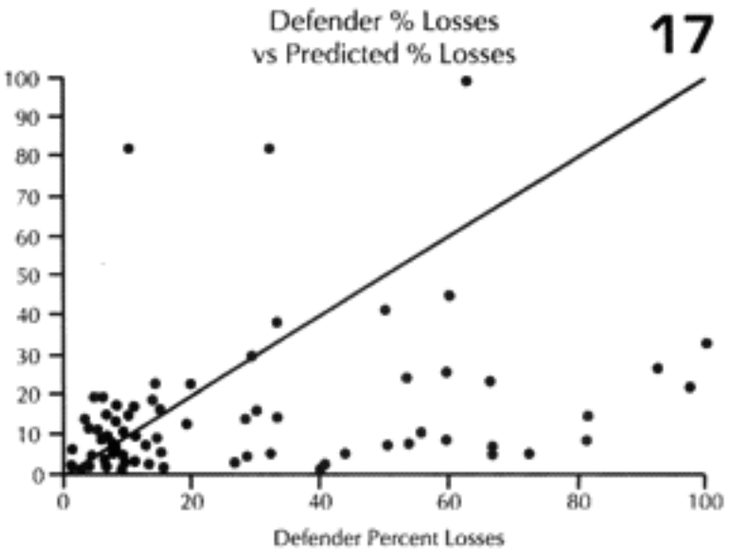
## SO WHERE WERE WE REALLY OFF? (WWI)

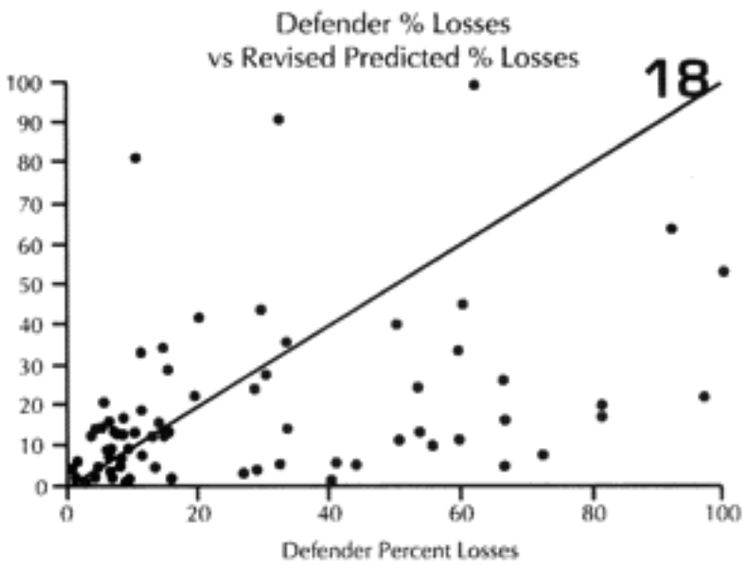
In the case of the attackers, we were getting a result in the ball park in two–thirds of the cases, and only two cases—N Wood I and Chaudun—were really off. Unfortunately, for the defenders we were getting a reasonable result in only 40% of the cases, and the model had a tendency

| World War I Attacker | | |
|---|---|---|
| *Predicted Casualties Off By:* | *Predicted* | *CEV Predicted* |
| ***-10 to -25*** | West Wood I | |
| ***-5 to -10*** | Bouresches I | |
| | St Amand | St Amand |
| | Bouzancy Rdg | Bouzancy Rdg |
| | Medeah Farm | Medeah Farm |
| | Essen Hook | Essen Hook |
| ***-5 to +5*** | 14 cases | 15 cases |
| ***+5 to +10*** | Remilly | Remilly |
| | | North Wood II |
| ***+10 to +25*** | North Wood I | North Wood I |
| | Chaudun | Chaudun |




| World War I Defender | | |
|---|---|---|
| *Predicted Casualties Off By:* | *Predicted* | *CEV Predicted* |
| ***-25 or more*** | Cantigny | Cantigny |
| | St Amand | St Amand |
| | Medeah Farm | Medeah Farm |
| | Essen Hook | Essen Hook |
| ***-10 to -25*** | West Wood II | |
| | North Wood IV | |
| ***-5 to -10*** | Hill 142 | |
| | Bouzancy Rdg | Bouzancy Rdg |
| ***-5 to +5*** | 6 cases | 9 cases |
| ***+5 to +10*** | Yvonne | |
| | Bouresches I | |
| | North Wood II | |
| | | North Wood I |
| | | Mayache Rvn |
| | | La Neuville |
| | | Hill 252 |
| ***+10 to +25*** | West Wood I | |
| | Mayache Rvn | |
| | La Neuville | |
| | | Yvonne |
| | | North Wood I |
| ***+25 or more*** | Beaupre Farm | Beaupre Farm |
| | Chaudun | Chaudun |
| | Remilly | Remilly |

to under– or over–predict. It is clear that the model understands attacker losses better than defender losses. I suspect this is related to the model having no breakpoint methodology. Also, defender losses may be more variable. I was unable to find a satisfactory explanation for the variation. One thing I did notice was that all four battles that were significantly under–predicted on the defender sides were the four shortest WWI battles. Three of these were also noticeably under–predicted for the attacker. Therefore, I looked at all 23 WWI engagements related to time. (*see table, top of next page*)

Looking back at the issue of time, it became clear the model was clearly under–predicting in battles of less than four hours. I therefore came up with the following time scaling formula:

If time of battle less than four hours, then multiply attrition by (4/(Length of battle in hours)).

| | |
|---|---|
| 3.75 | 1.07 |
| 3.5 | 1.14 |
| 3 | 1.33 |
| 2 | 2 |
| .5 | 8 |

What this formula does is make all battles less than four hours equal to a four–hour engagement. This intuitively looks wrong, but one must consider how we define a battle. A "battle" is defined by the analyst after the fact. The start time is usually determined by when the attack starts (or when the artillery bombardment starts) and end time by when the attack has clearly failed, or the mission has been accomplished, or the fighting has died down. Therefore, a battle is not de-

| Engagement Name | Hours | Attacker % Losses | CEV-Predicted Att % Losses | Defender % Losses | CEV-Predicted Def % Losses | Comment |
|---|---|---|---|---|---|---|
| 18. Essen Hook | 0.50 | 9.86 | 0.49 | 55.56 | 10.19 | x 5 |
| 2. Cantigny | 2.00 | 3.46 | 0.24 | 53.24 | 24.14 | x 2 |
| 12. St Amand | 2.00 | 10.43 | 1.04 | 100.00 | 53.25 | x 2 |
| 17. Medeah Farm | 2.00 | 12.86 | 4.89 | 53.55 | 13.55 | x 2 |
| 8. Bouresches II | 3.00 | 3.74 | 2.01 | 4.07 | 2.02 | x 2 |
| 1. Yvonne-Odette | 3.50 | 2.31 | 1.89 | 10.92 | 32.46 | D high/A low |
| 15. Berzy-le-Sec | 3.75 | 5.25 | 2.40 | 33.14 | 35.43 | A low |
| 10. North Wood II | 4.00 | 10.59 | 9.24 | 1.21 | 1.98 | Good |
| 13. Beaupre Farm | 4.00 | 2.79 | 1.18 | 32.04 | 90.62 | D high/A low |
| 16. Bouzancy Ridge | 4.00 | 6.60 | 1.51 | 49.82 | 40.07 | A low |
| 9. North Wood II | 4.50 | 11.31 | 19.62 | 1.26 | 5.74 | Too high |
| 4. West Wood I | 6.00 | 20.75 | 23.22 | 4.82 | 14.18 | D high |
| 5. Bouresches I | 6.00 | 12.46 | 10.79 | 13.76 | 15.24 | Good |
| 3. Hill 142 | 8.00 | 13.15 | 9.03 | 19.16 | 21.81 | Good |
| 23. Hill 252 | 8.00 | 5.53 | 5.68 | 11.00 | 18.67 | Good |
| 11. North Wood IV | 11.00 | 6.13 | 3.35 | 28.27 | 23.67 | Good |
| 6. West Wood II | 12.00 | 8.33 | 6.42 | 30.09 | 27.53 | Good |
| 7. North Wood I | 12.00 | 9.60 | 20.57 | 15.01 | 28.53 | Too high |
| 14. Chaudun | 12.00 | 8.07 | 19.43 | 62.50 | 100.00 | Too high |
| 21. La Neuville | 12.00 | 6.34 | 6.49 | 3.14 | 12.27 | D high |
| 22. Remilly | 12.00 | 2.07 | 7.27 | 10.14 | 81.08 | Too high |
| 19. Exermont | 14.00 | 6.60 | 7.10 | 5.90 | 8.62 | Good |
| 20. Mayache Ravine | 14.00 | 6.93 | 7.54 | 6.00 | 15.43 | D high |

fined by time, but by resolution. As such, any battle that only lasts a short time will still have a resolution, and as a result of achieving that resolution there will be considerable combat experience. Therefore, a minimum casualty multiplier of 1/6 must be applied to account for that resolution. We shall see if this is really the case when we run the second validation using the new battles, which have a considerable number of brief engagements. For now, this seems to fit.

As for all the other missed predictions, including the over–predictions, I could not find a magic formula that corrected them. My suspicion was that the multiplier of x4 would be a little too robust, but even after adjusting for the time equation, this left 14 of the attacker's losses under–predicted and six of the defender actions under–predicted. If the model is doing anything, it is under–predicting attacker casualties and over–predicting defender casualties. This would argue for a different multiplier for the attacker than for the defender (higher one for the attacker). We had six cases where the attacker's and defender's prediction's were both low, nine where they were both high, and eight cases where the attacker's prediction was low while the defender's prediction was high. We had no cases where the attacker's prediction was high and the defender's prediction was low. As all these examples were from the western front in 1918, US versus Germans, then the problem could also be that the model is under–predicting the effects of fortifications, or the terrain for the defense. It could also be indicative of a fundamental difference in the period that gave the attackers higher casualty rates than the defenders. This is an issue I would like to explore in more depth, and I may do so after I have more WWI data from the second validation.

## SO WHERE WERE WE REALLY OFF? (WWII)

In the case of the WWII results, we were getting results in the ball park in less than 60% of the cases for the attacker and in less than 50% of the cases in the case of the defenders. We were often significantly too low. Knowing that we were dealing with a number of Japanese engagements (seven), and they clearly fought in a manner that was different from most western European nations, we expected that they would be under–predicting, and some casualty adjustment would be necessary to reflect this. We also examined whether time was an issue (it was not). The under–predicted

| World War II Attacker | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | CEV Predicted |
| -10 to -25 | Tenaru River I | Tenaru River I |
| | Edson's Ridge | Edson's Ridge |
| | Lausdell XRds | Lausdell Xrds |
| -5 to -10 | Engebi I | Engebi I |
| | Eniwetok | Eniwetok |
| | VER-CHx | VER-CHx |
| | | Wake II |
| | | Makin Raid |
| -5 to +5 | 16 cases | 13 cases |
| +5 to +10 | | VER-RDMx |
| +10 to +25 | | |
| +25 or more | Chouigui Pass | Chouigui Pass |

| World War II Defender | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | CEV Predicted |
| -25 or more | Makin Raid | Makin Raid |
| | Tenaru River II | Tenaru River II |
| | Engebi | Engebi |
| | Lausdell XRds | Lausdell XRds |
| | Assenois | Assenois |
| -10 to -25 | Edson's Ridge | Edson's Ridge |
| | Eniwetok | Eniwetok |
| -5 to -10 | Chouigui Pass | |
| | VER-CHx | |
| -5 to +5 | 11 cases | 11 cases |
| +5 to +10 | VER-1BWx | VER-1BWx |
| | VER-4RWx | VER-4RWx |
| | VER-10Bx | |
| | | Wake II |
| | | VER-2ASx |
| | | VER-HXLx |

battles are listed in the next table:

| Engagement | Hours | No. of Engagements That Are Shorter | Comment |
|---|---|---|---|
| Makin Raid | 4 | 0 | Fanatic! |
| Assenois | 5 | 1 | Way off |
| Lausedell XRds | 5.75 | 2 | Way off |
| Wake II | 7 | 8 | A low/D high |
| Tenaru Riv II | 8.5 | 9 | Fanatic! |
| Tenaru Riv I | 9 | 10 | Fanatic! |
| Edson's Ridge | 12 | 11 | Fanatic! |
| VER-CHx | 12 | 11 | A low |
| Eniwetok | 23 | 20 | Fanatic! |
| Engebi | 24 | 21 | Fanatic! |

We temporarily defined the Japanese mode of fighting as "fanaticism." We decided to find a factor for fanatacism by looking at all the battles with the Japanese. They are listed below:

| Engagement | Attacker | Predicted | % | CEV Predicted | % |
|---|---|---|---|---|---|
| Wake II | Japan | -4.60 | 0.43 | -5.13 | 0.36 |
| Makin Raid | US | -4.53 | 0.75 | -9.50 | 0.48 |
| Tenaru River I | Japan | -17.47 | 0.36 | -12.74 | 0.54 |
| Tenaru River II | US | -0.60 | 0.77 | -0.76 | 0.71 |
| Edson's Ridge | Japan | -14.51 | 0.15 | -12.97 | 0.24 |
| Engebi Island | US | -6.07 | 0.17 | -5.80 | 0.21 |
| Eniwetok | US | -6.52 | 0.16 | -6.14 | 0.21 |
| **Average** | | | | | **0.39** |

| Engagement | Defender | Predicted | % | CEV Predicted | % |
|---|---|---|---|---|---|
| Wake II | US | 2.79 | 1.14 | 21.86 | 2.10 |
| Makin Raid | Japan | -65.55 | 0.29 | -27.78 | 0.70 |
| Tenaru River I | US | -4.13 | 0.33 | -4.56 | 0.30 |
| Tenaru River II | Japan | -66.57 | 0.18 | -61.60 | 0.24 |
| Edson's Ridge | US | -24.13 | 0.16 | -24.35 | 0.15 |
| Engebi Island | Japan | -75.00 | 0.23 | -75.00 | 0.23 |
| Eniwetok | Japan | -19.04 | 0.43 | -19.04 | 0.43 |
| **Average** | | | | | **0.59** |
| **Average less Wake II** | | | | | **0.34** |

Looking at what multiplier was needed, one notes that .39 times 2.5 = .975 while .34 times 2.5 = .85. This argues for a "fanatic" multiplier of 2.5. The non–fanatic opponent attrition multiplier is also 2.5. There was no indication that both sides should not be affected by the same multiplier.

We had now tentatively identified two "fixes" to the data. I am sure someone will call them "fudges," but I am comfortable enough with the logic behind them (especially the fanaticism) that I would dismiss such criticism. It was now time to look at the modern data, and see what would happen if these fixes were applied to it.

## SO WHERE WERE WE REALLY OFF? (Post-WWII)

| Post-World War II Attacker | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | CEV Predicted |
| -25 or more | Long Tan | Long Tan |
| | Prek Klok I | |
| | Prek Klok II | Prek Klok II |
| | Ap Bau Bang II | Ap Bau Bang II |
| | Lo Giang I | Lo Giang I |
| -10 to -25 | Tu-Vu | Tu-Vu |
| | Mapu | Mapu |
| | Buell II | Buell II |
| | | Prek Klok I |
| -5 to -10 | Lo Giang II | Lo Giang II |
| | Nui Ba Den | Nui Ba Den |
| | Mt. Longdon | Mt. Longdon |
| -5 to +5 | 17 cases | 17 cases |
| +5 to +10 | Goose Green | |
| | Salinas | Salinas |
| | | Cau Lanh |

| Post-World War II Defender | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | CEV Predicted |
| -25 or more | Tu-Vu | Tu-Vu |
| | Ninh Binh | Ninh Binh |
| | Cai Nuoc | Cai Nuoc |
| | ZDB050 | ZDB050 |
| | Hill 450 | Hill 450 |
| | Prek Klok I | Prek Klok I |
| | Ap Bau Bang II | Ap Bau Bang II |
| | Lo Giang II | Lo Giang II |
| | Mt Harriet | Mt Harriet |
| | Mt Longdon | Mt Longdon |
| -10 to -25 | Cau Lanh | Cau Lanh |
| | Lo Giang I | Lo Giang I |
| | Nui Ba Den | Nui Ba Den |
| | Two Sisters | |
| | Lipanda | |
| -5 to -10 | Mapu | Mapu |
| | Bir Gifgafa II | Bir Gifgafa II |
| | Goose Green | |
| | Tumbledown | |
| -5 to +5 | 8 cases | 9 cases |
| +5 to +10 | Pearls AFB | |
| | Lomba | |
| | TF Bayonet | |
| +10 to +25 | | Salinas |
| | | Pearls AFB |
| | | Lomba |
| | | TF Bayonet |

A total of 20 battles were noticeably under–predicted. We examined them to see if there was a pattern in this under–prediction.

**FANATICISM and CASUALTY INSENSITIVE SYSTEMS:**

It was quite clear from looking at the battalion–level data before we did the validation runs that there appeared to be two very different loss patterns, based upon—dare I say it—nationality. See the article in issue 4 of the newsletter, "Looking at Casualties Based Upon Nationality Using the BLODB." While this is clearly the case with the Japanese in WWII, it does appear that other countries were also operating in a manner that produced similar casualty results. So, instead of using the word fanaticism, let's refer to them as "casualty insensitive" systems. For those who really need a definition before going forward:

> "Casualty Insensitive" System: A social or military system that places a high priority on achieving the objective or fulfilling the mission and a low priority on minimizing casualties. Such systems tend to be "mission obsessive" versus using some form of "cost benefit" method of weighing whether the objective is worth the losses suffered to take it.

**EXAMPLES OF CASUALTY INSENSITIVE SYSTEMS:**

For the purpose of the database, casualty sensitive systems were defined as the Japanese and all highly motivated communist–led armies. These include:

Japanese Army, WWII
Viet Mihn
Viet Cong
North Vietnamese
Indonesian

We have included the Indonesians in this list even though it was based upon only one example.

In the WWII and post–WWII period, one would expect that the following armies would also be "casualty insensitive:"

Soviet Army in WWII
North Korean Army
Communist Chinese Army in Korea
Iranian "Pasdaran"

Data can certainly be found to test these candidates.

One could postulate that the WWI attrition multiplier of 4 that we used also incorporates the 2.5 "casualty insensitive" multiplier. This would imply that there was only a multiplier of 1.6 to account for other considerations, like adjusting to the impact of increased firepower on the battlefield. One could also postulate that certain nations, like Russia, have had "casualty insensitive" systems throughout their last 100 years of history. This could also be tested by looking of battles over time of Russians versus Germans compared to Germans versus British, US or French. One could easily carry this analysis back to the Seven Years' War. If this was the case, this would establish a clear cultural basis for the "casualty insensitive" multiplier, but to do so would require the TNDM to be validated for periods before 1900. This would all be useful analysis in the future, but is not currently budgeted for.

It was expected that the "casualty insensitive" multiplier of 2.5 derived from the Japanese data would be too high to apply directly to the armies. Much to our surprise, we found that this did not appear to be the case.

This partially or wholly explained the under–prediction of the 15 of our 20 significantly under–predicted post–WWII engagements. Time would explain another one, and four were not explained.

| | | No. of Engagements | |
|---|---|---|---|
| Engagement | Hours | That Are Shorter | Comment |
| Lo Giang I | 1 | 0 | Casualty Insensitive |
| Cai Nuoc | 1 | 0 | Casualty Insensitive |
| ZBD050 | 1 | 0 | Casualty Insensitive |
| Bir Gifgafa II | 1 | 0 | |
| Mapu | 2 | 4 | Casualty Insensitive |
| Nui Ba Den | 2 | 4 | Casualty Insensitive |
| Prek Klok II | 3 | 7 | Casualty Insensitive |
| Buell II | 3 | 7 | Casualty Insensitive |
| Prek Klok I | 4 | 9 | Casualty Insensitive |
| Lo Giang II | 4 | 9 | Casualty Insensitive |
| Two Sisters | 4 | 9 | |
| Ninh Binh | 6 | 13 | Casualty Insensitive |
| Long Tan | 6 | 13 | Casualty Insensitive |
| Lipanda | 6 | | |
| Cau Lanh | 8 | 16 | Casualty Insensitive |
| Ap Bau Bang II | 8 | 16 | Casualty Insensitive |
| Mt Harriet | 8 | 16 | |
| Mt Longdon | 9 | | |
| Tu-Vu | 12 | | Casualty Insensitive |
| Hill 450 | 12 | | Casualty Insensitive |

The model noticeably underestimated all the engagements under nine hours except Bir Gifgafa I (2 hours), Pearls AFB (4.5) and Wireless Ridge (8 hours). It noticeably under–estimated all the 15 "fanatic" engagements. If the formulations derived from the earlier data were used here (engagements less than 4 hours and fanatic), then there are 17 engagements in which one side is "casualty insensitive" or in which the engagement time is less than 4 hours. Using the above formulations then 17 engagements would have their casualty figures changed. These are shown at the top of the next page.

The modified percent loss figures are the CEV predicted percent loss times the factor for "casualty insensitive" systems (for those 15 cases where it applies) and times the formulation for battles less than 4 hours (for those 9 case where it applies).

Looking at the table at the top of the next page, it would appear that we are on the correct path. But to be safe, on the next page let's look at the predictive value of the 13 engagements for which we didn't redefine the attrition multipliers.

| Engagement | Length | Attacker % Losses | CEV-Predicted Att % Losses | Modified Att % Losses | Defender % | CEV-Predicted Def % Losses | Modified Def % Losses | Comment |
|---|---|---|---|---|---|---|---|---|
| 4. Cai Nuoc | 1 | 3.20 | 0.40 | 4.00 | 40.00 | 1.33 | 13.33 | 4 x 25 |
| 5 ZBD050 | 1 | 1.00 | 0.00 | 0.00 | 40.83 | 5.83 | 58.83 | 4 x 25 |
| 13. Bir Gifgafa II | 1 | 0.33 | 0.07 | 0.28 | 8.96 | 0.45 | 1.80 | x 4 |
| 14. Lo Giang I | 1 | 38.86 | 7.43 | 74.30 | 26.67 | 3.33 | 33.33 | 4 x 25 |
| 6. Mapu | 2 | 26.50 | 3.00 | 15.00 | 9.33 | 1.33 | 6.65 | 2 x 25 |
| 13. Bir Gifgafa I | 2 | 4.29 | 0.17 | 0.34 | 2.50 | 0.45 | 0.90 | x 2 |
| 16. Nui Ba Den | 2 | 8.00 | 2.50 | 12.50 | 15.56 | 1.67 | 8.35 | 2 x 25 |
| 10. Prek Klok II | 3 | 35.40 | 5.30 | 17.67 | 2.56 | 0.63 | 2.10 | 1.33 2.5 |
| 11. Buell II | 3 | 19.75 | 1.96 | 6.53 | 6.75 | 2.00 | 6.67 | 1.33 2.5 |
| 9. Prek Klok I | 4 | 58.40 | 34.80 | 87.00 | 32.32 | 5.49 | 13.73 | x 2.5 |
| 15. Lo Giang II | 4 | 9.40 | 1.60 | 4.00 | 50.38 | 11.38 | 28.45 | x 2.5 |
| 2. Ninh Binh | 6 | 3.06 | 0.71 | 1.78 | 59.58 | 11.58 | 28.95 | x 2.5 |
| 7. Long Tan | 6 | 46.47 | 4.80 | 12.00 | 4.33 | 4.67 | 11.68 | x 2.5 |
| 3. Cau Lanh | 8 | 0.60 | 7.40 | 18.50 | 60.00 | 45.00 | 100.00 | x 2.5 |
| 12. Ap Bau Bang | 8 | 44.78 | 15.56 | 38.90 | 44.00 | 5.33 | 13.33 | x 2.5 |
| 1. Tu-Vu | 12 | 17.14 | 2.97 | 7.43 | 59.52 | 33.33 | 83.33 | x 2.5 |
| 8. Hill 450 | 12 | 6.00 | 3.41 | 8.53 | 66.36 | 26.17 | 65.43 | x 2.5 |
| ***Average*** | | ***19.01*** | ***5.42*** | ***18.16*** | ***31.16*** | ***9.41*** | ***28.05*** | |
| ***Sum of Squares*** | | | ***6302.31*** | ***4407.47*** | | ***12189.90*** | ***6120.02*** | |
| ***Variance*** | | | ***370.32*** | ***259.26*** | | ***717.05*** | ***360.00*** | |
| ***Std Deviation*** | | | ***19.25*** | ***16.10*** | | ***26.78*** | ***18.97*** | |

The 13 engagements left unchanged:

| Engagement | Length | Attacker % Losses | CEV-Predicted Att % Losses | Defender % Losses | CEV-Predicted Def % Losses |
|---|---|---|---|---|---|
| 17. Mt. Hermon | 20 | 1.85 | 5.75 | 6.32 | 3.28 |
| 18. Goose Green | 15 | 9.31 | 10.40 | 15.11 | 13.22 |
| 19. Mt. Harriet | 8 | 1.76 | 1.76 | 81.25 | 17.75 |
| 20. Two Sisters | 4 | 1.97 | 0.98 | 13.25 | 4.75 |
| 21. Mt. Longdon | 9 | 12.50 | 5.00 | 66.67 | 16.33 |
| 22. Tumbledown | 11.25 | 7.47 | 3.88 | 11.11 | 7.11 |
| 23. Wireless R. | 8 | 2.12 | 2.42 | 9.23 | 9.38 |
| 24. Salinas | 12 | 3.33 | 8.83 | 29.18 | 43.63 |
| 25. Pearls AFB | 4.5 | 0.40 | 1.80 | 14.29 | 34.29 |
| 26. Lomba | 24 | 0.75 | 1.17 | 5.30 | 20.76 |
| 27. Cuatir River | 26 | 0.85 | 1.03 | 6.44 | 8.93 |
| 28. Lipanda | 6 | 0.16 | 0.25 | 13.26 | 4.64 |
| 29. TF Bayonet | 45 | 1.93 | 1.13 | 4.09 | 14.13 |
| ***Average*** | | ***3.42*** | ***3.42*** | ***21.19*** | ***15.25*** |
| ***Sum of Squares*** | | | ***119.63*** | | ***7696.01*** |
| ***Variance*** | | | ***9.20*** | | ***592.00*** |
| ***Std Deviation*** | | | ***3.03*** | | ***24.33*** |

So, we are definitely heading in the right direction now. We have identified two model changes—time and "casualty insensitive." We have developed preliminary formulations for time and for "casualty insensitive" forces. Unfortunately, the time formulation was based upon seven WWI engagements. The "casualty insensitive" formulation was based upon seven WWII engagements. Let's use all our data in the first validation database here for the moment to come up with figures with which we can be more comfortable:

| Engagement | Length | Attacker % Losses | CEV-Predicted Att % Losses | x2.5 Modified Att % Losses | Defender % Losses | CEV-Predicted Def % Losses | x2.5 Modified Def % Losses |
|---|---|---|---|---|---|---|---|
| 2. Makin Raid | 4 | 18.10 | 8.60 | 21.50 | 92.22 | 64.44 | 100.00 |
| 9. Prek Klok I | 4 | 58.40 | 34.80 | 87.00 | 32.32 | 5.49 | 13.73 |
| 15. Lo Giang II | 4 | 9.40 | 1.60 | 4.00 | 50.38 | 11.38 | 28.45 |
| 2. Ninh Binh | 6 | 3.06 | 0.71 | 1.78 | 59.58 | 11.58 | 28.95 |
| 7. Long Tan | 6 | 46.47 | 4.80 | 12.00 | 4.33 | 4.67 | 11.68 |
| 1. Wake II | 7 | 8.00 | 2.87 | 7.18 | 19.77 | 41.63 | 100.00 |
| 3. Cau Lanh | 8 | 0.60 | 7.40 | 18.50 | 60.00 | 45.00 | 100.00 |
| 12. Ap Bau Bang | 8 | 44.78 | 15.56 | 38.90 | 44.00 | 5.33 | 13.33 |
| 3. Tenaru Riv II | 8.5 | 2.63 | 1.87 | 4.68 | 81.48 | 19.88 | 49.70 |
| 3. Tenaru Riv I | 9 | 27.47 | 14.73 | 36.83 | 6.52 | 1.96 | 4.90 |
| 4. Edson's Rdg | 12 | 17.14 | 4.17 | 10.43 | 28.59 | 4.24 | 10.60 |
| 1. Tu-Vu | 12 | 17.14 | 2.97 | 7.43 | 59.52 | 33.34 | 83.33 |
| 8. Hill 450 | 12 | 6.00 | 3.41 | 8.53 | 66.36 | 26.17 | 65.43 |
| 8. Eniwetok | 23 | 7.75 | 1.61 | 4.03 | 33.26 | 14.22 | 35.55 |
| 7. Engebi | 24 | 7.35 | 1.55 | 3.88 | 97.18 | 22.18 | 55.45 |
| ***Average*** | | ***18.29*** | ***7.11*** | ***17.78*** | ***49.03*** | ***20.77*** | ***46.74*** |
| ***Sum of Squares*** | | | ***3986.27*** | ***2667.66*** | | ***20211.87*** | ***14509.26*** |
| ***Variance*** | | | ***265.75*** | ***177.84*** | | ***1347.46*** | ***967.28*** |
| ***Std Deviation*** | | | ***16.30*** | ***13.34*** | | ***36.71*** | ***31.10*** |

The highlighted entries in the table above indicate "casualty insensitive" forces. We are still struggling with the concept that having one side being casualty insensitive increases both sides' losses equally. We highlighted these in an attempt to find any other patterns we were missing. We could not.

