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MEASURING THE EFFECTS OF COMBAT IN CITIES PHASE I

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INTRODUCTION

Fighting in and around cities, sometimes defined as 'military operations on urbanized terrain' or MOUT, is a concern for military planners as the world becomes more urbanized. Planners are concerned not only with how to fight in such conditions, but also with attempting to represent such operations in current combat models. This study is distinctly oriented to that latter purpose, although there is no question, as with any in-depth analytical study, that there may be some broader lessons to be drawn from this effort.

Urban terrain can consist of cities, their suburbs and other built-up areas such as large towns, villages, and industrial complexes. For this study we will focus specifically on cities. While there is no shortage of examples of modern combat, there are surprisingly few examples of fighting that actually occurred within cities.[1] Fighting in cities tends to be avoided. Mobile operations tend to by-pass cities, rather than fight in them. The current concern over urban operations is because increasing urbanization and population density, the growing size of cities, and the growth of their extensive suburbs make it increasingly more difficult to avoid or bypass cities. Therefore, *The Dupuy Institute* (TDI) has focused its effort on researching actual combat in cities, in an attempt to determine what are the actual (as opposed to perceived) differences in casualty rates, force ratios, time and outcome between urban combat and combat in other types of terrain.

This study is focused on the impact of urban terrain on division-level engagements and army-level operations. These are the levels where records can easily be found, where *The Dupuy Institute* has already done considerable work, and where we have already developed extensive data bases. These databases utilize two-sided data drawn from the unit records of the opposing sides. However, the original TDI databases only contained five engagements in urban terrain and none in major cities. Therefore, it was essential to conduct additional research to add a collection of engagements in and around urban terrain.

While the focus of this study is urban operations, comparison to other operations – which in this case are operations in other types of terrain – is necessary if any meaningful understanding is to be gained. As such, existing TDI research, including the use of the *DuWar* databases, was utilized to provide a contrast to urban operations.

The actual research in urban operations was focused on creating division-level engagements and army-level operations in the same format as the *DuWar* database (a format similar to the CAA CHASE database). These urban operations are drawn primarily from engagements at Kharkov in 1943 (three separate battles), in France during 1944 including the Channel and Brittany port cities of Brest, Boulogne, Le Havre, Calais, and Cherbourg, as well as Paris, and the extended series of battles in and around Aachen in 1944. These are then contrasted to existing data TDI has collected on fighting in contrasting, non-urban terrain on the Eastern Front in 1943 and in Western Europe in 1944.

This report was primarily the work of TDI Executive Director Christopher Lawrence and of TDI Historian Richard C. Anderson.

[1] Appendix V is a list of examples of urban combat that occurred in the 20th century.

PREVIOUS STUDIES

This study is completely independent and does not rely on work done in previous studies. Still, *The Dupuy Institute* examined a number of recent studies that addresses MOUT. The primary purpose of this study is to provide quantitative inputs for combat modeling. The purposes of the other studies varied, but none were exclusively created for that purpose. Still, data was presented, statements were made and conclusions were reached in these studies that could have an impact on combat modeling, in addition to their impact on US defense planning and development of operational art. As such, TDI reviewed them for the sake of determining what hypotheses and conclusions they put forward, and whether these hypotheses and conclusions matched, confirmed, contradicted or could be tested to the data that TDI was collecting.

The results of this review are presented in Appendix VII, **Recent MOUT Literature**. Under **Recent MOUT Literature** we extracted statements, hypotheses and conclusions from the previous studies, and then tested them to the MOUT data that we have collected.

TDI did not conduct an exhaustive literature search, as such an effort would not have been possible within the limited time and budget of this project. The studies examined were those that could be easily located and that we felt had some significance. They are, from earliest to most recent:

R. D. McLaurin, Paul A. Jureidini, David S. McDonald (Abbot Associates, Inc.) and Kurt J. Sellers (Human Engineering Laboratory), *Modern Experience in City Combat* (Abbot Associates, Inc., published by the US Army Human Engineering Laboratory: Aberdeen Proving Ground, MD, March 1987).

Colonel (Retd) RA Leitch, MBE RGN, Dr. HR Champion, F.R.C.S. (Edin) F.A.C.S., Dr. JF Navein MB ChB M.RC.G.P. *Analysis of Casualty Rates & Patterns Likely to Result from Military Operations in Urban Environments* (US Marine Corps Commandant's Warfighting Laboratory: Washington, DC, November 1997).

Sean J. A. Edwards *Mars Unmasked: The Changing Face of Urban Operations* (RAND, MR-1173-A, 2000).

Russell W. Glenn *Heavy Matter: Urban Operation's Density of Challenges* (RAND, MR-1239, 2000).

Other studies, articles and papers were examined, including studies on urban engagements in Hue, Suez City, Groznyi and Mogadishu but these were not related closely enough to our work to be commented on in this study.

STUDY PLAN

Study Overview

Due to funding limitations this study was broken into two phases. The first phase was planned to cover analysis of division-level engagements in urban terrain. This was to include about 30 division-level engagements from the three Battles of Kharkov in February, March and August of 1943, at least six division-level engagements from the Channel and Brittany Ports operations (June—September 1944) and at least five division-level engagements from the fighting in Aachen, Germany (October 1944). These division-level engagements were to provide a baseline from which to compare operations in urban terrain with operations in non-urban terrain. They were to be compared to combat by similar units, in the same theater of operation, at roughly the same time, fighting in non-urban terrain. The baseline for operations in non-urban terrain would be the 49 existing Battle of Kursk engagements (July 1943), at least 31 Normandy and Breakout and Pursuit Engagements (June—September 1944), 18 existing Westwall and Lorraine Engagements, and 76 existing Ardennes Engagements (October 1944—January 1945).

The urban engagements and non-urban engagements were chosen so as to minimize cost by building on existing work and to allow us to compare the results not only in aggregate, but also by region, time and opponent. As such, the Kharkov engagements were to be compared to the Kursk engagements, the Channel and Brittany Port engagements were to be compared to the Normandy and Pursuit engagements, and the Aachen Engagements were to be compared to the Westwall, Lorraine and Ardennes Engagements. Thus, at least 41 urban engagements were to be compared to at least 174 non-urban engagements.

Study Timeline

The following major milestones occurred during this project.

- Contract received by *The Dupuy Institute* on 19 September 2001. The contract was dated 15 August 2001.
- Research began in the Allied and German European Theater of Operations (ETO) records on 11 September.
- Research began in the Russian records for Kharkov on 15 September.
- Research began in the German records for Kharkov on 12 October.
- Work began on creating engagements for the database in early October.
- Provided an In-process Review (IPR) to CAA on 5 November. No significant changes in direction or emphasis came from the IPR.
- Work began on the Final Report for Phase I on 3 December.
- Project Phase I and Final Report completed 11 January 2002.

Cleaning and Culling the Data Base

The original *Land Warfare Data Base* (LWDB) was based upon the concept of measuring battle results. It was unconcerned with partitioning the data by the length and scale of the battle. As a result, 'battle' was only loosely defined by time and scale – the data

base included ‘battles’ involving fewer than 1,000 troops to as many as 750,000 troops, with some lasting less than a day and others many months. As a result of the work for the *Enemy Prisoner of War (EPW) Study*, TDI discovered that it was culling those engagements from the analysis that were particularly small, since the statistical character of the smaller engagements was clearly different **because** of their small size.

In anticipation of this contract, *The Dupuy Institute* updated what it now refers to as the TDI *DuWar* suite of combat databases. This consists of eight different databases covering wars, small scale contingency operations, campaigns, pre-1900 battles, large actions, division-level engagements, battalion-level operations and small actions. Three of the eight data bases were originally developed from the *Land Warfare Data Base* (LWDB), which was originally developed as the CHASE database by the *Historical Evaluation and Research Organization* (HERO, a predecessor organization to TDI) under contract from CAA.

TDI has recently updated the databases. First, the existing TDI *Battalion-Level Operations Data Base* (BLODB), which was a *Reflex* data base, was converted to an *Access* database. The BLODB was originally created as a validation database for Trevor N. Dupuy's *Tactical Numerical Deterministic Model* (TNDM). The new Access database was assembled by moving some engagements that were battalion-level from the old LWDB and adding the engagements from the old Reflex database. This was an independent TDI effort that was not part of this contract, but since it "cleaned up” the division-level database, it has had some effect on this MOUT Study.

Second, because some of the large engagements in the original LWDB were inappropriate for a division-level data base, TDI transferred 55 of them from the *Division-Level Engagement Data Base* (DLEDB) to their own separate data base, the *Large Action Data Base* (LADB). Finally, three very small engagements were transferred from the DLEDB to a new *Small Action Data Base* (SADB).

As a result of these changes, the LADB consisted of 55 engagements, the DLEDB of 332 engagements, the BLODB of 89 engagements, and the SADB of 3 engagements. Only the DLEDB was used for Phase I of this effort, although it may be possible to later conduct an analysis of battalion-level urban combat. TDI has also prepared a *DuWar User's Manual*.

The DLEDB engagements are normally only those that lasted from one to five days, that occurred in the 20th century, and which were fought between division, corps or brigade-size units. As a result the number of engagements were reduced, primarily because of the transfer of the army, battalion and company-size engagements from the database. This revision effectively removed the size and duration outliers from the database. The revised count of existing division-level engagements remains 49 for Kursk, nine for Normandy/Breakout and 68 for Westwall/Ardennes. The *DuWar Database* currently consists of:

Abbreviation	**Description**	**Period**	**Number of Cases**
WACCO	List of wars and conflicts	1898 - 1998	793
SCCO	Contingency Operations, in depth	1944 - 2001	203
CADB	Army-level Campaigns	1904 - 1991	183
LADB	Army-level Battles	1912 - 1973	55
DLEDB	Division-level Engagements	1904 - 1991	443
BLODB	Battalion-level Engagements	1918 - 1991	129

SADB	Small-Actions	1944 - 1982	3
BADB	Battles	1600 - 1900	243

The databases are programmed in *Access* and are documented in the *DuWar User's Manual*. Some (LADB, DLEDB, BLODB and BADB) include elements built from the *Land Warfare Data Base* (LWDB) of 603 engagements (an earlier version of the LWDB was the CAA CHASE data base of 599 engagements). Currently the *DuWar Databases* includes 873 LWDB-type engagements.

Definition of Urban Terrain

One of the first issues encountered in this study was defining what exactly constitutes “urban” terrain. Urban terrain may vary from suburban sprawl and large villages to Manhattan-like urban development. TDI sub-categorized the urban terrain engagements as four types:

1. **Urban terrain:** a well developed built up area with a number of buildings taller than two-stories. In effect, cities; including warehouses, industrial parks, rail yards and regular parks.
2. **Suburban terrain:** the suburban areas that typically surround American and other cities, primarily consisting of housing and small business buildings. Suburban terrain is typified by some degree of continuous development and settlement.
3. **Conurbation:** defined as "an aggregation of continuous networks of urban communities" or a "city surrounded by large numbers of urban districts." TDI specifically uses this term to describe the pattern of settlement commonly seen in Europe, where large numbers of small and medium villages or built up areas exist, with large tracts of clearly undeveloped land between them. As such, a division-level operation would be expected to encompass one or more of these villages, and they would serve as significant strongpoints in any defensive scheme.
4. **Shantytowns:** the rather extensive collection of low-lying, and fairly insubstantial, temporary structures that often make up significant sections of major cities in third-world countries.

Operations Before, During and After the City Fighting

Another issue encountered was the possible necessity of characterizing and analyzing the operations that occur before, during and after the city fighting. They may be basically defined as:

1. **Approach operations**: the engagements that occur when approaching an urban area and just before entering it. It is suspected that there may be some difference in these operations when they are compared to operations in other non-urban terrain.
2. **Proximity operations:** the engagements that occur in the non-urban terrain around a city or built-up area during fighting in those areas. These may differ from other non-urban operations in that their purpose and pacing may be driven by what occurs in the adjacent urban areas. Also, since they occur at the same time and in the same area, and often with the same units as those fighting in the city, these are particularly useful for comparison to the related urban operations.

3. **Exit operations:** the engagements fought after the urban area has been penetrated and when the engagement transitions back to non-urban terrain. It is unknown if there is any difference between exit operations and other operations in non-urban terrain, but it appears worth exploring further.
4. **Mop-up operations:** the engagements – often fought by smaller units – to clear and or secure a city. This often includes combat – usually at a much lower level of intensity – and can sometimes consume considerable time and resources. As such, these operations need to be studied further.

Although these operations may be significant, the study of these four categories of urban related operations was not included as part of Phase I or the proposed Phase II of this study. Still, TDI ensured that data useful for the further analysis of such operations was recorded as research in the various archival records was done.

What Was Done

The Dupuy Institute found that once the European Theater of Operations battles were explored in depth, a significantly greater number of engagements could be generated from these battles. It was determined that at least 46 division-level engagements occurring in an urban environment could be created from the ETO data. While most of the engagements were not urban, most did occur in conburban terrain, and as such were useful for analysis. Since the archival material was extensive and complete for both the US and German side, and since the forces involved were a good representation of the modern US Army, TDI decided that this research should have first priority.

The ETO offered more accessible and better records for the opposing sides than did most other theaters in World War II. And the armies involved (US, UK, Canadian and German) all had doctrines familiar to the modern US Army, and the performance differences between the armies were not as significant as in some other theaters. Therefore, producing as many urban and conurban engagements from this theater as possible was most useful. The ETO engagements that were completed for Phase I are:

	Urban	**Conurban**	**Non-urban**
Aachen	9	12	2
Boulogne	3	2	2
Calais	1	2	3
Dieppe	1		
Le Havre	2		1
Cherbourg	2	1	4
Brest	5	5	2
Paris	1		
	--	--	--
	24	22	14

As a result, the Eastern Front work was given a lower priority than was originally planned. In the original plan, one-half of the Kharkov engagements were to be completed in Phase I, and one-half in Phase II. Indeed, most of the scheduled Eastern Front research has been completed for Phase I. This includes conducting all the German research, inputting the

data for the German side for 37 division-level engagements, and completing most of the Soviet research. However, due to a number of niggling problems, the Soviet research effort was not completed by the end of November, and therefore it was not possible to input the data for the Soviet side of the engagements in a timely manner.

The problems experienced with the Soviet research were minor, but were sufficient to prevent the research from being completed on schedule.

The schedule budget for this contract was only 80 percent of what was programmed due to the pass-though cost of the contract. Still, the Institute has completed 60 new engagements in Phase I, a total of 46 new urban and conurban and 14 new non-urban, only one short of the proposed 61.

	Existing	**New**	
Aachen			
Urban		9	
Conurban		12	
Non-Urban		2	
Channel Ports			
Urban		14	
Conurban		10	
Non-urban		12	
Normandy/Pursuit			
Urban(Paris)		1	
Non-urban	9		
Westwall/Lorraine (Non-Urban)	11		
Ardennes (Non-urban)	57		
Total			137
Urban			24
Conurban			22
Non-Urban			91

Phase II

Phase II will be an expansion of the Phase I work and will also examine the impact of urban combat on army-level operations.

Completion of the Kharkov Engagements

The Kharkov research will also be completed in Phase II and is expected to produce the following additional engagements:

	February 1943	March 1943	August 1943
Urban		3	3—8
Conurban	10	27	3—22
Non-urban	1	4	

The work for the February and March engagements are substantially complete and the count of engagements will not change. The count of the August engagements may change once work starts on them. This phase II work will then examine 46 more urban and conurban engagements from Kharkov and compare them to at least 49 non-urban Kursk engagements.

Army-level Operations

Phase II will also address army-level operations. Army-level operations will be examined using the *DuWar* CaDB by adding three army-level operations from the Kharkov campaigns and comparing them to 14 new army-level operations from the Kursk Campaign. For the ETO, we will examine 12 operations (two existing and 10 new) from the Normandy and Breakout and Pursuit campaigns, 10 operations (one existing and nine new) from the Westwall and Lorraine campaigns and 10 operations (all new) from the Ardennes Campaign. Since there appears to be only three army-level urban operations in the ETO to directly compare these to (Aachen, Geilenkirchen-Juelich and Metz), we will examine the relative differences between the casualty rates, force ratios, length of time, and outcomes between the army-level operations and the division-level operations. We will then examine the difference between the division-level urban engagements and the division-level non-urban engagements to see if a reasonable set of comparisons and rules for army-level operations can be developed.

In the case of the Eastern Front data from Kharkov and Kursk, the comparison can be done directly between both army-level urban and non-urban operations, and between division-level engagements and army-level operations.

Analysis Plan for Phase I and II (Data Base Analysis)

The analysis will be twofold. First we will identify a set of Urban engagements in the *DuWar* databases (from the DLEDB and the CDB). These will be compared and contrasted statistically to other related non-urban engagements. First, division-level engagements are examined in Phase I. Twenty-five urban and conurban Channel Coast and Paris engagements are compared to 21 non-urban engagements from the Normandy and Pursuit Across France campaigns and 21 urban and conurban Aachen engagements are compared to 70 engagements from the Westwall, Lorraine and Ardennes campaigns. Rhat analysis is addressed in this report.