Now, there may be a more sophisticated measurement of this other than the brute force method of multiplying both sides by 2.5. This might include different multipliers depending on whether one is the fanatic vs non–fanatic side or different multipliers for attack or defense. First, I cannot find any clear indication that there should be a different multiplier for the attacker or defender. A general review of the data confirms that. Therefore, we are saying that the combat relationships between attacker and defender do not change in high intensity or casualty insensitive battles from those experienced in the norm.

What is also clear is that our multiplier of 2.5 appears to be about as good a fit as we can get from a straight multiplier. It does not appear that there is any significant difference between the attrition multiplier for types of "casualty insensitive" systems, whether they are done because of worship of the emperor or because the commissar will shoot slackers. Apparently the mode of fighting is more significant for measuring combat results than how one gets there, although certainly having everyone worship the emperor is probably easier to "administer."

This still leaves us having to look at whether we should develop a better formulation for time. See the top of the next page.

"Non-Fanatic" Engagements of less than 4 hours:

| Engagement | Length | Attacker % Losses | CEV-Predicted Att % Losses | xTime Modified Att % Losses | Defender % Losses | CEV-Predicted Def % Losses | xTime Modified Def % Losses |
|---|---|---|---|---|---|---|---|
| 18. Essen Hook | 0.5 | 9.86 | 0.49 | 3.92 | 55.56 | 10.19 | 81.52 |
| 13. Bir Gifgafa II | 1 | 0.33 | 0.07 | 0.28 | 8.96 | 0.45 | 1.80 |
| 2. Cantigny | 2 | 3.46 | 0.24 | 0.48 | 53.24 | 24.14 | 48.28 |
| 12. St Amand | 2 | 10.43 | 1.04 | 2.08 | 100.00 | 53.25 | 100.00 |
| 17. Medeah Frm | 2 | 12.86 | 4.89 | 9.78 | 53.55 | 13.55 | 27.10 |
| 13. Bir Gifgafa I | 2 | 4.29 | 0.17 | 0.34 | 2.50 | 0.45 | 0.90 |
| 8 Bouresches II | 3 | 3.74 | 2.01 | 2.68 | 4.07 | 2.02 | 2.69 |
| 1. Yvonne-Odet | 3.5 | 2.31 | 1.89 | 2.16 | 10.92 | 32.46 | 37.10 |
| 15. Berzy-le-Sec | 3.75 | 5.25 | 2.40 | 2.56 | 33.14 | 35.43 | 37.79 |
| ***Average*** | | ***5.84*** | ***1.47*** | ***2.70*** | ***35.77*** | ***19.10*** | ***37.46*** |
| ***Sum of Squares*** | | | ***278.19*** | ***147.36*** | | ***7240.85*** | ***2160.87*** |
| ***Variance*** | | | ***30.91*** | ***16.37*** | | ***804.54*** | ***240.10*** |
| ***Std Deviation*** | | | ***5.56*** | ***4.05*** | | ***28.36*** | ***15.50*** |

For fairly obvious reasons, we are still concerned about this formulation for battles of less than one hour, as we have only one example, but until we conduct the second validation, this formulation will remain as is.

Now the extreme cases:

List of all engagements less than 4 hours where one side was fanatic:

| Engagement | Length | Attacker % Losses | CEV-Predicted Att % Losses | xTFx2.5 Modified Att % Losses | Defender % Losses | CEV-Predicted Def % Losses | xTFx2.5 Modified Def % Losses |
|---|---|---|---|---|---|---|---|
| 4. Cai Nuoc | 1 | 3.20 | 0.40 | 4.00 | 40.00 | 1.33 | 13.33 |
| 5. ZDB050 | 1 | 1.00 | 0.00 | 0.00 | 40.83 | 5.83 | 58.30 |
| 14. Lo Giang I | 1 | 38.86 | 7.43 | 74.30 | 26.67 | 3.33 | 33.33 |
| 6. Mapu | 2 | 26.50 | 3.00 | 15.00 | 9.33 | 1.33 | 6.65 |
| 16. Nui Ba Den | 2 | 8.00 | 2.50 | 12.50 | 15.56 | 1.67 | 8.35 |
| 10. Prek Klok II | 3 | 35.40 | 5.30 | 17.67 | 2.56 | 0.63 | 2.10 |
| 11. Buell II | 3 | 19.75 | 1.96 | 6.53 | 6.75 | 2.00 | 6.67 |
| ***Average*** | | ***18.96*** | ***2.94*** | ***16.57*** | ***20.24*** | ***2.30*** | ***18.39*** |
| ***Sum of Squares*** | | | ***2801.68*** | ***1699.25*** | | ***3548.34*** | ***1120.23*** |
| ***Variance*** | | | ***400.24*** | ***271.32*** | | ***506.91*** | ***160.03*** |
| ***Std Deviation*** | | | ***20.01*** | ***16.47*** | | ***22.51*** | ***12.65*** |

It would appear that these formulations of time and "casualty insensitivity" have passed their initial hypothesis formulations tests. We are now willing to make changes to the model based upon this and run the engagements from the second validation data base to test it.

**CONCLUSIONS:**

With these two changes made, then the final fit for the battalion–level validation is:

| Attacker Percent Losses | Average | Standard Deviation |
|---|---|---|
| Actual | 9.5 | |
| Predicted with CEV | 5.75 | 10.73 |
| Predicted with Modifications | 9.44 | 9.18 |

| Defender Percent Losses | Average | Standard Deviation |
|---|---|---|
| Actual | 26.59 | |
| Predicted with CEV | 17.93 | 27.49 |
| Predicted with Modifications | 26.71 | 24.12 |

| Attacker Percent Losses | WWI Average | Standard Deviation | WWII Average | Standard Deviation | Post-WWI Average | Standard Deviation |
|---|---|---|---|---|---|---|
| Actual | 8.05 | | 7.36 | | 12.26 | |
| Predicted with CEV | 7.45 | 5.42 | 5.62 | 8.49 | 4.55 | 14.63 |
| Predicted with Modifications | 7.92 | 4.87 | 7.93 | 7.56 | 11.77 | 12.3 |

| Defender Percent Losses | WWI Average | Standard Deviation | WWII Average | Standard Deviation | Post-WWI Average | Standard Deviation |
|---|---|---|---|---|---|---|
| Actual | 26.29 | | 26.58 | | 26.84 | |
| Predicted with CEV | 29.41 | 27.74 | 14.25 | 29.38 | 11.94 | 25.75 |
| Predicted with Modifications | 36.52 | 23.44 | 22.41 | 27.81 | 22.49 | 21.45 |

And just to make sure that I'm not just tweaking the model in any old direction so that it fits better, let's look at the prediction of the ones that were not modified:

| *Attacker Percent Losses* | *WWI (16 cases)* | | *WWII (16 cases)* | | *Post-WWII (13 cases)* | |
|---|---|---|---|---|---|---|
| | ***Average*** | ***Std Dev*** | ***Average*** | ***Std Dev*** | ***Average*** | ***Std Dev*** |
| Actual | 8.58 | | 5.06 | | 3.42 | |
| Predicted (unmodified) | 9.90 | 5.09 | 5.87 | 8.44 | 3.42 | 3.03 |
| *Defender Percent Losses* | *WWI (16 cases)* | | *WWII (16 cases)* | | *Post-WWII (13 cases)* | |
| | ***Average*** | ***Std Dev*** | ***Average*** | ***Std Dev*** | ***Average*** | ***Std Dev*** |
| Actual | 18.38 | | 15.77 | | 21.19 | |
| Predicted (unmodified) | 31.59 | 25.66 | 9.95 | 22.65 | 15.25 | 24.33 |

The ones that were not modified were doing better in prediction that the ones that were modified before their modification. It appears that by focusing on two issues, time and "casualty insensitive" systems, we have improved those predictions in a rational manner, resulting in a better fit overall. This fit was based upon a rational analysis of combat and the data.

In general, we are getting reasonable average results and the model is holding up well across all periods, **once the two special considerations were accounted for.**

## A LITTLE MORE BASIC STATISTICS:

For the entire set of data, the mean is 9.44 for the attacker and 26.71 for the defender; the standard deviation is 9.18 for the attacker and 24.12 for the defender. The number of examples is 76, the degree of freedom is 75. Therefore the confidence intervals are:

| *Attacker Confidence Interval* | *Average* | | *T-Stat* | *x 9.18/√76* | *Confidence Interval Low* | *High* |
|---|---|---|---|---|---|---|
| 80% | 9.44 | + / - | 1.295 | x 1.053 | 8.08 | 10.80 |
| 90% | 9.44 | + / - | 1.669 | x 1.053 | 7.68 | 11.20 |
| 95% | 9.44 | + / - | 1.994 | x 1.053 | 7.34 | 11.54 |
| *Defender Confidence Interval* | *Average* | | *T-Stat* | *x 24.12/√76* | *Confidence Interval Low* | *High* |
| 80% | 26.71 | + / - | 1.295 | x 2.767 | 23.13 | 30.29 |
| 90% | 26.71 | + / - | 1.669 | x 2.767 | 22.09 | 31.33 |
| 95% | 26.71 | + / - | 1.994 | x 2.767 | 21.19 | 32.23 |

Now, if this is based on modified data, I'm not sure what this really means statistically. The standard deviation is not of the sample, but of the error in the sample from the real world. But as I had already calculated the standard deviation for this sample, I figured this paper wouldn't be complete without a little more math.

# TDI Profile: Joseph A. Bulger, Jr.

Col. Bulger graduated from the US Military Academy at West point in 1952 with a BS in Engineering, and went on to earn an MS in Aerospace Engineering from theuniversity of Michigan in 1960. He also attended the Armed Forces Staff College in 1967.

After serving 25 years in the US Air Force as a fighter pilot—including 269 combat missions over Vietnam in an F-100—and R&D staff officer, Col. Bulger spent 15 years with Boeing in the weapons performance analysis business. His engineering assignments included flight test engineering, development planning for tactical and strategic systems, manned military space programs (Dynasoar and Manned Orbiting Laboratory), and conventional (non–nuclear) weapons design and performance analysis. He was a consultant at the Dupuy Institute on the Dupuy Air Combat Model (DACM) project before taking over as project manager.
His assignments included:

* 1955-1958: Landstuhl AB, Germany; F-86 pilot
* 1959-1960: Univ. of Michigan, MS Aero/Astro Engineering
* 1960-1966: Edwards AFB, California; Flight Test Engineering (Research Simulation)
* 1966-1967: Armed Forces Staff College, Norfolk, Virginia
* 1967-1968: Bien Hoa, RVN; F-100 pilot (269 combat missions)
* 1968-1969: Los Angeles AFS, California; Manned Orbiting Laboratory, Crew Training
* 1969-1973: HQ AFSC, Andrews AFB, Maryland; Strategic Development Planning
* 1973-1977: Eglin AFB, Florida; Tactical Weapons Planning and Development
* 1977-1992: Boeing, Seattle, Washington; Manager, Theater Warfare Systems Analysis

Col. Bulger maintains an extensive and lively discussion on the future of warfare on his Web page at http://www.halcyon.com/jbulger.

# How Data is Laid Out (Supplement for the User's Guide)

by José Perez

**The TNDM Database**

The individual data files used in the TNDM will be referred to as tables: the rows represent different records and the columns represent the fields that make up each record. When linked together, these tables make up the TNDM database.

**The Data Tables**

Currently there are a small number of data tables in the TNDM. They are, by name and contents:

**COUNTRY.DBF:** Countries
**ENG_FOR.DBF:** The units assigned to an attacker/defender in an engagement.
**ENG_TOE.DBF:** For those units manually created for an engagement, this table contains the weapons list for each OLI category. This includes a count of the number of weapons.
**FORCE.DBF:** Units listed by country. The data includes the count of weapon systems and OLI value for each weapon category: Armor, Infantry, Antitank, Towed artillery, SP Artillery, Anti-Air, Fixed wing aircraft, and Rotary wing aircraft; and the mobility systems: Trucks, Motorcycles, Tracked vehicles, Fixed wing aircraft and Rotary wing aircraft.
**OLI.DBF:** Weapon systems listed by country within weapon category. Includes weapon components such as bombs, rockets, tank guns, etc. Data includes various weapon characteristics.
**UNIT_TOE.DBF:** For those units created with the aid of the OLI database (OLI.DBF), this database contains the weapons list for each OLI category. This includes a count of the number of weapons.

The engagement data is in a different type of file. The data for each engagement is stored in a file that is unique to that engagement. For example, if an engagement is named Antietam, its data file is called ANTIETAM.DAT. If an engagement is being continued, it might be saved as ANTIETAM.CNT; a CNT file contains the status of both sides as of the end of the engagement.

**Database Organization**

The relationships between these tables is shown in the table at the bottom of this page.

**More on the Tables**

If you refer to the *TNDM User's Guide*, you will note that a great deal of information is stored in the engagement file: terrain, weather, recovered equipment, force strengths, reinforcements, etc. This information is sufficient to run the engagement even if the associated records in ENG_FOR.DBF (Engagement Forces) and ENG_TOE.DBF (Engagement Forces TO&E) are missing.

The Country table is used primarily for reference. It is automatically updated when new countries are added to the Units table (FORCE.DBF).

The Engagement Forces table was created to make increase the flexibility of the TNDM. It is used to store information about each unit in the attacking and defending forces in an engagement. When manually created units are used in an engagement, they can be recalled from the Engagement Forces table and changed to meet the analyst's needs. This also allows the analyst to modify "standard" units within the engagement without having to change a unit's data in FORCE.DBF.

The Engagement Forces TO&E table was created to make it easier to create units

| | Engagement | Country | Eng_For | Eng_TOE | Force | OLI | Unit_TOE |
|---|---|---|---|---|---|---|---|
| Engagement | — | N/A | By nation, unit, A/D, and Eng | By nation, unit, A/D, and Eng | N/A | N/A | N/A |
| Country | N/A | — | N/A | N/A | N/A | N/A | N/A |
| Eng_For | By Eng | N/A | — | By Eng, nation, and unit | N/A | N/A | N/A |
| Eng_TOE | By Eng | N/A | By Eng, unit, category, & wpn | — | N/A | N/A | N/A |
| Force | N/A | Nation | N/A | N/A | — | N/A | By nation and unit |
| OLI | N/A | N/A | N/A | By nation and weapon | N/A | — | By nation and weapon |
| Unit_TOE | N/A | N/A | N/A | N/A | By nation and unit | N/A | — |

manually. It is similar to Unit_TOE.DBF (Unit TO&E), which is used to document the weapons that compose each combat system category. This enables the analyst to use the weapons database (OLI.DBF) to create and modify units. However, if the analyst has already calculated the OLI scores for each weapon category, he has the option to enter total OLI scores and strengths manually.

FORCE.DBF is the table which contains summary information about all of the "standard" units used in the model. These units are organized by nation. Because of how aircraft are handled by the TNDM, helicopters and airplanes are included in this table as individual units. Because it is now linked to the OLI (Weapons) table, it is now possible to create and modify units without having to calculate the OLI score and strength manually. Also, using this approach documents the composition of weapons in each category by recording the weapons in the Unit TO&E table.

OLI.DBF is the Weapons table. It contains the characteristics for a wide variety of weapons: artillery, infantry weapons, armored vehicles, airplanes, helicopters, bombs, etc. It can be used to create new units; it can also be used to store hypothetical weapons.

**Future Data Organization**

At this time, there is no need to create links between engagements. However, the TNDM could be modified to allow the user to analyze battles by treating different sections of the front line as engagements. These sections could then be combined or broken down into even more sections. The results could then be combined to calculate an overall result for the entire battle. This would require creating a table that records which engagements compose a battle.

Another possible change would be to alter the TNDM to allow the withdrawal of individual units. Currently, the TNDM does not make it easy to withdraw units; the current strength of the unit must be calculated and the analyst must manually subtract it from the force. A better alternative would be to record each unit individually in a Daily Strength table. When the unit was withdrawn, the TNDM would look up the unit in the Daily Strength table and automatically subtract it from the force.

It is also possible to create a table that links together the various engagement files that depict the various phases of a battle. For example, a specific battle might be broken up into three engagements. The first engagement would be the initial contact between opposing sides; the second would begin when reinforcements arrive; and the third would begin when the losing side begins to withdraw.

**Summary**

This article has not covered any of the reference tables that are used to calculate engagement results and weapon scores. But in reviewing the data used in the TNDM it is clear that there are large amounts of it. Some of it is calculated and then discarded after the results of an engagement are generated. Other data is saved and presented in the engagement report. But it is how the data is connected to tables or other data in the TNDM that makes it useful. In considering how to change the TNDM to make it more useful, one needs to consider the data that is already present and how it is linked together. In some cases, data tables had to be created in order to create links. As a database programmer, I am well aware that information has no real value if the data is incoherent and disorganized. But sometimes all you need to create a structure for that data is to start drawing lines between data points.

I hope this article will encourage you to look at the documentation in the *User's Guide* and consider how a different view of the TNDM data might make your work easier.

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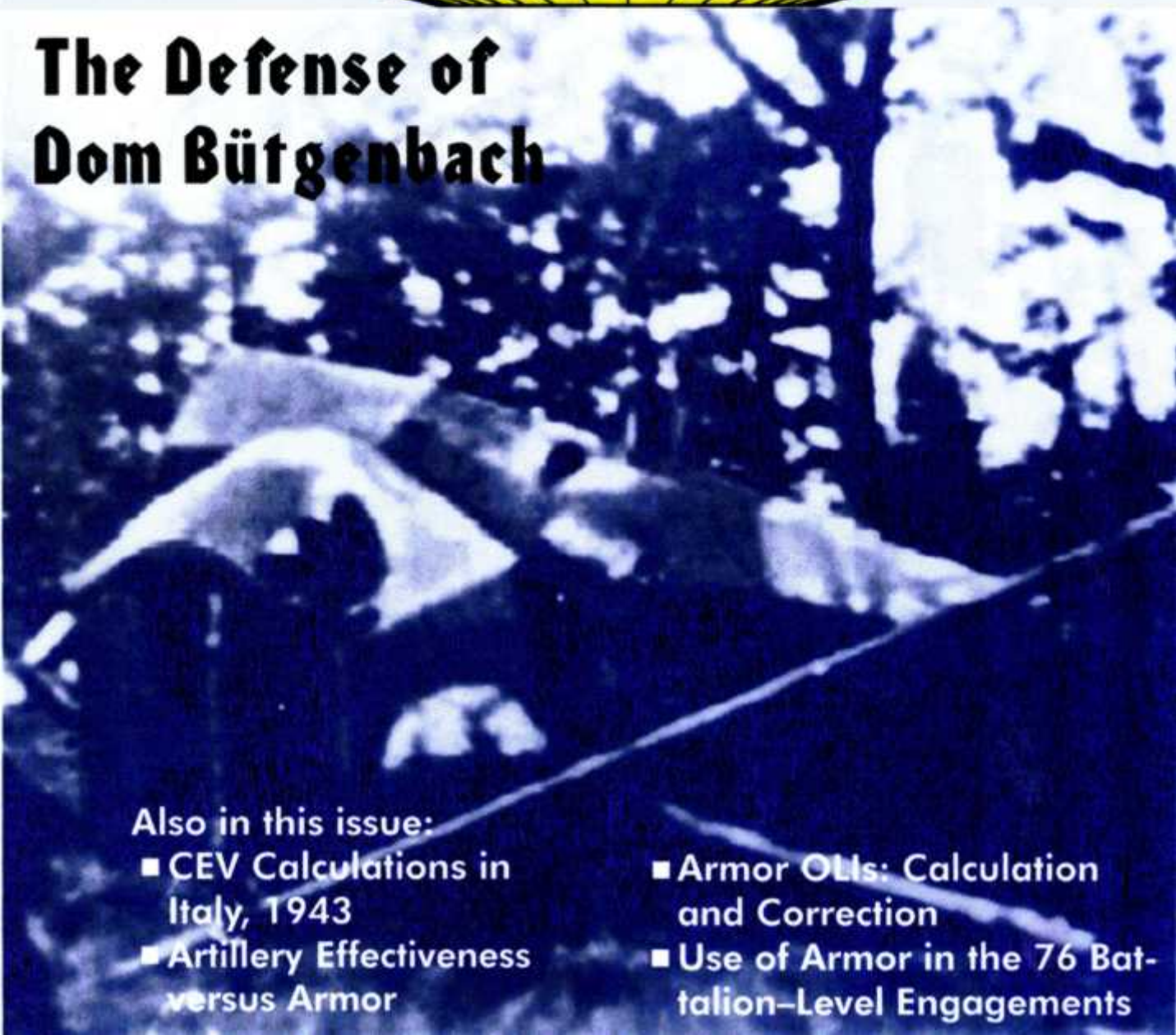
# THE INTERNATIONAL TNDM NEWSLETTER



## The Defense of Dom Bütgenbach

Also in this issue:

- CEV Calculations in Italy, 1943
- Artillery Effectiveness versus Armor
- Armor OLIs: Calculation and Correction
- Use of Armor in the 76 Battalion-Level Engagements

# INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this sixth issue of our newsletter Christopher Lawrence, Dave Bongard, Richard Anderson, José Perez, and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically–based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

(1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;

(2) Training, cultural and psychological profiles, and flow of information;

(3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in–house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically–based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.

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IN HONOR OF THE MEMORY OF THE LATE

**Trevor N. Dupuy**

Col., USA

**International TNDM Newsletter**

***Publisher***
The Dupuy Institute

***Editor***
Christopher A. Lawrence

***Production Manager***
Jay Karamales
Olórin Press

***Contributing Editors***
Richard C. Anderson
David Bongard
Jay Karamales
José Perez

**The Dupuy Institute**

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Col. Trevor N. Dupuy

***President***
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Eugene Visco

***Administrative Offices***
The Dupuy Institute
1497 Chain Bridge Rd
Suite 100
McLean, VA 22101 USA

VOX: 703-356-1151
FAX: 703-356-1152
NikatTDI@aol.com

# From the Editor...

This issue focuses on armor. The modeling of armor is perhaps one of the more controversial aspects of the TNDM and one that I am not entirely satisfied with. I do have some tentative suggestions for changing the way armor is addressed and am looking for comments and opinions from our readers.

The lead article by Jay Karamales is a bald–faced attempt (initiated by me, not Jay) to generate a little attention for his recent book, *Against the Panzers* (McFarland, 1996). I hope the article proves interesting for our readers. It came out of an armor/anti–armor study Jay did for CAA (Concepts Analysis Agency).

The article from Niklas Zetterling is our first real article from "outside" the Institute. It is also our first published criticism of the QJM/TNDM. I prepared a response, which follows, but suffice it to say that Mr. Zetterling has hit upon several valid points and problems.

The rest of this issue is oriented towards armor. First we have an article developed from our ongoing artillery suppression study on measuring the effects of artillery on armor. We then have a brief discussion from José Perez on the changes we made to the armor OLIs in the TNDM. There is also an article from Dave Bongard that displays the differences between the old QJM armor OLIs and the new TNDM OLIs, along with a discussion of the problems created by the new OLIs. Finally, I address how we are considering correcting these problems.

We also have two articles from our ongoing battalion–level validation effort. One is on the use of armor in the battalion–level engagements, and the other is a summation of the article on predicting casualties from the previous issue. Apparently, I needed a few more tables to properly explain everything.

For "Who is TDI," we have included a little background on Jay Karamales, who in addition to being a programmer, analyst, historian, writer, and renaissance man, does all the graphics and layout for this newsletter. If this newsletter looks sexy, its because he added the sex. As usual, Jay refuses to submit a real picture, even though he was the one who first suggested that we include people's pictures in the newsletter. I will settle for a picture of his wife. *[Note from Jay: instead I have used a picture of my daily inspiration, scientist Charles Darwin. Sorry, Chris!]*

We did meet last month with the South African users of the TNDM. They are making good use of the TNDM as part of their package of models they use for training. They are basically using it as their attrition calculator within a larger set of models. I am going to do my best to convince them to write up an article on how they are using the TNDM.

The first issue of the second year of publication will include an article written by Trevor N. Dupuy that was never before published called "Technology and the Human Factor in War." In the next issue we will also have a complete TNDM analysis of Dom Bütgenbach. I expect to also include some more articles on our battalion–level validation work. We have still to conduct our analysis of the advance rates and a summary conclusion. We also need to test all these changes to our second battalion–level validation data base of 121 battles from 1914 through 1991. This will be filling in the back pages of the Newsletter for several more issues. I expect to have some more "outside" articles for the next issue. I did have to delay the article on the use of mines and fortifications at Kursk—simply haven't had the time to edit my old draft and bring it up to standards. It will show up in next issue or the one after that.

That is all for now. If you have any questions, please contact me. Addresses, e–mail addresses, and phone numbers are in the masthead.

# The Defense of Dom Bütgenbach

by Jay Karamales

*[Note: Given the fact that the battle discussed in this article saw the American 26th Infantry Regiment pitted against the German 26th SS-Panzergrenadier Regiment, German unit designations throughout the article will be in boldface to minimize confusion.]*

**Introduction**

It often comes as a surprise to casual students of World War II in Western Europe when they realize just how often the US Army was on the defensive, fending off German attacks or counterattacks. How is this possible, one might think, when the Allied Armies swept through France after Operation Cobra, not stopping until they reached the German border with dry fuel tanks? Certainly the Germans were able to surprise the Americans with the counteroffensive into the Ardennes in December, but what about the spring of 1945? Surely the Germans were too exhausted and depleted to mount attacks worth mentioning?

The reason for the surprising abundance of defensive battles fought by the US Army in Europe is twofold. First, Adolf Hitler was fascinated with the concept of the surprise armored attack, the sudden pincer movement that would disorient his opponent and initiate a sweeping reversal of the fortunes of battle. He had tried this strategy a number of times on the Eastern Front, with mixed and ephemeral results. The American Army got its first taste of this kind of battle at Mortain in August 1944, when Hitler threw most of his remaining panzer reserves in France at the boundary between the US First and Third Armies. The attack served only to destroy valuable German tanks and veteran crews, and to hasten the formation of the Falaise Pocket, but it was a clear indication of the types of counterattacks Hitler favored. In a sense, Mortain was the Ardennes writ small.

The second reason was that German tactical doctrine specified that when an important position was captured by the enemy, an immediate counterattack should be launched to retake the position before enemy consolidated his gains. If armor was available, whether in the form of tanks, tank destroyers, or self–propelled guns, this counterblow could be quite effective against a disorganized enemy.

The Battle of Dom Bütgenbach was a result of Hitler's armored drive into the Ardennes forest of Belgium in December 1944. Two mighty tank armies—the **6th Panzer Army (6th PzArmy)** in the north and **5th PzArmy** in the south—struck the thin American line along a broad front. **The 6th PzArmy** was composed largely of SS troops, Hitler's darlings, and as such was entrusted with the primary objective of the operation, the seizure of Antwerp. Unexpectedly stiff resistance from the green US 99th Infantry Division (99th ID) and veteran 2nd ID halted **6th PzArmy's** attack almost before it began, and its commander swung his forces to the southwest in an attempt to outflank the American position. The troops and tanks of the **12th SS–Panzer Division** were met at the little crossroads of Dom Bütgenbach by the men of the American 1st Infantry Division, and the ensuing clash would largely determine the outcome of the fighting for the northern shoulder of the Battle of the Bulge.

**The German Forces at Dom Bütgenbach**

The success of the **6th PzArmy's** thrust through the Ardennes was the responsibility of its commander, Oberstgrüppenführer der Waffen–SS (General) Josef "Sepp" Dietrich. Dietrich had been Hitler's chauffeur and bodyguard back in 1923 and was still one of the Führer's most trusted officers. Dietrich had at his command the strongest of the three German armies in the Ardennes, composed of nine divisions in three corps: the **LXVII Armeekorps** and the **I** and **II SS–Panzer Korps**. The **LXVII AK**, on the army's north flank, contained the **326th** and **246th Volksgrenadier Divisions**. Their task was to break through the American lines around Monschau and block any American counterthrust from the north. To the south, the **I SS–PzK**, with the **1st** and **12th SS–Panzer Divisions** and **12th** and **277th VGDs**, was to make the army's chief effort, attacking into the gap at Losheim and through the Krinkelter Wald at Krinkelt–Rocherath to open a route into Malmédy and on to Liege on the Meuse. To exploit the breakthrough, Dietrich held the **II SS–PzK**, with the **2d** and **9th SS–Panzer Divisions**, in reserve.

The **12th SS–Panzer Division "Hitlerjugend"** was assigned the task of taking the northernmost routes to the Meuse. The division, named after the Hitler Youth organization and containing many of that group's teenage volunteers in its ranks, had earned a reputation in Normandy for being bold and merciless. Engaged against the British and Canadians at Caen, the division had been nearly destroyed, only 300 riflemen and 10 tanks remaining when it reached the safety of the Westwall in August 1944. Over the next three months, **"HJ"** had a high priority for receiving replacements, and by 16 December it was nearly back to full strength with 23,346 men (including a hundred or so foreign non–combatant volunteers, known as *hilfswilligers*, or *hiwis*). This figure is slightly deceiving, however, since 2,000 of these replacements were Luftwaffe men hastily trained as infantry and assigned to the division during the first two weeks of November. The cadre of experienced officers and NCOs in the division was very small, and most of the staff officers were green. These defects were most apparent in the panzergrenadier regiments, who the divisional commander, SS–Colonel Hugo Kraas, felt were not even ready for defensive duty, much less for a major attack. The divisional armored reconnaissance battalion had, in actual strength, only one light armored rifle company.

The real backbone of the division, the **12th SS–Panzer Regiment**, was down to one battalion, although this battalion was fortunate in being well–manned with seasoned veterans of all ranks. To help offset its deficiency in tanks, the **560th Heavy Panzerjäger** (self-propelled tank destroyer) **Battalion** was attached to the regiment in mid–December to act as its second battalion. The **560th** was a regular Heer (army) unit, not a Waffen–SS formation. Although it was unusual to link SS and non–SS units in this way, it was not unheard of and there is no record of difficulties in command or control of the arrangement; some vehicles in the **12th SS–PzRegt** even seemed to have mixed SS/Wehrmacht crews. The battalion was composed of the heavily armored Mk IV and Mk V Jagdpanther self–propelled tank destroyers, and these non–turreted vehicles were at a distinct disadvantage in an attack role, especially against the more agile American M–4 Sherman tank. In addition, the mix of four types of vehicles in the panzer regiment—two types of panzers and two of jagdpanzers—was a logistical nightmare for the division's already overloaded support units. The panzer regiment was at 90% full strength in personnel and 80% strength in vehicles, with 39 Mk IV Tanks and 41 of the dreaded Mk V Panthers in its **I Bn** and 14 Mk V Jagdpanthers and 21 Mk IV Jagdpanthers in the **560th Hvy PzJg Bn (II Bn)**. The **12th SS–PzJg Bn**, the division's organic self–propelled tank destroyer battalion, had an additional 22 PzJg IV/48 Jagdpanzers at the start of the campaign. The division also had 120 armored half–tracks at its disposal, most of them in the **26th SS–PzGren Regt** (as was normally the case, since one of the two grenadier regiments was designed to be more mechanized than the other).

The **"HJ" Division's** artillery support, the **12th SS–Artillery Regiment**, was at a severe disadvantage in that it was comprised only of towed (rather than self–propelled) artillery pieces (105 and 150mm), plus a towed rocket–launcher (nebelwerfer) battalion. The artillery officers and staff, however, were all veterans. The division's other technical and support units had survived the withdrawal from France intact as well.

The chief handicap to the division's mobility at the start of the Ardennes Campaign was its lack of motorized transport. Fully 25% of its trucks had not been replaced after Normandy, and the **25th SS–Panzergrenadier Regiment (Motorized)** had almost no motor transport left and was relegated largely to marching on foot. To make matters worse, the division's train capacity could hold no more than 300 tons, about 50% of its TO&E capacity.

**Delay at Krinkelt–Rocherath**

The German Ardennes Offensive broke upon the Americans on the morning of 16 December 1944. Although the Americans were greatly surprised that the Germans were capable of mounting a large offensive operation, the Germans were, from the beginning, victims of overoptimistic planning and guilty of underestimating American tenacity. While the secondary attacks of the **5th PzArmy** and **7th Army** to the south initially made rapid progress, Dietrich's **6th PzArmy** took all day on the 16th just to clear the belt of woods to its front. By the end of the day the **12th** and **277th VGDs** had exhausted themselves just pushing the American line back a couple of miles, and the commander of **I SS–PzK** felt compelled to commit the **12th SS–PzD** to force its own penetration of the American line. Nowhere did they achieve an appreciable penetration. As a result, on the 17th the **"HJ" Division** fought its way through the Krinkelter Wald to the twin villages of Krinkelt–Rocherath. Here, the division struggled for two bloody days against the American 2nd and 99th IDs, expending precious strength in unsuccessful attempts to force the breakthrough that the volksgrenadiers were to have achieved in the first few hours.

Finally, on the 19th, the German commanders admitted the futilty of continuing to attack against such a resolute American defense, and began to shift the **12th SS–PzD** to the southwest in an attempt to make an end run around the American V Corps at Bütgenbach. Luck was again not with the division, however, as it took most of the next two days for it to move just a few miles to its assembly point at Büllingen. This was due to the fact that the more direct route from Krinkelt to Büllingen was covered by US fire, which forced the division to backtrack along the muddy forest trails to its original starting point, and then to drive through Losheimergraben with the rest of the corps' traffic.

The **12th SS–PzD** suffered heavy losses at Krinkelt–Rocherath due to the fierce delaying actions of the US 2d and 99th US IDs which were determined to hold the area until a more solid defense line could be established on the Elsenborn Ridge to the west. The **"HJ" Division** losses were two Mk IV panzers, eighteen MK V Panthers, and one PzJg IV destroyed, and a further eight Panthers and two PzJg IVs damaged. These losses, followed by the difficult withdrawal and displacement southeast on muddy roads in the bitter cold, meant that the SS troops were far from "fresh" when they finally began to dribble into Büllingen. But their morale was unbroken, they still believed in their cause and in their own fighting ability, and were determined to sacrifice everything to accomplish their assigned mission: seize the highway that ran from Büllingen through Bütgenbach to Liege and the Meuse. However, the delay at Krinkelt–Rocherath had allowed someone to get to Bütgenbach before them.

**The American Forces at Dom Bütgenbach**

The 1st Infantry Division (nicknamed "the Big Red One" because of its shoulder patch emblem) was transferred to V Corps control at 2400 on 16 December to plug the gaps in the US lines. The 1st was arguably the most veteran unit in the US Army, having seen battle in North Africa, Sicily, and Normandy. After fighting across France in July and August 1944, the division was badly mauled in the battle for Aachen in September and October, and again in November in the bloody fighting for the Hürtgen Forest. In early December, the 1st was sent to the Ardennes to recuperate, being short more than 3,300 men, most of which were from the front–line combat elements.

The 2d Battalion (E, F, G, and H Companies) of the

26th Infantry Regiment, which was to defend so tenaciously at Dom Bütgenbach, was among those units that had suffered heavily in the Hürtgen Forest. E and F Companies, with two heavy machine gun platoons of H Co attached, had been surrounded and destroyed in the town of Merode from 30 November to 3 December. G Co was also hard hit. On 7 December, two days after the division pulled out of the forest and moved to Aubel, Belgium, to rest, it received a wave of replacements to fill some of the gaps. When the 2/26th moved to Dom Bütgenbach on 17–18 December, E and F Cos were only up to 60% strength, with about 100 men each, and these men were 90% green replacements and 10% hospital returnees. G Co was especially weak, with only about 50 men, although only 10 to 15 percent of these were replacements, the rest veterans. The two machine gun platoons of H Co had to be completely rebuilt, and between them they could only count eight veteran members. In the entire 2/26th, there were only seven officers remaining who had been with the unit on D–Day: four in the battalion HQ, three in the line. The battalion suffered some minor equipment shortages (the companies having only four Browning Automatic Rifles (BARs) apiece, and there being a scarcity of rifle grenade launchers). The battalion heavy weapons, however, (machine guns, mortars, bazookas, etc.) were at full strength or above. The battalion's vehicle situation was excellent, since it was only short by two jeeps. In total, the 26th Infantry Regiment had about 2500 men, rather than the 3000+ it should have had.

**"We Fight and Die Here"**

While a handful of American engineers and scattered groups of men from the 2nd and 99th IDs were fighting a slowly losing battle to hold the Büllingen–Bütgenbach highway against the German advance, they were unaware that help was already on the way. At 1145 on 16 December, the first day of the offensive, the 1st Infantry Division, resting near Aubel, went on six–hour alert. At 0230 on the 17th, the 26th Infantry Regiment set out for Camp Elsenborn and commitment on the V Corps' southern flank, which by that time was wide open thanks to the attacks of 5th PzArmy. Although briefly delayed by the necessity of hunting down some German paratroopers who were dropping in the division's path, the first units of the 26th reached Camp Elsenborn by 0700 on the 17th (just as some engineers holding Büllingen were overrun) and the remainder of the regiment arrived by 0900. The Americans were told that the Germans had captured the town of Büllingen at 0700 that morning, and with it a large fuel dump that 1st Army had established there. Fearing that the Germans might secure the vital highway running from Büllingen through Bütgenbach to Malmédy and Liege, the 26th quickly moved to guard the important road junction at Domäne Bütgenbach, 2 km southeast of Bütgenbach. "Domäne" is a German word meaning a manor held by a lord, and, indeed, such an estate overlooked the vital crossroads.

The 2/26th, commanded by LtCol Derrill M. Daniel, drove onto the grounds of the manor house at 1300 on 17 December, some seven hours after **KG Peiper** of the **1st SS-PzD** had passed through Büllingen. The men of the 2/26th relieved the battered engineers who had been defending the crossroads for about ten hours against German probing attacks, and the engineers began moving back to Bütgenbach about 1500.

The large stone manor house, with its flanking stone–foundation wooden barns and nearby gardens, was situated in a narrow valley between two hills, one to the north (Hill 598) and one to the south (Hill 613). These hills were mostly devoid of cover except for some straight rows of tall, widely spaced spruce trees on either side of the trails that criss–crossed the estate. Along the slope of a low ridge that ran almost a kilometer south of the manor lay the edge of the Bütgenbacher Heck, a dense strip of coniferous forest. This ridge was crowned by Hill 613. A kilometer beyond that, out of sight over the hill's crest, was the crossroads known locally as Morschheck, which was occupied at the moment by paratroops of the **3d Fallschirmjäger Division**. The main east–west highway that the Germans wanted so desperately ran southwest past the manor, dipping into another small valley about 500m to the east. Through this valley the Schwarzenbach creek flowed north toward Lac de Bütgenbach. The road rose again on the other side of the stream bed and split into two roads, both of which led into Büllingen, 2 km from the manor house. Another main road led due north out of Morschheck, over the top of Hill 613, and plunged down the long hillside to a junction with the Büllingen–Bütgenbach highway about 100m east of the manor house.

After having carefully examined the advantages and disadvantages offered by the terrain, LtCol Daniel set about positioning his troops. G Co went east toward Büllingen and dug in behind a row of trees running along the top of a hill on the east side of the Schwarzenbach. E Co took up positions behind similar treelines south of the manor, about halfway up the hill which led to the Bütgenbacher Heck and Morschheck. F Co moved southwest to cover the area between the other two companies, digging its foxholes on the reverse slope of a ridge scarcely half a kilometer from Morschheck. This was the same ridgetop occupied by the engineers earlier that morning. LtCol Daniel parceled out the machine gun and bazooka teams from H Co, the battalion's heavy weapons company, among the other companies to stiffen the defense line. He positioned the 81mm mortars behind Hill 598, from where they could support the whole perimeter. Due to the depleted condition of his battalion, Daniel could spare only one platoon of G Co as a ready reserve. This he stationed behind the manor house, from where it could quickly be committed wherever needed.

The nature of the terrain and the fog which blanketed the area compelled LtCol Daniel to place his antitank assets well forward, where they would have sufficient visibility to support the foxhole lines. He set up three towed 57mm antitank guns covering the road running east to Büllingen, and supported them with three M–10 self–propelled tank destroyers mounting 3–inch guns. He sent three

more AT guns to bolster the main line of resistance, or MLR, in the E and F Co areas. As part of their ammunition supply, each of the 57mm guns had seven to ten rounds of British discarding sabot (DS) ammunition, which had been issued before D–Day. Designed originally for the British 2–pounder gun, these rounds used a disposable sleeve, or sabot, to allow them to fit in the larger American guns. The resulting round had a lighter weight and greater velocity, about 4200 ft/sec as compared to 2900 ft/sec, than the normal 57mm rounds. Given this impetus, a DS round could penetrate approximately six inches (154mm) of armor at a 30° slope. This made the obsolescent 57mm gun a dangerous weapon again, even against the fearsome Panther tank and Jagdpanther tank destroyer, whose frontal armor was impervious to the 57's normal armor–piercing (AP) round.

LtCol Daniel kept four M–4 Sherman tanks around his CP as a mobile reserve. He set up his command post in one wing of the stone manor house, along with the battalion aid station. E and H Companies established their company command posts in the barns to the west and east of the manor house, respectively, while F and G Companies colocated their CPs in a hut alongside the Büllingen road just behind their MLR. The battalion observation post was located on the third floor of the manor house, which provided a good line of sight over the entire battalion sector.

LtCol Daniel was not very happy with his battalion's defensive positions, although they were the best that could be found under the circumstances. After the war, in a letter to Donald Rivette, former commander of his AT Company, Daniel wrote:

> "The reverse slope defense on the right flank [E Co] was just necessary. We couldn't go very far south to get on the crest of the hill because that would add several hundred yards to the MLR and I just didn't have enough men for that. Besides, if we did go to the hill we would have to curve over into the woods with the MLR and that would take even more men. So we went where I thought we had a reasonable chance. The hedgerow was bad, I admit it was a perfect target. But either side (north or south) of the hedgerow was even worse. If to the south there was no concealment and each foxhole could be definitely spotted. If to the north we would have concealment from ground observation afforded by the hedgerow, but also the hedgerow would limit our own observation to a marked degree. Besides, if the line was moved far enough north to get away from fire directed at the hedgerow, the line would be too close to the CP. So we took the hedgerow, which made a reverse slope defense—no help for it."[1]

To provide as much protection as possible for his men from what was expected to be intensive German artillery fire, LtCol Daniel ordered that all front–line positions, including crew–served weapons, be enhanced with overhead cover, usually in the form of wooden planks laid over the top of the foxholes. To facilitate this, Daniel had a load of lumber trucked to the battalion from Bütgenbach. Further, his men camouflaged their positions with whatever materials were at hand, and they piled up sandbags around the fighting pits.

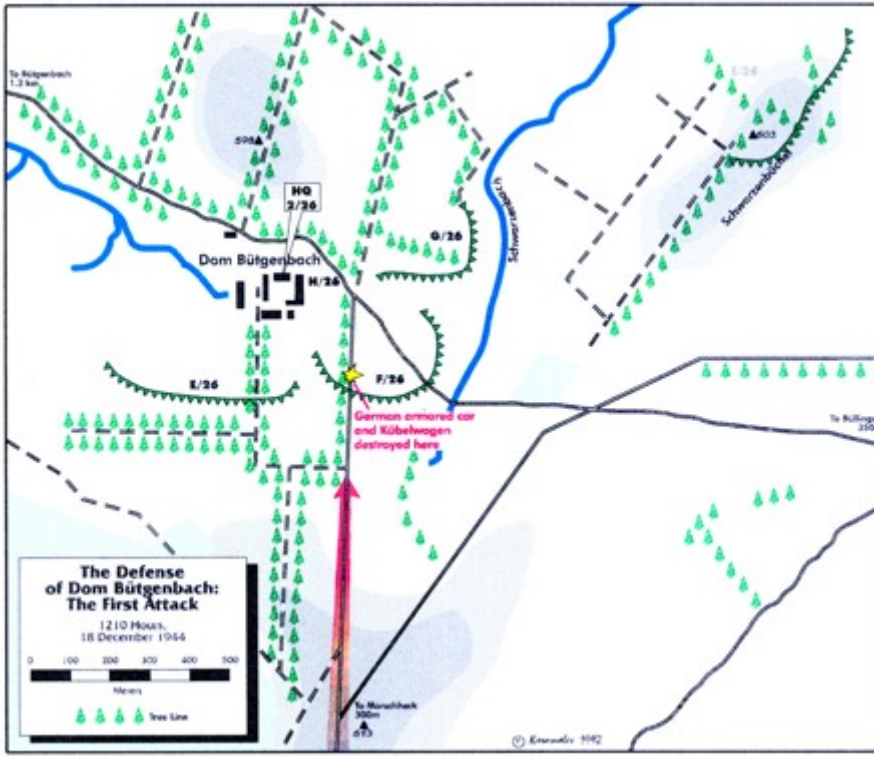
The 2/26th had finished digging in around Dom Bütgenbach by 1700 on 17 December. Meanwhile, the 3d Bn had moved to occupy the hilltop sector between G Co and the railroad embankment which paralleled Warche River. Its positions were as exposed as those of the 2d Bn except for a sparsely wooded patch on top of Hill 503 known as the Schwarzenbüchel, or "Black Beech Forest." The 1st Bn stayed in reserve in Bütgenbach. This left the 2d Bn's right flank hanging on air, and its rear vulnerable to attack from the west or southwest.

As darkness fell around 1830, LtCol Daniel ordered each of his companies to prepare one 60mm mortar to fire illumination rounds during the hours of darkness. Telephoning the regimental HQ in Bütgenbach, he also requested that each of the supporting artillery battalions have one howitzer layed to fire illuminating shells every night. Regiment agreed, and informed Daniel that since 1800, the 7th and 32d Field Artillery Battalions had established new positions from which to support the 26th. The regiment's normal supporting artillery battalion, the 33d FA Bn, had been in place since 1430. Other artillery battalions were also on the way to Elsenborn to augment the V Corps defenses. At dusk, Daniel met with the company commanders in his office in the manor house CP. They had all heard rumors over the past two days of American soldiers giving up to the Germans or fleeing to the rear. He was determined that the 2/26th would acquit itself better than that. Although at Dom Bütgenbach the regimental combat team was effectively isolated from the rest of the division, it had fought under those conditions before at Kasserine in Africa and at Barrafranca in Sicily. Daniel had therefore adopted a slogan for the battalion, which he wanted passed on to every man in the battalion: "We fight and die here."[2]

After dark, even with his men tired from the long move and hours of digging foxholes in the cold, LtCol Daniel still sent out patrols to assess the situation. It proved to be a wise move. The patrol to Büllingen soon came running back to the manor house, the men saying they had seen about 100 American prisoners in the town and over a thousand German infantrymen. A second patrol snuck up the hill to the south to establish a listening post at the edge of the Bütgenbacher Heck, while a third patrol reported a brief skirmish with Germans to the southwest of the Domäne. This skirmish led to the fear (as yet unfounded) that the town of Weywertz, to the west of 2d Bn, might have been taken. Feeling the ring of steel tighten around them, the American soldiers waited anxiously through the long winter night.

[1] Letter, Derrill Daniel to Donald Rivette, 19 October 1948.

[2] Thomas Gendron, *The Operations of the 2d Battalion, 26th Infantry (1st US Infantry Division) at Dom Bütgenbach, Belgium, 18–21 December 1944.*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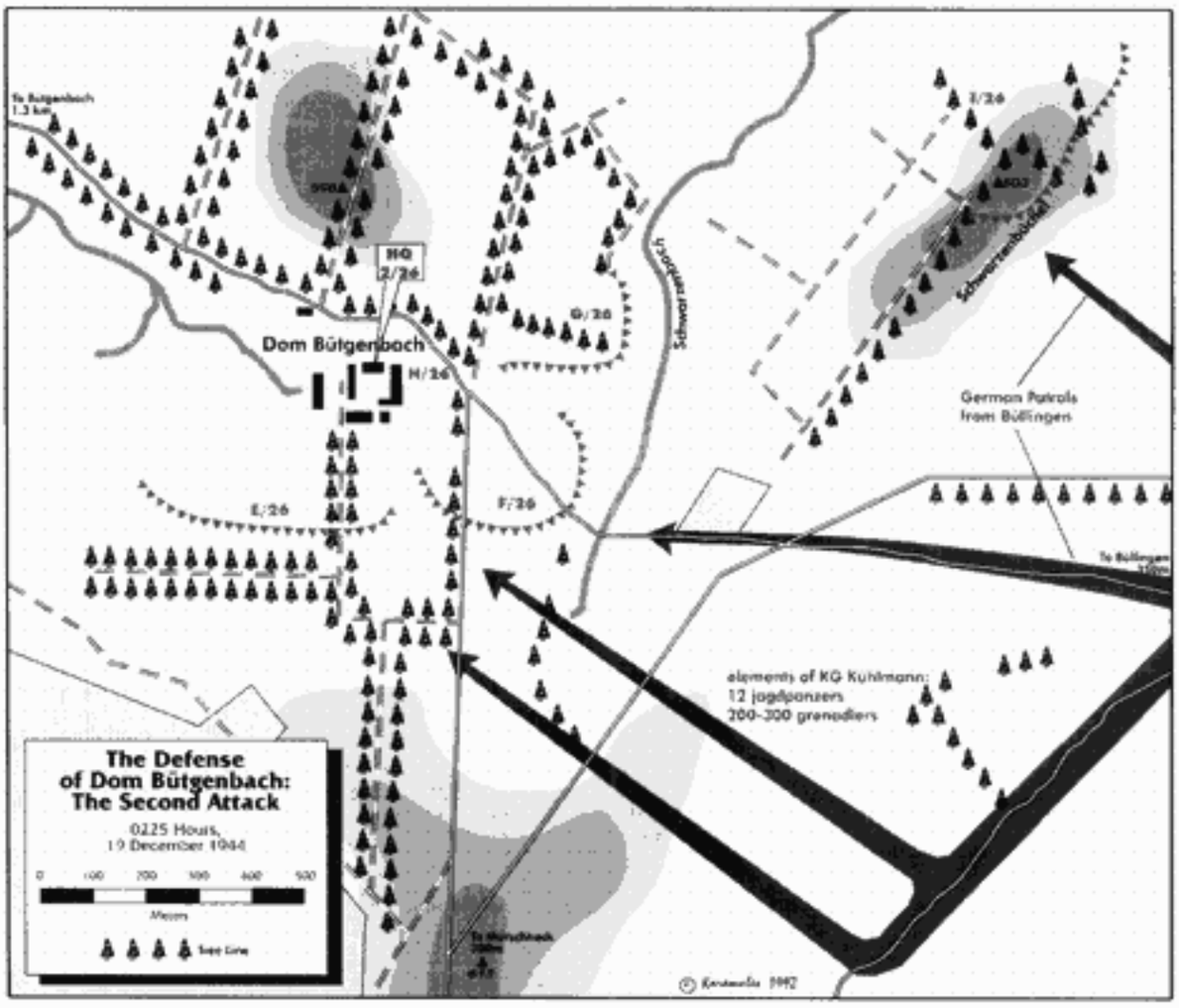



ready arrived, plus a few tanks, as well as **KG Bremer** as noted above. The rest of the division approached Büllingen via Losheim and Losheimergraben, broken into three march groups. The first of these groups to reach Büllingen was **KG Kühlmann**, composed of the **12th SS–PzRegt** under SS–Maj Kühlmann, the **III Bn** of the **26th SS–PzGren Regt**, led by SS–Capt Georg Urabl, along with that regiment's **13th Kompanie** of sIG 33 self–propelled infantry howitzers, and the **I Bn** of the **12th SS–Artillery Regt** of towed 105mm guns. The second group was **KG Müller**, with the **12th SS–PzJg Bn**, the **25th SS–PzGren Regt** (minus **I Bn** and **13th** and **15th Kompanies**), **II/12th SS–Artillery Regt** (towed 105mm howitzers) under SS–Maj Günter Neumann, one company of the **12th SS–Pionier (Engineer) Bn**, and two companies of towed AA guns. This group also included the Operations Staff of the Divisional Headquarters, minus SS–Col Kraas and his escort, who were still directing the division's withdrawal from Krinkelt–Rocherath from their CP at Hollerath. The division XO would direct the attack on Dom Bütgenbach until SS–Col Kraas arrived. The third march group was **KG Krause**, composed of the bulk of the **26th SS–PzGren Regt** (–**III Bn**), the **III** (towed 155mm) and **IV** (nebelwerfer) **Bns** of the **12th SS–Artillery Regt** plus the regimental HQ, the **12th SS–Flak Bn**, and the rest of the **12th SS–Pionier Bn**.

While **12th SS–PzD** was moving into Büllingen, the Americans at Dom Bütgenbach were far from idle. They continued to dig in and strengthen their defensive positions, while calling down harassing artillery fire on unobserved but likely German assembly areas in Büllingen and the Bütgenbacher Heck. At 2350 on the 18th the 2/26th received a shipment of 100 antitank mines, which they immediately laid to block the roads leading to the Domäne from Büllingen and Morschheck.