In Phase II, 46 urban and conurban Kharkov engagements will be compared to about 49 Battle of Kursk engagements. This will complete the analysis of the division-level engagements. The second part of Phase II will analyze the army-level urban and non-urban operation. The selection for these is more limited, but will include 14 Kursk Campaign operations, three Kharkov operations, 12 Normandy and Pursuit Across France operations, and 20 Westwall, Lorraine and Ardennes operations.

Data will be used to made the following comparisons:

1) Force Ratios
2) Mission Success (Outcome)
3) Casualty Rates
4) Armor Loss Rates
5) Duration of Combat (Time)

6) Advance Rates
7) Linear Density

In addition to this detailed analysis, in Phase II, TDI will also undertake a macro examination of such operations, reviewing the urban fight in context with the operations around it, and drawing general conclusions based upon those examples. Many of the operations in the attached list (Appendix V) will be addressed in this macro look, and some statistical representation may be developed, but by its nature, such a view will be less rigorous than that derived from the databases.

Finally, in Phase II, TDI will develop a set of rules that describes how one can represent urban combat in combat models. These rules will be contrasted with combat in other terrain, so that such rules may be included within any model.

Unplanned Analysis

The Dupuy Institute has discovered over the course of numerous studies, that a byproduct of research into one subject is an accumulation of data that is usable for analysis beyond what was originally contracted. As has become our habit, as time and budget allow, TDI will examine other facets of the problem and will look at issues in ways different from what was originally proposed. For this project this includes a number of unplanned analytical efforts.

First, not only did we collect data on the fighting in cities, but also on the fighting that occurred while getting to the city, the fighting that went on around the city, the fighting during the exit from the city, and related mopping up actions in the city. This leads to an ability to look at issues such as advance rates and casualties involving the same forces that advanced on the city, fought in the city and conducted the pursuit after exiting the city. This is discussed in-depth in this report as a series of **Case Studies** covering the Battle of Aachen and the Channel Port battles.

Second, some of the data can shed light on other issues, and as such, these are discussed briefly in this report as **Other Issues**. These include analysis of armor losses, the frequency and degree of surprise as a factor in urban combat, the use of consumables (focusing on ammunition, but including remarks addressing other logistic items) in urban combat, and whether human factor differences are magnified in urban combat.

Third, since this study utilizes World War II data only, and some elements of the world have changed since then, TDI will briefly discuss what the impact of any changes might be. This section of the report is titled **CHANGES IN TECHNOLOGY AND THE POSSIBLE IMPACT ON URBAN WARFARE**.

Finally, our review of the current literature analyzing urban operations has elicited a number of statements, hypotheses and conclusions regarding urban. We have decided to test them as best we may, and see how they fit to our real-world data. In Appendix VII of this report titled **Recent MOUT Literature** we determine whether or not various statements, hypotheses and conclusions are supported, unsupported or contradicted by the data we have collected.

RESEARCH

Research for the European Theater of Operations Engagements

Research for the ETO was relatively straightforward. Richard Anderson utilized the resources of the US National Archives to obtain records for the US Army, the German Army and casualty records for the British Commonwealth Army. The existing records of *The Dupuy Institute*, drawn from the US National Archives, the Federal German Archives and the British Public Records Office supplemented these. Much of the information regarding the Commonwealth operations at the Channel Ports was derived from the postwar accounts of the Canadian Military Headquarters Historical Section, which are available online. Data for the engagements was derived entirely from these primary sources. Secondary sources were only consulted for narrative material.

Few other urban engagements in the ETO in 1944 remain to be explored. Most have already been accounted for in this study. The option of investigating urban engagements during the last year of the war in Germany was not seriously considered. First, the German records in 1945 are of poor quality, most unit records were simply never collected in the last chaotic six months of the war. Second, most of the urban fighting occurred in March or later, when the German Army was in full retreat, demoralized, and in some cases surrendering en masse. Human factor difference would certainly play a much bigger part in the results of that data. As a result, this data could not be directly comparable to non-urban 1944 data.

Research for the Russian Front Engagements

The Russian research was, as always, more complicated. TDI was forced to replace its original Russian research team, which we have used since 1993. Our new researcher obtained permission to work in the Russian Military Archives and began work on 15 September. He is working full-time on this project and has been approved for work in the Archives through 2002.

All data used for the Kharkov and Kursk engagements are drawn from primary sources, the original unit records. Those for the German forces are from the US National Archives and the Federal German Archives those for the Soviet forces are from the Russian Military Archives.

DATA DESCRIPTION

Aggregated Data, Urban versus Non-urban Engagements

The analysis of the ETO engagements in Phase I compares urban combat in the Channel and Brittany ports and Paris with non-urban combat during the Normandy and Breakout and Pursuit campaigns. Urban combat in Aachen is compared with non-urban combat during the Westwall, Lorraine and Ardennes campaigns.

	Urban Channel Ports Brest and Paris	**Non-urban Normandy and Breakout & Pursuit**
Number of Engagements	25	21
Average Attacker Strength	44,621	33,018
Average Defender Strength	10,312	16,376
Average Force Ratio	8.01	3.55
Weighted Force Ratio	4.33	2.02
Percent Attacker Wins	84.00	71.43
Average Battle Length (days)	1.08	2.52
Average Attacker MBT Strength	171	185
Average Defender MBT Strength	8	43
Average Attacker Casualties	215	888
Average Defender Casualties	3,121	1,711
Average Attacker Casualties per day	199	352
Average Defender Casualties per day	2,890	678
Average Attacker Percent Loss per day	0.45	1.49
Average Defender Percent Loss per day	44.13	9.63
Weighted Attacker Percent Loss per day	0.45	1.07
Weighted Defender Percent Loss per day	28.03	4.44
Average Advance Rate (km/day)	2.45	2.59
Attacker Linear Density (men/km)	4,614.17	2,072.20
Attacker Weighted Linear Density	3,331.89	1,896.96

	Urban Aachen	Non-urban Westwall, Lorraine, and Ardennes
Number of Engagements	21	70
Average Attacker Strength	22,672	17,473
Average Defender Strength	9,913	10,332
Average Force Ratio	2.43	2.13
Weighted Force Ratio	2.29	1.69
Percent Attacker Wins	95.24	58.57
Average Battle Length (days)	1.00	1.70
Average Attacker MBT Strength	151	100
Average Defender MBT Strength	37	43
Average Attacker Casualties	134	343
Average Defender Casualties	530	547
Average Attacker Casualties per day	134	202
Average Defender Casualties per day	530	322
Average Attacker Percent Loss per day	0.57	0.97
Average Defender Percent Loss per day	5.58	3.99
Weighted Attacker Percent Loss per day	0.59	1.15
Weighted Defender Percent Loss per day	5.35	3.11
Average Advance Rate (km/day)	0.96	2.81
Attacker Linear Density (men/km)	2,089.17	2,068.95
Attacker Weighted Linear Density	1,773.26	1,355.58

A cursory examination of these statistics does not provide any immediate illumination regarding the impact of urban warfare on combat. The force ratios involved tend to be fairly typical of all engagements in the *DuWar* DLEDB except for those Urban engagements from the Channel Ports, Brest and Paris data set, where they are very favorable to the attacker. In both sets of Urban engagements, the mission success rate of the attacker is high. That is probably driven by the circumstances in those campaigns, and is not indicative of the nature of urban combat. In both Urban data sets the casualty rates for the attacker is noticeably lower than in the Non-urban data sets. For the defender, they are higher, and in the "Channel Ports" engagements, much higher. Armor loss rates are addressed later in the Data Base Analysis section of this report. The average engagement length is driven by the definition of what constituted each engagement and is not an indication of any difference that may have been caused by the urban environment. The advance rates are fairly typical, except for the "Channel Ports," where it is very low (but where the attacker did achieve a

very favorable casualty ratio). Density is again typical, with the "Channel Ports" having higher density.

Overall, it is clear that the nature of the "Channel Ports" engagements are different from the rest, having very favorable force ratios, very favorable casualty ratios, low advance rates and higher density. The favorable casualty ratio is due to the defender in most cases being encircled (since the Allied attackers enjoyed naval supremacy and aerial superiority), and as a result at some point in the series of engagements they had 100 percent of their remaining force captured. The low advance rate may be more related to the more relaxed pace of operations, as these battles were being conducted well to the rear of the front.[1] It does not seem to indicate a difference in terrain, as the same difference does not show up in the Aachen engagements. The higher densities also appear to be situation specific.

What stands out in the two data sets is the lower attacker casualty rates. They tend to be about one-half of those found in Non-urban engagements. The higher defender casualty rates in the Urban engagements are probably due to the lop-sided nature of the engagements and their results. This will be examined further.

Aggregated Data, Urban versus Conurban Engagements

The first question raised is whether or not there is a significant difference between the Urban and Conurban combat. A simple glance at the aggregate statistics may suffice to answer that question.

	Urban Channel Ports Brest and Paris	**Conurban Channel & Brittany Ports**
Number of Engagements	11	14
Average Attacker Strength	46,077	43,477
Average Defender Strength	9,367	11,054
Average Force Ratio	9.51	6.83
Weighted Force Ratio	4.92	3.93
Percent Attacker Wins	72.73	92.86
Average Battle Length (days)	1.00	1.14
Average Attacker MBT Strength	194	153
Average Defender MBT Strength	8	8

[1] It should be noted that there is a fine distinction involved here. It is well understood that the Allies were in desperate need of viable ports to relieve their logistical problems in the fall of 1944, and it is obvious that the plan of operations for the Channel Ports were designed to be completed much more quickly than they actually were. However, it is also obvious that the tempo of these operations as they were carried out was much less intense than would otherwise be expected. The density of the fortifications and the likelihood of higher casualties resulting from a more vigorous assault were obvious factors that affected the decisions made in these operations.

	Urban Channel Ports Brest and Paris	Conurban Channel & Brittany Ports
Average Attacker Casualties	238.73	195.79
Average Defender Casualties	4,800.64	1,802.00
Average Attacker Casualties per day	238.73	171.31
Average Defender Casualties per day	4,800.64	1,576.75
Average Attacker Percent Loss per day	0.47	0.43
Average Defender Percent Loss per day	66.21	26.79
Weighted Attacker Percent Loss per day	0.52	0.39
Weighted Defender Percent Loss per day	51.25	14.26
Average Advance Rate (km/day)	4.91	0.82
Attacker Linear Density (men/km)	6,549.28	3,324.09
Attacker Weighted Linear Density	3,771.18	3,037.28

	Urban Aachen	Conurban Aachen
Number of Engagements	10	11
Average Attacker Strength	19,265	25,770
Average Defender Strength	7,738	11,891
Average Force Ratio	2.54	2.32
Weighted Force Ratio	2.49	2.17
Percent Attacker Wins	100	90.91
Average Battle Length (days)	1.00	1.00
Average Attacker MBT Strength	98	199
Average Defender MBT Strength	38	36
Average Attacker Casualties	80.50	183.45
Average Defender Casualties	521.20	538.64
Average Attacker Casualties per day	80.50	183.45
Average Defender Casualties per day	521.20	538.64
Average Attacker Percent Loss per day	0.42	0.71
Average Defender Percent Loss per day	7.05	4.25
Weighted Attacker Percent Loss per day	0.42	0.71
Weighted Defender Percent Loss per day	6.74	4.53

	Urban Aachen	Conurban Aachen
Average Advance Rate (km/day)	0.46	1.42
Attacker Linear Density	1,605.42	2,528.94
Weighted Attacker Linear Density	1,605.42	1,908.89

In the case of the "Channel Ports" comparison, the data compares the 11 urban engagements to 14 engagements coded in the DLEDB as Conurban, Urban/RM (urban/rolling mixed) and Conurban/RM. In the case of the Aachen comparison, the data compares 10 engagements coded Urban/Conurban to 11 engagements coded Conurban and Conurban/RM.There is little difference between these engagements. They do not seem to show any pattern of difference between the Urban and Conurban engagements.

Terrain Types Found in Non-urban Engagements

The Non-urban engagements were also fought over a range of terrain. Coded in the DLEDB as Rolling, Bare (RB), Rolling, Mixed (RM), Rugged, Wooded (RgW), and Rugged, Mixed (RgM), they break down as follows:

	Normandy and Breakout & Pursuit	Westwall, Lorraine and Ardennes
Rolling, Bare/Rolling, Mixed	0	1
Rolling, Mixed	20	25
Rolling, Mixed/Rugged, Mixed	0	3
Rugged, Mixed	1	11
Rugged, Wooded	0	30

Eleven of the engagements included an opposed river crossing as part of the main attack. Since the Westwall, Lorraine and Ardennes data sets included a number of engagements that occurred in rugged terrain, a comparison between them and the engagements that occurred in rolling mixed terrain is warranted.

	Rolling Mixed	Rugged, Mixed or Wooded
Number of Engagements	29	41
Average Attacker Strength	19,146	16,291
Average Defender Strength	12,387	8,879
Average Force Ratio	2.14	2.13
Weighted Force Ratio	1.55	1.83
Percent Attacker Wins	51.72	63.41

	Rolling Mixed	Rugged, Mixed or Wooded
Average Battle Length (days)	2.31	1.23
Average Attacker MBT Strength	119	86
Average Defender MBT Strength	60	30
Average Attacker Casualties	546.72	198.83
Average Defender Casualties	596.72	511.20
Average Attacker Casualties per day	236.64	156.77
Average Defender Casualties per day	258.28	403.06
Average Attacker Percent Loss per day	1.12	0.86
Average Defender Percent Loss per day	2.40	5.11
Weighted Attacker Percent Loss per day	1.24	0.96
Weighted Defender Percent Loss per day	2.09	4.54
Average Advance Rate (km/day)	2.07	3.33
Attacker Linear Density (men/km)	2,293.04	1,910.45
Attacker Weighted Linear Density	1,319.45	1,387.15

This data may be somewhat skewed by the large number of failed German attacks in rolling, mixed terrain (ten cases) that are included. For example, if just the US attacks in rolling mixed terrain are compared to US attacks in rugged mixed or wooded terrain, then the following would result:

	Rolling Mixed	Rugged, Mixed or Wooded
Number of Engagements	16	31
Average Attacker Strength	18,822	14,876
Average Defender Strength	9,268	9,029
Average Force Ratio	2.26	1.81
Weighted Force Ratio	2.03	1.65
Percent Attacker Wins	81.25	64.52
Average Battle Length (days)	3.06	1.00
Average Attacker MBT Strength	133	94
Average Defender MBT Strength	49	25

Average Attacker Casualties	635.94	109.84
Average Defender Casualties	779.44	389.84
Average Attacker Casualties per day	207.65	109.84
Average Defender Casualties per day	254.51	389.84
Average Attacker Percent Loss per day	1.05	0.74
Average Defender Percent Loss per day	2.41	4.79
Weighted Attacker Percent Loss per day	1.10	0.74
Weighted Defender Percent Loss per day	2.75	4.32
Average Advance Rate (km/day)	1.60	3.87
Attacker Linear Density (men/km)	2,946.56	1,285.35
Weighted Attacker Linear Density	2,229.09	1,126.14

The same comparison for the German engagements shows:

	Rolling Mixed	**Rugged, Mixed or Wooded**
Number of Engagements	13	10
Average Attacker Strength	19,544	20,676
Average Defender Strength	16,225	8,417
Average Force Ratio	1.98	3.13
Weighted Force Ratio	1.20	2.46
Percent Attacker Wins	15.38	60
Average Battle Length (days)	1.38	2.10
Average Attacker MBT Strength	102	62
Average Defender MBT Strength	90	46
Average Attacker Casualties	436.92	474.70
Average Defender Casualties	373.85	887.40
Average Attacker Casualties per day	315.56	226.05
Average Defender Casualties per day	268.56	422.57
Average Attacker Percent Loss per day	1.21	1.24
Average Defender Percent Loss per day	2.38	6.10
Weighted Attacker Percent Loss per day	1.61	1.09
Weighted Defender Percent Loss per day	1.66	5.02
Average Advance Rate (km/day)	2.65	1.66
Attacker Linear Density (men/km)	1,488.71	3,848.25

Attacker Weighted Linear Density	889.31	2,871.63

It is obvious from this breakdown of the data, that what is really driving the statistics for the German cases is the force ratio and the outcome of the battles. Since most of the German attacks in rolling terrain occurred at low odds, against forces with significant armor, and with the attack usually failing, they naturally end up with very poor statistical results. On the other hand, the German attacks in rugged terrain are at much better odds, with a higher density of troops and better results. Still, it is difficult to derive any conclusions about the effects of terrain from this data.