Around 2230, K Co of the 3/26th reported hearing vehicle noises inside Büllingen. This was the sound of **III/26th SS–PzGren Regt** of **KG Kühlmann**, assembling for a reconnaissance in force toward Bütgenbach. The SS–panzergrenadiers had relieved the men of the **12th VGD** who had been holding the town, and the volksgrenadiers crossed the Warche to rejoin their comrades on the Hohen Berg for an attack on Wirtzfeld. After establishing the battalion CP, recon patrols from the **III/26th** advanced out of the town and fanned out toward the Schwarzenbüchel, Dom Bütgenbach, Morschheck, and the Riechels–Busch. The latter two patrols encountered elements of the **3d FJD** who, despite being in the area for a couple of days, had no information concerning American defenses in the area. The patrol to the Schwarzenbüchel ran into strong defensive fire from the 3/26th and withdrew into Büllingen. The bulk of the recon force, consisting of 12 jagdpanzers of the **560th Hvy PzJg Bn** and 20 half–tracks and trucks carrying 200–300 infantry, headed southwest out of Büllingen down the road to Morschheck.[5] At 0225, after going about a kilometer, most of the half–tracks and trucks stopped and the infantry disembarked, forming up in two assault columns behind the jagdpanzers, which then set off cross–country in a northwesterly direction toward Dom Bütgenbach. This preparation occurred about 700 yards in front of F Co's positions. A smaller force of half–tracks drove straight down the main road to the Domäne, where two of them were destroyed by antitank fire in front of the American MLR.

To stop the main thrust from the southeast, the commander of F Co immediately called for prearranged artillery concentrations to be fired on the advancing Germans. He also ordered his 60mm mortars to fire illuminating rounds over the area. The 33d FA Bn responded quickly, firing salvos of

[5]American sources report that the Germans used tanks in this attack, but in *Kriegsgeschichte der 12.SS Panzerdivision "Hitlerjugend"*, Band II, Meyer is very positive that these were Jagdpanthers.

HE, white phosphorus, and starshells. This barrage hit two of the infantry trucks on the road, and their burning hulks helped illuminate the battlefield and silhouetted the approaching Germans. The right–hand column of the German double attack, consisting of five jagdpanzers with accompanying infantry, was stopped cold by the combination of artillery, mortars, small arms, and antitank fire. The other column, seven jagdpanzers with one or two companies of infantry, fared only marginally better. Some of the jagdpanzers mired in the swampy low ground even before they reached the American lines; others were discouraged by the heavy bazooka and antitank fire. The grenadiers were completely pinned down and failed to reach the US line. However, three of the jagdpanzers ran the gauntlet of the American fire and broke through E Co's positions. They got onto the Morschheck road leading to the Domäne and headed for the battalion CP. Seeing this, the 2/26th duty officer urgently requested that 155mm artillery be fired on the tanks since 105mm rounds were to small too affect them. The 5th FA Bn's howitzers responded right away, and they were soon joined by two battalions of the V Corps' heavy artillery.

By this time the jagdpanzers had reached the area of the manor house, and had wounded five or six GIs with HE fire from their main guns. The 155mm artillery shells, falling dangerously close to the battalion CP in the manor house, had the desired effect of chasing the German vehicles off. They turned around and headed back out through the US foxhole line, at which point two of the three were disabled either by artillery, tank destroyer, antitank, or bazooka fire, or some combination thereof. Their crews bailed out and ran for the safety of the German lines.

By 0325, an hour after it had begun, the first serious German effort to capture Bütgenbach had been repulsed. The grenadiers and remaining vehicles withdrew into Büllingen. They were later able to recover some of their damaged or bogged vehicles using the darkness and thick fog as cover. At daylight, two patrols from F Co ventured into the attack area and counted over 100 German dead, three destroyed jagdpanzers, and four destroyed trucks, three of them overturned by the force of the artillery blasts. A relative calm settled over the battlefield but it didn't last long.

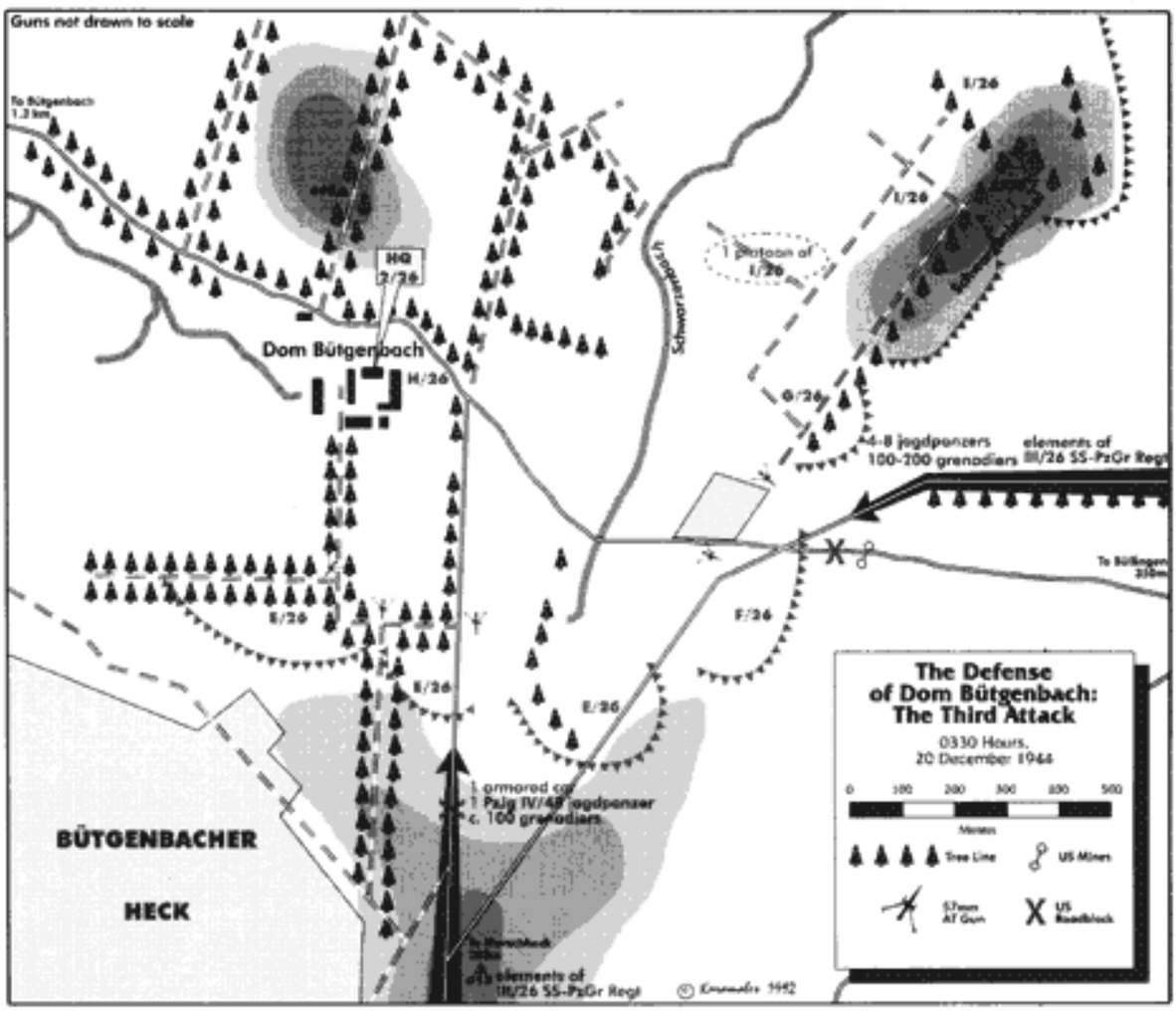
**The Third Attack: The Vise**

Following the hour–long German attack in the pre–dawn darkness of 19 December, Col John F.R. Seitz, commander of the US 26th Infantry Regiment, began moving elements of his 1st Bn out of reserve positions in Bütgenbach. Company B dug in along the north side of the Büllingen–Bütgenbach road between the town and the Domäne. Soon after, A Co move to new positions 1000 yards south of Bütgenbach to tie in with B Co. This had the added benefit of guarding 2d Bn's hitherto–open right flank, and by 0500 the gap between the two battalions was reduced to 600 yards. B Co would cover this gap by fire during the daytime and establish outposts there at night.

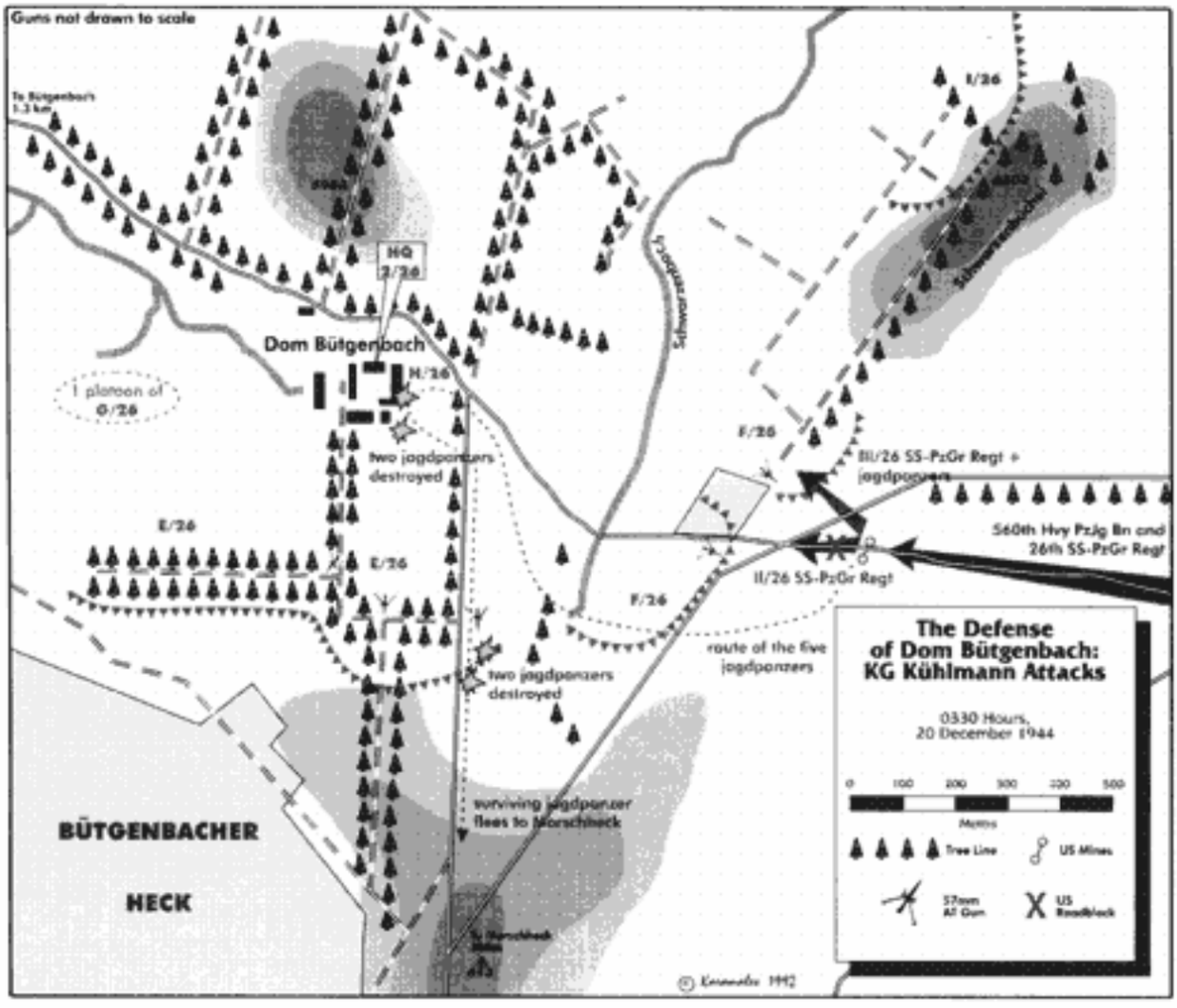
About 0630, shortly after daylight, the Germans began shelling the 2d Bn's positions with artillery and mortar fire which gradually increased in intensity throughout the morning until it reached its peak at 1000. At 1010, the second German attack of the day hit the American positions from south and east.

The first force came out of Morschheck, over the crest of Hill 613 and down the road to the Domäne used by the armored car and Kübelwagen the previous day. Leading the attack was another eight–wheeled armored car, probably an Sd Kfz 234/3, with a 75mm gun in a rotating turret.[6] Fol-

[6]American eyewitness accounts say the armored car had a 50mm antitank gun in its turret; that would indicate that it was a Sd Kfz 234/2 Puma. However, the German *gliederung* (Table of Organization) for the **12th SS–PzD** for 19 Dec 44 shows no such vehicles in the division's inventory. The *gliederung* does indicate that



lowing closely behind was a large armored vehicle. Contemporary accoubts claim this vehicle was a Mk V Panther tank, but the only Panthers in the **12th SS–PzD** were in **I Bn** of **12th SS–PzRegt**, which was at that time still on its way to Büllingen from Krinkelt–Rocherath. This second vehicle was probably from the **12th SS–PzJg Bn** of **KG Müller**, and was almost certainly a PzJg IV/48 Jagdpanzer. Together, these vehicles protected the advance of a company of SS infantry, who were probably from **III/26th SS–PzGren Regt**. Because of the heavy fog blanketing the area, the American gun crews let the Germans approach to within 100 yards of their positions in order to increase their chances of a hit on the vehicles, and to confirm their identity as enemy. The crew of 2d Gun Squad, 2d Platoon of the Regimental Antitank Co had just finished setting up their 57mm AT gun on the MLR a few minutes before the attack, and now they drew a bead on the approaching vehicles. On command, they began firing the gun as quickly as they could reload it, hammering out three armor piercing (or possibly discarding sabot) rounds in a few seconds. The first two shells were aimed at the Jagdpanzer which, being the most heavily armed and armored of the two vehicles, was the greater threat. Both rounds struck the Jagdpanzer and damaged it enough that it was forced to limp back up the hill to its own lines. But the AT gun's muzzle flashes had given away its location, and the armored car swung its turret to fire at the gun. Armored car and AT gun fired simultaneously. The American 57mm shell struck the armored car and destroyed it instantly. However, the German 75mm round also found its mark, destroying the AT gun and killing two members of the gun crew, Cpl Hale Williams and PFC Richard Wollenberg. A third crewman was blinded by the blast, and a fourth would have to be evacuated because of battle fatigue. The German advance from Morschheck now ground to a halt because the grenadiers could not advance against the deadly American artillery and small arms fire without tank support. The commanding officer of E Co, Capt Pierre Stepanian, called in 81mm mortar and artillery fire on the exposed Germans, and nearly the entire company was slaughtered before the American foxholes. Those few SS who were able to stumble back into the Bütgenbacher Heck were ambushed and killed by the men of the American listening post still hiding just inside the forest's edge.




Twenty minutes after the start of the southern attack, the Germans launched another assault westward out of Büllingen. This time they employed between four and eight of the huge jagdpanzers and an infantry force reckoned to be at least a company and possibly a battalion, probably those elements of **III/26 SS–PzGren Regt** which did not take part in the southern attack. This force advanced along the secondary road that ran parallel to and north of the main Büllingen–Bütgenbach road, perhaps because they anticipated that the Americans would have mined that route. Again, because of the fog, the Americans allowed the SS troops to approach close to their positions. The GIs could catch glimpses of the grenadiers through the fog, seeing them deployed in perfect attack formation behind the jagdpanzers. When the Germans reached a point about 100 yards from the American line, the leading SS officer called out for the Americans to surrender. The Americans answered him with a hail of fire. All the small arms of F and G Companies opened up, as well as bazookas, tank destroyers, and the two AT guns covering the east–west road. These latter destroyed the two leading jagdpanzers and again the German advance halted.

The Germans' morning barrage had cut F Co's communication lines to the battalion CP and disabled both the

the **12th SS–Recon Bn** contained 17 Sd Kfz 234/1 cars with 20mm guns, and six Sd Kfz 234/3 cars with 75mm guns. It would almost certainly have been one of these that was involved in this action. See von Senger und Etterlin, *German Tanks of World War II*, pp. 154–156; Hoffschmidt and Tantum, *German Tank and Antitank of World War II*, pp. 212–213.

company's radio and the radio used by the artillery forward observer stationed with the company, so they had to rely on the company's organic 60mm mortars to help drive off the Germans.

After an hour of frustrated attempts, the grenadiers began to fall back. Unable to penetrate the American perimeter on either side, they withdrew into Büllingen. Further attacks would have to wait until the arrival of more of the panzergrenadiers. Also, the Germans were by now running short of ammunition because the muddy roads were delaying the supply units. Under increasing time pressure to break through the US defense and open the highway to Malmedy, the **"Hitlerjugend" Division** had to content itself with artillery harassment of Dom Bütgenbach for the rest of 19 December.

**The Fourth Attack: KG Kühlmann Attacks**

Throughout 19 December, elements of the **12th SS–PzD** straggled into Büllingen, hampered by the muddy, clogged roads and tired from two days of hard fighting at Krinkelt–Rocherath. At some point during the afternoon the rocket–launcher (nebelwerfer) battalion of the **12th SS–Artillery Regt** arrived and fired at least one barrage of rockets at the 2/26th positions at Dom Bütgenbach; the other three artillery battalions kept up a light but steady rain of shells throughout the day.

Under pressure to attack quickly to seize Bütgenbach and open Rollbahn C, SS–Col Kraas reorganized **KG Kuhlmann** to include the tanks of **I Bn/12th SS–PzRegt**; the entire **26th SS–PzGren Regt**; the jagdpanzers of the **560th Hvy PzJg Bn**; and the **II/12th SS–Artillery Regt** of towed 105mm howitzers. This force assembled as set out as soon as it was fully dark, around 2310, to mount a concentrated attack on the US positions east of Dom Bütgenbach. The **III/26** secured the assembly area in the west section of Büllingen and pushed a screen of scouts forward while the **I/26** and the jagdpanzers of the **560th** moved down both sides of the Büllingen–Bütgenbach highway. The force took a wrong turn, however, and got lost in the darkness. It ended up south of the Domäne near Morschheck at about 0150, and Capt Stepanian of E Co, 2/26, again called upon the 1st Division's supporting artillery to blast the German column. The 5th, 33d, and 955th FA Bns, as well as one 90mm battery from the 414th AAA Bn and a battery of 8–inch guns, answered the call and the resulting 10–minute barrage knocked out two of the **560th's** Jagdpanzer's IV/48s. It was some time before the kampfgruppe could turn around and reassemble back in its proper starting area. Finally, at 0330 on the 20th, the Germans neared the Americans' eastern perimeter.

Just before reaching the American lines, the kampfgruppe split into three columns. The northernmost force, a company of Jagdpanthers and some infantry of **III/26th SS–PzGren Regt**, had the task of clearing the troops of the US 3/26th from the Schwarzenbüchel on Hill 503 in order to protect the attack's flank; it succeeded in occupying the southern part of the hill, but there the attack stalled and the grenadiers were locked in combat for hours with the American infantry along the treeline.

The center group rolled due west down the highway for a clash with F Co, which had been alerted by the sounds of battle on Hill 503. The commander of the lead Jagdpanzer was struck in the head and killed by an American bullet before his vehicle reached the foxhole line. His driver, panicking, quickly threw the vehicle into reverse before it could be hit by antitank fire, and rammed into the following Jagdpanzer. Despite the snarl this caused, the attackers pressed on, and heavy combat ensued between the Americans of F Co and the Germans of **II/26 SS**. One of the M–10 self–propelled tank destroyers of the 634th TD Bn was in the area, near the F Co CP, and could have been of great value in supporting against the German thrust, but the crew, in the confusion of battle thinking themselves surrounded, disabled their vehicle and fled toward the Battalion CP at the Domäne.

The leftmost German force enjoyed the most success. A company of Jagdpanzer IV/48s accompanied by infantry from the **I/26 SS** encountered a belt of American mines across the road a hundred yards or so in front of the MLR, so they swung southwest off the main road and headed for the seam between E and F Companies using unpaved trails along the hillsides. The Germans skirted just south of the boggy source of the Schwarzenbach Creek, but several of the 45–ton Jagdpanzers became mired in the soft mud, some up to their rear decks. Five of the Jagdpanzers from **1st Kompanie** managed to make it up the hill and through the American foxhole line, but the grenadiers were again checked by the heavy American artillery and small arms fire. Once through the MLR, the Jagdpanzers turned around briefly to spray the American positions from the rear with machine gun and HE fire. This fire knocked out some of the 57mm AT guns and caused casualties among the infantry, including destroying three bazooka teams and a machine gun section of four or five men from H Co, but it also aided in further pinning the German infantry on the other side of the MLR. After a few minutes the Jagdpanzers turned northwest to continue their mission of breaking through to the Domäne. leaving the grenadiers and GIs to fight it out in the heaviest combat the regiment had ever seen. The smoke of battle added to the fog and darkness in obscuring visibility, and several German panzerfaust teams were able to get close enough to knock out the US AT guns with their rockets. German artillery and mortar fire continued to crash down on the American positions all through the battle. The Germans had captured several American soldiers during the fighting, and when they were later interrogated the Germans learned for the first time that they were facing the 26th Regiment of the 1st Infantry Divsion.

The five Jagdpanzers of **1st Kompanie** pushed on alone, driving through the American rear area to within 100 yards of the manor house, where they began firing their 75mm guns directly into the building. Without their supporting infantry, however, they were vulnerable to close combat tactics. American bazooka teams set out to hunt the Jagdpanzers among the buildings of the Domäne and knocked out two of

them. The other three vehicles chose to withdraw and headed for the road to Morschheck. After they passed through the MLR, however, the crews of the American AT guns in the E Co sector were able to spot the vehicles' exhaust flashes through the smoke and fog, and destroyed two more Jagdpanzers in short order.

Fearing that his infantry line was in danger of collapse from the enormous pressure being exerted by the panzergrenadiers, LtCol Daniel committed his battalion reserve, the platoon from G Co, to counterattack and restore the MLR in the F Co area. He also called the Regimental CP in Bütgenbach and requested a company from 1st Bn, which was too far west to be hit by the German attack. Col Seitz approved, and sent C Co to the 2d Bn area at once. Daniel forwarded two platoons to reinforce F Co, which was being badly chewed up, and kept two platoons as his new battalion reserve.

Meanwhile, in the center astride the highway, the battle still raged. Three of the giant jagdpanzers broke through the foxhole line and engaged the US tanks and self–propelled tank destroyers along the ridgeline on the southern part of Hill 503. The US armor pounded away at the German vehicles until they were either destroyed or they retreated back through the MLR. Two Sherman tanks and an M–10 TD were knocked out in this action. Further north, some German armor also closed with the elements of the 3d Bn in the Schwarzenbüchel. I Co took out some tanks with their bazookas, tanks, and tank destroyers, while 155mm salvos knocked out others. Heavy machine gun fire from L Co kept the panzergrenadiers from advancing into the Schwarzenbüchel.

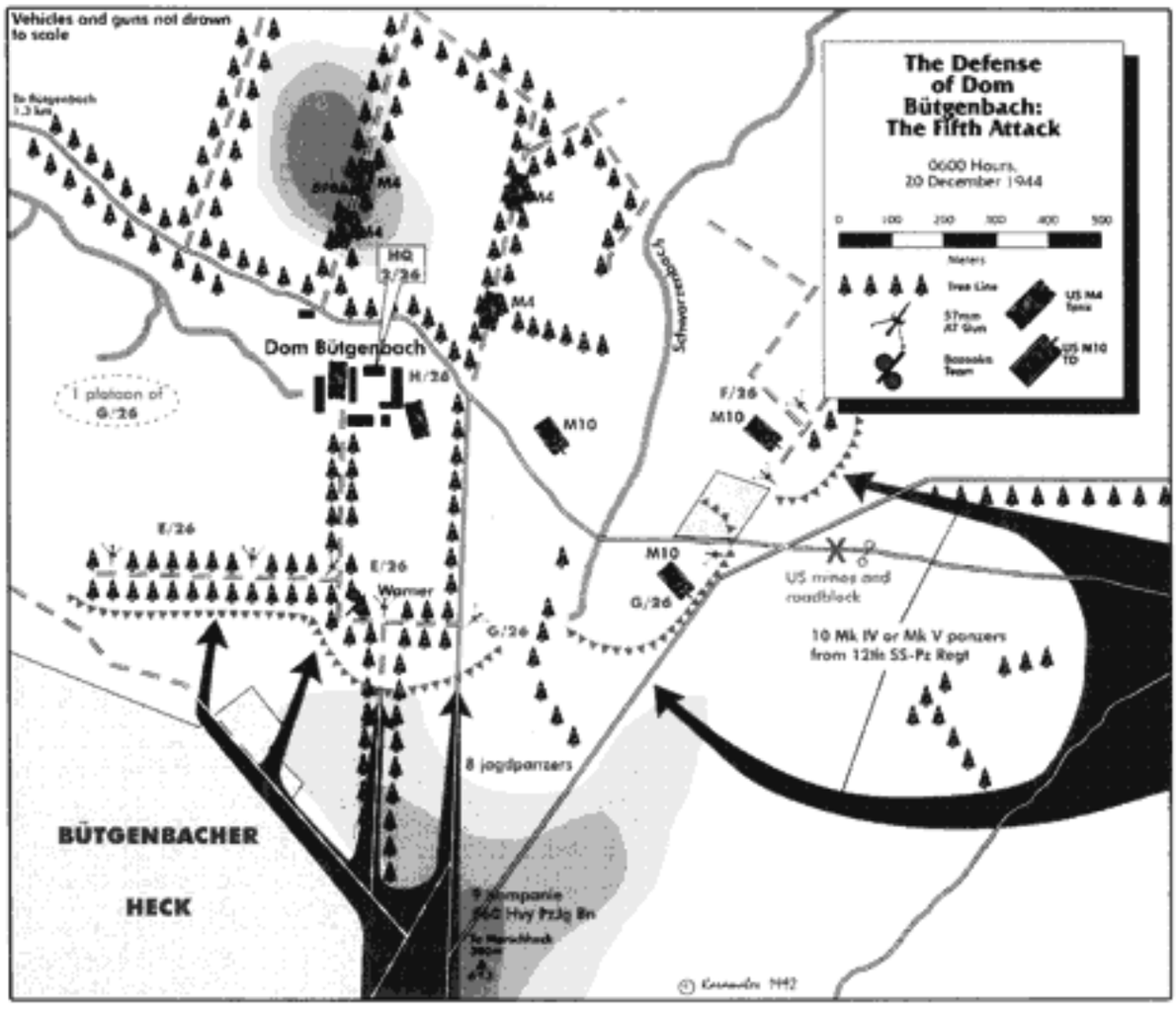
The German attack petered out by 0530. Their artillery fire continued hitting the American lines even as the panzergrenadiers and jagdpanzers pulled back into Büllingen. It had been a near run thing to say the least. By the end of the attack, only 17 rounds of bazooka ammunition were left in all of 2d Bn, and the surviving bazooka teams were reduced to scrounging odd rocket rounds from the crews of the AT Co's 57mm AT guns. The German artillery had cut with communications with Regiment early in the morning, and the 2d Bn had also lost radio contact during the fighting. The MLR was a shambles, desperately in need of repair, and LtCol Daniel was urgently calling for more mines to help block the German advance routes. He only had the two platoons from C Co as a battalion reserve. Another attack might cause the whole US defense around Dom Bütgenbach to collapse.

The **12th SS–PzD** had suffered another bloody nose as well. At least 12 jagdpanzers had been destroyed or damaged in the morning's attack, and the panzergrenadier battalions had suffered heavy casualties. As the remnants of the attacking force withdrew into Büllingen, SS–Col Kraas immediately regrouped them for a second assault, hoping the Americans would crack before his own men did. This time, the attack from Büllingen would be supported by a simultaneous attack from Morschheck.

**The Fifth Attack: The Heroism of Corporal Warner**

SS–Colonel Kraas launched his second attack within 30 minutes, sending a force of ten tanks westward out of Büllingen and eight jagdpanzers south from Morschheck. This time, the two remaining tank destroyers and three AT guns of F Co were ready to meet them, and as the German tanks crested the small ridge in single file about 300 yards in front of F Co, the concentrated fire from the American pieces knocked out all ten, one by one. Again, the American artillerty and small arms fire pinned down the supporting grenadiers, and the attack on the 2/26th's left flank accomplished nothing.

At the same time, the jagdpanzers of **9th Kompanie, 560th Hvy PzJg Bn**, rolled down the hill out of Morschheck, fanning out a bit to cover more of the American line. The G Co platoon that LtCol Daniel had committed earlier was now



practically annihilated by German tank fire, but the heavy American defensive artillery fire kept the German infantry from overrunning the survivors and deflected the advance of the jagdpanzers. As the armor approached the MLR, a shell from somewhere struck the **9th Kompanie** commander's Mk V Jagdpanther, setting it on fire. He managed to turn the vehicle around and drive it back into Morschheck, where he commandeered the **11th Kompanie's** command vehicle and returned to the battle. While he was gone, his panzer force was further reduced by the American defenses. Artillery fire destroyed or immobilized three of the jagdpanzers before they even reached the US lines. The commander of one of the 57mm AT gun crews, Sgt Stanley Oldenski, saw some of the panzers trying to break through the MLR to his right (west), and sent out some members of his gun crew armed with a bazooka to try to secure that flank.[7] He could also see gun flashes from two more of the German tank destroyers about 75 yards to his left. While Oldenski acted as loader, his gunner, Cpl Henry "Red" Warner, began firing DS shells at the Germans. He put four rounds into the first jagdpanzer, destroying it. Then he hit another with one round, stopping it, but he fired three more rounds into the hulk to make sure it was dead (this firing of "insurance" rounds was standard procedure among American AT and TD gun crews). On Warner's final shot, however, the AT gun's breech block jammed and the gun would not return to battery. As Warner struggled to fix the weapon, a third jagdpanzer appeared out of the mist, approaching straight toward his gun and firing its bow machine gun. The rest of the crew dove into nearby foxholes for cover, but Warner continued wrestling with the jammed gun. Unable or unwilling to fire his main gun at the American weapon, the German tank commander apparently decided to just run over it. He stood up and poked his head out of the hatch to direct the vehicle's movement. When the panzer was about 10 yards away from the gun, Warner gave up trying to fix it, pulled his .45 caliber pistol and fired at the tank commander, then dove into the slit trench between the gun trails. Warner heard the tank race its engine and speed toward him, and he fully expected to be crushed by it. When it was scant feet from the AT gun, however, the jagdpanzer stopped, went into reverse, and backed away at full speed. Warner, incredulous, peeked out from his trench and saw the German tank commander slumped half out of the hatch, apparently killed by one of his pistol shots.

Soon the Germans were again in retreat and, thanks to the combined fire of four American artillery battalions, no German infantry had been able to penetrate the MLR. By 0800 the attack was over, and although the Germans would launch smaller infantry attacks every four or five hours until nightfall, these were easily repulsed. For the rest of the day the surviving front–line troops continued to improve their defensive positions and lay protective minefields. LtCol Daniel also strengthened E Co's line by attaching to it one of the C Co rifle platoons.

[7]These men later claimed to have knocked out one German panzer with their bazooka, but their claim was never verified.

Around 1300 on the 20th, Regiment pulled the 3d AT Platoon of the Regimental AT Co out of the line on 3d Bn's sector in the Schwarzenbüchel and sent its four 57mm AT guns to replace the gun losses suffered by 2d Bn in the morning's attacks. This made a total of eight AT guns in the battalion's MLR. The 3d Plt dug in its guns in the soft earth behind the hedgerow of poplar trees running east–to–west in the E Co sector. They fully expected another German tank attack, knowing how important the Büllingen–Bütgenbach highway behind them was to the German commanders; they also knew that their gunshields ( 3/4–inch thick steel) would stop bullets but were useless against the main gun rounds those tanks would be firing.

In Büllingen and Morschheck, the Germans were counting their losses. When the unit reassembled later in the day, the **560th Hvy PzJg Bn** found that it had only three battleworthy Jagdpanthers and 10 Jagdpanzer IV/48s left. These were consolidated into a single company for the next attack, scheduled for 21 December, and the vehicles were sent to Büllingen for repairs, refueling, and replenishment of ammunition. Once there, however, the American shelling of the town was so heavy that the vehicles were forced to pull back another two kilometers to the hamlet of Tiefenbach to complete their replenishment.

**The Last Attack: High Water Mark**

Time was running out for the **12th SS–PzD**. American forces had closed in behind **KG Peiper** thirty kilometers to the west, and Peiper's armored battlegroup was surrounded and being cut to pieces by American counterattacks. A US armored division was still clinging to St. Vith in the south. After almost a week of heavy fighting, none of the roads assigned to carry **"Hitlerjugend"** to the Meuse had been opened. Worse yet, the Americans grew stronger daily as they mobilized more reserves, while each day more broken panzers littered the hillsides around Dom Bütgenbach.

Accordingly, SS–Col Kraas prepared for an all–out attack with all three of his grenadier battalions, to be supported by every operational tank and tank destroyer in his division. He planned to attack with two battalions abreast out of the Bütgenbacher Heck, the **III/25 SS** on the left supported by the remaining panzers and jagdpanzers of the **12th SS–PzRegt**, and the **II/26 SS** on the right, reinforced by the jagdpanzers of the **12th SS–PzJg Bn**. The armored infantry of the **III/26 SS** would be kept in reserve in the forest, to be used to exploit any breakthrough by attacking in conjunction with the **12th SS–PzRegt** to seize Bütgenbach. The axis of the attack was to carry the Germans south and then west of Dom Bütgenbach, bypassing the stubborn American defenders there and cutting them off by capturing Bütgenbach behind them. Once that town was occupied, blocking forces would push across the railway embankment north of town to stop any American counterattack from the north. Supporting the attack were all four battalions of the division's organic artillery: **I Bn** (105mm) at Büllingen, **II Bn** (105mm) and **IV Bn** (nebelwerfer) in Hünningen, and **III Bn** (150mm) south of Honsfeld. The starting time for the attack was 0340 hours

on 21 December.

The **II/26th SS–PzGren Regt** set out from Hünningen to its assembly area in the Riechels–Busch at 2300 hours on 20 December. A light but steady artillery barrage on the American positions around the Domäne masked the sounds of its movement. Most of the other units scheduled to attack reached their assembly areas by 0300, when the four artillery battalions began a massive bombardment of the American positions, using all the guns, mortars, and rocket launchers at their disposal. This barrage was by far the worst the defenders at Dom Bütgenbach had experienced in the whole war, and its effects were telling. The front line troops suffered one–third to one–half casualties (many of whom were still lying untended in their foxholes when the German ground attack began), and many of their weapons were destroyed by direct hits. All wire communications between units were cut, and even some of the radios, which so far had been used more or less successfully for backup communications, were damaged by the concussions. The shelling disabled the two M–4s north and northwest of the manor house, part of the battalion's mobile reserve, as well as the M–10 tank destroyer near the east barn of the manor. Both the east and west barns were also set on fire; the west barn soon burned down to its stone foundation, forcing the H Co CP there to move into the barn with the E Co CP. The nebelwerfer salvos were particulatly devastating: 96 rockets landing in one earth–wrenching blast. Before long, all that was left of the American MLR were isolated groups of infantry and AT guns separated by wide undefended gaps.

In the manor house, LtCol Daniel could do nothing while his battalion was being shredded. As yet, no German infantry or tanks had appeared, so he had no targets for his artillery. Instead, in addition to pressing for more counterbattery fire in hopes of lessening the German barrage, he called down concentrations on likely German assembly areas in Büllingen and in the Bütgenbacher Heck. He recalled later that between four and twelve battalions of artillery fired in support of his battalion that day; actually there were at least 10 battalions involved, including battalions from the 2d and 99th Divisions that were tied into the 1st Division's fire control center. Patrols later found about 200 dead Germans in the woods in front of E Co, silent testimony to the disruption this must have caused the German attack.

The American artillery was not the only problem the German attack faced that morning. By 0330, ten minutes before the scheduled attack time, all the attacking units were in their designated assembly areas except the **II/26 SS**, which had set out from Hünningen four and a half hours earlier. The battalion staff tried urgently to establish radio contact with any of the companies, and when that failed the battalion adjutant and ADC set out in a Kübelwagen to find them. Meanwhile SS–Col Kraas, in his division CP in Morschheck, ordered the attack delayed until 0430 so the missing battalion could be found. The artillery barrage against the Americans slackened but did not stop completely.

The "Hitlerjugend" Division had still not located its missing battalion by 0430. Now SS–Col Kraas was worried that the attack might not get started until dawn, at which point his troops would have to undergo flanking fire from the American positions at the Domäne while trying to bypass

rage, an eerie silence descended over the battlefield. The American AT gun crews, who had been huddling in their trenches for three hours listening to shell fragments clang off their gunshields, crawled shakily out of their holes, relieved to find their guns still intact. At the far western end of the American line, S/Sgt Noah Collier, commander of one of the 57s from 3d Plt, AT Co, told his crew, "Load Sabot. Hold your fire until you can get a flank shot at about twenty feet." Soon, the men heard the squeaking of tank treads and shouts in German.

After leaving Morschheck, the panzers and half–tracks of **"Hitlerjugend"** had no room to spread out and deploy in proper attack formation until they had passed the northeastern corner of the Bütgenbacher Heck, so for a brief interval they had to travel in a direction almost parallel to the American front line. At first they received no fire of any kind from the tree–lined hedgerows where they knew the American positions to be, and they suspected that after the previous day's attack, the Americans had little or no antitank defense left. To relieve the oppressive silence and possibly to suppress any Americans still left, the tank crews fired a few machine gun bursts into the treeline 150 meters to their right. This terrain feature was at the limit of their vision in the fog and darkness, and the Americans were, indeed, waiting there for the Germans. The lead Panther of the attack column, commanded by SS–1Lt Schnittenhelm, had just reached the protruding square patch of the Bütgenbacher Heck when one of the US 57mm AT guns fired, striking the Panther in the right flank and detonating its ammunition. The tank was flung into the air by the force of the explosion and a huge mushroom cloud of oily black smoke enveloped the tank. Two of the crew clambered out of the wreck, but SS–1Lt Schnittenhelm was not one of them. Captain Hils of the **560th Hvy PzJg Bn**, following behind in his Jagdpanther, was now in command, and over his vehicle's radio he ordered the force to turn toward the US line and prepare to attack. He examined his map once again to orient himself, then fired a flare toward the manor house to indicate the final attack direction. The men in the other panzers and jagdpanzers awaited the signal to advance, "Marsch! Marsch!" but when no such signal was given after a few moments they turned back to see Hils' Jagdpanther on fire, his crew abandoning the vehicle. Hils himself was nowhere to be seen. Unnerved by the loss of two commanders in such a short space of time, the Germans hesitantly advanced. As soon as the panzers and half–tracks full of infantry came in full view of the MLR, a terrific American defensive artillery barrage began plunging into the formation, plowing up the hillside and devastating the exposed foot infantry.

Despite the American bombardment, the young SS grenadiers in their camouflage smocks charged the American line, yelling and firing their weapons. Behind the treeline, Sgt Collier picked up a BAR left near his gun by two wounded infantrymen and began spraying the onrushing Germans. Another member of his gun crew, PFC Donald Rose, also fired his M–1 carbine into the attackers. As they rushed from the woods, the Germans were in a line almost perpendicular to the American MLR, so Rose and Collier were in an excellent position to fire into the attackers' flank. So intent were they on holding back the grenadiers that they almost failed to notice the Jagdpanther which loomed out of the fog to the left of their AT gun. Rose quickly dropped his carbine to assist the gunner, Cpl Irwin Schwartz, in taking on the behemoth. Schwartz fired the already–loaded Sabot round, which struck the Jagdpanther's front left drive sprocket. This caused the left track to jam and the vehicle's forward motion made it slue around sideways. Rose loaded another Sabot round and Schwartz fired into the Jagdpanther's now exposed right flank. A tongue of yellow flame shot out of the vehicle and, burning furiously, it ground to a halt. Despite Collier's withering fire, the nearby grenadiers were now so close that Rose and Schwartz picked up their carbines and added their fire to his. After a few minutes they saw a Mk IV panzer driving along the woodline to their front. They reloaded and fired the 57 three times in rapid succession, amd the stricken panzer stopped with smoke pouring from it.

Once again taking up their carbines, Rose and Schwartz moved about 10 feet down the line to support Sgt Collier and his BAR. As they did so, on of the grenadiers fired a panzerfaust whose rocket struck their gun and knocked it off its pintle. With no gun to man, they remained on the MLR for over an hour, firing and throwing hand grenades, until they ran out of rifle ammunition. During that time, Sgt Collier dashed out in front of the MLR to help a wounded GI even though he himself was wounded in the leg. He disappeared into the fog and was never seen again.

About 150 meters to the east, another 3d AT Platoon gun crew was also being hard pressed. As the German tanks rolled down the hill from the forest, the gun squad leader, Sgt Kolar, rousted his men from their foxholes and readied their gun for action. Two panzers appeared together out of the fog, heading straight for their gun. Kolar fired at the nearest of the two. His shell hit and penetrated, and the crew reloaded and fired again to make sure of killing the tank. Just as this second shot struck the panzer a burst of machine gun fire from the other tank hit the AT gun as it was returning to battery and disabled it. His crew now bereft of their gun, Kolar snatched up a bazooka and, with one of his crewmen, crawled out into the fog to hunt down the other panzer. Both men were wounded and captured by the Germans.

The third gun of 3d Platoon, AT Co, was another 200 meters or so east of Kolar's gun, at the intersection of the long east–west hedgerow and a north–south trail leading directly to the Domäne. This gun, commanded by Joseph Harris, pointed southwest rather than south in order to cover the whole western part of E Co's line and enable it to flank fire at any tanks advancing from the Bütgenbacher Heck. Harris, a corporal, was one of only three men remaining out of the gun's original 10–man crew, the others having been killed or wounded by the terrible German artillery barrage that morning. No sooner did the shelling stop than Harris, climbing out of his foxhole, dimly saw a tank through the fog to his right, about halfway between his gun and Kolar's. While he and his crew were loading their AT gun, the tank fired,

lobbing a huge HE shell down the hill toward the manor house. As the gun's muzzle blast briefly parted the haze, the vehicle was revealed to be not a tank at all, but a self–propelled 150mm infantry howitzer on an old Mk II panzer chassis, known as the Sd Kfz 121, or sIG 33.[8] This vehicle's armor was very thin, only 20mm thick at best, but Harris couldn't know that; he understandably considered any German tracked vehicle with a big gun to be a "tank." He fired the AT gun four times, enough to set the sIG on fire.[9] While so engaged, however, Harris and his crew failed to notice a Mk IV tank slowly moving up on their left. The panzer fired an AP round which detonated against the gunshield and rent open the AT gun's barrel just above the breech block. The force of the impact also blew the gun off its pintle. Stunned by the explosion, Harris and his men were overwhelmed and captured by the storming SS grenadiers a few minutes later.

This incident did not go unnoticed by Cpl Red Warner, the West Virginian who had knocked out two panzers and driven a third off with his pistol the previous day. Warner's gun was guarding the north–south trail paralleling the main Morschheck–Dom Bütgenbach road, about 50 meters east of Harris' gun. Since his assistant gunner (and apparently also Sgt Oldenski, the gun squad leader) had already been incapacitated, Warner loaded the AT gun himself and fired at the panzer that destroyed Harris' gun. His shell struck the Mk IV just in front of its right rear idler wheel and smoke began to pour from the rear of the tank. The panzer was immobilized, but it was still deadly: as Warner reached for another shell, the tank swept its turret around and fired a burst from its coaxial machine gun just as Warner was slamming his second shell into the breech. He was hit and died moments later, still trying to close the gun's breech. For his heroism in the defense of Dom Bütgenbach, Warner was posthumously awarded the Medal of Honor.

Having destroyed or neutralized all the AT guns west of the Morschheck road, the surviving German panzers proceeded to drive up and down the MLR, crushing automatic weapons emplacements and crews alike and machine gunning the helpless US soldiers. At one point a panzer drover through a gap in the 500–yard–long hedgerow. The tank commander climbed out of his turret hatch and dropped to the ground, forcing an American soldier into the tank at gunpoint. Some of the GIs still manning their foxholes in the eastern portion of E Co's line heard pistol shots, and they assumed that the SS were methodically shooting the American wounded and prisoners (rumors of the Malmédy massacre and other SS atrocities at Krinkelt–Rocherath and Honsfeld had already filtered down to the men at Dom Bütgenbach).

As soon as they crossed to the north side of the treeline, the attacking panzers were taken under fire by the M–4 Sherman tank stationed at the southeast corner of the barnyard and by the two M–4s on the slope of Hill 598 north of the manor house. Around 0800, eight Mk IV panzers of **5th Kompanie, 1/12th SS–PzRegt**, made a dash for the manor house. One was quickly destroyed and another damaged by the two Shermans around the CP. Those Shermans in turn were destroyed by the panzers' return fire. Three of the German tanks veered northeast and wound up in 3d Bn's sector, where the Americans eventually destroyed them with AT guns and bazooka teams. The remaining three panzers moved onto the grounds of the estate, hiding behind the barns to escape further fire from the Shermans on Hill 598. Running right behind them were five or six SS–panzergrenadiers, the only German infantry to make it through the American MLR throughout the entire siege. The Germans sought cover in an old hospital tent that had been set up to one side of the manor house but that had been abandoned a few days before when the fighting started. Four senior NCOs, staff officers and radiomen from the American CP formed a small strike force and ventured outside the manor house, eliminating the grenadiers after a brief firefight.

Inside the house, LtCol Daniel monitored the course of the battle with growing concern. He kept up a steady stream of calls into the regimental CP for more artillery fire, and the resulting unbroken ring of exploding steel was all that prevented the panzergrenadiers from passing unmolested through the former American positions on the hill. The 300 yard gap between the edge of the Bütgenbacher Heck and the Morschheck road was wide open, and German tanks were roaming freely over the area. Daniel knew that if the German infantry were allowed the exploit this gap, all of the 2d and 3d Battalions would be cut off and destroyed. He was determined not to let that happen.

The three Mk IVs near the manor house had maneuvered so that they were still covered by the south barn, but they could fire their 75mm guns directly into the manor house from only 75 yards away. This they did, trying to penetrate the building and force the command staff there to surrender, but the four–foot–thick stone walls of the old house withstood even this direct pounding. Nevertheless, as a precaution, LtCol Daniel ordered all papers in the CP to be burned.

The two platoons of C Co that had been retained as a reserve were still available, stationed around the crossroads just east of the manor house, but Daniel couldn't move them to reinforce the E Co positions because of the tanks roaming around the CP area. By the same token, however, the Mk IVs were cut off from their infantry support and were vulnerable to bazooka teams, and they couldn't withdraw to their own lines (as they had by now been ordered to do by radio) without exposing themselves to fire from the Sherman tanks on Hill 598.

In the 2d Battalion's eastern sector, F Co (having also been badly hit by the morning's bombardment) was holding off periodic attacks from Büllingen and suffering consid-

[8]According to RH 10/321, the *gliederung* of the **12th SS–PzD**, there were six of these vehicles attached to the **III/26th SS–PzGren Regt** on 15 December, but by the time of this attack on 21 December, only four were left.

[9]The AT Company commander, Captain Rivette, examined these hits two days later and found all four to be within a two–foot circle.

erable casualties. To their left, K Co of 3d Bn around the Schwarzenbüchel was attacked by 10 panzers and a battalion or so of infantry, possibly the **I/26 SS**. One of K Co's bazooka teams got one of the panzers, and the AT guns on the battalion's left flank knocked out four more, but this did not deter the advance of the grenadiers. At one point they advanced so far that Germans and Americans were fighting hand–to–hand in the trenches and the K Co commander, Capt Botts, called down final protective fire on his own foxhole. Capt Botts survived the resulting artillery fire, which prevented the SS from breaking through the line. Although their attacks continued throughout the day, the Germans achieved no penetration of the MLR.

Around 0900, the commanding officer of the AT Co, Capt Donald Rivette, left his company CP in Bütgenbach to check on his gun squads around the Domäne. As he left Bütgenbach, accompanied by his jeep driver and his Reconnaissance Sergeant, he could see three or four tanks burning on top of Hill 613 to their right front. They did not see any American infantry anywhere along the road all the way to the Domäne, nor could they see any where they knew the MLR to be, behind the hedgerow about halfway up Hill 613. Rivette, not knowing that portion of the line had been overrun, concluded that the infantry must be deep down in their foxholes. As they rounded a bend in the road the stone manor house came into view, and Rivette warned his driver to slow down while making the sharp turn into the estate's driveway. Fortuitously, however, the driver's foot hit the gas pedal instead of the brake and the jeep lurched forward just as one of the Mk IV tanks behind the south barn let loose a long machine gun burst at the vehicle. Rivette was slightly wounded in the back, and the sergeant suffered a minor cheek wound. The driver quickly wheeled the jeep to the back of the CP building and the three men dashed inside. There Rivette was informed of the grave crisis facing the 2/26th, and his 2d Platoon leader told him that several of the AT gun crews had been wiped out. The CP staff knew that the number of dead, wounded, and missing was staggeringly high, but they hadn't yet been able to compile a complete count.

The situation around Dom Bütgenbach remained relatvely static for the next few hours. The 2d and 3d Battalions' defenses east of the Morschheck road held against periodic attacks, while the German infantry was kept from exploiting the breakthrough the panzers had made in the west only by the massed fire of the American artillery battalions. Occasionally one of the panzers hiding behind the south barn at the estate would move out just far enough to fire an HE round at the CP, while inside the battalion staff prayed that the thick stone walls would hold just a little longer. The panzers also fired a few times at the E and H Co command posts in the east barn, scoring three direct hits. Every time the panzers exposed themselves this way to take a shot, the Shermans on the hill began firing furiously to try and knock them out, but the panzers were showing themselves too little and too briefly for the M–4s to get a good shot.

About 1000 a renewed infantry–tank attack struck at the remnants of the G Co platoon positioned between E and F Cos, southeast of the Domäne. As the German tanks silhouetted themselves coming over the ridgeline, however, one of the M–10 tank destroyers from A Co, 634th TD Bn, knocked out seven of them in rapid succession. The other M–10 guarding the road from Büllingen destroyed one panzer at 500 yards, while the 57mm guns of the AT platoon were credited with at least one kill, knocking out a Mk IV tank at 50 yards. Again, the combination of small arms and massive artillery fire stopped the German infantry cold, but not before they had put intense pressure on the front line troops.

At 1030 LtCol Daniel urgently requested that Regiment send another rifle company to reinforce his position, and specified that they should be equipped with extra bazookas to handle the large number of German tanks engaged against him. Regiment responded quickly, and within an hour E Co of the 18th Inf Regt was on its way to shore up the 2/26th's positions. By 1200, with no sizable penetration of the American lines after six hours of heavy combat, the Germans all across the 2d Bn's front began to pull back. Fighting was still heavy for a while, and the three Mk IVs at the manor house severely curtailed the Americans' freedom of movement in that area, but the pressure on the MLR was noticeably reduced. LtCol Daniel ensured that the curtain of artillery fire south of the manor house was maintained until he could move infantry there to reoccupy the foxhole line and evacuate his wounded. At 1250 he further requested a platoon of self–propelled tank destroyers from Regiment so that he could eliminate the panzers on the manor house grounds and restore his infantry's freedom of movement. Co E of the 18th Infantry Regiment arrived shortly afterwards, but since the panzers still threatened any movement in the area, Daniel ordered them to wait behind Hill 598.

In response to Daniel's request for tank destroyers, at 1305 a platoon of four M–36 TDs from the 613th TD Bn moved to positions just west of the Domäne, covering their advance from Bütgenbach with smoke grenades. Daniel ordered them to position themselves to fire through the south barn at the panzers. The TD platoon leader placed two of his vehicles at the east end of the manor house, from where they could fire at the east end of the barn, and two by a small roadside building to the west, with a line of sight to the west side of the south barn. They began firing their 90mm guns through the flimsy wooden upper walls of the barn, and with each salvo they worked their shots about 10 feet closer toward the center of the barn. This pattern of converging shells so unnerved two of the panzer commanders that they turned their tanks southward and raced for the safety of their own lines. The M–36s picked them both off when they were halfway up the hill. The third tank, however, held its ground. Daniel called down a barrage of mortar fire on the south barn to flush it out, but to no avail. He considered using 155mm artillery, since this was the only shell big enough to actually damage the tank, but its proximity to the manor house convinced him otherwise. Finally, at about 1600 hours and under cover of thickening fog and descending darkness, the last panzer took a parting shot at the CP then turned and fled up the hill toward Morschheck. Ironically, its last shot fi-

nally penetrated the manor house wall and wounded nine men inside.

For all intents and purposes, the last German attack on the Domäne Bütgenbach was over. The **12th–SS Panzer Division** tried one last time, on 22 December, to seize Bütgenbach, but that defense against that attack primarily involved the 1st Bn of the 26th Inf Regt farther to the west. The defense that "stuck out like a sore thumb" at the manor house had held.

**Aftermath**

As the grenadiers and panzers withdrew into Morschheck and Büllingen on the afternoon of 21 December, the weary US 2/26th began rebuilding its defenses and preparing for the next German attack. Engineers layed a belt of 2400 mines in front of the MLR, built two strong roadblocks to block the approaches from north and south, and erected three rows of concertina wire across the battalion's entire front.

These defenses, however, were not to be tested. After the unsuccessful attack on 22 December west of the Domäne, the Germans despaired of ever opening Rollbahn C and reaching Liege. The battered **12th SS–PzD** was withdrawn from the Bütgenbach area and sent south and west, where it was subsequently committed in the battle for Bastogne. Volksgrenadier units that were too weak to attack were sent in its stead to defend Büllingen and Morschheck against any American counterattacks. As Hugh Cole, author of the Army's official history of the Battle of the Bulge, put it, the defenders of Dom Bütgenbach "had knocked part of Hitler's personal plan into a cocked hat."

In four days of fighting, the **12th SS–Panzer Division "Hitlerjugend"** had suffered over 1,200 casualties, more than 782 of which were killed, including losses incurred at Krinkelt–Rocherath. In its first week of commitment in the Ardennes counteroffensive, the division lost a total of 47 panzers, jagdpanzers, and self–propelled guns, 15 armored half–tracks, one armored car, one Kübelwagen (jeep), two rocket launcher batteries (due solely to American counter-battery artillery fire), and an unknown but large number of trucks. US patrols sent out to the Bütgenbacher Heck on 23 December reported German dead "as common as grass" on the hillside above E Co's MLR, and found over 300 dead along the edge of the forest. The commander of M (heavy weapons) Co, 3d Bn, told Capt Rivette of the AT Co that the bodies of dead panzergrenadiers were piled so high in front of 3d Bn's positions that special patrols had to be sent out to clear them from the "final protective line."

The American casualties were proportionally no less severe. The 26th Infantry Regiment lost six bazookas, five 57mm AT guns, six BARs, two .30cal machine guns, three M–10 self–propelled tank destroyers, and three M–4 Sherman tanks defending Dom Bütgenbach. Worse, the regiment suffered 13 officers and 487 men killed, wounded, or captured. Since 1st Division as a whole lost 15 officers and 948 men between 16 and 24 December, that meant that 51% of the division's enlisted losses and a whopping 87% of the officer casulties came from the 26th Regiment alone. After the German attack subsided on the afternoon of 21 December, 2/26th had elements of six companies holding the line—its own E, F, and G Cos supported by heavy weapons from H Co, plus C Co from 1st Bn and parts of E Co of the 18th regiment. A headcount taken that night in the foxholes of the men available for duty revealed that E and F Cos had 75 men apiece, G Co had 55, and H Co had 80. C Co from 1st Bn had 75 men also, while even the "fresh" E/18 could muster only 125.