Distribution of Allies versus Germans as Attacker

Due to the nature of fighting in the European Theaters of Operations, in most cases the allies were the attackers. This is true for all the Urban and Conurban engagements and for most of the Non-urban engagements

	Allied Attacker	**German Attacker**
Channel Ports, Brest and Paris	25	0
Normandy, Breakout and Pursuit	17	4
Aachen	21	0
Westwall, Lorraine and Ardennes	47	23

Only in the case of the Ardennes Campaign do we find a significant number of German attacks. The aggregate statistics for those cases do differ from when the Allies are attacking.

	Allies Attacking Ardennes	**Germans Attacking Ardennes**
Number of Engagements	47	23
Average Attacker Strength	16,219	20,036
Average Defender Strength	9,100	12,830
Average Force Ratio	1.96	2.48
Weighted Force Ratio	1.78	1.56
Percent Attacker Wins	70.21	34.78
Average Battle Length (days)	1.70	1.70
Average Attacker MBT Strength	107	85
Average Defender MBT Strength	29	71
Average Attacker Casualties	288.94	453.35
Average Defender Casualties	522.47	596.00
Average Attacker Casualties per day	169.75	267.36
Average Defender Casualties per day	306.95	351.49

	Allies Attacking Ardennes	Germans Attacking Ardennes
Average Attacker Percent Loss per day	0.84	1.22
Average Defender Percent Loss per day	3.98	4.00
Weighted Attacker Percent Loss per day	1.05	1.33
Weighted Defender Percent Loss per day	3.37	2.74
Average Advance Rate (km/day)	3.10	2.22
Attacker Linear Density (men/km)	1,850.87	2,514.60
Attacker Weighted Linear Density	1,399.75	1,288.32

This data does not show a clear difference between Allied versus German combat effectiveness. It is certain that on the average they were close to one another in these cases. A more detailed analysis of this subject may be found in the Human Factors section of this report.

Definitions

The definitions used for these terms are the same as those used for the EPW study. They are repeated below for clarity.

Force Ratios

Force ratios are measured as the personnel strength of the attacker divided by the personnel strength of the defender. These strengths are the sum, at the start of an engagement, of all personnel in the force subject to enemy fire, including generally combat and combat support troops but also service support troops if subject to enemy fire.

The *DuWar* Data Bases also include data on equipment, including light and main battle tanks and the number of field guns. Considerable material was gathered in the creation of these files. *The Dupuy Institute* has -- for most of the engagements -- a detailed count of the weapons, that includes all large caliber weapons. Although it may have been possible to measure the force ratios based upon a scoring system of the weapons, this was not done for three reasons.

First, to assemble, count and score the weapons would have taken a considerable additional effort, perhaps as much as that spent upon any single phase of the enabling contracts. As such, counting and scoring could not be done within the budget that was available.

Second, a scoring system was required that was "valid." To date, there is no method of validating a scoring system outside of the model that it is used in. Only one such scoring system has been validated within a model (Trevor N. Dupuy's Operational Lethality Indices). Other scoring systems exist based upon "face validation." Any analytical use of a scoring system would have to include a test of its reliability (prediction capability). As such, any such effort would either require accepting a scoring system based upon faith or conducting an independent test of the validity of the scoring system. Accepting a system based upon faith does not necessarily improve the accuracy or confidence of the resulting analysis. Testing a scoring system is time consuming and would have required additional effort.

Third, in many cases, a scoring system would not have significantly changed the strength ratio in the engagements. In many cases the opposing forces were similar in armament and organization. It is unknown if the force ratios for those engagements where there was an asymmetrical organization of the opposing forces would have changed significantly in any consistent direction. It is possible that the changes in the force ratios from using a scoring system would have averaged out, resulting in no significant change in the analytical results.

Outcome

The seven engagement outcomes are defined as:

1) Limited Action - An engagement characterized by limited activity by either side. In this case the category of attacker and defender may be arbitrary, but is usually determined by the side on the strategic or operational offensive during the period of the engagement.
2) Limited Attack - An engagement where the attackers offensive activity is characterized by patrols, raids or by attacks with limited objectives. Limited attacks include feints and secondary attacks that are part of larger battles.
3) Failed Attack - An engagement where the attacker attempts to mount a significant attack with the intention of dislodging the enemy, but does not make a significant advance and does not achieve its objective.
4) Attack Advances - An engagement where the attacker advances, but does not achieve a clear-cut penetration of the defender's position. Depending on the degree with which the attack achieved its objective, the attacker may or may not be the winner.
5) Defender Penetrated - An engagement where the attacker achieves a penetration of the defender's position. In this case the attacker is almost invariably the winner.
6) Defender Enveloped - An engagement where the attacker achieves a penetration or breakthrough of the defender position and successfully envelopes or surrounds a major part of the defending force.
7) Other – Is any outcome that could not be described by the other six categories.

Note that these definitions were applied based upon a careful analysis of the course of the engagement and its result. The definition was not simply based upon "winners" and "losers" or on the assigned mission accomplishment scores of the participants.

THE IMPACT OF HUMAN FACTORS ON THE DATA

While the analytical and operations research community seems to shy from discussing or measuring the impact of human factors on combat, it is undeniable that human factors are a significant aspect of combat. *The Dupuy Institute* does not feel that an analysis of military operations is complete without at least accounting for the impact of those human factors.

Not all armies are the same, nor do they always fight as well as their opponents. There are differences in morale, motivation, training and doctrine that result in measurable differences in combat performance, both in how they fight and in how well they fight. Relative differences in performances between opposing forces can skew the results of any analytical study.

Therefore, it is necessary to account for these differences if one is to be able to draw valid conclusions from the historical record. This can be done by making sure that only data where opponent's differences are minimized are used, by developing a method to adjust the data to account for these differences, or by using a side-by-side analysis that compares only data from the same opponents. Of course, the first two of these methods requires some means of measuring human factors.

In the case of this study, there is not much concern with human factors. First, the ETO data even though it involved the armed forces of the US, UK, Canada and Germany does not display much difference between the opponents. This was initially determined in the analysis of human factors done in our report for the *Capture Rate Study, Phase I and II*. In that report, we compared combat performance, primarily casualty effectiveness, in 44 US versus German engagements in Italy between September 1943 and October 1944, 31 UK versus German engagements in Italy from September 1943 to June 1944, and 71 US versus German engagements in the Ardennes from December 1944 to January 1945. Our relevant conclusions were:[1]

1. The Germans and the US were roughly equivalent in combat effectiveness, with the US being within 20 to 30 percent of the Germans (possibly lower). This appears to have been especially true in Italy, although they may have had the same combat effectiveness in the Ardennes. The overall impact of US versus German combat effectiveness is not significant enough to bias further analysis.
2. The Germans and the UK were within the same order of magnitude of combat effectiveness, with the UK perhaps being somewhat inferior (by 20 to 50 percent). While this may have had some impact on the result of the battles, it was not a significant enough difference to bias further analysis, especially considering the small number of German versus UK engagements.
3. Therefore, all the data from the Italian and Ardennes engagements, whether US, UK, or German, can be used interchangeably to determine EPW rates.

There is no strong reason to believe that these conclusions have changed significantly for the ETO engagements used in this analysis. Almost all of the Ardennes

[1] *Capture Rate Study, Phase I and II*, (The Dupuy Institute: McLean, VA, 6 March 2001), page 61.

engagements used in this analysis were also used in the *Capture Rate Study*. While we have made no tests of Canadian combat performance, we are fairly comfortable assuming that their performance did not differ significantly from that of the US and British forces.

The *Capture Rate Study* also examined the combat performance of Soviet versus German forces, and clearly saw a significant difference. As such, one cannot automatically mix figures and analysis from the Eastern European Theater and the Western European Theater. Still, this data is useful if one understands the differences. This will be discussed in more depth in Phase II of this study, when the Eastern Front data is compared to the ETO data.

In the case of this study, we relied primarily on comparing Urban and Conurban engagements with similar non-urban engagements. We examined forces that were similar or the same, fighting in different environments during the same period of time. These side-by-side comparisons ensured that any technology differences remain constant and any performance differences remained constant. With the number of variables kept to a minimum, this provided some confidence that differences observed in the Urban and Conurban engagements compared to the non-urban engagements are indeed caused by the differences in terrain or by the combat situation.

Ways to Measure Relative Combat Effectiveness

Still, it is interesting to look at the measurement of human factors here and the relative combat performance capability exhibited by opponents. Performance differences in opposing combat forces may be looked at using three measures developed by Trevor N. Dupuy:

Mission Accomplishment

Mission accomplishment is a measure of who won or lost. This can be done either by judgment or by whether or not the attacker advanced. *The Dupuy Institute* prefers to use judgment, since in some cases the attacker may make limited advances in attacks that are otherwise considered disastrous. This is not uncommon. In most cases, however, there is not a difference between the results of judgment and those made from a rigid rule based upon advanced rates. Scoring mission success can further refine Mission accomplishment. Scoring both sides from 0 to 10, with the higher score “winning” did this. Again this was based upon the analysts judgment. Since measuring mission accomplishment is so subject to individual judgment and thus potentially imprecise it was decided not to use it for further analysis.

Casualty Effectiveness

Casualty effectiveness is the ability of one side to cause casualties on another, relative to its own losses. This is probably the best measure of combat effectiveness, although it also has some weaknesses. Casualty reports are not always as precise as would be hoped and not all nationalities classify or report their casualties in the same way. This is a particular problem in reporting wounded and makes comparisons of total casualty figures difficult. Reporting total casualties means summing killed-in-action (KIA), wounded-in-action (WIA) and missing-in-action (MIA). It is what is used for casualty comparisons for this study, even though there remains some concern over how WIA is reported. There is some alternate metrics to total casualties. One could compare total killed on both sides. This

will generate odd comparisons if one side has a lot of MIA resulting in a low number (under-reporting) of KIA. One could also compare total losses, that is, total KIA and MIA. This metric may be useful, but it too has problems. In a situation where a defender is overrun, a certain percent of those who would normally be WIA become CIA. As such, the attacker casualties include KIA and MIA, while the defender casualties include KIA, MIA and those WIA that could not escape (which are recorded as MIA). This inflates the overrun defender losses relative to the attacker. It was decided to keep total casualties as a measurement, since it was felt to produce a more consistent result across a wide range of engagements. However, casualty effectiveness is not always the best measure of mission effectiveness.

Spatial Effectiveness

Spatial effectiveness is a third way of measuring combat effectiveness. Spatial effectiveness is the measurement (usually in kilometers-per-day) of the ability to advance. This is probably the weakest metric and as such is not used in this study. There is clearly a combat effectiveness difference between armies when it comes to their ability to maneuver and exploit opportunities. Still there are problems with this metric. Opposed advance rates are often surprisingly difficult to measure. Furthermore they are often driven by the availability of gaps in the enemy line and are heavily influenced by factors such as terrain, mobility capability and the degree that an army is motorized. Sometimes advance rates are limited by the desire of an attacker to advance or by what or where his objectives are. In some cases, they are limited by the depth of the terrain (for example, battles in the Pacific Atolls in WWII).

Conditions of Combat

Finally, all of these measurements need to consider the conditions of combat. These include not only any inherent advantages gained from being on the defense, but also terrain, weather, and a host of other factors. Furthermore, these measurements also need to consider the mix of weapons and the capabilities of the weapons of each side. Obviously, a heavy armor force well supported by artillery will have a greater effective combat power than an unsupported mass of infantry. Lastly, the effects of air power need to be considered. To address these three factors (conditions, weapons and air power) would require an analytical structure, most likely a combat model, that is well beyond the scope and budget of this project. Therefore, these factors were not considered except in the most basic forms.

With these considerations in mind, *The Dupuy Institute* attempted a first order measure of the effectiveness of forces by different nationalities by trying to find a simple measure of mission accomplishment, casualty effectiveness and spatial effectiveness.

Mission Accomplishment

Mission accomplishment can be measured by analyst judgment (one side wins or losses) or by scoring (each side is scored as to their degree of success), or by outcome (the seven outcome categories developed by TDI). The problem with outcome as a success measurement is that it does not measure the results of "Limited Action," "Limited Attack," or "Other." Therefore we utilized the mission success percentage based upon analyst judgment of winner and loser. We also calculated the average mission accomplishment scores for each side, but did not use them for further analysis.

	Normandy, Breakout & Pursuit	Westwall, Lorraine & Ardennes	Channel Ports, Brest & Paris	Aachen
Allied Attack				
Number of Cases	17	47	25	21
Percent Success, win/loss	88.00	70.00	84.00	95.00
Average Score, attacker	6.41	6.04	6.80	6.67
Average Score, defender	3.94	4.89	3.48	4.67
Lowest Force Ratio	1.35	1.01	1.85	1.72
Highest Force Ratio	28.63	4.62	45.53	3.32
Average Force Ratio	4.00	1.96	8.01	2.43
Weighted Force Ratio	2.12	1.78	4.33	2.29
German Attack				
Number of Cases	4	23	None	None
Percent Success, win/loss	0.00	35.00		
Average Score, attacker	3.25	5.26		
Average Score, defender	6.50	5.65		
Lowest Force Ratio	0.92	0.55		
Highest Force Ratio	2.20	8.20		
Average Force Ratio	1.63	2.48		
Weighted Force Ratio	1.22	1.56		

This strongly indicates that the Allies were more mission-effective than the Germans, although much of the differences can be explained by the higher Allied force ratios and air power. Still, in the critical Ardennes battles Allied air power only played a part in small number of engagements. Most of the German attacks were executed in poor weather when there was little or no Allied air. Furthermore, most of the US Ardennes attacks in the database are those of the III Corps in late December, when poor weather limited the available air support.

All German attacks were against US forces. There were three British Attacks and 14 Canadian Attacks. These were all from the various Channel Port Urban and Non-urban operations, and as such all tend to be successful attacks with high force ratios. There is some concern that there may have been differences in the operations of the different Allies, in particular between British and US forces. This clearly showed up in the Italian Campaign data used for the *Capture Rate Study*. Since there are only three British engagements and 14 Canadian engagements in the *Urban Warfare Data Base*, then there is not a statistically significant number to make such an analysis. Based upon our observations from the Italian Campaign data, the differences are not great enough to significantly skew the statistics, therefore we are comfortable with lumping the different Allies together.

Casualty Effectiveness

We measure Casualty Effectiveness as the number of casualties suffered by the attacker compared to those suffered by the defender. A comparison of the results from the database is shown (the number of engagements in the set are in parenthesis and the range of force ratios are shown below the “low-odds” sets):

Normandy, Breakout & Pursuit Data	**Average Force Ratio**	**Average Loss Ratio**	**Weighted Force Ratio**	**Weighted Loss Ratio**
All Allied Attacks (17)	4.00	0.64	2.12	0.37
US Low-odds Attacks (4) 1.35 to 1.67-to-1	1.56	1.43	1.54	0.47
All German Attacks (4)	1.63	2.68	1.22	1.75
German Low-odds Attacks (2) 0.92 to 1.56-to-1	1.24	4.18	1.02	2.00

Westwall, Lorraine and Ardennes Data	**Average Force Ratio**	**Average Loss Ratio**	**Weighted Force Ratio**	**Weighted Loss Ratio**
All US Attacks (47)	1.96	0.95	1.78	0.55
US Low-odds Attacks (29) 1.01 to 1.67-to-1	1.46	0.76	1.44	0.59
All German Attacks (23)	2.48	1.63	1.56	0.76
German Low-odds Attacks (13) 0.55 to 1.53-to-1	1.03	1.49	0.95	0.87

Channel Ports, Brest and Paris	**Average Force Ratio**	**Average Loss Ratio**	**Weighted Force Ratio**	**Weighted Loss Ratio**
All Allied Attacks (25)	8.01	0.17	4.33	0.07

Aachen	**Average Force Ratio**	**Average Loss Ratio**	**Weighted Force Ratio**	**Weighted Loss Ratio**
All US Attacks (21)	2.43	0.36	2.29	0.25

Low odds attacks were defined as any attacks occurring at a force ratio less than 1.70-to-1, since this excluded all the urban engagements. This follows the definition as used in the *Capture Rate Study*, where greater than 1.48-to-1 were defined as "high-odds" and those less than or equal to 1.48-to-1 were defined as "low-odds."[2]

One of the concerns with analyzing this data is that the German morale may have been declining as they were pushed across France. This may have affected the combat results. Since the Channel Ports, Brest, Paris, Normandy and Breakout and Pursuit operations cover from June to September 1944 and the Aachen, Westwall, Lorraine and Ardennes operations cover from October 1944 to January 1945, if there was such a morale effect, than it should show up in the results. In fact, the data shows the reverse tendency, with the German performance being better at Aachen and in the Ardennes cases than in the Channel Ports and Normandy cases. This may be in part due to the selection of the engagements. In the case of the Normandy data, 12 of the 21 non-urban engagements are those in and around the Channel Ports. These tend to be somewhat skewed, it is evident that the German forces were neither of the highest quality nor did the have very good morale. A wider selection of engagements from the fighting in Normandy during June and July 1944 should be assembled before any such conclusions are drawn.[3]

It is clear that the US forces in the data sets had superior casualty effectiveness. If we look at just the Ardennes data for a moment, and compare the force ratios between the US and the German attacks, and the loss ratios between the US and the German attacks, we find that:

[2] These "definitions" of "low" and "high" odds were developed based upon how the data clustered, that is, where the "gaps" in the data were found to have occurred.