Credit for the defense must be shared with the various supporting battalions of American artillery. These units were no less instrumental than the infantry in stopping the German attacks. On 18 December, the battalions supporting the 1st Infantry fired a total of 26 missions; on 19 December, 102 missions; on the 20th, 169; on the 21st, 291; and on 22 December, they fired an incredible 334 missions, More often than not they fired until they were out of ammunition or until the guns were to hot to handle. In one eight–hour period on the 21st, when continuous artillery explosions were all that kept the German infantry from overrunning LtCol Daniel's CP, 10,000 rounds were fired to support his position. The 2/26th's mortar sections at Dom Bütgenbach fired 750 rounds that same day. The 955th FA Bn fired 555 rounds in a single interdiction and harassment mission and a total of 2,054 rounds for the day, the battalion's largest one–day ammunition expenditure of the war.

Despite the losses of men and material that the 2/26th endured, the price paid must be compared to the cost of a German breakthrough at Dom Bütgenbach. Given an open highway to Malmédy, the **I SS–PzK** could have attacked against the flanks of the 2d and 99th Divisions and possibly overrun the Elsenborn Ridge. Such a move would have nullified the courageous stand of the 2d and 99th Divisions in and around Krinkelt–Rocherath. While the Germans almost certainly would not have been able to retake Antwerp or force the Western Allies to sue for a separate peace, as Hitler had hoped, they might very well have reached the Meuse and established strong blocking positions. The American stand at Dom Bütgenbach helped channel the German advance westward, an operationally pointless direction for the advance, and allowed a strong northern shoulder to be maintained from which counterattacks would be launched once the Allies regained the initiative.

# CEV Calculations in Italy, 1943

by Niklas Zetterling

Perhaps one of the most debated results of the TNDM (and its predecessors) is the conclusion that the German ground forces on average enjoyed a measurable qualitative superiority over its US and British opponents. This was largely the result of calculations on situations in Italy in 1943–44, even though further engagements have been added since the results were first presented. The calculated German superiority over the Red Army, despite the much smaller number of engagements, has not aroused as much opposition. Similarly, the calculated Israeli effectiveness superiority over its enemies seems to have surprised few.

However, there are objections to the calculations on the engagements in Italy 1943. These concern primarily the database, but there are also some questions to be raised against the way some of the calculations have been made, which may possibly have consequences for the TNDM.

Here it is suggested that the German CEV superiority was higher than originally calculated. There are a number of flaws in the original calculations, each of which will be discussed separately below. With the exception of one issue, all of them, if corrected, tend to give a higher German CEV.

**The Database on Italy 1943–44**

According to the database the German divisions had considerable fire support from GHQ artillery units. This is the only possible conclusion from the fact that several pieces of the types 15cm gun, 17cm gun, 21cm gun, and 15cm and 21cm nebelwerfer are included in the data for individual engagements. These types of guns were almost exclusively confined to GHQ units. An example from the database are the three engagements Port of Salerno, Amphitheater, and Sele–Calore Corridor. These take place simultaneously (9–11 September 1943) with the German 16th Pz Div on the Axis side in all of them (no other division is included in the battles). Judging from the manpower figures, it seems to have been assumed that the division participated with one quarter of its strength in each of the two former battles and half its strength in the latter. According to the database, the number of guns were:

| | |
|---|---|
| 15cm gun | 28 |
| 17cm gun | 12 |
| 21cm gun | 12 |
| 15cm NbW | 27 |
| 21cm NbW | 21 |

This would indicate that the 16th Pz Div was supported by the equivalent of more than five non–divisional artillery battalions. For the German army this is a suspiciously high number; usually there were rather something like one GHQ artillery battalion for each division, or even less. Research in the German Military Archives confirmed that the number of GHQ artillery units was far less than indicated in the HERO database. Among the useful documents found were a map showing the dispositions of 10th Army artillery units. This showed clearly that there was only one non–divisional artillery unit south of Rome at the time of the Salerno landings, the III/71 Nebelwerfer Battalion. Also the 557th Artillery Battalion (17cm gun) was present, it was included in the artillery regiment (33rd Artillery Regiment) of 15th Panzergrenadier Division during the second half of 1943. Thus the number of German artillery pieces in these engagements is exaggerated to an extent that cannot be considered insignificant. Since OLI values for artillery usually constitute a significant share of the total OLI of a force in the TNDM, errors in artillery strength cannot be dismissed easily.

While the example above is but one, further archival research has shown that the same kind of error occurs in all the engagements in September and October 1943. It has not been possible to check the engagements later during 1943, but a pattern can be recognized. The ratio between the numbers of various types of GHQ artillery pieces does not change much from battle to battle. It seems that when the database was developed, the researchers worked with the assumption that the German corps and army organizations had organic artillery, and this assumption may have been used as a "rule of thumb." This is wrong, however; only artillery staffs, command and control units were included in the corps and army organizations, not firing units. Consequently we have a systematic error, which cannot be corrected without changing the contents of the database. It is worth emphasizing that we are discussing an exaggeration of German artillery strength of about 100%, which certainly is significant. Comparing the available archival records with the database also reveals errors in numbers of tanks and antitank guns, but these are much smaller than the errors in artillery strength. Again these errors do always inflate the German strength in those engagements I have been able to check against archival records.

These errors tend to inflate German numerical strength, which of course affects CEV calculations. But there are further objections to the CEV calculations.

**The Result Formula**

The "result formula" weighs together three factors: casualties inflicted, distance advanced, and mission accomplishment. It seems that the first two do not raise many objections, even though the relative weight of them may always be subject to argumentation.

The third factor, mission accomplishment, is more dubious however. At first glance it may seem to be natural to include such a factor. After all, a combat unit is supposed to accomplish the missions given to it. However, whether a unit accomplishes its mission or not depends both on its own qualities as well as the realism of the mission assigned. Thus the mission accomplishment factor may reflect the qualities of

the combat unit as well as the higher HQs and the general strategic situation. As an example, the Rapido crossing by the US 36th Infantry Division can serve. The division did not accomplish its mission, but whether the mission was realistic, given the circumstances, is dubious. Similarly many German units did probably, in many situations, receive unrealistix missions, particularly during the last two years of the war (when most of the engagements in the database were fought). A more extreme example of situations in which unrealistic missions were given is the battle in Belorussia, June–July 1944, where German units were regularly given impossible missions. Possibly it is a general trend that the side which is fighting at a strategic disadvantage is more prone to give its combat units unrealistic missions.

On the other hand it is quite clear that the mission assigned may well affect both the casualty rates and advance rates. If, for example, the defender has a withdrawal mission, advance may become higher than if the mission was to defend resolutely. This must however not necessarily be handled by including a missions factor in a result formula.

I have made some tentative runs with the TNDM, testing with various CEV values to see which value produced an outcome in terms of casualties and ground gained as near as possible to the historical result. The results of these runs are very preliminary, but the tendency is that higher German CEVs produce more historical outcomes, particularly concerning combat.

**Supply Situation**

According to scattered information available in published literature, the US artillery fired more shells per day per gun than did German artillery. In Normandy, US 155mm M1 howitzers fired 28.4 rounds per day during July, while August showed slightly lower consumption, 18 rounds per day. For the 105mm M2 howitzer the corresponding figures were 40.8 and 27.4. This can be compared to a German OKH study which, based on the experiences in Russia 1941–43, suggested that consumption of 105mm howitzer ammunition was about 13–22 rounds per gun per day, depending on the strength of the opposition encountered. For the 150mm howitzer the figures were 12–15.

While these figures should not be taken too seriously, as they are not from primary sources and they do also reflect the conditions in different theaters, they do at least indicate that it cannot be taken for granted that ammunition expenditure is proportional to the number of gun barrels. In fact there also exist further indications that Allied ammunition expenditure was greater than the German. Several German reports from Normandy indicate that they were astonished by the Allied ammunition expenditure.

It is unlikely that an increase in artillery ammunition expenditure will result in a proportional increase combat power. Rather it is more likely that there is some kind of diminished return with increased expenditure.

**General Problems with Non–Divisional Units**

A division usually (but not necessarily) includes various support services, such as maintenance, supply, and medical services. Non–divisional combat units have to a greater extent to rely on corps and army for such support. This makes it complicated to include such units, since when entering, for example, the manpower strength and truck strength in the TNDM, it is difficult to assess their contribution to the overall numbers.

Furthermore, the amount of such forces is not equal on the German and Allied sides. In general the Allied divisional slice was far greater than the German. In Normandy the US forces on 25 July 1944 had 812,000 men on the Continent, while the number of divisions was 18 (including the 5th Armored, which was in the process of landing on the 25th). This gives a divisional slice of 45,000 men. By comparison the German 7th Army mustered 16 divisions and 231,000 men on 1 June 1944, giving a slice of 14,437 men per division. The main explanation for the difference is the non–divisional combat units and the logisitical organization to support them. In general, non–divisional combat units are composed of powerful, but supply–consuming, types like armor, artillery, antitank and antiaircraft. Thus their contribution to combat power and strain on the logistical apparatus is considerable. However I do not believe that the supporting units' manpower and vehicles have been included in TNDM calculations.

There are however further problems with non–divisional units. While the whereabouts of tank and tank destroyer units can usually be established with sufficient certainty, artillery can be much harder to pin down to a specific division engagement. This is of course a greater problem when the geographical extent of a battle is small.

**Tooth–to–Tail Ratio**

Above was discussed the lack of support units in non–divisional combat units. One effect of this is to create a force with more OLI per man. This is the result of the unit's "tail" belonging to some other part of the military organization.

In the TNDM there is a mobility formula, which tends to favor units with many weapons and vehicles compared to the number of men. This became apparent when I was performing a great number of TNDM runs on engagements between Swedish brigades and Soviet regiments. The Soviet regiments usually contained rather few men, but still had many AFVs, artillery tubes, AT weapons, etc. The Mobility Formula in TNDM favors such units. However, I do not think this reflects any phenomenon in the real world. The Soviet penchant for lean combat units, with supply, maintenance, and other services provided by higher echelons, is not a more effective solution in general, but perhaps better suited to the particular constraints they were experiencing when forming units, training men, etc. In effect these services were existing in the Soviet army too, but formally not with the combat units.

This problem is to some extent reminiscent to how density is calculated (a problem discussed by Chris Lawrence in a recent issue of the Newsletter). It is comparatively easy

to define the frontal limit of the deployment area of force, and it is relatively easy to define the lateral limits too. It is, however, much more difficult to say where the rear limit of a force is located.

When entering forces in the TNDM a rear limit is, perhaps unintentionally, drawn. But if the combat unit includes support units, the rear limit is pushed farther back compared to a force whose combat units are well separated from support units.

To what extent this affects the CEV calculations is unclear. Using the original database values, the German forces are perhaps given too high combat strength when the great number of GHQ artillery units is included. On the other hand, if the GHQ artillery units are not included, the opposite may be truc.

**The Effects of Defensive Posture**

The posture factors are difficult to analyze, since they alone do not portray the advantages of defensive position. Such effects are also included in terrain factors.

It seems that the numerical values for these factors were assigned on the basis of professional judgement. However, when the QJM was developed, it seems that the developers did not assume the German CEV superiority. Rather, the German CEV superiority seems to have been discovered later. It is possible that the professional judgement was about as wrong on the issue of posture effects as they were on CEV. Since the British and American forces were predominantly on the offensive, while the Germans mainly defended themselves, a German CEV superiority may, at least partly, be hidden in two high effects for defensive posture.

When using corrected input data on the 20 situations in Italy September–October 1943, there is a tendency that the German CEV is higher when they attack. Such a tendency is also discernible in the engagements presented in *Hitler's Last Gamble*, Appendix H, even though the number of engagements in the latter case is very small.

As it stands now this is not really more than a hypothesis, since it will take an analysis of a greater number of engagements to confirm it. However, if such an analysis is done, it must be done using several sets of data. German and Allied attacks must be analyzed separately, and preferably the data would be separated further into sets for each relevant terrain type. Since the effects of the defensive posture are intertwined with terrain factors, it is very much possible that the factors may be correct for certain terrain types, while they are wrong for others. It may also be that the factors can be different for various opponents (due to differences in training, doctrine, etc.). It is also possible that the factors are different if the forces are predominantly composed of armor units or mainly of infantry.

One further problem with the effects of defensive position is that it is probably strongly affected by the density of forces. It is likely that the main effect of the density of forces is the inability to use effectively all the forces involved. Thus it may be that this factor will not influence the outcome except when the density is comparatively high. However, what can be regarded as "high" is probably much dependent on terrain, road net quality, and the cross–country mobility of the forces.

Conclusions

While the TNDM has been criticized here, it is also fitting to praise the model. The very fact that it can be criticized in this way is a testimony to its openness. In a sense a model is also a theory, and to use Popperian terminology, the TNDM is also very testable.

It should also be emphasized that the greatest errors are probably those in the database. As previously stated, I can only conclude safely that the data on the engagements in Italy in 1943 are wrong; later engagements have not yet been checked against archival documents. Overall the errors do not represent a dramatic change in the CEV values. Rather, the Germans seem to have (in Italy 1943) a superiority on the order of 1.4–1.5, compared to an original figure of 1.2–1.3.

During September and October 1943, almost all the German divisions in southern Italy were mechanized or parachute divisions. This may have contributed to a higher German CEV. Thus it is not certain that the conclusions arrived at here are valid for German forces in general, even though this factor should not be exaggerated, since many of the German divisions in Italy were either newly raised (e.g., 26th Panzer Division) or rebuilt after the Stalingrad disaster (16th Panzer Division plus 3rd and 29th Panzergrenadier DIvisions) or the Tunisian debacle (15th Panzergrenadier Division). ⊕

**List of Engagements Checked**

| | |
|---|---|
| Port of Salerno | 9–11 Sept 1943 |
| Amphitheater | 9–11 Sept 1943 |
| Sele–Calore Corridor | 11 Sept 1943 |
| Vietri I | 12–15 Sept 1943 |
| Battipaglia | 12–15 Sept 1943 |
| Tobacco Factory | 13–14 Sept 1943 |
| Eboli | 17 Sept 1943 |
| Battipaglia II | 17–18 Sept 1943 |
| Vietri II | 17–18 Sept 1943 |
| Grazzanise | 12–14 Sept 1943 |
| Capua | 13 Oct 1943 |
| Triflisco | 13–14 Oct 1943 |
| Monte Acero | 13–14 Oct 1943 |
| Caiazzo | 13–14 Oct 1943 |
| Castel Volturno | 13–15 Oct 1943 |
| Dragoni | 14–17 Oct 1943 |
| Monte Grande I | 16–17 Oct 1943 |
| Canal I | 17–18 Oct 1943 |
| Canal II | 18–20 Oct 1943 |

# Response to Niklas Zetterling's Article

by Christopher A. Lawrence

Mr. Zetterling is currently a professor at the Swedish War College and previously worked at the Swedish National Defense Research Establishment. As I have been having an ongoing dialogue with Prof. Zetterling on the Battle of Kursk, I have had the opportunity to witness his approach to researching historical data and the depth of research. I would recommend that all of our readers take a look at his recent article in the *Journal of Slavic Military Studies* entitled "Loss Rates on the Eastern Front during World War II." Mr. Zetterling does his German research directly from the Captured German Military Records by purchasing the rolls of microfilm from the US National Archives. He is using the same German data sources that we are. Let me attempt to address his comments section by section:

**The Database on Italy 1943-44:**

Unfortunately, the Italian combat data was one of the early HERO research projects, with the results first published in 1971. I do not know who worked on it nor the specifics of how it was done. There are references to the Captured German Records, but significantly, they only reference division files for these battles. While I have not had the time to review Prof. Zetterling's review of the original research, I do know that some of our researchers have complained about parts of the Italian data. From what I've seen, it looks like the original HERO researchers didn't look into the Corps and Army files, and assumed what the attached Corps artillery strengths were. Sloppy research is embarrassing, although it does occur, especially when working under severe financial constraints (for example, our Battalion–Level Operations Database). If the research is sloppy or hurried, or done from secondary sources, then hopefully the errors are random, and will effectively counterbalance each other, and not change the results of the analysis. If the errors are all in one direction, then this will produce a biased result.

I have no basis to believe that Prof. Zetterling's criticism is wrong, and do have many reasons to believe that it is correct. Until I can take the time to go through the Corps and Army files, I intend to operate under the assumption that Prof. Zetterling's corrections are good. At some point I will need to go back through the Italian Campaign data and correct it and update the Land Warfare Database. I did compare Prof. Zetterling's list of battles with what was declared to be the forces involved in the battle (according the Combat Data Subscription Service) and they show the following attached artillery:

| *Engagement Number* | *Engagement Name* | *Attached Corps Artillery* |
|---|---|---|
| 1 | Port of Salerno | 1/4 XIV Corps Artillery |
| 2 | Amphitheater | 1/4 XIV Corps Artillery |
| 3 | Sele–Calore Corridor | 1/2 LXXVI Pz Corps Artillery |
| 5 | Vietri I | 1/2 XIV Corps Artillery |
| 6 | Battipaglia I | 1/2 LXXVI Pz Corps Artillery |
| 4 | Tobacco Factory | 1/2 LXXVI Pz Corps Artillery |
| 9 | Eboli | None |
| 8 | Battipaglia II | 1/2 LXXVI Pz Corps Artillery |
| 7 | Vietri II | 1/2 XIV Corps Artillery |
| 10 | Grazzanise | 1/8 XIV Corps Artillery |
| 11 | Capua | 1/4 XIV Corps Artillery |
| 12 | Triflisco | 2/5 XIV Corps Artillery |
| 13 | Monte Acero | 1/5 VI Corps Artillery |
| 14 | Caiazzo | 2/5 VI Corps Artillery |
| 15 | Castel Volturno | 1/8 XIV Corps Artillery |
| 16 | Dragoni | 1/4 XIV Corps Artillery |
| 20 | Monte Grande | 1/8 XIV Corps Artillery |
| 17 | Canal I | 1/8 XIV Corps Artillery |
| 18 | Canal II | 1/8 XIV Corps Artillery |

It is clear that the battles were based on the assumption that there was Corps–level German artillery. A strength comparison between the two sides is displayed in the chart on the next page.

**The Result Formula:**

CEV is calculated from three factors. Therefore a consistent 20% error in casualties will result in something less than a 20% error in CEV. The mission effectiveness factor is indeed very "fuzzy", and these is simply no systematic method or guidance in its application. Sometimes, it is not based upon the assigned mission of the unit, but its perceived mission based upon the analyst's interpretation. But, while I have the same problems with the mission accomplishment scores as Mr. Zetterling, I do not have a good replacement. Considering the nature of warfare, I would hate to create CEV's without it. Of course, Trevor Dupuy was experimenting with creating CEV's just from casualty effectiveness, and by averaging his two CEV scores (CEVt and CEVl) he heavily weighted the CEV calculation for the TNDM towards measuring primarily casualty effectiveness (see the article in issue 5 of the *Newsletter*, "Numerical Adjustment of CEV Results: Averages and Means"). At this point, I would like to produce a new, single formula for CEV to replace the current two and its averaging methodology. I am open to suggestions for this.

**Supply Situation:**

The different ammunition usage rate of the German and US Armies is one of the reasons why adding a logistics

| | US | (Allied) | British | German |
|---|---|---|---|---|
| **Ground Forces** | | | | |
| Armies | 1 | | | 1 |
| Corps | 1 | | 1 | 2 |
| Divisions | | | | |
| Infantry | 2 | | 2 | |
| Mechanized | | | | 3 |
| Armored | | | 1 | 3 |
| Airborne | 1 | | | |
| ***Division Totals*** | **3** | | **3** | **6** |
| | | | | |
| ***Personnel Totals*** | | ***103,500*** | | ***97,300*** |
| | | | | |
| **Aircraft** | | | | |
| Bombers | | 870 | | |
| Fighters | | 670 | | |
| Transports | | 300[2] | | |
| ***Aircraft Totals***[3] | | ***1,840*** | | ***502*** |
| | | | | |
| **Artillery**[4] | | | | |
| 75mm Howitzer (incl SP) | 53 | | 27 | 104 |
| 105mm Howitzer (incl SP) | 216 | | 24 | |
| 155mm Howitzer | 76 | | | |
| 155mm Gun | 24 | | 12 | |
| 3-in Tank Destroyer | 156 | | | |
| 25-pdr (incl SP) | | | 192 | |
| 3-in Howitzer | | | 18 | |
| 4.5-in Gun | | | 8 | |
| 7.2-in Gun/Howitzer | | | 16 | |
| 5.5-in Gun/Howitzer | | | 24 | |
| 88mm Gun | | | | 42 |
| 105mm Gun/Howitzer | | | | 21 |
| 105mm Gun/Howitzer | | | | 129 |
| 150mm Howitzer (hvy or inf) | | | | 34 |
| 150mm Gun (hvy)/Howitzer | | | | 55 |
| 170mm Gun | | | | 4 |
| 210mm Howitzer | | | | 5 |
| ***Artillery Totals*** | ***525*** | | ***321*** | ***394*** |
| | | | | |
| **Armor** | | | | |
| Light Tank | 181 | | 55 | 85 |
| Medium Tank | 294 | | 194 | 290 |
| ***Armor Totals*** | ***475*** | | ***249*** | ***375*** |

[1] Does not include Eighth Army divisions advancing from the "toe" that arrived too late to take part in the Salerno actions.
[2] Plus 400 gliders.
[3] German figures are for estimated serviceable aircraft. This figure is 75% of total German and Italian planes in southern Italy. The Italian craft were actually of little use and the figure is therefore probably high.
[4] Figures are not available for coastal artillery. Stamps and Esposito, *A Military History of World War II*, on p. 120 states: "included in the mobile defense was a railway battery of 132mm guns, usually kept on a track just north of Agripoli. Observation from such dominating terrain features as Mount Soprano would enable the enemy to direct fire on the gulf, the beaches, and the plain."

module is high on my list of model corrections. This was discussed in Issue 2 of the *Newsletter*, "Developing a Logistics Model for the TNDM." As Mr. Zetterling points out, "It is unlikely that an increase in artillery ammunition expenditure will result in a proportional increase in combat power. Rather it is more likely that there is some kind of diminished return with increased expenditure." This parallels what I expressed in point 12 of that article: "It is suspected that this increase [in OLIs] will not be linear."

The CEV does include "logistics." So in effect, if one had a good logistics module, the difference in logistics would be accounted for, and the Germans (after logistics is taken into account) may indeed have a higher CEV.

**General Problems with Non–Divisional Units**
**Tooth-to-Tail Ratio**

Point taken. The engagements used to test the TNDM have been gathered over a period of over 25 years, by different researchers and controlled by different management. What is counted when and where does change from one group of engagements to the next. While I do think this has not had a significant result on the model outcomes, it is "sloppy" and needs to be addressed.

**The Effects of Defensive Posture**

This is a very good point. If the budget was available, my first step in "redesigning" the TNDM would be to try to measure the effects of terrain on combat through the use of a large LWDB–type database and regression analysis. I have always felt that with enough engagements, one could produce reliable values for these figures based upon something other than judgement. Prof. Zetterling's proposed methodology is also a good approach, easier to do, and more likely to get a conclusive result. I intend to add this to my list of model improvements.

**Conclusions**

There is one other problem with the Italian data that Prof. Zetterling did not address. This was that the Germans and the Allies had different reporting systems for casualties. Quite simply, the Germans did not report as casualties those people who were lightly wounded and treated and returned to duty from the divisional aid station. The United States and England did. This shows up when one compares the wounded to killed ratios of the various armies, with the Germans usually having in the range of 3 to 4 wounded for every one killed, while the allies tend to have 4 to 5 wounded for every one killed. Basically, when comparing the two reports, the Germans "undercount" their casualties by around 17 to 20%. Therefore, one probably needs to use a multiplier of 20 to 25% to match the two casualty systems. This was not taken into account in any the work HERO did.

Because Trevor Dupuy used three factors for measuring his CEV, this error certainly resulted in a slightly higher CEV for the Germans than should have been the case, but not a 20% increase. As Prof. Zetterling points out, the correction of the count of artillery pieces should result in a higher CEV than Col. Dupuy calculated. Finally, if Col. Dupuy overrated the value of defensive terrain, then this may result in the German CEV being slightly lower.

As you may have noted in my list of improvements (Issue 2, "Planned Improvements to the TNDM"), I did list "re–validating" to the QJM Database. As part of that revalidation process, we would need to review the data used in the validation data base first, account for the casualty differences in the reporting systems, and determine if the model indeed overrates the effect of terrain on defense.

# Artillery Effectiveness versus Armor

by Richard C. Anderson, Jr.

The effectiveness of artillery against exposed personnel and other "soft" targets has long been accepted. Fragments and blast are deadly to those unfortunate enough to not be under cover. What has also long been accepted is the relative—if not total—immunity of armored vehicles when exposed to shellfire. In a recent memorandum, the United States Army Armor School disputed the results of tests of artillery versus tanks by stating, "...the Armor School nonconcurred with the Artillery School regarding the suppresive effects of artillery...the M–1 main battle tank cannot be destroyed by artillery..."

This statement may in fact be true,[1] *if the advancement of armored vehicle design has greatly exceeded the advancement of artillery weapon design in the last fifty years*. However, if the statement is not true, then recent research by TDI[2] into the effectiveness of artillery shellfire versus tanks in World War II may be illuminating.

The TDI search found that an average of 12.8 percent of tank and other armored vehicle losses[3] were due to artillery fire in seven cases in World War II where the cause of loss could be reliably identified. The highest percent loss due to artillery was found to be 14.8 percent in the case of the Soviet 1st Tank Army at Kursk (Table II). The lowest percent loss due to artillery was found to be 5.9 percent in the case of Dom Bütgenbach (Table VIII).

The seven cases are split almost evenly between those that show armor losses to a defender and those that show losses to an attacker. The first four cases (Kursk, Normandy I, Normandy II, and the "Pocket") are engagements in which the side for which armor losses were recorded was on the defensive. The last three cases (Ardennes, Krinkelt, and Dom Bütgenbach) are engagements in which the side for which armor losses were recorded was on the offensive.

Four of the seven cases (Normandy I, Normandy II, the "Pocket," and Ardennes) represent data collected by operations research personnel utilizing rigid criteria for the identification of the cause of loss. Specific causes of loss were only given when the primary destructive agent could be clearly identified. The other three cases (Kursk, Krinkelt, and Dom Butgenbach) are based upon combat reports that—of necessity—represent less precise data collection efforts. However, the similarity in results remains striking.

The largest identifiable cause of tank loss found in the data was, predictably, high–velocity armor piercing antitank rounds. AP rounds were found to be the cause of 68.7 percent of all losses. Artillery was second, responsible for 12.8 percent of all losses. Air attack as a cause was third, accounting for 7.4 percent of the total lost. Unknown causes, which included losses due to hits from multiple weapon types as well as unidentified weapons, inflicted 6.3% of the losses and ranked fourth. Other causes, which included infantry antitank weapons and mines, were responsible for 4.8% of the losses and ranked fifth.

Curiously, at Kursk, in the case where the highest percent loss was recorded, the German forces opposing the Soviet 1st Tank Army—mainly the XLVIII Panzer Corps of the Fourth Panzer Army—were supported by proportionately fewer artillery pieces (approximately 56 guns and rocket launchers per division) than the US 1st Infantry Division at Dom Bütgenbach (the equivalent of approximately 106 guns per division)[4]. Nor does it appear that the German rate of fire at Kursk was significantly higher than that of the American artillery at Dom Bütgenbach. On 20 July at Kursk, the 150mm howitzers of the 11th Panzer Division achieved a peak rate of fire of 87.21 rounds per gun. On 21 December at Dom Bütgenbach, the 155mm howitzers of the 955th Field Artillery Battalion achieved a peak rate of fire of 171.17 rounds per gun.[5]

Table IX shows the distribution of cause of loss by type or armor vehicle. From the distribution it might be inferred that better protected armored vehicles may be less vulnerable to artillery attack. Nevertheless, the heavily armored vehicles still suffered a minimum loss of 5.6 percent due to artillery. Unfortunately the sample size for heavy tanks was very small, 18 of 980 cases or only 1.8 percent of the total.

[1] The statement may be true, although it has an "unsinkable Titanic," ring to it. It is much more likely that this statement is an hypothesis, rather than a truism.

[2] As part of this article a survey of the Research Analysis Corporation's publications list was made in an attempt to locate data from previous operations research on the subject. A single reference to the study of tank losses was found, Group 1 Alvin D. Coox and L. Van Loan Naisawald, *Survey of Allied Tank Casualties in World War II*, CONFIDENTIAL ORO Report T-117, 1 March 1951.

[3] The percentage loss by cause excludes vehicles lost due to mechanical breakdown or abandonment. If these were included, they would account for 29.2 percent of the total lost. However, 271 of the 404 (67.1%) abandoned were lost in just two of the cases. These two cases (Normandy II and the Falaise Pocket) cover the period in the Normandy Campaign when the Allied armies broke through the German defenses and began the pursuit across France.

[4] The US artillery at Dom Bütgenbach peaked on 21 December 1944 when a total of 210 divisional and corps pieces fired over 10,000 rounds in support of the 1st Division's 26th Infantry.

[5] Data collected on German rates of fire are fragmentary, but appear to be similar to that of the American Army in World War II. An article on artillery rates of fire that explores the data in more detail will be forthcoming in a future issue of this *Newsletter*.

The data are limited at this time to the seven cases.[6] Further research is necessary to expand the data sample so as to permit proper statistical analysis of the effectiveness of artillery versus tanks.[7]

[6] An eighth case was considered, but was not included in this article. This was the report of tank losses by the 1st US Army from June 1944 through April 1945. The data were incomplete, reporting all indirect fire and direct fire losses as caused by "gunfire." However, internal evidence implies that of the 898 losses reported in the study, as many as 250 (27.8 percent) may have been caused by indirect artillery fire.

[7] There is strong evidence that extensive data on armored vehicle losses are available in the captured German Army records from World War II. Most of this data would cover the German experience on the Eastern Front versus the Soviet Army.

**Table I. Kursk, Soviet 1st Tank Army Strength and Loss by Unit, 4-18 July 1943**[8]

| Unit Tank Type | Participated | Lost | Artillery | Air | Burned | Breakdown |
|---|---|---|---|---|---|---|
| **3rd Mechanized Corps** | | | | | | |
| T-34 | 195 | 145 | 20 | 0 | 108 | 17 |
| T-70 | 35 | 16 | 3 | 0 | 10 | 3 |
| **6th Tank Corps** | | | | | | |
| T-34 | 155 | 146 | 13 | 5 | 106 | 22 |
| T-70 | 32 | 30 | 5 | 2 | 19 | 4 |
| **31st Tank Corps** | | | | | | |
| T-34 | 175 | 146 | 32 | 3 | 102 | 9 |
| T-70 | 42 | 32 | 7 | 0 | 10 | 15 |
| **180th Tank Brigade** | | | | | | |
| T-34 | 43 | 37 | 2 | 0 | 33 | 2 |
| T-70 | 23 | 18 | 0 | 0 | 16 | 2 |
| T-60 | 6 | 3 | 0 | 0 | 1 | 2 |
| **86th Tank Brigade**[9] | | | | | | |
| T-34 | 41 | 27 | 0 | 0 | 27 | 0 |
| T-70 | 3 | 1 | 0 | 0 | 1 | 0 |
| T-60 | 9 | 3 | 0 | 0 | 3 | 0 |
| **203rd Heavy Tank Regiment** | | | | | | |
| KV-1 and KV-2 | 11 | 8 | 1 | 1 | 5 | 1 |
| **192nd Tank Brigade** | | | | | | |
| Grant | 31 | 25 | 1 | 0 | 21 | 3 |
| Stuart | 24 | 11 | 0 | 0 | 9 | 2 |
| ***Total*** | ***825*** | ***648*** | ***84*** | ***11*** | ***471*** | ***82*** |

[8] The data were found in reports of the 1st Tank Army (Fond 299, Opis' 3070, Delo 226). Obvious math errors in the original document have been corrected (the total lost column did not always agree with the totals by cause). The total participated column evidently reflected the starting strength of the unit, plus replacement vehicles. "Burned" in Soviet wartime documents usually indicated a total loss, however it appears that in this case "burned" denoted vehicles totally lost due to direct fire antitank weapons. "Breakdown" apparently included both mechanical breakdown and repairable combat damage.

[9] Note that the brigade report (Fond 3304, Opis' 1, Delo 24) contradicts the army report. The brigade reported that a total of 28 T-34s were lost (9 to aircraft and 19 to "artillery") and one T-60 was destroyed by a mine. However, this report was made on 11 July, during the battle, and may not have been as precise as the later report recorded by 1st Tank Army. Furthermore, it is not as clear in the brigade report that "artillery" referred only to indirect fire HE and not simply to both direct and indirect fire guns.

**Table II. Kursk, Soviet 1st Tank Army Strength and Losses, 4-18 July 1943**

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Breakdown | Other | Unknown |
|---|---|---|---|---|---|---|---|
| T-34 | 501 | 67 | 8 | 376 | 50 | 0 | 0 |
| T-70 | 97 | 15 | 2 | 56 | 24 | 0 | 0 |
| T-60 | 6 | 0 | 0 | 4 | 2 | 0 | 0 |
| KV-1 and KV-2 | 8 | 1 | 1 | 5 | 1 | 0 | 0 |
| Grant | 25 | 1 | 0 | 21 | 3 | 0 | 0 |
| Stuart | 11 | 0 | 0 | 9 | 2 | 0 | 0 |
| ***Total*** | ***648*** | ***84*** | ***11*** | ***471*** | ***82*** | ***0*** | ***0*** |

**Percentage Loss by Type and Cause (Excluding Breakdowns)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| T-34 | 451 | 14.9% | 1.8% | 83.3% | 0.0% | 0.0% |
| T-70 | 73 | 20.5% | 2.7% | 76.7% | 0.0% | 0.0% |
| T-60 | 4 | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% |
| KV-1 and KV-2 | 7 | 14.3% | 14.3% | 71.4% | 0.0% | 0.0% |
| Grant | 22 | 4.5% | 0.0% | 95.5% | 0.0% | 0.0% |
| Stuart | 9 | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% |
| ***Total*** | ***566*** | ***14.8%*** | ***1.9%*** | ***83.2%*** | ***0.0%*** | ***0.0%*** |

**Table III. Normandy I, German Armor Losses, 6 June-7 August 1944**[10]

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tiger | 8 | 0 | 0 | 7 | 0 | 1 | 0 |
| Panther | 80 | 7 | 8 | 36 | 9 | 7 | 13[11] |
| Panzer IV | 20 | 2 | 2 | 10 | 2 | 2 | 2 |
| ***Total*** | ***108*** | ***9*** | ***10*** | ***53*** | ***11*** | ***10*** | ***15*** |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tiger | 8 | 0.0% | 0.0% | 87.5% | 12.5% | 0.0% |
| Panther | 71 | 9.9% | 11.3% | 50.7% | 9.9% | 18.3% |
| Panzer IV | 18 | 11.1% | 11.1% | 55.6% | 11.1% | 11.1% |
| ***Total*** | ***97*** | ***9.3%*** | ***10.3%*** | ***54.6%*** | ***10.3%*** | ***15.5%*** |

[10] From ORS Report No. 17.

[11] Five of the 13 counted as unknown were penetrated by both armor piercing shot and by infantry hollow charge weapons. There was no evidence to indicate which was the original cause of the loss.

**Table IV. Normandy II, German Armor Losses, 8-31 August 1944**[12]

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tiger | 27 | 0 | 0 | 1 | 26 | 0 | 0 |
| Panther | 96 | 1 | 3 | 11 | 74 | 1 | 6 |
| Panzer IV | 96 | 3 | 7 | 11 | 68 | 0 | 7 |
| Panzer III | 3 | 0 | 0 | 0 | 3 | 0 | 0 |
| ***Total*** | ***222*** | ***4*** | ***10*** | ***23*** | ***171*** | ***1*** | ***13*** |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tiger | 1 | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% |
| Panther | 22 | 4.5% | 13.6% | 50.0% | 4.5% | 27.3% |
| Panzer IV | 28 | 10.7% | 25.0% | 39.3% | 0.0% | 25.0% |
| Panzer III | 0 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Total*** | ***51*** | ***7.8%*** | ***19.6%*** | ***45.1%*** | ***2.0%*** | ***25.5%*** |

[12] From ORS Report No. 17.

**Table V. The Falaise Pocket, German Armor Losses, August 1944**[13]

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tanks | 90 | 2 | 6 | 8 | 65 | 0 | 9 |
| SP Guns | 31 | 2 | 5 | 2 | 16 | 2 | 4 |
| AC & APC | 56 | 5 | 25 | 1 | 20 | 1 | 4 |
| ***Total*** | ***177*** | ***9*** | ***36*** | ***11*** | ***101*** | ***3*** | ***17*** |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tanks | 25 | 8.0% | 24.0% | 32.0% | 0.0% | 36.0% |
| SP Guns | 15 | 13.3% | 33.3% | 13.3% | 13.3% | 26.7% |
| AC & APC | 36 | 13.9% | 69.4% | 2.8% | 2.8% | 11.1% |
| ***Total*** | ***76*** | ***11.8%*** | ***47.4%*** | ***14.5%*** | ***3.9%*** | ***22.4%*** |

[13] From ORS Report No. 15. The "Pocket" was the area west of the line Falaise-Argentan and east of the line Vassy-Gers-Domfront in Normandy that was the site in August 1944 of the beginning of the German retreat from France. The German forces were being enveloped from the north and south by Allied ground forces and were under constant, heavy air attack.

**Table VI. Ardennes, German Armor Losses, 16 December 1944-16 January 1945**[14]

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tiger II | 5 | 0 | 1 | 1 | 3 | 0 | 0 |
| Panther | 47 | 3 | 3 | 16 | 20 | 0 | 5 |
| Panzer IV | 5 | 0 | 0 | 1 | 1 | 1 | 2 |
| SP Gun | 18 | 1 | 1 | 10 | 4 | 1 | 1 |
| AC & APC | 26 | 4 | 1 | 8 | 11 | 0 | 2 |
| **Total** | **101** | **8** | **6** | **36** | **39** | **2** | **10** |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tiger II | 2 | 0.0% | 50.0% | 50.0% | 0.0% | 0.0% |
| Panther | 27 | 11.1% | 11.1% | 59.3% | 0.0% | 18.5% |
| Panzer IV | 4 | 0.0% | 0.0% | 25.0% | 25.0% | 50.0% |
| SP Gun | 14 | 7.1% | 7.1% | 71.4% | 7.1% | 7.1% |
| AC & APC | 15 | 26.7% | 6.7% | 53.3% | 13.3% | 7.7% |
| **Total** | **62** | **12.9%** | **9.7%** | **58.1%** | **3.2%** | **16.1%** |

[14] From ORS Joint Report No. 1. A total of an estimated 300 German armor vehicles were found following the battle.

**Table VII. Krinkelt, German Armor Losses, 17-20 December 1944**[15]

| Unit Tank Type | Lost[16] | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tanks | 77 | 8 | 0 | 44 | 0 | 25 | 0 |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tanks | 77 | 10.4% | 0.0% | 57.1% | 32.5% | 0.0% |

[15] Data from 38th Infantry After Action Report (including "Sketch showing enemy vehicles destroyed by 38th Inf Regt. and attached units 17-20 Dec. 1944"), from 12th SS–PzD strength report dated 8 December 1944, and from strengths indicated on the OKW briefing maps for 17 December (1st [circa 0600 hours], 2d [circa 1200 hours], and 3d [circa 1800 hours] situation), 18 December (1st and 2d situation), 19 December (2d situation), 20 December (3d situation), and 21 December (2d and 3d situation).

[16] Losses include confirmed and probable losses.

**Table VIII. Dom Bütgenbach, German Armor Losses, 19-21 December 1944**

| Unit Tank Type | Lost | Artillery | Air | AP Shot | Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Tanks | 51 | 3 | 0 | 35 | 0 | 6 | 7 |

**Percentage Loss by Type and Cause (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Tanks | 51 | 5.9% | 0.0% | 68.6% | 11.8% | 13.7% |

[17] Data from Combat Interview "26th Infantry Regiment at Dom Bütgenbach" and from 12th–SS PzD, *ibid.*

**Table IX. Percentage Losses by Type (Excluding Abandoned)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Heavy | 18 | 5.6% | 11.1% | 77.8% | 5.6% | 5.6% |
| Medium | 643 | 13.1% | 4.8% | 75.0% | 1.7% | 5.4% |
| Light | 137 | 17.5% | 20.4% | 54.0% | 0.7% | 7.4% |
| Other[18] | 182 | 8.8% | 6.6% | 54.4% | 18.7% | 11.5% |

[19]

[18] Heavy armor includes the KV-1, KV-2, Tiger, and Tiger II.[20]

[19] Medium armor includes the T-34, Grant, Panther, and Panzer IV.

[20] Light armor includes the T-60, T-70, Stuart, armored cars, and armored personnel carriers.

**Table X. Summary of Armor Losses, Tables II-VIII**

| Engagement | Lost | Artillery | Air | AP Shot | Breakdown/ Abandoned | Other | Unknown |
|---|---|---|---|---|---|---|---|
| Kursk | 648 | 84 | 11 | 471 | 82 | 0 | 0 |
| Normandy I | 108 | 9 | 10 | 53 | 11 | 10 | 15 |
| Normandy II | 222 | 4 | 10 | 23 | 171 | 1 | 13 |
| Falaise Pocket | 177 | 9 | 36 | 11 | 101 | 3 | 17 |
| Ardennes | 101 | 8 | 6 | 36 | 39 | 2 | 10 |
| Krinkelt | 77 | 8 | 0 | 44 | 0 | 25 | 0 |
| Dom Bütgenbach | 51 | 3 | 0 | 35 | 0 | 6 | 7 |
| **Total** | **1384** | **125** | **73** | **673** | **404** | **47** | **52** |

**Percentage Loss by Cause (Excluding Abandoned and Breakdown)**

| Type | Lost | Artillery | Air | AP Shot | Other | Unknown |
|---|---|---|---|---|---|---|
| Kursk | 566 | 14.8% | 1.9% | 83.2% | 0.0% | 0.0% |
| Normandy I | 97 | 9.3% | 10.3% | 54.6% | 10.3% | 15.5% |
| Normandy II | 51 | 7.8% | 19.6% | 45.1% | 2.0% | 25.5% |
| Falaise Pocket | 76 | 11.8% | 47.4% | 14.5% | 3.9% | 22.4% |
| Ardennes | 62 | 12.9% | 9.7% | 58.1% | 3.2% | 16.1% |
| Krinkelt | 77 | 10.4% | 0.0% | 57.1% | 32.5% | 0.0% |
| Dom Bütgenbach | 51 | 5.9% | 0.0% | 68.6% | 11.8% | 13.7% |
| **Total** | **980** | **12.8%** | **7.4%** | **68.7%** | **4.8%** | **6.3%** |

# Calculating an OLI Score for Armored Fighting Vehicles

by José Perez

The calculation of an OLI score for Armored Fighting Vehicles (AFVs) has undergone some changes since the TNDM was first created. These changes were the result of work done by Richard Anderson and Chip Sayers. The work was concluded in October 1994.

The changes made by Richard Anderson appeared in version 1.6 (22 September 1991). They consisted of adding the Visibility, Low–Light Capability, Power Traverse, Stabilization, Range Finding, and Ballistic Computer factors for the calculation of AFV OLI scores. The primary reason for adding these factors was to clarify the superiority of the latest generation tanks. Anderson's analysis of AFV OLI scores made it clear that modern tanks like the US's Abrams M1 were not getting scores that reflected the updated fire control and low–light capability systems in these tanks.

In general, the addition of these factors did little to change the OLI scores of most AFVs. However, those with Low-Light Capability, Stabilization, and the latest fire control systems received a boost. For example, a typical AFV might have increased its score by as little as 10% with the addition of these factors, but an AFV with a thermal imager, powered traverse, main gun stabilization, laser range finder, and ballistic computer correction for cant, ammunition, crosswind, and barrel got an OLI score that was 94% higher.

Chip Sayers' work was based an analysis of the engines, weight, size, and armor of newer tanks. His analysis indicated that the OLIs for these weapons did not reflect improvements in armor and engines. Changes were made to the Vehicle Supply, Vehicle Punishment, Radius of Action (multiplier became 0.06), and Battlefield Mobility Factors. Also, Height, Length, Ground Pressure, and Horsepower were added as factors in calculating the Battlefield Mobility Factor.

The values for the Armor Types range from 1.0 for Unimproved Armor to 1.3025 for Super–Hard Armor with Reactive Armor. This meant that a tank could receive as much as 30% more if it had the appropriate armor type. However, the resulting score did not reflect the result of increased weight: the reduced radius of action and the need for an engine with more horsepower.

The Vehicle Supply Factor calculation was changed from:

*Equation 1*

6.0 * Load / ((6.0 * Load) + Firing Rate of Primary Weapon)

to:

*Equation 2*

SQRT[ 6.0 * Load / ((6.0 * Load) + Firing Rate of Primary Weapon) ]

where SQRT = square root of
Load = rounds of ammunition for the main gun.

The original equation generally gives a result that is less than 1.0. The greater the firing rate, the smaller the result. Applying a square root to the equation reduces the effect of the firing rate. For example, if equation 1 produces the result 0.98, then equation 2 gives 0.9899.

The Vehicle Punishment Factor was originally a value entered by the analyst. Chip Sayers changed it by creating an equation to calculate it:

*Equation 3*

1.2 * Armor Type * Weight / (2.0 * Height * Length)

The effect of this equation is that the Vehicle Punishment Factor increases as the Armor Type is improved and the Weight increases. But it decreases if the Height or Length of the AFV increase.

The equation for the Radius of Action Factor is:

*Equation 4*

0.6 * SQRT( Range )

Equation 4 produces a Radius of Action Factor that increases slowly as the Range increases. The consequence of applying the square root operation to the Range also means that short–ranged AFVs are penalized, but AFVs with a longer range must have an enormously greater range in order to benefit substantially.

The Battlefield Mobility Factor equation is:

*Equation 5*

0.04 * SQRT[ (Horsepower/Weight) * Speed / Ground Pressure]

As the weight increases, the Battlefield Mobility Factor (BMF) decreases. If Ground Pressure increases, the BMF decreases. But if Horsepower or Speed increase, so does the BMF.

Many of these factors are indirectly related. For example, increased horsepower usually results in higher speeds, if all other factors remain constant. However, the horsepower is usually increased because of an increase in weight. Armor improvements can result in greater weight. Increased weight normally results in a higher ground pressure and a shorter range.

The benefit of these changes is that improvements to an AFV, such as an engine with greater horsepower or better armor, can be reflected in its OLI score.

# AFV Values in the TNDM

## "Old (QJM) Method versus Chip Sayers' "Improved Method"

by David L. Bongard

For some time, I have been aware of a potential problem in the TNDM over the calculation of Armor, or rather Armored Fighting Vehicle (AFV) OLIs. This has arisen in large measure because Col. Dupuy replaced the original, QJM–derived, calculation of Armor OLIs with a newer, more technology–oriented calculation method provided by Chip Sayers, a defense analyst with whom he had professional contact.

The "original" or "old" method for calculating Armor OLIs was, or is, comparatively simple. First, the individual OLIs of the on–board weapons are added together, modified by the multi–barrel multipliers for additional weapons after the second, so that a tank with a main gun (OLI of 90), a heavy AA machinegun (OLI of 0.984), and two light machineguns (OLIs of 0.420) would have a combined on–board OLI of 90 + 0.984 + (0.5 * 0.420) + (0.333 * 0.420) = 91.334. This sum is multiplied by the Battlefield Mobility Factor (or BMF, 0.15 times the square root of the vehicle road speed in kilometers per hour, or kph), and that product in turn multiplied by the Radius of Action Factor (or RAF, 0.08 times the square root of the vehicles operational range on roads, in kilometers). To that product is added the vehicle's Punishment Factor, calculated by multiplying one–quarter (0.25) of the vehicle weight in metric tons, by the square root of twice the vehicle weight.

That resulting sum is multiplied by the Rapidity of Fire Effect (RFE), the Fire Control Effect (FCE), the Ammunition Supply Factor (ASF), and the Amphibious Effect Factor (x 1.05 if the vehicle can ford, x 1.1 if it can "swim"). The RFE and the ASF were both determined by consulting graphs, resulting in factors ranging from 0 to 0.99. The result of all of these multiplications yields the AFV OLI.

[(Tot OLIs x BMF x RAF) + PF] x RFE x FCE x ASF x AmphF = AFV OLI

The newer method for calculating Armor OLIs is that developed by Chip Sayers in summer 1990. This was later modified, partly upon some suggestions provided by Rich Anderson, to produce the following methodology. The main weapon OLI is added to the OLIs for other on–board weapons, after those OLIs have been modified to account for ammunition supply. This total sum is multiplied by the BMF and RAF, as before, and then **multiplied** by a Punishment Factor (rather than having the Punishment Factor added to the existing sum), an Armor Factor, a Vehicle Mobility Factor (a modified version of the old Amphibious Factor). The PF is modified by the vehicle's side cross section, determined from its length and height, on the assumption that bulkier vehicles utilize a smaller portion of their full mass for armor than do more compact AFVs. The VMF is modified by the vehicle's ground pressure, this last expressed in kg per square cm.

Finally the result is multiplied by the Vehicle Attack Factor (VAF). The VAF is determined by taking the square root of a sequence of nine sub–factors, all of which are multiplied together. These nine factors are: (1) Visibility Factor (0.9 for enclosed vehicles, 1.0 for open–topped); (2) Low–Light Capability Factor, varying from 1.0 to 1.1; (3) Turret Traverse Factor (0.9 for fixed mount, 1.0 for manual traverse, 1.1 for powered traverse); (4) Stabilized Main Gun Factor (1.0 for unstabilized, 1.1 for stabilized); (5) Range Finder Factor, ranging from 1.0 (stadiametric) to 1.2 (laser); and (6) through (9), four capabilities for on–board ballistic or fire–control computers, correcting for cant, ammunition type, crosswind, and barrel condition, worth 1.05 each if the capability is present, and 1.0 if not. The maximum multiplier from the nine VAF components is 1.7473, the square root of which (and therefor the maximum VAF) is 1.3218.

Tot OLIs x BMF x RAF x PF x VMF x VAF = AFV OLI

VAF = SQRT (VisF x LLCF x TravF x SGF x RgFF x FCCFs)

It is worthwhile to examine how these two methodologies model the same two vehicles. Listed in the first table on the next page are about two dozen modern AFVs, designated by nation of origin, overall type (tank, IFV, recon vehicle), old OLI, and new OLI. The parenthetical numbers below reflect the numbers employed in the TNDM itself as the OLI values for the respective AFVs.

A few notes on these AFVs are warranted. The TAM is built in Argentina to a Thyssen–Henschel design; it mounts a 105mm gun on a 32.5 metric ton chassis. The Rooikat is an indigenous South African–designed armored car with advanced fire control and electronics systems, intended to replace its aging force of French–built AML-90 armored cars. The Rooikati105 is up–gunned with a low–recoil 105mm cannon. The U.S. FMBT–120 is based on a tank design which won a design contest in *Armor* magazine in 1993; it is armed with a 120mm smoothbore cannon, a coaxial 30mm chain gun, a 40mm automatic grenade launcher, and carries eight Stinger SAMs. The M8 AGS shown here carries the mode–two detachable armor suite, comprising composite–armor plates. The BMP–3 is the newest–generation Soviet/Russian infantry fighting vehicle, armed with a 100mm smoothbore gun (which can also fire ATGMs), and a 30mm autocannon co-axial with the larger gun.

## Modern AFVs

| Nation | Vehicle | Old OLI | New OLI |
|---|---|---|---|
| Argentina | TAM MBT | 522 | 571 |
| South Africa | Rooikat AC | 178 | 64 |
| | Rooikat-105 | 698 | 258 |
| Germany | Leopard 2 MBT | 743 | 1355 |
| | Marder 2 IFV | 177 | 63 |
| | Luchs AC | 112 | 13 |
| | Fuchs TPz-1 APC | 20 | 0.241 |
| UK/Britain | MCV-80 IFV | 222 | 200 |
| | FV-101 Scorpion | 114 | 83 |
| | FV-107 Scimitar | 52 | 33 |
| | FV-432 track APC | 19 | 0.79 |
| | FV-4211 Fox AC | 32 | 13 |
| | Challenger MBT | 517 | 1016 |
| USA | FMBT-120 | 993 | 3035 |
| | M1A2 MBT | 639 | 1436 |
| | M8 AGS | 380 | 764 |
| | M2A2 IFV | 169 | 249 |
| | M113A2 APC | 14 | 1.08 |
| USSR/Russia | T-80U MBT | 577 | 1489 |
| | T-72M1 MBT | 635 | 990 |
| | BMP-3 IFV | 263 | 290 |
| | BMP-2 IFV | 190 | 124 |
| | BRDM-2 AC | 9.35 | 0.42 |
| | MT-LB track APC | 13 | 0.68 |
| | BTR-70 whld APC | 13 | 1.28 |

As an additional comparison, I present below twenty–one AFVs (mostly tanks) from the latter part of World War II (1943–1945). It is immediately apparent from comparing the OLI scores that the newer method sharply penalizes all World War II AFVs, by a factor of roughly 50%. Armored cars lose a much greater portion of the "old" OLI score, in most cases between 90% and 95%. Assault guns and a few other vehicles (the U.S. M–10 and M–36 TDs) lose less, between 18% and 40%. This is due largely to the fact that, excepting powered turrets, none of the VAF components apply to World War II–era AFVs, nor do they carry anything except plain ordinary steel armor.

It is worth noting here that the "old OLI" methodology relatively short–changed modern main battle tanks; even the relatively simple and lightweight TAM gained a 9.4% "bonus" from conversion to the "new TNDM" methodology. Similarly, the heavilyiarmed BMP–3 gains a 10.35% bonus in transition to the new methodology. The shift is even greater for heavier tanks, ranging from a factor of 2.0 to a factor of over 3.0 for the FMBT–120. Likewise, the M8 AGS (Armored Gun System) increased its OLI by a factor of just over 2.0.

On the other hand, lighter AFVs suffered notable declines in OLI values when translated into the "new TNDM" methodology. The MCV–80 Warrior IFV suffers a "less" of almost 10%, while the FV–101 Scorpion loses over 27% of its old OLI value, and the FV–107 Scimitar loses 35.4%. Likewise, the BMP–2 loses 34.5% of its value, almost the same proportion as the FV–107 Scorpion. Stunningly, the Rooikat lost 63.9% of its value through conversion to the "new" system, and the Rooikat–105 (with an admittedly near–ridiculously high OLI) dropped 64.1%, a nearly–identical proportion. The more lightly–armed British FV4211 Fox armored car lost only 58% of its "old QJM" value with conversion to the new format. The BRDM–2, though, lost a staggering 95.5% of its OLI score through conversion to the new method.