[3] Unfortunately data for the daily losses of German forces in Normandy are extremely limited. It may be possible to assemble accurate estimates for them, but the time and effort, and expense, for creating them will of necessity be high. This should be considered as part of a Phase III effort.

	US versus German Force Ratio Advantage	US versus German Loss Ratio Advantage
All attacks		
average ratios	0.79	1.72
weighted ratios	1.14	1.38
Low odds attacks		
average ratios	1.42	1.96
weighted ratios	1.52	1.47

Keying from the weighted force and loss ratios, it would appear that the US had about a 20 to 30 percent casualty effectiveness advantage. A look at the table of aggregated statistics from the section on Data Description will make this clearer.

	Allies Attacking Ardennes	Germans Attacking Ardennes
Number of Engagements	47	23
Average Attacker Strength	16,219	20,036
Average Defender Strength	9,100	12,830
Average Force Ratio	1.96	2.48
Weighted Force Ratio	1.78	1.56
Percent Attacker Wins	70.21	34.78
Average Battle Length (days)	1.70	1.70
Average Attacker MBT Strength	107	85
Average Defender MBT Strength	29	71
Average Attacker Casualties	288.94	453.35
Average Defender Casualties	522.47	596.00
Average Attacker Casualties per day	169.75	267.36
Average Defender Casualties per day	306.95	351.49
Average Attacker Percent Loss per day	0.84	1.22
Average Defender Percent Loss per day	3.98	4.00
Weighted Attacker Percent Loss per day	1.05	1.33
Weighted Defender Percent Loss per day	3.37	2.74
Average Advance Rate (km/day)	3.10	2.22
Attacker Linear Density (men/km)	1,850.87	2,514.60
Attacker Weighted Linear Density	1,399.75	1,288.32

This does show that the US had more armor in the attack, and definitely had more armor in the defense. This last point may help explain the higher German casualties when they were attacking. The average defender casualties and percent loss per day is the same whether the US or the Germans were attacking. What is different is the attacker casualties (and percent loss per day). This clearly is higher for the Germans attacks. While the difference in armor may help explain the higher German losses, how much of an impact it had is difficult to determine. Unfortunately, breaking down the 23 German attacks into armor-heavy, armor-supported and infantry engagements as was done in the *Capture Rate Study* would create much smaller data sets with much lower levels of confidence, and still would not address the other factors that may be influencing the higher German loss results.

These other factors might include morale differences in German units, since the German Army at this time was not very homogeneous in training, experience, recruitment or motivation. The differences in quality from unit to unit were certainly much more varied in the German Army compared to the US Army, with the quality of German-SS, Foreign (Volunteer)-SS, Regular Army, Luftwaffe Parachute, and Volksgrenadier formations varying considerably. Some units were very experienced, were well trained, equipped and supplied, while other units were newly raised, briefly trained and occasionally abysmally equipped and supplied. Other factors that could bias the results include differences in air support and logistics, both of which sometimes favored the Americans, but rarely favored the Germans.

The way casualties were reported also differed between the US and the Germans. German casualty summaries normally only reported those wounded evacuated to a field hospital. Since German field hospitals were normally found at army-level and were usually well to the rear, many lightly and some moderately wounded Germans were never recorded as such. The US Army, with some exceptions,[4] consistently reported most of the wounded-in-action, including many lightly and moderately wounded and all severely wounded, partly due to superior and more immediate medical support and partly due to differing personnel accounting methodologies. As a result US forces were probably reported an average of about 20 to 30 more wounded than did the Germans, even when the number actually wounded may have been exactly the same. This difference alone could account for most of the differences in casualty effectiveness between the forces.

Finally, because of the poor quality of German records late in the war, the data for the Ardennes engagements is simply not as good as the data found for the other engagements in the database (particularly the data found for the Italian Campaign or the Battle of Kursk). After June 1944 the available German data is simply not the best to use for complete and accurate analysis.[5] As a result more data is estimated, reducing confidence in the result (although there is no reason to believe that the estimates are biased or grossly inaccurate).

While the data does suggest a 20 to 30 percent or greater casualty effectiveness advantage for the US over the Germans, this may be fully explainable by other factors. In

[4] The lightly wounded "carded-for-record-only" casualties were the major exception. However, it appears that occasionally at army-level, all lightly wounded, not-evacuated, were excluded from WIA statistics.

[5] For instance, the data for the German LXXXI Corps in the Aachen battles is very complete on a daily basis and suffers from only minor gaps and inconsistencies. However, since the corps was relieved from responsibility for the forces north of the city on 11 October we cannot create engagements for that sector after that date, since there are no records available from the LXXIV Corps and I SS-Panzer Corps which took over.

fact combat effectiveness between the two appears to have been close to parity. Still, there was a clear difference between the US and German casualty effectiveness in the Italian Campaign, which points to either a decline in the German Army (which is fairly well documented) or an improvement in the US Army.

Spatial Effectiveness

Spatial Effectiveness can be measured by advance rates. A simple comparison shows the following (the number of cases is sometime less than the number of engagements due to some incomplete data on advance rates):

	Normandy, Breakout & Pursuit	**Westwall, Lorraine & Ardennes**	**Channel Ports, Brest & Paris**	**Aachen**
Allied Attacks				
Number of Cases	13	47	22	21
Percent Success	88.00	70.00	84.00	95.00
Range of data (km)	0 to 12.7	0 to 19.6	0 to 27	0.2 to 3
Average Advance Rate	3.00	3.10	2.49	0.96
Outcome IV-VII Cases	11	38	19	18
Range of data (km)	0 to 12.7	0 to 19.6	0 to 15	0.2 to 3
Average Advance Rate	3.00	3.73	1.46	1.00
German Attacks				
Number of Cases	4	23		
Percent Success	0.00	35.00		
Range of data (km)	-0.8 to 4	0 to 7.6		
Average Advance Rate	1.25	2.22		
Outcome IV-VII Cases	0	13		
Range of data		1.33 to 7.6		
Average Advance Rate		3.48		

If we eliminate six outliers then we have:

	Normandy, Breakout & Pursuit (-1 outlier)	**Westwall, Lorraine & Ardennes** (-3 outliers)	**Channel Ports, Brest & Paris** (-2 outliers)	**Aachen**
Allied Attack				
Number of Cases	12	44	20	21
Range of data (km)	0 to 7.3	0 to 8.0	0 to 2.5	0.2 to 3.0
Average Advance Rate	2.19	2.06	0.64	0.96
Outcome IV-VII Cases	10	35	18	18
Range of data (km)	0 to 7.3	0 to 8.0	0 to 2.5	0.2 to 3.0
Average Advance Rate	2.03	2.48	0.71	1.00
German Attacks				
Number of Cases	4	23		
Percent Success	0.00	35.00		
Range of data (km)	-0.8 to 4	0 to 7.6		
Average Advance Rate	1.25	2.22		
Outcome IV-VII Cases	0	13		
Range of data (km)		1.33 to 7.6		
Average Advance Rate		3.48		

What this shows is that the Germans may have actually had a higher spatial effectiveness than the Allies, meaning that they achieved higher advance rates under similar conditions. This is demonstrated in the Ardennes data where the Germans achieved an advance rate of 2.22 kilometers-per-day when only 35 percent of their attacks succeeded, but 3.48 kilometers-per-day in their 13 successful attacks. Since all the "outliers" came from the US attacks, this skews the statistics.

The other point the data shows is that advance rates for urban combat are considerably lower than for non-urban combat. This will be discussed in depth in the analysis section.

US, UK and Canadian Comparisons

While there is a limited number of UK and Canadian engagements, a comparison between them may be of interest. The British and Canadians were the attacker in all of their cases. Therefore, they are only compared to those engagements where the US was the attacker.

	Normandy, Breakout & Pursuit		
	US	**UK**	**Canadian**
Number of Cases	11	1	5
Different Units	5	1	1
Percent Success	82	100	100
Average Score, attacker	6.09	7.00	7.00
Average Score, defender	4.36	4.00	7.00
Lowest Force Ratio	1.35	4.06	2.84
Highest Force Ratio	2.87	4.06	28.63
Average Force Ratio	1.95	4.06	8.49
Average Loss Ratio	0.90	0.04	0.19
Less outlier:			
Highest Force Ratio			4.07
Average Force Ratio			3.46
Average Loss Ratio			0.24
Average Attacker % Loss	1.01	0.16	0.25
Average Defender % Loss	3.36	15.21	24.77
Less outlier:			
Average Attacker % Loss			0.30
Average Defender % Loss			5.97
Advance Rate Cases	11	0	2
Lowest Advance Rate	0		0
Highest Advance Rate	12.7		2
Average Advance Rate	3.36		1.00
Less Outlier:			
Highest Advance Rate	7.30		
Average Advance Rate	2.43		

	Channel Ports, Brest and Paris		
	US	**UK**	**Canadian**
Number of Cases	14	2	9
Different Units	2	1	2
Percent Success	86.00	100.00	78.00
Average Score, attacker	6.50	8.00	7.00
Average Score, defender	3.64	3.50	3.22
Lowest Force Ratio	1.85	4.78	2.99
Highest Force Ratio	36.65	10.33	45.53
Average Force Ratio	6.85	7.56	9.93
Average Loss Ratio	0.18	0.04	0.19
Less Outlier			
Highest Force Ratio	11.96		12.11
Average Force Ratio	4.55		5.48
Average Loss Ratio	0.19		0.21
Average Attacker % Loss	0.57	0.41	0.27
Average Defender % Loss	37.13	76.85	42.55
Advance Rate Cases	14	0	8
Lowest Advance Rate	0		0
Highest Advance Rate	15		27
Average Advance Rate	1.45		4.31
Less Outlier:			
Highest Advance Rate	1.7		2.5
Average Advance Rate	0.41		1.07

Even though the number of data points is small, there are some clear patterns. Compared to the UK and Canadians, the US tended to attack at lower odds and with higher casualties. This parallels the pattern also found in the Italian data for the *Capture Rate Study*. No clear pattern can be discerned from Mission Accomplishment or Spatial Effectiveness. It does appear that advance rates in Urban combat are less than those in Non-urban fighting.

Conclusions

With regard to this analysis, the differences in performance between the US, German, British and Canadian forces are not significant enough to bias the analysis. Furthermore, since we are doing side-by-side comparisons between urban and non-urban terrain, this is not a critical issue. It may become more important in Phase II, when we examine the East Front data from 1943. From the experience found in the *Capture Rate Study*, we do expect to see more noticeable differences in performance between the Germans and Russians.

Still, there are several interesting tendencies in this data that we wish to note:

1. The pattern of US fighting appears to differ from British and Canadian operations. The US forces tend to attack at lower odds and with higher casualties. This parallels the pattern found in the *Capture Rate Study* Italian data.
2. There is no indication that German army performance declined between June and December 1944. In fact, the data shows the reverse, but this is probably driven more by the selection of engagements and units involved.
3. The US Army was clearly superior in two of the three measurements of combat effectiveness. They were twice as likely to succeed in combat (70 percent versus 35 percent in the Ardennes), even though the average odds in their attacks were about the same as the German attacks.
4. The US also displayed superior casualty causing effectiveness. They may have been 20 to 30 percent better than their opponent may, whether attacking or defending, but that may also be fully explained by other factors. As such, without a more in-depth analysis, it appears that there was rough parity between the casualty effectiveness of the two forces. This does appear to be a change from the Italian data.
5. The German Army may have achieved better spatial effectiveness.
6. Overall, there appears to be a difference in the nature of German and US combat methods, with the casualty effectiveness of the two being almost the same, but with the Germans attacking at lower odds and with higher casualties. The large number of marginal German attacks, that often failed, certainly skew the statistics, but also may reflect a doctrinal difference between the two armies. This doctrinal difference may also explain the possibly higher advance rate of the Germans. This needs to be examined in more depth, and more cases from the ETO need to be developed, before any solid conclusions can be reached.

OTHER FACTORS

Since there is always concern about misidentifying the independent variable, or causative factor, of a correlation, *The Dupuy Institute* decided to test the data to see if force ratios or unit size influenced the data and possibly skewed the results. We have done similar tests before, including in the *Capture Rate Study*, and Trevor Dupuy did the same in his book *Understanding War*. The exploration done here is limited to the simplest comparisons, since no correlation was expected except between unit size and casualty rates. All of the charts were based upon 128 to 137 data points. (Charts 1 and 2 are presented in two formats, full and truncated, for clarity.)

First, Force Ratio (Attacker Strength divided by Defender Strength) was tested to Casualty Ratio (Attacker Losses divided by Defender Losses). As can be seen, there is no clear relationship between Force Ratio and Casualty Ratio. (See Chart 1: Force Ratio versus Casualty Ratio and Chart 1[1].)

Second, Force Ratio was tested to Distance Advanced. Again, as can be seen, there is no clear relationship between Force Ratio and Distance Advanced. (See Chart 2: Force Ratio versus Distance Advanced and Chart 2[1].)

Third, Attacker and Defender Size were compared to the Percent Loss-per-Day for the Attacker and Defender (respectively). As can be seen, as unit size gets smaller, the casualty rates increase. This trend continues very noticeably as units get smaller than brigade-size and this has already been shown in *Understanding War* and the *Capture Rate Study*. Our data on unit size cuts off before this effect really distorts the statistics. This relationship is the fundamental reason that TDI separated its databases into army-level, division-level and battalion-level sets, well before this project began. The failure of some of the recent referenced urban warfare studies to understand or appreciate this well documented effect is hard to understand in light of the available literature. (See Chart 3: Attacker Size versus Casualties and Chart 4: Defender Size versus Casualties.)

Fourth, Attacker Size was compared to Linear Density. As can be seen, there is no particular pattern relating Attacker Size to Linear Density. It appears that this is entirely driven by the situation in the battle. (See Chart 5: Attacker Size versus Linear Density.)

Fifth, Linear Density was compared to Casualty Rates. This last point is of particular interest, for if such a relationship exists, then a postulated increase in density as a result of units deploying in urban terrain should tend to show an increase in casualties. As can be seen, if there is a relationship, it is actually the reverse, that is, the engagements with the highest linear density have fairly low casualties. (See Chart 6: Linear Density versus Attacker Casualties.)

Two conclusions are drawn from this examination, both confirmed by our previous work. First, there is a correlation between Unit Size and Casualty Rates. Any analysis must account for this if it is to be valid. *The Dupuy Institute* accounts for it by separating the databases by level of combat (army, division and battalion). Second, there is no direct correlation between Unit Density and Casualties. Even if one could establish that unit densities go up in an urban environment, it does not mean that casualties will increase. And, since the highest density operations have relatively low losses, this would indicate that linear density is determined by the tactical and operational situation.

Chart 1: Force Ratio versus Casualty Ratio

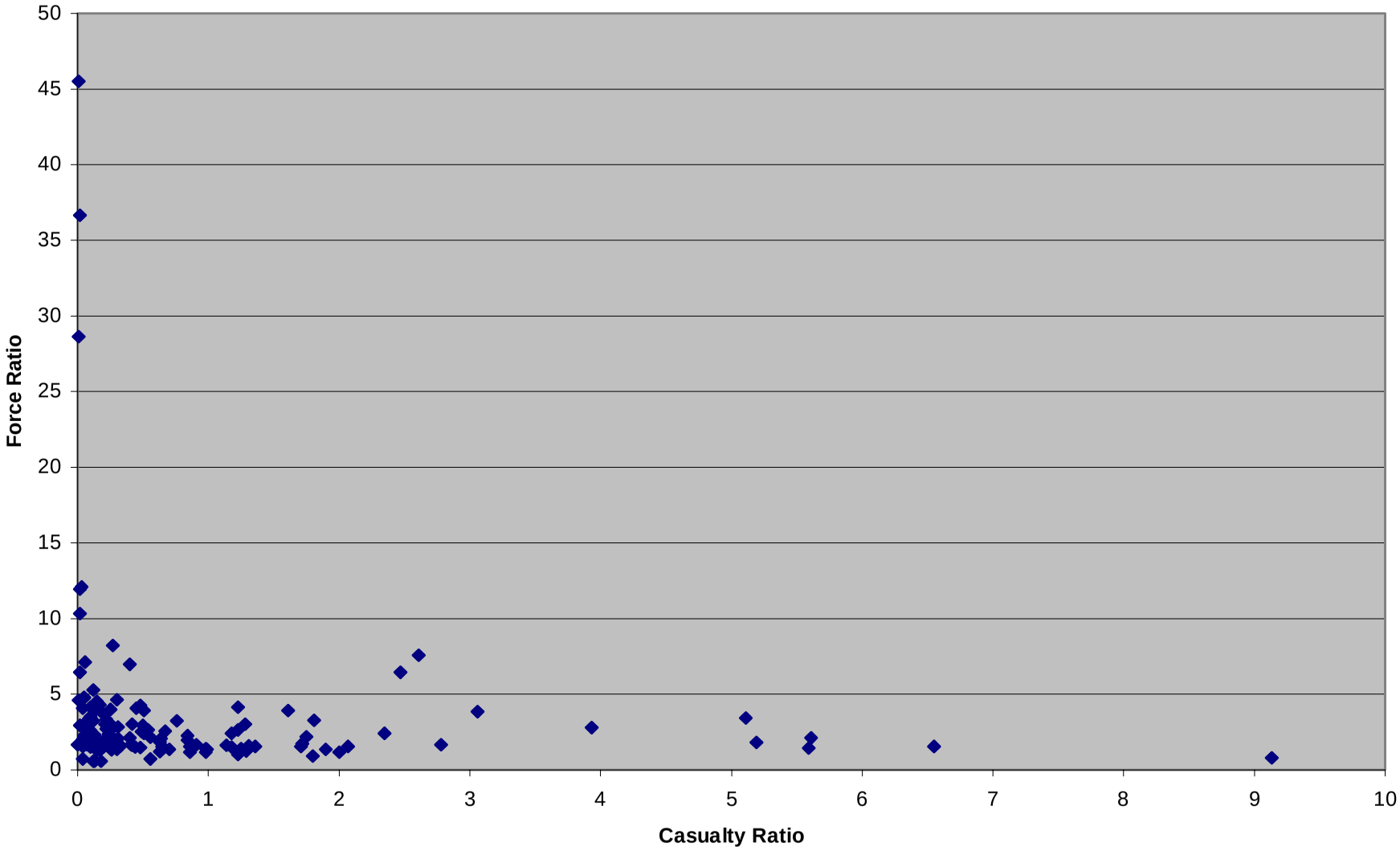


Chart 1[1]: Force Ratio versus Casualty Ratio (Truncated)

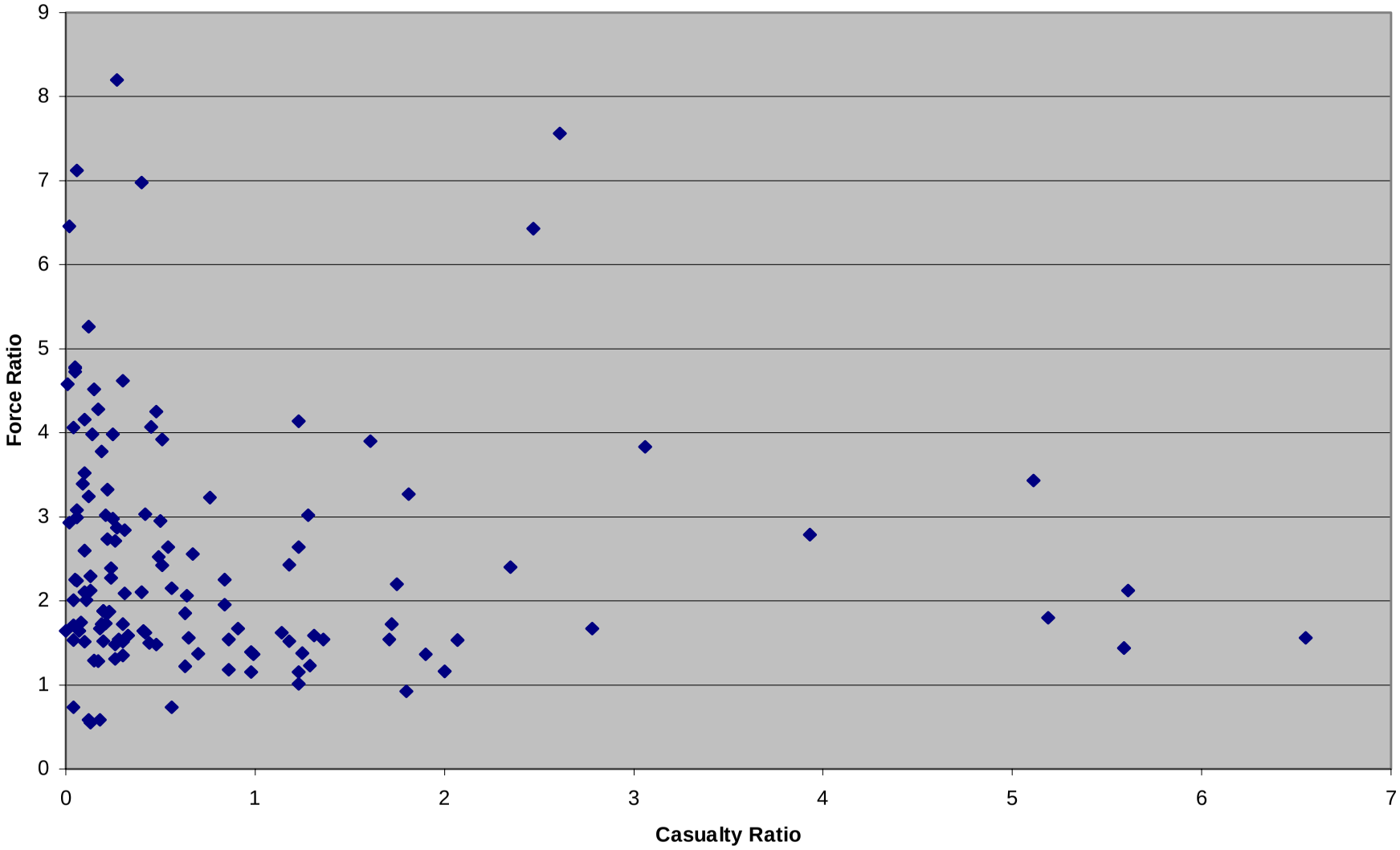


Chart 2: Force Ratio versus Distance Advanced

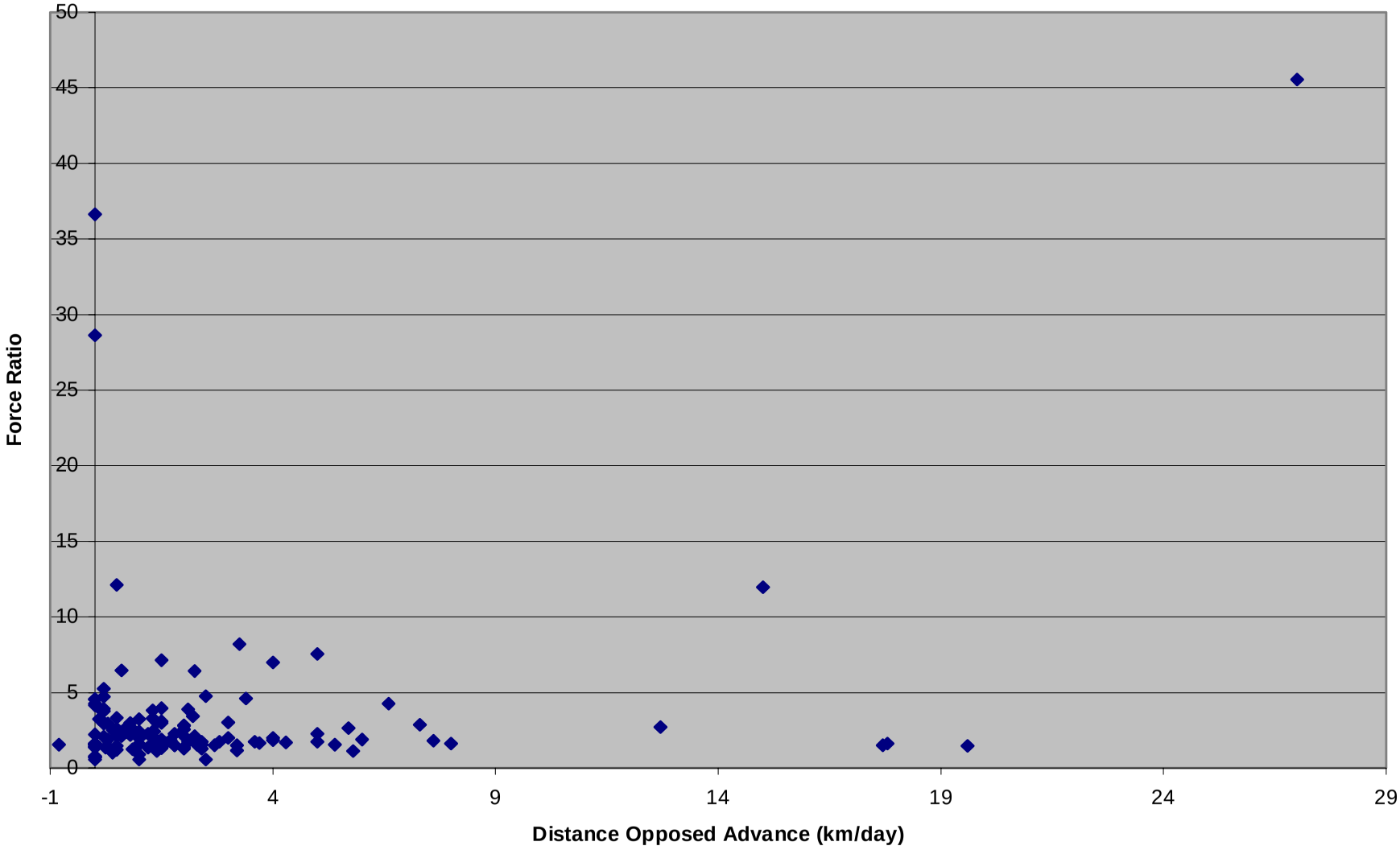


Chart 2[2]: Force Ratio versus Distance Advanced (Truncated)