Slightly different distinctions are noticeable for World War II AFVs. Armored cars have generally suffered a 90–95% decline in OLI value when translated from the old methodology to the new, while tanks, even light ones like the M5A1, have dropped by 25–50%. The major exception to this is the enormous PzKw VIB King Tiger, which declined from 360 to 108, in part because of its size (over 10 meters long, just over 3.0 meters tall), low engine power (only 500 hp, the same as on the 20 ton lighter Panther), and high ground pressure figures, as well as its limited operational range and comparatively low speed.

## World War II AFVs

| Nation | Vehicle | Old OLI | New OLI |
|---|---|---|---|
| Germany | PzKw-IVJ | 167 | 76 |
| | PzKw-VG Panther | 251 | 114 |
| | PzKw VIB King Tiger | 360 | 108 |
| | StuG-IIIG | 117 | 71 |
| | SdKfz-234/2 AC | 128 | 13 |
| | SdKfz-250/1 Lt HT | 4.454 | 1.267 |
| | SdKfz-251/1 Hv HT | 8.6 | 0.96 |
| USSR | BA-32 AC | 45 | 5.4 |
| | T-34/C | 193 | 133 |
| | T-34/85 | 275 | 210 |
| | SU-76 | 109 | 58 |
| | SU-100 | 298 | 247 |
| USA | M8 AC | 73 | 4.63 |
| | M4A2 Sherman | 192 | 100 |
| | M4 (76) | 212 | 113 |
| | M-10 TD | 211 | 159 |
| | M-36 TD | 276 | 172 |
| | M5A1 Lt Tank | 55 | 36 |
| | M3A1 Halftrack | 10 | 3.35 |
| | LVT(A)-4 | 117 | 38 |
| UK | Bren carrier | 2.953 | 0.2 |

Clearly, the "new TNDM" methodology strongly favors heavy and well–armed AFVs. Main Battle Tanks (MBTs) come off particularly well. More lightly–armored vehicles, excepting those that are especially heavily armed, come off poorly. Although not shown here, lightly–armed AFVs, such as APCs and recon vehicles armed only with machineguns, suffer particularly heavily, with scores between 10.0 and 19.0 under the "old QJM" calculations, and OLI scores in the 0.42 to 1.28 range under the "new TNDM" range.

Such light vehicles suffer in comparison with the older method of OLI Calculation because, under the old system, the additive PF comprised a major portion of the entire OLI. At low combat weights, the "new TNDM" method PF multiplier can be as low as 0.25, and coupling this to the generally low OLIs for machineguns, yield extremely low vehicle OLIs.

The real question in all of this is whether the model accurately assesses the battlefield, operational, and campaign value of light armored fighting vehicles and light armored vehicles generally. It certainly seems true that an APC armed with a machinegun is a more valuable combat asset than simply the machinegun alone, no matter how lightly armored the APC. Yet this nearly self–evident principle is clearly violated in the case of the BTR–70, whose 14.5mm heavy machinegun has an OLI of 1.165 on its own, while the BTR-70 is given only a 1.282. The situation with the BRDM–2 is even worse, as that vehicle is armed with a 14.5mm HMG and a PKT 7.62mm MG, yet has an OLI of only 0.424, or just 36.4% of the value of its heavy machinegun.

Something needs to be done here, either excepting "light AFVs and light armored vehicles" from the "new TNDM" methodology of OLI calculation, or developing an alternate method for OLI calculation in such cases so that the real combat value of these systems is not sold short.

# How Would We Correct Armor OLIs?

by Christopher A. Lawrence

One of the problems that we are addressing in this issue is the difference between the old QJM armor OLIs and the new TNDM armor OLIs. The problem with armor in the QJM/TNDM is that one score is used to address two entirely different functions. Armor has a use in the battlefield as a weapon system against "soft" targets and for exploitation (what I refer to as its "general" combat value), and it has a tank/antitank role. Certain vehicle characteristics, like thickness of armor and muzzle velocity, are more important for the vehicle's tank/antitank role than they are for its other roles. In fact, some of the characteristics of the vehicle that make it good for its tank/antitank role hinder it in its other roles.

The old QJM OLIs tended to underrate the antitank functions of the AFVs, resulting in large scores for lightly armored and poorly gunned vehicles and scores that were clearly too low for main battle tanks. The current system may make the error in the opposite direction, overrating the "general" combat value of the main battle tank because of the emphasis on its antitank role, while underrating the "general" combat value of all other AFVs. If a correction is needed, then it would appear that the solution could take on one of three characteristics:

1. Find a new OLI score that produces a balanced score between the different combat uses.
2. Have two different OLI scores for tanks, one for its "general" combat value and one for its tank/anti-tank value.
3. Separate out the tank/anti-tank function into a separate engagement module, using something like SSPKs for resolution.

Of course, one could produce a "balanced" score by simply averaging the two OLI systems, but I am not really sure what we've done at that point. There are many advantages to a single scoring system, one of them being elegance of use.

Having two separate scoring systems, one for its "general" combat value and one for its tank/antitank role is a relatively easy correction to make to the model, *once one figures out how to score these two different functions.*

The third option, which is to use SSPKs for calculating armor/antiarmor subroutine would involve keeping an AFV OLI for "general" combat use, with the SSPKs used primarily to determine armor attrition and the who wins the "armor battle." This method is fraught with all the usual problems of building a bottom–up model using SSPKs, including how to determine how much engagement there is, who engages who, what are the conditions of the engagement, etc. Such a subroutine could grow to be bigger than the basic model.

If the scoring system is changed, then we would need to revalidate the model to a series of engagements where considerable armor was present. In fact, I would be very tempted to start the analysis of changing the scoring system by running the TNDM with the old QJM armor values through all the engagements, and then running it with the new values, and see which scoring system performs better for which battles.

No scoring system can be validated outside of the model in which it is used. Therefore one is left with developing a scoring system that one thinks feels good, and then validating the model with the new scoring system in place.

# Use of Armor in the 76 Battalion–Level Engagements

by Christopher A. Lawrence

One of the items that was not included in the earlier listings of the engagements in the Battalion–Level Operations Database (BLODB) was the number and type of AFVs on each side. Most of the engagements had no significant armor resources, but several, were in fact heavy armor engagements. One of my concerns was whether the model has been having prediction problems due to armor being in the engagement. Therefore, in the last three columns of the table, I have identified those engagements in which we had a prediction problem with predicted winner/loser, attacker losses, or defender losses. All the engagements with armor are listed below:

| World War I | | | | | | | Prediction Problem | | |
|---|---|---|---|---|---|---|---|---|---|
| Engagement | Total Attacker AFVs | Total Defender AFVs | Attacker's % of OLI | Defender's % of OLI | Attacker's AFVs per 1000 troops | Defender's AFVs per 1000 troops | Winner/Loser | Attacker Losses | Defender Losses |
| Cantigny | 12 | | 0.1 | | 1.4 | | | | |
| St. Amand Farm | 5 | | 18.5 | | 4.3 | | | Y (low) | |
| Beaurepaire Farm | 12 | | 1.1 | | 2.7 | | | | Y (v. high) |
| Medeah Farm | 3 | | 0.8 | | 1.6 | | Y | | Y (v. low) |
| Essen Hook | 3 | | 0.7 | | 2.1 | | | Y (low) | Y (v. high) |
| Exermont | 11 | | 1.0 | | 2.1 | | Y | | |
| Mayache Ravine | 13 | | 1.2 | | 2.4 | | Y | | |
| La Neuville | 13 | | 1.6 | | 2.4 | | Y | | |

| World War II | | | | | | | Prediction Problem | | |
|---|---|---|---|---|---|---|---|---|---|
| Engagement | Total Attacker AFVs | Total Defender AFVs | Attacker's % of OLI | Defender's % of OLI | Attacker's AFVs per 1000 troops | Defender's AFVs per 1000 troops | Winner/Loser | Attacker Losses | Defender Losses |
| Tenaru 2 | 4 | | 6.3 | | 2.2 | | | | Y (v. low) |
| Chougui Pass | 13 | 25 | 79.5 | 76 | 28.0 | 133 | Y | Y (v. high) | |
| Mte Maggiore | | 18 | | 17.9 | | 5.5 | | | |
| Engebi I | 55 | | 8.0 | | 13.3 | | | | Y (v. low) |
| Eniwetok | 34 | | 9.5 | | 13.1 | | | | |
| Lausdell XRds | 102 | 3 | 63.5 | 8.7 | 30.9 | 5 | | Y (v. low) | Y (v. low) |
| Assenois | 33 | 6 | 28.3 | 61.1 | 18.3 | 12.3 | | | Y (v. low) |
| Veritable 7BW | 14 | | 47.0 | | 16.5 | | | | |
| Veritable 57G | 14 | | 41.6 | | 18.9 | | | | |
| Veritable 1BW | 14 | | 42.7 | | 18.9 | | | | |
| Veritable 1HL | 14 | | 47.3 | | 18.9 | | | | |
| Veritable 4RW | 14 | | 43.4 | | 18.9 | | | | |
| Veritable 10B | 14 | | 50.3 | | 18.9 | | | | |
| Veritable 1GH | 11 | | 40 | | 14.9 | | | | |
| Veritable 9C | 11 | 3 | 48.7 | 28.8 | 15.2 | 19.5 | Y | | |
| Veritable 2AS | 9 | | 45.9 | | 12.2 | | Y | | |
| Veritable XHL | 14 | | 59 | | 18.9 | | Y | | |
| Veritable CH | | 3 | | 19.4 | | 7.5 | Y | Y (low) | |

| Post-World War II | | | | | | | Prediction Problem | | |
|---|---|---|---|---|---|---|---|---|---|
| Engagement | Total Attacker AFVs | Total Defender AFVs | Attacker's % of OLI | Defender's % of OLI | Attacker's AFVs per 1000 troops | Defender's AFVs per 1000 troops | Winner/Loser | Attacker Losses | Defender Losses |
| Tu-Vu | | 5 | | 29.7 | | 11.9 | Y | Y (low) | Y (high) |
| Ninh Binh | 17 | | 25.5 | | 20.0 | | | | Y (v. low) |
| Prek Klok II | | 4 | | 0.0 | | 2.5 | | Y (v. low) | |
| Buell II | | 4 | | 12.6 | | 10 | | Y (v. low) | |
| Ap Bau Bang II | | 6 | | 13.2 | | 40 | | Y (low) | Y (v. low) |
| Bir Gifgafa I | 60 | 30 | 94.3 | 67.6 | 17.1 | 15 | | | |
| Bir Gifgafa II | 67 | 54 | 79.4 | 93.8 | 22.1 | 16.1 | | | |
| Mt. Hermon | 9 | 9 | 13.3 | 14.1 | 3.3 | 5.7 | | | |
| Tumbledown | 4 | | 3.2 | | 5.7 | | | | |
| Wireless Ridge | 4 | | 4.0 | | 6.1 | | | | |
| Lomba River | 38 | 28 | 46.2 | 43.6 | 34.0 | 12.4 | | | Y (high) |
| Cuatir River | 104 | 33 | 43.9 | 41.6 | 38.4 | 14.2 | | | |
| Lipanda | 41 | 23 | 44.1 | 27.7 | 33.8 | 10.2 | | | |
| TF Bayonet | 107 | 7 | 26.3 | 8.8 | 29.6 | 3 | | | Y (high) |

KEY:

v. low = For attacker, prediction is 10 to 25 percentage points below actual percent casualties.
For defender, prediction is 25 or more percentage points below actual percent casualties.

low = For attacker, prediction is 5 to 10 percentage points below actual percent casualties.
For defender, prediction is 10 to 25 percentage points below actual percent casualties.

high = For attacker, prediction is 5 to 10 percentage points above actual percent casualties.
For defender, prediction is 10 to 25 percentage points above actual percent casualties.

v. high = For attacker, prediction is 10 to 25 percentage points above actual percent casualties, except for Chouigui Pass, where the prediction is more than 25 percentage points above actual casualties.
For defender, prediction is 25 or more percentage points above actual percent casualties.

This table is a summation of all the engagements in the final battalion–level validation:

| Summation of Data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | All Engagements: | Problem Predicting Casualties | | Engagements with Armor: | Problem Predicting Casualties | |
| Era | Total Engagements | Engagements with Armor | Problem Predicting Winner/Loser | A | D | Problem Predicting Winner/Loser | A | D |
| WWI | 23 | 8 | 7 | 7 | 7 | 4 | 2 | 3 |
| WWII | 23 | 18 | 5 | 6 | 6 | 5 | 3 | 4 |
| Post-WWII | 30 | 14 | 1 | 12 | 14 | 1 | 4 | 5 |
| **Total** | **76** | **40** | **13** | **25** | **27** | **10** | **9** | **12** |
| % of Total Engagements | | 53% | | | | 77% | 36% | 44% |

As can be seen, while 53% of the engagements included armor, 77% of the engagements in which we had a problem predicting winner/loser included armor, whereas only 36% of the engagements in which we had a problem predicting attacker losses included armor, and only 44% of the engagements in which we had problems predicting defender losses included armor. It did not, therefore, appear that the presence of armor in an engagement was causing any prediction errors.

At this point, I ceased trying to do any further analysis. Quite simply, I could not see any pattern that would indicate that any of the prediction problems that I am having is related to the presence or absence of armor. If anyone sees a pattern, please let me know.

# The Second Test of the Battalion–Level Validation

## Predicting Casualties Final Scorecard

by Christopher A. Lawrence

While writing the article on the use of armor in the BattalioniLevel Operations Database (BLODB), I discovered that I had really not completed my article in the last issue on the results of the second battalion–level validation test of the TNDM, casualty predictions. After modifying the engagements for time and fanaticism, I didn't publish a final "scorecard" of the problem engagements. This became obvious when I needed that scorecard for the article on tanks. So the "scorecards" are published here and are intended to complete the article in the previous issue on predicting casualties.

As you certainly recall, amid the 40 graphs and charts were six charts that showed which engagements were "really off." They showed this for unmodified engagements and CEV modified engagements. We then modified the results of these engagements by the formula for time and "casualty insensitive" systems. We are now listing which engagements were still "off" after making these adjustments.

Each table lists how far each engagement was off in gross percent of error. For example, if an engagement like North Wood I had 9.6% losses for the attacker, and the model (with CEV incorporated) predicted 20.57%, then this engagement would be recorded as +10 to +25% off. This was done rather than using a ratio, for having the model predict 2% casualties when there was only 1% is not as bad of an error as having the model predicting 20% when there was only 10%. These would be considered errors of the same order of magnitude if a ratio was used. So below are the six tables.

| World War I Attacker | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| **-5 to -10** | St Amand | St Amand |
| | Bouzancy Rdg | Bouzancy Rdg |
| | Medeah Farm | |
| | Essen Hook | Essen Hook |
| **-5 to +5** | 15 cases | 16 cases |
| **+5 to +10** | Remilly | Remilly |
| | North Wood II | North Wood II |
| **+10 to +25** | North Wood I | North Wood I |
| | Chaudun | Chaudun |

| World War I Defender | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| **-25 or more** | Cantigny | |
| | St Amand | |
| | Medeah Farm | Medeah Farm |
| | Essen Hook | |
| **-10 to -25** | | |
| **-5 to -10** | Bouzancy Rdg | Bouzancy Rdg |
| **-5 to +5** | 9 cases | 11 cases |
| **+5 to +10** | West Wood I | West Wood I |
| | Mayache Rvn | Mayache Rvn |
| | La Neuville | La Neuville |
| | Hill 252 | Hill 252 |
| **+10 to +25** | Yvonne | |
| | North Wood I | North Wood I |
| **+25 or more** | Beaupre Farm | Beaupre Farm |
| | Chaudun | Chaudun |
| | Remilly | Remilly |
| | | Essen Hook |
| | | Yvonne |

Seven of the World War I battles were modified to account for time. In the case of the attackers we are now getting results with plus or minus 5% in 70% of the cases. In the case of the defenders, we are now getting results of plus or minus 10% in 70% of the cases. As the model doesn't fit the defender's casualties as well as the attacker's, I use a different scaling (10% versus 5%) for what is a good fit for the two.

Two cases remain in which the predictions for the attacker are still "really off" (over 10%), while there are six (instead of the previous seven) cases in which the predictions for the defender are "really off" (over 25%).

| World War II Attacker | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| -10 to -25 | Tenaru River I | |
| | Edson's Ridge | |
| | Lausdell XRds | Lausdell Xrds |
| -5 to -10 | Engebi I | |
| | Eniwetok | |
| | VER-CHx | VER-CHx |
| | Wake II | |
| | Makin Raid | |
| -5 to +5 | 13 cases | 17 cases |
| +5 to +10 | VER-RDMx | VER-RDMx |
| | | Tenaru River I |
| +10 to +25 | | |
| +25 or more | Chouigui Pass | Chouigui Pass |

| World War II Defender | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| -25 or more | Makin Raid | |
| | Tenaru River II | Tenaru River II |
| | Engebi | Engebi |
| | Lausdell XRds | Lausdell XRds |
| | Assenois | Assenois |
| -10 to -25 | Edson's Ridge | Edson's Ridge |
| | Eniwetok | |
| -5 to -10 | | |
| -5 to +5 | 11 cases | 12 cases |
| +5 to +10 | VER-1BWx | VER-1BWx |
| | VER-4RWx | VER-4RWx |
| | VER-2ASx | VER-2ASx |
| | VER-HXLx | VER-HXLx |
| | | Makin Raid |
| +10 to +25 | Wake II | |
| +25 or more | | Wake II |

Seven of the World War II battles were modified to account for "casualty insensitive" systems (all Japanese engagements). Time was not an issue in the World War II engagements because all the battles lasted four hours or more. In the case of the attackers, we are now getting results with plus or minus 5% in almost 75% of the cases. In the case of the defenders, we are now getting results of plus or minus 10% in almost 75% of the cases. We are still maintaining the different scaling (5% versus 10%) for what is a good fit for the two.

Now in only two cases (used to be four cases) are the predictions for the attacker really off (over 10%), while there are still five cases in which the predictions for the defender are "really off" (over 25%).

| Post-World War II Attacker | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| -25 or more | Long Tan | Long Tan |
| | Prek Klok II | |
| | Ap Bau Bang II | |
| | Lo Giang I | |
| -10 to -25 | Tu-Vu | |
| | Mapu | Mapu |
| | Buell II | Buell II |
| | Prek Klok I | |
| | | Prek Klok II |
| -5 to -10 | Lo Giang II | Lo Giang II |
| | Nui Ba Den | |
| | Mt Longdon | Mt Longdon |
| | | Ap Bau Bang II |
| | | Tu Vu |
| -5 to +5 | 17 cases | 18 cases |
| +5 to +10 | Salinas | Salinas |
| | Cau Lanh | |
| +10 to +25 | | Cau Lanh |
| +25 or more | | Lo Giang I |
| | | Prek Klok I |

| Post-World War II Defender | | |
|---|---|---|
| Predicted Casualties Off By: | Predicted | Time Modified CEV Predicted |
| -25 or more | Tu-Vu | |
| | Ninh Binh | Ninh Binh |
| | Cai Nuoc | Cai Nuoc |
| | ZDB050 | |
| | Hill 450 | |
| | Prek Klok I | |
| | Ap Bau Bang II | Ap Bau Bang II |
| | Lo Giang II | |
| | Mt Harriet | Mt Harriet |
| | Mt Longdon | Mt Longdon |
| -10 to -25 | Cau Lanh | |
| | Lo Gianh I | |
| | Nui Ba Den | |
| | | Prek Klok I |
| | | Lo Giang II |
| -5 to -10 | Mapu | |
| | Bir Gifgafa II | Bir Gifgafa II |
| | Two Sisters | Two Sisters |
| | Lipanda | Lipanda |
| | | Nui Ba Den |
| -5 to +5 | 9 cases | 10 cases |
| +5 to +10 | | Lo Giang I |
| | | Long Tan |
| +10 to +25 | Salinas | Salinas |
| | Pearls AFB | Pearls AFB |
| | Lomba | Lomba |
| | TF Bayonet | TF Bayonet |
| | | ZDB050 |
| | | Cau Lanh |
| | | Tu-Vu |

Only 13 of the 30 post–World War II engagements were not changed. Two were modified for time, eight were modified for "casualty insensitive" systems, and seven were modified for both conditions.

In the case of the attackers we are now getting results within plus or minus 5% in 60% of the cases. In the case of the defenders, we are now getting results within plus or minus 10% in around 55% of the cases. We are still maintaining the different scaling (5% versus 10%) for what is a good fit for the two.

We have seven cases (used to be eight cases) in which the attacker's predictions are "really off" (over 10%), while there are only five cases (used to be 10 ) in which the defender's casualty predictions are "really off" (over 25%).

## Repetitious Conclusion

To repeat some of the statistics from the article in the previous issue, in a slightly different format:

| *World War I Engagements* | *Actual Average Attacker % Losses* | *Predicted Average Attacker % Losses* | *Standard Deviation* | *Actual Average Defender % Losses* | *Predicted Average Defender % Losses* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| 23 Engagements | 8.05 | 7.45 | 5.42 | 26.29 | 29.41 | 27.74 |
| | | | | | | |
| As corrected (total) | 8.05 | 7.92 | 4.87 | 26.29 | 36.52 | 23.44 |
| 16 unmodified | 8.58 | 9.90 | 5.09 | 18.38 | 31.59 | 25.66 |
| 7 modified | 6.84 | 3.38 | 4.34 | 44.35 | 47.78 | 17.35 |

| *World War II Engagements* | *Actual Average Attacker % Losses* | *Predicted Average Attacker % Losses* | *Standard Deviation* | *Actual Average Defender % Losses* | *Predicted Average Defender % Losses* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| 23 Engagements | 7.36 | 5.62 | 8.49 | 26.58 | 14.25 | 29.38 |
| | | | | | | |
| As corrected (total) | 7.36 | 7.93 | 7.56 | 26.58 | 22.41 | 27.81 |
| less Wake II[1] | | | | 26.89 | 18.89 | 22.71 |
| | | | | | | |
| 16 unmodified | 5.06 | 5.87 | 8.44 | 15.77 | 9.95 | 22.65 |
| 7 modified | 12.63 | 12.65 | 5.00 | 51.29 | 50.89 | 36.99 |
| less Wake II | | | | 56.54 | 42.70 | 22.89 |

[1] At Wake II, the defenders (US Marines) surrendered after suffering 19.77% casualties. The revised predicition had them suffering 100%, which certainly would have been the case had they not surrendered.

| *Post-World War II Engagements* | *Actual Average Attacker % Losses* | *Predicted Average Attacker % Losses* | *Standard Deviation* | *Actual Average Defender % Losses* | *Predicted Average Defender % Losses* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| 30 Engagements | 12.26 | 4.55 | 14.63 | 26.84 | 11.94 | 25.75 |
| | | | | | | |
| As corrected (total) | 12.26 | 11.77 | 12.30 | 26.84 | 22.49 | 21.45 |
| 13 unmodified | 3.42 | 3.42 | 3.03 | 21.19 | 15.25 | 24.33 |
| 17 modified | 19.01 | 18.16 | 16.10 | 31.16 | 28.05 | 18.97 |

| *Other Data Summations (this is a repeat from the last issue)* | *Actual Average Attacker % Losses* | *Predicted Average Attacker % Losses* | *Standard Deviation* | *Actual Average Defender % Losses* | *Predicted Average Defender % Losses* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| 15 "cas. insensitive" | 18.29 | 17.78 | 13.34 | 49.03 | 46.74 | 31.10 |
| less Wake II | | | | 51.12 | 42.94 | 24.01 |
| | | | | | | |
| 9 time corrected | 5.84 | 2.70 | 4.05 | 35.77 | 37.46 | 15.50 |
| | | | | | | |
| 7 time corrected and "cas. insensitive" | 18.96 | 18.57 | 16.47 | 20.24 | 18.39 | 12.65 |

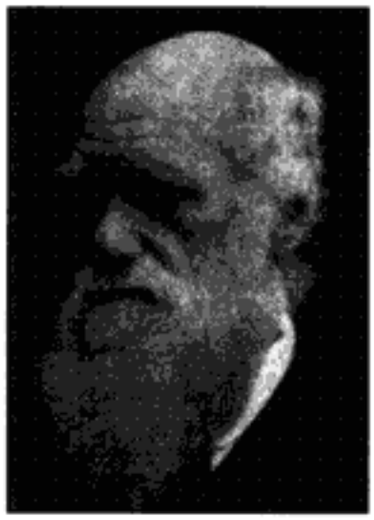
| *Final Fit on the Data (this is a repeat from the last issue)* | *Actual Average Attacker % Losses* | *Predicted Average Attacker % Losses* | *Standard Deviation* | *Actual Average Defender % Losses* | *Predicted Average Defender % Losses* | *Standard Deviation* |
|---|---|---|---|---|---|---|
| World War I | 8.05 | 7.92 | 4.87 | 26.29 | 36.52 | 23.44 |
| World War II | 7.36 | 7.93 | 7.56 | 26.58 | 22.41 | 27.81 |
| Post-World War II | 12.26 | 11.77 | 12.30 | 26.84 | 22.49 | 21.45 |
| ***Total*** | ***9.50*** | ***9.44*** | ***9.18*** | ***26.59*** | ***26.71*** | ***24.12*** |

# TDI Profile: Jay Karamales

Robert Heinlein once wrote that specialization is for insects; another way of describing someone who subscribes to that credo could be "jack of all trades, master of none" and would be an appropriate introduction to this newsletter's production manager and contributing editor, Jay Karamales.

Jay was trained as a computer scientist, attending George Mason University in Virginia during the early 1980s. After stints as a White House consultant, data processing manager for a regional bank, and computer scientist for the USDA, Jay went to work for Trevor Dupuy's Data Memory Systems Inc. in 1987. Col. Dupuy hired him to design the Ardennes Campaign Simulation Database, and to be DMSI's general computer guru. Along the way, though, Jay's latent interest in history was piqued by the nature of the historical research and analysis going on around him. Then Chris Lawrence press-ganged him into helping with some of the research for the ACSDB, including the German unit location data. (Jay had taken five years of German in school, so that he could understand what the Germans were saying in the old war movies without relying on the subtitles.)

By 1989 DMSI had fallen on hard times because of the lack of defense funding for such frills as historical research. Fortunately Jay was able to secure a position at Science Applications International Corporation as half-historian, half-programmer/analyst, which suited his short attention span quite well. The highlight of his tenure at SAIC was producing the Anti-Armor Defense Data (A2D2) study for the US Army and British DOAE, under the aegis of noted British OR expert David Rowlands. A2D2 formed the basis for Jay's book *Against the Panzers*, co-authored by Allyn R. Vannoy and published in 1996 by McFarland & Co. of Jefferson NC. While at SAIC Jay also enjoyed designing databases, writing modeling and simulation software, installing and administering networks, and contributing to other small historical projects.



In early 1996 Jay left SAIC to form a software design company, C.K. Analytical Services Inc., with several childhood friends. So far, burdensome wealth has eluded them, so Jay has been sure to maintain ties with DMSI's successor organization, The Dupuy Institute. His consulting work for TDI has consisted primarily of assisting his old boss, Chris Lawrence, to compile and maintain the Kursk Database, and to oversee the physical construction of this newsletter via Jay's small computer graphics company, Olórin Press.

Jay lives in Vienna, Virginia, with his wife Maureen and two terriers, Darwin and Pixel. In his spare time, which amounts to about 20 minutes every other week, he paints Civil War miniatures, collects antique maps, designs computer wargames, listens to Celtic music, and works on the sequel to *Against the Panzers.*