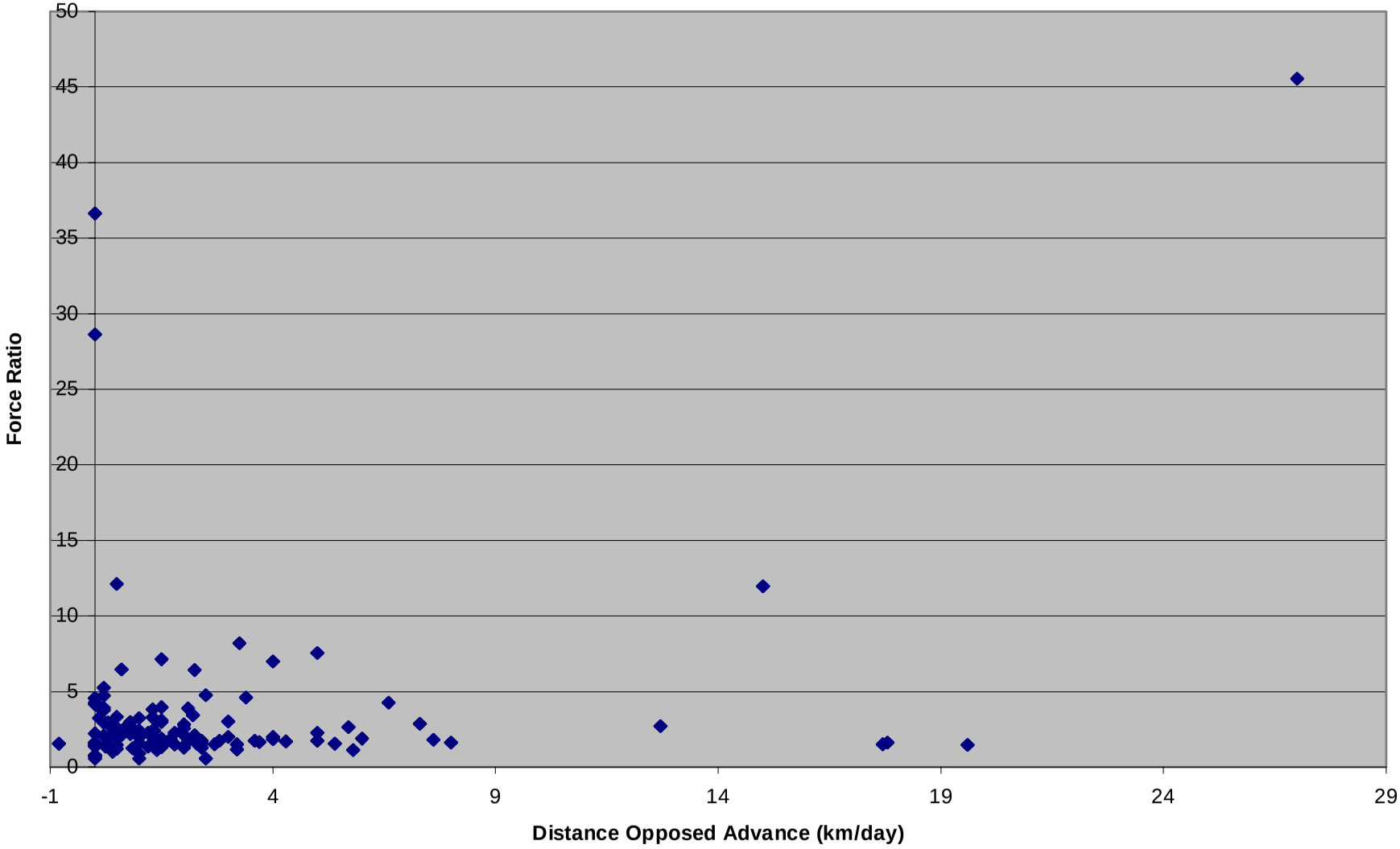


Chart 3: Attacker Size versus Casualties

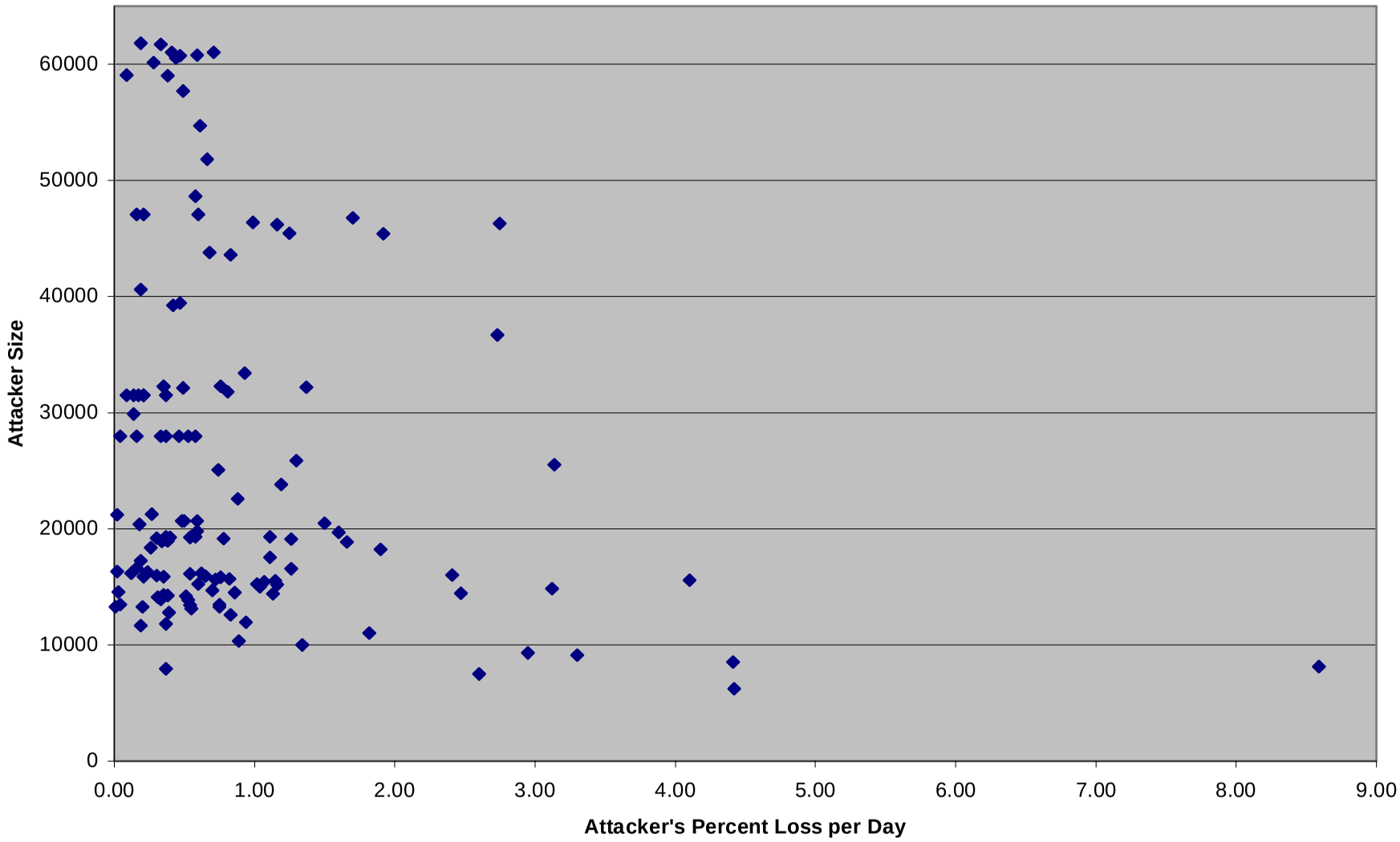


Chart 4: Defender Size versus Casualties

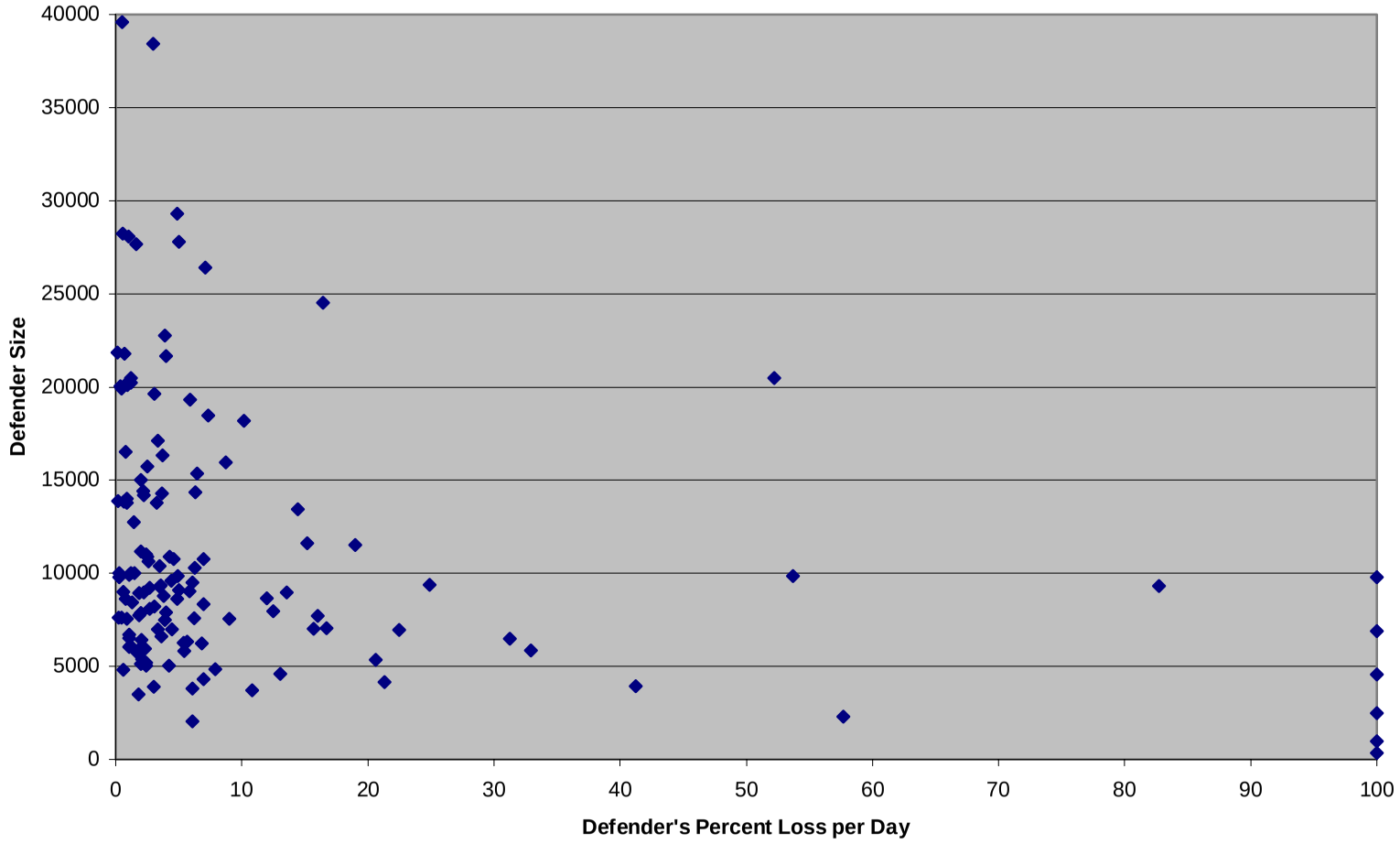


Chart 5: Attacker Size versus Linear Density

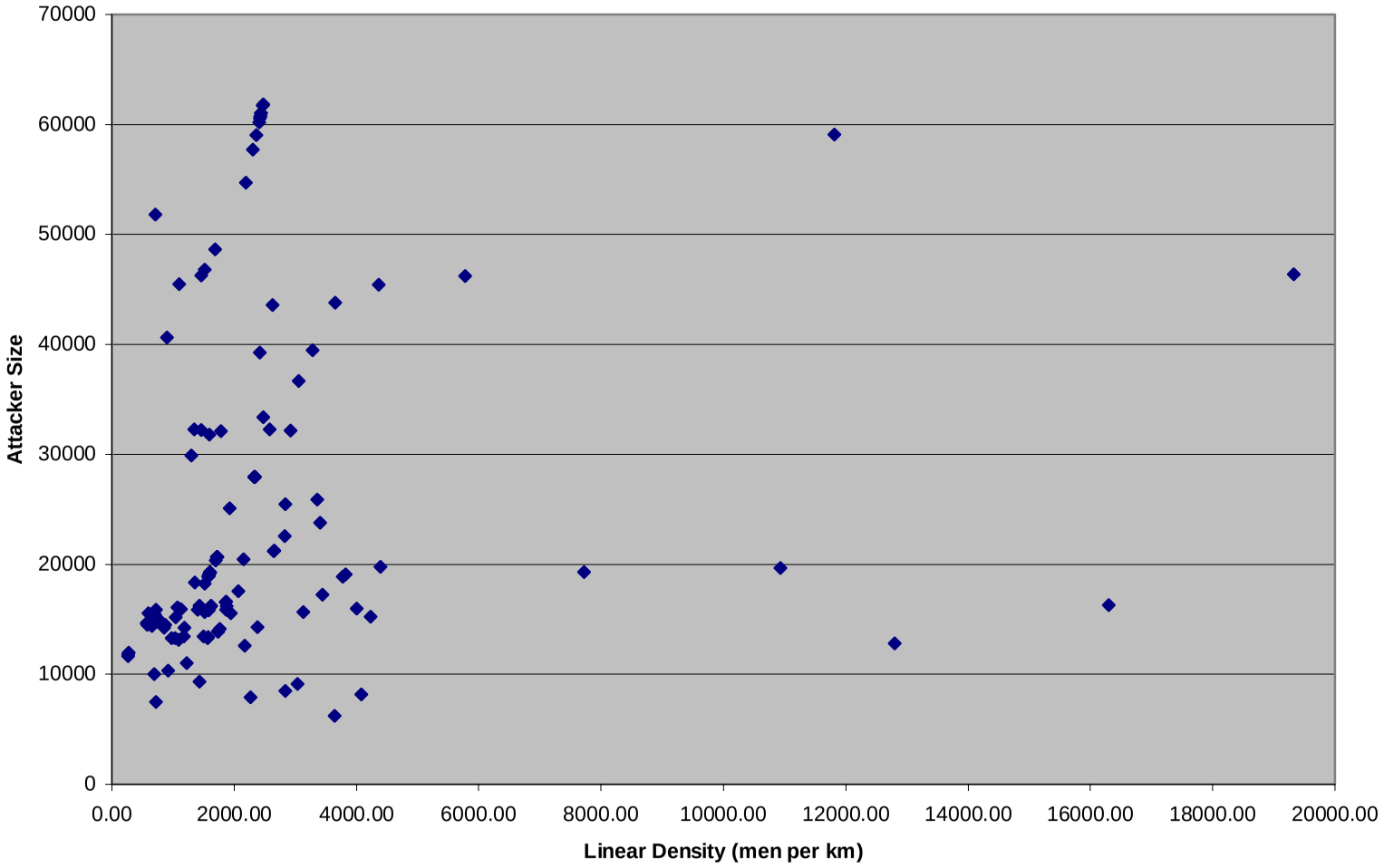
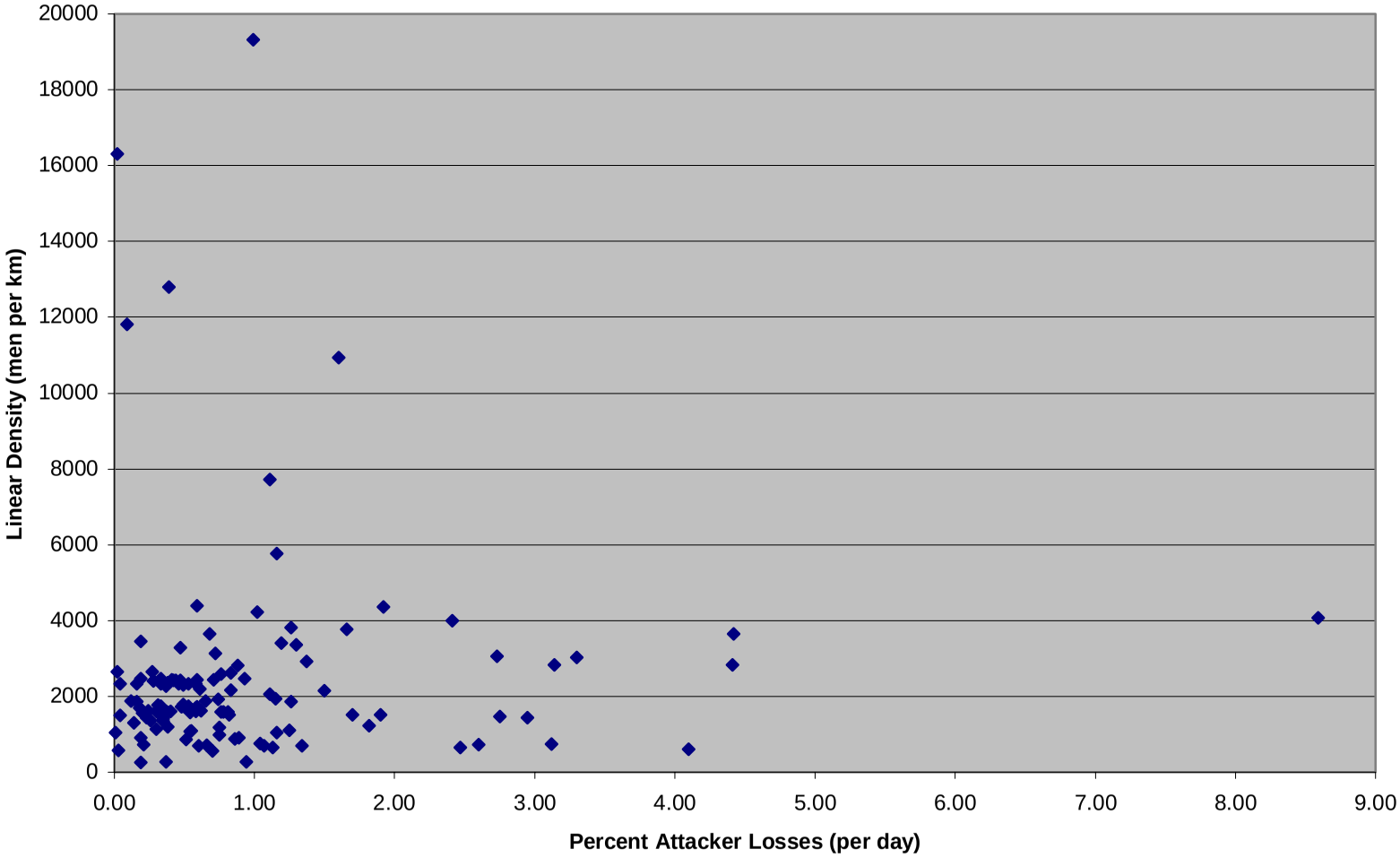


Chart 6: Linear Density versus Attacker Casualties



DATA BASE ANALYSIS

The 137 cases of Urban and Non-urban combat in the European Theater of Operations were analyzed in some depth in an attempt to answer seven questions. The questions were what was the impact of urban terrain on:

1. Force Ratios
2. Mission Success (Outcome)
3. Casualty Rates
4. Armor Loss Rates
5. Duration of Combat (Time)
6. Advance Rates
7. Linear Density

The Effect of Urban Terrain on Outcome

Since much of this analysis examines daily casualty rates, some factors may lead to noticeably different casualty rates among the four sets of data. Differences could be caused by force ratios if they were noticeably different between data sets and if one set of data contained a large number of high casualty outcomes. As outcome clearly influences casualties, then the breakdown of outcomes among the data sets needs to be examined.

	Channel Ports, Brest and Paris	**Normandy and Breakout and Pursuit**
Limited Action	3	-
Limited Attack	-	-
Failed Attack	-	6
Attack Advances	14	11
Defender Penetrated	4	3
Defender Enveloped	-	-
Other	4	1

	Aachen	**Westwall, Lorraine and Ardennes**
Limited Action	-	1
Limited Attack	3	7
Failed Attack	-	11
Attack Advances	17	37
Defender Penetrated	-	13
Defender Enveloped	-	1
Other	1	-

As was discussed in depth in *The Dupuy Institute Capture Rate Study*, the outcome of the engagement appears as the primary determiner of casualty rates. Therefore, for our analysis, we compared engagements of similar outcomes and force ratios. A summary of

outcomes III (Attack Failed), IV (Attack Advances) and V (Defender Penetrated) shows the following.[1]

Force Ratio	Cases	Terrain	Result
0.55 - 1.01	5	Non-urban	Attack Failed
1.23 - 1.38	3	Non-urban	Attack Failed
1.15 - 1.48	9	Non-urban	Attack Advances
1.18 - 1.29	4	Non-urban	Defender Penetrated
1.53 - 1.88	7	Non-urban	Attack Failed
1.50 - 1.87	19	Non-urban	Attack Advances
1.51 - 1.64	3	Non-urban	Defender Penetrated
1.72 - 1.95	4	Urban	Attack Advances
2.20 - 2.56	2	Non-urban	Attack Failed
2.01 - 2.87	11	Non-urban	Attack Advances
2.01 - 2.99	15	Urban	Attack Advances
2.01 - 2.64	2	Non-urban	Defender Penetrated
3.02 - 4.62	10	Non-urban	Attack Advances
3.23 - 5.26	10	Urban	Attack Advances
3.03 - 4.28	2	Non-urban	Defender Penetrated
4.16 - 4.78	2	Urban	Defender Penetrated
6.43 - 7.56	2	Non-urban	Attack Advances
7.12 - 12.11	2	Urban	Attack Advances
6.98 - 8.20	2	Non-urban	Defender Penetrated
6.46 - 11.96	2	Urban	Defender Penetrated

It is clear that the force ratios have a major impact on the outcomes. The lack of any failed Urban attacks is due to the favorable force ratios. The lowest force ratio that an Urban attack is made at is 1.72-to-1, and only four attacks are made at less than 2.00-to-1. In the case of the Non-urban attacks, of the nine attacks made at between 1.71 and 2.00-to-1, only three failed. No attacks, Urban or Non-urban, executed with a ratio above 2.56-to-one, failed. There were a total of ten Urban attacks made between 2.00-to-1 and 2.56-to-1 and nine Non-urban attacks made in the same range. Two of the Non-urban attacks in these cases failed.

Overall, it appears that force ratios are a major factor in determining outcome. It does not appear that the difference between Urban and Non-urban terrain significantly influenced this result. We cannot see a difference between results in Urban terrain and Non-urban terrain, nor can a difference be seen between rugged terrain and non-rugged terrain.[2] Force ratios again have a major impact on the outcomes, but it does not appear that the difference between rolling-mixed, rugged-mixed or rugged-wooded terrain significantly influenced the outcomes. What it does indicate is that if a difference in the effect between rolling terrain and rugged terrain cannot be demonstrated, then the difference in effect between Urban and Non-urban terrain is also likely to be minimal. However, the difference in terrain could effect combat power and the results by 20 to 30 percent, without it showing

[1] A complete set of the analytical tables used to generate this summary (including the results for outcomes I, II, VI, and VII) and those following may be found in Appendix VI.
[2] See Appendix VI, Table 2.

up in this analysis. Differences that small cannot be conclusively demonstrated given the small number of cases and the considerable variation found in the data. However, it is possible to create some specific rules relating force ratios to outcomes.

Force Ratio	**Result**
0.55 to 1.01-to-1.00	Attack Fails
1.15 to 2.56-to-1.00	Attack may succeed
2.71-to-1.00 and higher	Attack advances

It is in the "attack may succeed" area where we may detect some differences caused by terrain effects. In the range of 1.15 to 2.56-to-1.00, we found the following:

Cases	**Attack Fails**	**Attack Advances**	**Defender Penetrated**
55	12 (21.82 percent)	35 (63.64 percent)	8 (14.55 percent)

For the Urban versus Non-urban cases, we found the following:

	Cases	**Attack Fails**	**Attack Advances**	**Defender Penetrated**
Non-Urban	55	12 (21.82%)	35	8
Urban	14	0	14	0
Rolling	25	6 (24.00%)	17	2
Rugged	30	6 (20.00%)	18	6

Clearly little can be concluded from this data. The data appears to support a null hypothesis, that is, that the terrain (be it Urban versus Non-urban or rolling versus rugged) has no significantly measurable influence on the outcome of battle.

The Effect of Urban Terrain on Casualties

Again, as discussed in our *Capture Rate Study*, the outcome of a battle, rather than the force ratio, is the primary determiner of the loss rate. A simple comparison of average losses by outcome demonstrate this:

Channel Ports, Brest & Paris	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
Number of Cases	3			14	4		4
Average percent attacker losses/day	0.40			0.53	0.31		0.37
Average percent defender losses/day	40.25			20.74	61.35		100
Normandy & Pursuit							
Number of Cases			6	11	3		1
Average percent attacker losses/day			3.34	0.87	0.54		0.04
Average percent defender losses/day			5.59	5.22	3.71		100
Aachen							
Number of Cases		3		17			1
Average percent attacker losses/day		0.70		0.57			0.18
Average percent defender losses/day		3.69		4.92			22.47
Westwall, Lorraine & Ardennes							
Number of Cases	1	7	11	37	13	1	
Average percent attacker losses/day	0.03	0.86	1.85	0.90	0.59	0.39	
Average percent defender losses/day		0.45	1.21	4.15	3.19	6.54	21.30

The percentages used were simple straight averages. The result would change slightly if a weighted average was used, or if outliers were deleted, but the overall relationship within the data would not change. The data shows two trends (if one compares similar outcomes in the Urban data sets with similar outcomes in the Non-urban data sets).

Firstly, the attacker casualties are lower in Urban warfare when compared to the Non-urban data. Secondly, the defender casualties higher and, more significantly, it appears that the ratio of attacker casualties to defender casualties is more favorable to the attacker in Urban warfare. These tendencies may have been driven by the selection of the Urban engagements and to a lesser extent the selection of the Non-urban engagements.

The selection of the Non-urban engagements is also not unbiased. The Normandy Campaign and Breakout and Pursuit data sets primary problem is that they contain too few cases. Another twenty or so examples need to be collected. The Ardennes data, by its size is more robust, but still has some problems. A number of the German offensive engagements come from the early part of the campaign, when they suffered a number of sharp repulses inflicted upon them by some very determined US units fighting in terrain that was clearly unsuited to the armor-heavy formations the Germans deployed. A number of the cases are from the US Third Army counterattack in late December that was particularly successful against what appears to have been an occasionally demoralized opponent. As a result, the data base contains an excess of particularly stubborn and successful defenses and a series of particularly successful attacks. This probably skews the casualty figures slightly.

Still, while more data would provide a more refined and accurate analysis, it does not appear that more data would change the overall results. **Overall, any way the data is sectioned, the attacker casualties in the Urban engagements are less than in the Non-urban engagements, and the casualty exchange ratio favors the attacker as well. Because of the selection of the data, there is some question whether these observations can be extended beyond this data, but it does not provide much support to the notion that urban combat is a more intense environment than non-urban combat.**

The Effect of Urban Terrain on Advance Rates

Opposed Advances Rates may be influenced by urban terrain. The *DuWar* DLEDB records advance rates in kilometers-per-day. A simple summary shows this relationship:

	Number of Cases	**Average Advance Rate**	**Five Highest Advance Rates**
Channel Ports	22	2.49	27, 15, 2.5, 1.7, 1.5
Normandy & Pursuit	17	2.59	12.7, 7.3, 6, 4, 3.6
Aachen	21	0.96	3, 2.25, 2.1, 1.8, 1.5
Ardennes	70	2.81	19.6, 17.8, 17.7, 8, 7.6

As can be seen, the averages are very much driven by the high advance rates, for example the 27 kilometers one day advance found for one of the Channel Port engagements. If a figure of 10 kilometers was taken as a maximum (and in this case meaning that 10 kilometers was substituted for any figure greater than that), the following averages would result:

	Number of Cases	Average Advance Rate	Average Force Ratio	Weighted Force Ratio
Channel Ports	22	1.49	8.01	4.33
Normandy & Pursuit	17	2.43	3.55	2.02
Aachen	21	0.96	2.43	2.29
Ardennes	70	2.45	2.13	1.69

This does not result in a great difference in the Non-urban engagement sets, but does show them to have a nearly identical average rate (2.43 and 2.45), while both Urban data sets show a much lower average (1.49 and 0.96). As the average combat ratio of the Channel Ports engagements is noticeably higher that the Aachen engagements, it is not surprising that they have a higher average advance rate as well.

The Urban data set is characterized by a large number of limited or minor advances. Categorizing the advance rates by the number of cases for each distance advanced can best show this:

Advance	Channel	Normandy	Aachen	Ardennes
Negative or Zero	5	3	0	13
up to 1 km/day	9	5	15	10
up to 2 km/day	5	3	3	17
up to 3 km/day	1	1	3	10
up to 4 km/day	0	2	0	7
up to 5 km/day	0	0	0	4
from 5 to 10 km/day	0	2	0	6
greater than 10 km/day	2	1	0	3

As can be seen, in 67.44 percent of the Urban cases, the advance was less than one kilometer-per-day, compared to 35.63 percent in the Non-urban cases. Advance rates of less than three kilometers-per-day accounted for 95.35 percent of the Urban cases, but only 71.26 percent on the Non-urban cases. These differences are despite the higher force ratios and more favorable outcomes that characterize the Urban engagement set. **Therefore, it would appear that one of the primary results of urban terrain is that it slows opposed advance rates.** It may be possible to produce a more precise estimate based upon outcome:

Average Daily Advance Rate in kilometers by outcome:

	I	II	III	IV	V	VI	VII
Urban							
Cases	3	3	0	31	2	0	4
Advance Rate	9[3]	0.73	-	0.96	7.80	-	0.13
Non-urban							
Cases	1	7	17	44	16	1	1
Advance Rate	0	0.36	1.06	3.02	5.37	1.50	0

[3] Includes one case with a 27 kilometer-per-day advance rate.

Looking further into the outcome IV (Attack Advances) engagements, since this is the only place where we have a statistically significant number of engagements for both sides, we find:

Advance	**Urban**	**Non-Urban**
Negative or Zero	1	1
up to 1 km/day	19	8
up to 2 km/day	7	17
up to 3 km/day	4	5
up to 4 km/day	0	4
up to 5 km/day	0	4
from 5 to 10 km/day	0	3
greater than 10 km/day	0	2

There is no question that the averages are heavily influenced by the number of Non-urban advance rates greater than three kilometers a day. However if those are deleted we still have an average of 0.96 kilometers-per-day for urban engagements compared to an average of 1.41 kilometers-per-day for Non-urban engagements, both based upon 31 total cases. For the Non-urban engagements, if the two highest advances are excluded from the average (19.6 and 17.8 kilometers-per-day), leaving the highest advance rate at 7.6 kilometers-per-day, then the average is 2.27 kilometers-per-day based upon 42 cases. Overall, the data is very consistent, with Urban advance rates being one-half to one-third of Non-urban advance rates. In summary:

	Cases	**Urban**	**Non-Urban**	**Ratio**
Channel Ports (Urban) versus Normandy (Non-urban) Engagements	22 vs 17	2.49	2.59	0.96
Aachen (Urban) versus Ardennes (Non-urban) Engagements	21 vs 70	0.96	2.81	0.34
Channel versus Normandy Engagements, modified	22 vs 17	1.49	2.43	0.61
Aachen versus Ardennes Engagements, modified	21 vs 70	0.96	2.45	0.39
Outcome IV Engagements	31 vs 44	0.96	3.02	0.32
Outcome IV Engagements, low force ratio attacks	14 vs 12	1.23	2.59	0.47
Outcome IV Engagements, medium force ratio attacks	12 vs 7	0.66	1.76	0.38
Outcome IV Engagements, high force ratio attacks	5 vs 3	0.94	3.55	0.26

Therefore, one can conclude that the average advance rate in urban combat should be one-half to one-third that of non-urban combat.

The Effect of Urban Terrain on Force Density

The linear density of the attacker, which is the number of attacker personnel per kilometer of front, was the primary measurement used for this analysis. This was chosen, rather than a measure of area density, since it is often not known where the rear boundary of a unit was, the boundary was often applied inconsistently, and since it would include many

personnel of service and service support units rather than combat and combat support units.[4] The attacker density was chosen since it was larger than the defender density except for the seven cases where the defender outnumbered the attacker. We utilized the attacker density throughout the analysis for consistency. The average density for each data set was:

	Number of Cases	**Average Linear Density**	**Weighted Average Linear Density**
Channel Ports	20	4,614.17	3,331.89
Normandy	17	2,072.20	1,869.96
Aachen	21	2,089.17	1,773.26
Ardennes	70	2,068.95	1,355.58

These clearly contain a few outliers. For example, the five lowest and highest cases in each set are:

	Five Lowest Cases	**Five Highest Cases**
Channel Ports	1,299.78	19,332.08
	2,331.08	16,300.00
	2,331.08	11,816.40
	2,331.08	5,774.25
	2,331.08	4,365.19
Normandy	709.67	4,075.00
	721.15	3,446.40
	902.64	3,129.20
	1,103.40	2,833.33
	1,464.78	2,833.00
Aachen	1,188.67	7,718.80
	1,344.96	3,401.86
	1,464.00	2,924.82
	1,575.80	2,823.13
	1,580.00	1,784.33
Ardennes	264.57	12,800.00
	268.32	10,932.78
	272.07	4,394.00
	564.96	4,228.89
	580.96	4,000.00

[4] This last could be argued, and has been argued endlessly before. However, limiting the count to combat and combat support personnel, and those service and service support personnel found in a division and its attachments, simplifies the measurement process in the *DuWar* DLEDB, which after all is a division-level data base.

As can be seen, the linear densities above 10,000 are outside of the norm, as are those below 300. If the two highest and the two lowest densities are removed from the Ardennes set, and the three highest and three lowest from the Channel Ports set, then the following results:

	Number of Cases	**Average Linear Density**
Channel	14	2,777.35
Normandy	17	2,072.20
Aachen	21	2,089.17
Ardennes	66	1,826.68

As can be seen, the Channel Ports clearly have the highest density of all data sets, while the Ardennes have the lowest. This is not surprising, since the Channel engagements were mostly sieges with narrowly defined frontages. The Ardennes was mostly heavily wooded with a much more limited road net. It does not appear that the urban nature of the terrain is what is making the difference. The difference in linear density between the Urban and Non-urban cases may be summarized as:

	Number of Cases	**Ratio of Linear Densities Urban versus Non-Urban**
Channel versus Normandy	20 vs 17	
Average		2.23
Weighted Average		1.78
Adjusted Average		1.34
Aachen versus Ardennes	21 vs 70	
Average		1.01
Weighted Average		1.31
Adjusted Average		1.14

In light of the similarity of the Aachen data to the Ardennes data, and of the Aachen data to the Normandy data (which are nearly identical), one is left with the conclusion that the higher density in the Channel Ports cases, which appears to be by a factor of two, is mostly due to them being akin to sieges, rather than field battles. While there is some difference between the Aachen and Ardennes cases, it is probably more to due to the restricted nature of the terrain in the Ardennes than it is due to urban terrain in the city of Aachen. **Overall, there is little evidence that operations in urban terrain result in a higher linear density of troops, although the data does seem to trend in that direction.**

The Effect of Urban Terrain on Armor

Much of the current discussion and analysis of the effects of urban warfare point to the heavy armor losses suffered by the attacking Israelis in the city of Suez in October 1973 and by the Russians at Grozny in January 1995. However, in our analysis of 46 cases of urban combat, we found no such heavy armor loss. In fact, armor losses were fairly low in

most of the urban operations examined, although we did not have loss data for all the engagements:[5]

	No. of Cases	Average MBT Strength	No. of Cases	Average Daily Tank Losses	Average Percent Tank Losses	Weighted Percent Tank Losses
Channel Ports						
Attacker	25	170.68	15	0.74	0.49	0.37
Defender	11	8.36	2	6.94	100.00	64.19
Normandy						
Attacker	21	185.24	16	7.83	4.48	3.57
Defender	12	43.25	4	2.77	1.94	4.54
Aachen						
Attacker	21	150.90	16	7.00	2.74	3.33
Defender	21	37.10	19	4.47	14.86	12.67
Ardennes						
Attacker	70	99.89	51	7.00	6.23	5.66
Defender	70	42.50	44	6.63	10.11	13.55

These aggregated figures provide a pretty clear picture, even though the loss data is partly incomplete. All of these operations whether Urban or Non-urban tended to have attackers which were "tank heavy." The defenders had some armor, except in the Channel Ports cases, where it appears that they were limited to a small company-size contingent of open-topped, lightly-armored tank destroyers. For the Aachen and Non-urban cases, the average daily tank loss for the attacker were almost identical. The daily percent loss for the attacker clearly shows that the armor losses in Urban terrain were lower than in Non-urban terrain. The results in the Channel Ports engagements are clearly skewed by the very one-sided armor forces engaged, and as a result Allied armor losses were very low. Defender armor losses were not always well recorded.

Overall, the total number of tanks recorded lost is fairly small (although, again, not all engagements had losses recorded):

	Attacker Total Tanks Lost	Defender Total Tanks Lost
Channel	12	15
Normandy	316	28
Aachen	112	90
Ardennes	607	496

In the Channel Ports engagements, the worse case was four tanks lost in a single day by the attacker. For the defender it was 13 lost in one day, when the city of Brest

[5] In the total data set there were some cases of zero armor losses, zero armor presence as well as an occasional simple lack of any record regarding armor. In addition, in some cases it was evident that the armor loss data included combat and non-combat (mechanical) losses as well as both destroyed and damaged vehicles. Also, in the *DuWar* DLEDB armor losses does not distinguish between MBT and light tanks. However the loss of light tanks was usually minor in any case.

surrendered. However, the Brest case is anomalous since it is not known on which particular day – of the 24-odd in that battle – that any of the armored vehicles were lost.

The Aachen cases generated some substantial armor losses. However, it appears likely that few of them were due to urban fighting or incurred within the city. The five days of heaviest armor loss for the attacker (30, 25, 12, 9 and 8 tanks lost) were all part of the 30th Infantry Division attack between 3 and 8 October, 1944, fought in a mixture of rolling mixed and Conurban terrain. This attack also accounted for three of the six highest tank losses by the defender. Overall, these six days of battle (six cases) accounted for 87 tanks lost by the attacker (78 percent) and 36 tanks lost by the defender (40 percent). Armor losses declined after the battle transitioned into what is coded as Conurban terrain. Outside of these cases, both attacker and defender never lost more than seven tanks in a day except for one case where the defender lost 14. Overall, it does not appear that armor losses from fighting in the Urban and Conurban terrain around Aachen was higher than that in Non-urban terrain, and in fact it appears lower.

Overall, it appears that armor losses in Urban terrain are the same as, or lower than armor losses in Non-urban terrain. And in some cases it appears that armor losses are significantly lower in Urban than Non-urban terrain.

The Effect of Urban Terrain on Force Ratios

We have already utilized Force Ratios as part of the analyses, to section the data base. However, the specific question dealt with here is whether force ratio somehow is a dependent variable, that is, does the presence of Urban terrain lead an attacker to fight with a higher force ratio, or a lower one?

	Number of Cases	**Average Force Ratio**	**Weighted Force Ratio**
Channel Ports	25	8.01	4.33
Normandy	21	3.55	2.02
Allied Attacks Only	17	4.00	2.12
Aachen	21	2.43	2.29
Ardennes	70	2.13	1.69
US Attacks Only	47	1.96	1.78

Although the force ratio for the Channel Ports engagements is clearly higher than the Normandy engagements, this is probably driven entirely by the nature of the operations. The Non-urban battles were clearly a mixture of engagements that were not always carefully organized and include four German counterattacks. These German attacks were executed at a low force ratio and they are excluded from the results for Normandy, Allied Attacks Only, in the table above.

The Aachen Urban data set is much closer in general to the Non-urban data, although it is still higher than the Ardennes Non-urban data set. The Ardennes data includes 23 German attacks, with an extreme mixture of both low and high force ratio attacks. However, the data set does not change much if those 23 are deleted as outliers.

The Channel Ports and Aachen Urban engagements effectively were set-piece engagements. The attacker had time to mass forces and make detailed thoroughly planned and rehearsed preparations for an offensive. As a result the higher force ratio probably

reflects that fact more than any intrinsic effect of the terrain, especially in the case of the Channel Ports and Brest, where the defender was isolated and incapable of reinforcement.

The Effect of Urban Terrain on the Duration of Combat

Due to the nature of the data collected, little concrete could be determined concerning the effect of cities upon the duration of the combat. In the *DuWar* DLEDB the determination of the length of an engagement is based upon one of two different criteria.

One is event based, that is, it is considered that an engagement lasts only until an easily determined milestone is reached. That milestone could be a breakpoint or another decision point in the engagement (the achievement of assigned objectives, the arrival of significant reinforcements, and the descent of night would all be examples). This criterion is also utilized when the records available do not support the analysis of an engagement by discrete time segments as finite as a day. Most of the engagements originally created as part of the CHASE Database and the Hero/DMSi Land Warfare Database were of this type.

The other criterion is based solely upon time and is normally a single day. As such, the average length of the engagement has nothing to do with the time required to complete the engagement. Most of the engagements added to the original CHASE/LWDB Databases as part of the *DuWar* DLEDB are of this type.

As a result, little regarding time requirements can be concluded from a direct analysis of the database. However, this issue is addressed further in the case studies that look more closely at the battles of Brest and Aachen.

Conclusions

The overall conclusions that may be derived from an analysis of the data are:

1. Urban combat did not significantly influence the Mission Accomplishment (Outcome) of the engagements.
2. Urban combat may have influenced the casualty rate. If so, it appears that it resulted in a reduction of the attacker casualty rate and a more favorable casualty exchange ratio compared to Non-urban warfare. Whether or not these differences are caused by the data selection or by the terrain differences is difficult to say, but regardless, there appears to be no basis to the claim that Urban combat is significantly more intense with regards to casualties than is Non-urban warfare.
3. The average advance rate in Urban combat should be one-half to one-third that of Non-urban combat.
4. Overall, there is little evidence that the presence of urban terrain results in a higher linear density of troops, although the data does seem to trend in that direction.
5. Overall, it appears that the loss of armor in Urban terrain is the same or lower than that found in Non-urban terrain, and in some cases is significantly lower.
6. Urban combat did not significantly influence the Force Ratio required to achieve success or effectively conduct combat operations.
7. Nothing could be determined from an analysis of the data regarding the Duration of Combat (Time) in Urban versus Non-urban terrain.

URBAN COMBAT OPERATIONS AND BATTLE CASUALTIES, CASE STUDIES

Some writers have postulated that urban combat operations incur large numbers of casualties by the opponents, and particularly by the attacker. Furthermore, it has been postulated that these casualties and associated casualty rates tend to be much higher than those found in operations in other types of terrain. In one recent study of urban warfare the following statement was made.

> *The cost to the attacker was considered high in the majority of the cases. Attacker cost was deemed high in casualties, time, and resources, respectively, in 68, 55, and 59 percent of the cases studied. ("High cost" is, of course, relative to the percentage of total resources and time expended and the results achieved. A high cost does not necessarily imply that the results were not worth the price.)* [1]

In another recent study done for the US Marine Corps, a casualty estimate for combat in urban terrain was developed from which the following statements could be derived.[2]

- For offensive operations in urban terrain, a rate of 30 to 50 casualties per 1,000 troops per day (3.0 to 5.0 percent-per-day) should be expected, with a battalion (evidently considered to be about 500 strong) suffering 25 casualties per day and a brigade (about 5,000 strong) suffering 250 casualties per day.
- For transitional operations in urban terrain a rate of 15 to 30 casualties per 1,000 troops per day (1.5 to 3.0 percent-per-day) should be expected. A battalion would suffer fewer than 15 and a brigade fewer than 150 casualties.
- For defensive operations in urban terrain a rate of 10 to 15 casualties per 1,000 troops per day (1.0 to 1.5 percent-per-day) should be expected. A battalion will suffer fewer than 20 and a brigade fewer than 50 casualties.

An extrapolation of these rates would imply that division-level offensive operations in urban terrain should result in a 9.0 to 15.0 percent-per-day casualty rate,

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[1] R.D. McLaurin, et al, *Modern Experience in City Combat*, US Army Human Engineering Laboratory, Aberdeen, MD, 1987, page 18. Curiously, in an otherwise excellent paper, this declaration regarding casualties is unsupported by any comprehensive collection of data or analysis in their case studies. Most of the cases contain no casualty data whatsoever.

[2] Colonel (Retd) R.A. Leitch MBE RGN, et al, *Analysis of Casualty Rates & Patterns Likely to Result from Military Operations in Urban Environments*, US Marine Corps Commandant's Warfighting Laboratory, Washington, DC, 1997, Tables 19, 20 and 21. The analytical underpinnings for these estimates are data taken from three case studies, the Battle for Hue in 1968, Operation Peace for Galilee in Lebanon 1982, and the Russian military operations in Chechnya. One is hard put to accept the catastrophic estimates put forward by this study. After extensive research covering some 35 years of study and the analysis of over 135 engagements involving US divisions in the ETO, the highest single-day divisional loss rate found remains 10 percent. The 99th Infantry Division suffered that loss on 17 December 1944 in the Ardennes (close rivals for that claim would be the 106th Infantry Division 19 December and the 17th Airborne Division 8 January 1945, both also occurring in the Ardennes).

that in transitional operations the divisional rate would be 4.5 to 9.0 percent-per-day, and that in defensive operations the divisional rate would be 3.0 to 4.5 percent-per-day. However, these rates are actually three to fifteen times **higher** than the average percent-per-day casualty rate experienced by US Army divisions in engagements during World War II.[3] It is also much higher than the actual attrition rates experienced in urban combat in the case studies found in this report.

The 2nd US Infantry Division Casualty Experience in the Battle for Brest

For the US 2nd Infantry Division in the Battle for Brest, it is possible to derive very accurate daily divisional battle casualty data. For 1—18 September the division suffered a total of 111 KIA, 952 WIA and 29 MIA, for a total of 1,092 battle casualties.[4] The average daily divisional battle casualty rate for the period was 0.384 percent per day, approximately one-eighth the rate estimated in the study above.

Furthermore, the Battle for Brest can be separated into three distinct phases. In the first phase (25 August—9 September) US forces were engaged in open terrain, fighting through a fortified belt surrounding the city, in an effort to close up onto the outskirts of the city itself. It was not until the evening of 8 September that house-to-house fighting began, and the division was not fully engaged in the city proper until early on 10 September.[5] During this phase the 2nd Division on 2 September suffered its peak level of attrition for the month when 136 battle casualties (a rate of 0.983 percent-per-day) were lost. The overall average attrition rate for the period 1—9 September during the first phase was 0.446 percent-per-day.

In the second phase (10—14 September) the division battled through the outskirts of the city reaching the city wall (part of the fortifications built to protect the city and naval base in the 17th and 18th century) at the end of the period. The fighting was characterized as 'house-to-house' and was considered to be highly intense. The peak during the period was 10 September, when 92 casualties (a rate of 0.639 percent-per-day) were incurred. Nevertheless, the average casualty rate decreased, to 0.427 percent-per-day.[6] The daily casualty rates also decreased as the division drove into the urban area, from 0.639 on 10 September, to 0.497 on 11 September, to a similar 0.507 on 12 September, to 0.226 on 13 September, and 0.265 on 14 September.

In the third phase (15—18 September) the division initially paused to regroup, mop up and contemplate the problem presented by the formidable city wall.[7] On 15 and

[3] Trevor N. Dupuy, *Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War*, HERO Books, Fairfax, VA, 1990, page 42.

[4] NARA RG 407, Entry 427, 302-1, 2nd Infantry Division G-1 Reports, June to December 1944, Box 5978. These reports were prepared some time after the battle and are obviously more accurate than the Estimated Loss Reports found in RG 331, Records of Allied Operational and Occupation Headquarters, World War II, SHAEF Command Staff, G-1 Admin Section Decimal File 1944-1945, Box 38, 12th Army Group G-1 Daily Summaries and RG 407, Entry 427, European Theater of Operations Theater Historian, Combat Interviews, Box 24014, Folder 14, Operations of the 2nd Infantry Division at Brest.

[5] See Operations of the 2nd Infantry Division at Brest.

[6] It may be that the losses of 10 September were more indicative of the previous fighting in the fortified belt around the city. On 9 September the rate was a very similar 0.636 percent-per-day.

[7] The Brest city wall was similar in construction – masonry-faced rammed earth – and layout to that encountered by US Marines during the battle for the Citadel of Hue in Vietnam during the Tet Offensive of 1968. However, the Brest wall was about twice as thick and higher, and the Germans had improved it by

16 September division and corps artillery pounded the area inside the old city wall as the division mopped up the area outside it. Direct and indirect artillery fires and careful probing for weak points eventually developed a few weak points in the barrier and the assault into the heart of the city began on 17 September. An initial, small, penetration was made at 1830 hours, but was repulsed. A later attack, at 2000 hours, penetrated south along the course of the Enfold River. A minor German counterattack failed and, with their defenses compromised, the garrison surrendered at 1530 hours on 18 September.

The average casualty rate for this period was 0.203 percent-per-day, with, as would be expected, a peak of 0.244 percent-per-day on 17 September. During the 'lull' of 15 and 16 September, when artillery hammered the city and mopping up of the suburbs was completed, the rate fell to 0.215 and 0.143 percent-per-day, respectively. During the opening attack on the wall on 17 September the rate climbed to 0.244 percent-per-day, falling to 0.209 percent-per-day on the last day of fighting. Even if only the last two days of fighting in the heart of the built up area of the city were considered, the average loss rate would have been only 0.226 percent-per-day.

The 1st US Infantry Division Casualty Experience in the Battle for Aachen

The losses of the 1st Division at Aachen follow a pattern similar to that experienced by the 2nd Division at Brest. In the two-week long battle the division suffered a total of 1,096 battle casualties for an average loss rate of 0.593 percent-per-day.[8]

On the first day of the battle, 8 October, the division suffered a total of 150 battle casualties for a loss rate of 1.066 percent-per-day. This relatively high level of attrition was maintained on 9 October, when casualties totaled 104 for a loss rate of 0.733 percent-per-day. On both of these days the division was attacking to the north from positions well east of the city, in an effort to isolate the city from the main German defensive line. No fighting occurred in the built up area of the city and the initial attack seized the only major conurban area in the zone of the first two days of fighting – the town of Verlautenheide – before the Germans could develop a defense of it.

On the following day, 10 October, the first mention of house-to-house fighting in the division zone was made, when elements of the 18th Infantry successfully attacked the village of Haaren.[9] Also, the 26th Infantry, which was tasked to assault the city itself, made a limited attack to seize positions overlooking the city and sent a surrender demand under flag of truce into the city. The division loss this day was 69, for a rate of 0.494 percent-per-day, one-half that of the first day and about two-thirds that of the previous day. Fighting on the outskirts of the city at Verlautenheide and Haaren continued for the next two days as the Germans attempted numerous counterattacks. Division losses hovered near one-half percent-per-day, 0.448 percent-per-day on 11 October and 0.518 percent-per-day on 12 October. The 26th Infantry continued to clear areas of the factory areas on the outskirts of the city, and only met with moderate resistance.

On 13 October the 26th Infantry completed clearing out the factory areas and the 18th Infantry consolidated its positions at Haaren and Verlautenheide. The division losses

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constructing modern steel-reinforced concrete emplacements to guard the exterior, and barracks, tunnels and other emplacements to strengthen the interior.

[8] 1st Infantry Division, Office of the A.C. of S., G-1, Report of Operations for October, dated 1 November, NARA RG 407, Entry 427, 301-1, June 1944 to 31 December 1948, Box 5672.

[9] History of the VII Corps for the period 1—31 October 1944, NARA RG 407, Entry 427, 207-0.3 6 June to December 1944, Box 3827.

were only 54 for a rate of 0.379 percent-per-day. On 14 October the drive into the city continued, with little other activity reported in the division zone. Losses totaled 71 for a rate of 0.429 percent-per-day.

The following day saw the beginning of a major counterattack by German forces seeking to reestablish contact with the city garrison. The 18th Infantry at Haaren and Verlautenheide easily repulsed the attack, but on their right the 16th Infantry had more difficulty. Despite this threat, the 26th Infantry continued the methodical clearing of the city without interruption. The intense German counterattacks continued through 16 October. Unsurprisingly, the losses of the 1st Division increased during this period. On 15 October the loss was 76 for a rate of 0.542 percent-per-day, increasing to 112 and 0.789 percent-per-day on 16 October. By 17 October the first major German counterattack was defeated. On that day the 1st Division losses decreased to 58 and a rate of 0.408 percent-per-day. The 26th Infantry continued to make slow progress into the city.

On 18 October a second attempt was made by the Germans to relieve the city. The heaviest weight of the German counterattack fell on the 18th Infantry defending Haaren and Verlautenheide, while the 26th Infantry continued to advance in the city, seizing the city center (made up of a complex of buildings in a park-like setting, the Palace Hotel and the Kurhaus on Observatory Hill). Losses were 103 for a rate of 0.660 percent-per-day. The German counterattack continued on 19 October strongly supported by artillery, which inflicted heavy casualties on the 18th Infantry. The 26th Infantry continued to methodically clear the city block by block. Losses were the heaviest since the beginning of the offensive on 8 October, a total of 112 for a rate of 0.864 percent-per-day.

Casualties on 20 October continued to be high, there were a total of 100 for a rate of 0.710 percent-per-day. Resistance in the city remained strong, but the counterattacks to relieve the city petered out. However, German artillery support continued to be strong and inflicted numerous casualties. A reflection of this may be seen in the ratio of KIA to WIA in the 1st Division during the battle. Overall, the ratio from 8 to 21 October was 1-to-5.67 (151 KIA to 856 WIA), higher than the 1-to-4 or 1-to-5 range that would normally be expected. In the final four days of the battle, as German artillery support increased, the ratio increased to 1-to-8.26 (27 KIA to 111 WIA).[10]

On 21 October the defenders of the city capitulated, ending the battle. Losses declined to a total of 36 for a rate of 0.261 percent-per-day.

Overall, the effects of the fighting in the city of Aachen upon the casualties of the 2nd Division are difficult to assess. Unlike Brest, there is less clear delineation between when the fighting at Aachen transitions from countryside, to conurban and then urban terrain. Furthermore, only two of the eight battalions of the division were actively engaged in the battle fought in the city, and only two or three more were engaged in the conurban village complex outside the city. The peak loss rates incurred during the period when urban combat was going on – 16 and 18—20 October – are closely associated with a period of strong German counterattacks to relieve the city, and a strong increase in

[10] That the German artillery support increased drastically from the start to the end of the battle may be found not only in the comments regarding the strength of the German barrages found in the American records, but also in the German records as well. A German analysis noted that the number of their firing batteries increased by 13 percent from the period 1—10 October to 11—20 October and that the number of rounds they fired increased by 50 percent. See "Beurteilung der feindl. Artillerie vor dem LXXXI.A.K." (Estimate of Enemy Artillery Opposed to the LXXXI Army Corps), NARA Microfilm RG 242, T314, R1597, F0246.

German artillery support. It may also be significant that what was evidently one of the most difficult objectives in the city, the spa hotel complex on Observatory Hill, consisted of several large buildings surrounded by park land.

It may be that additional insights could be gained by an examination of the regimental and battalion-level loss rates in this battle. However, such an examination is outside the scope of the current phase of this study, and – in the interests of time and budgetary constraints – was not researched.

Conclusion

Overall, it appears that the assumption that combat in an urban environment produces higher numbers of battle casualties and/or loss rates is unsupported and appears to be strongly contradicted. In fact, indications are that the opposite may in fact be true, that combat in an urban environment produces lower numbers of casualties and/or loss rates.

URBAN COMBAT OPERATIONS AND COMBAT STRESS, CASE STUDIES

Combat is a stressful environment by any measure. 'Battle fatigue,' 'shell shock,' 'combat exhaustion,' and 'traumatic stress syndrome' is just a few of the terms that have been applied to the effects of combat on the human psyche. Anecdotally it would appear that the loss of situation awareness, limited communications and close proximity of the enemy found in urban combat increases the stresses felt by soldiers in that environment. However, just as for battle casualties, no evidence can be found for the effects of increased stress in urban combat.

The 29th US Infantry Division Combat Exhaustion Study

One very interesting document relating to combat stress was prepared by Major David L. Weintrob, the Division Psychiatrist of the 29th Division in the European Theater of Operations on 2 October 1944.[1] The Division Psychiatrist was a position only authorized by War Department Table of Organization on 12 January 1944, just five months prior to D-Day and over two years after the first major commitment of US Army ground forces in North Africa. Officially, the Division Psychiatrist was attached to the Division Staff as an advisor to the Division Surgeon.

Luckily, prior to D-Day it was decided to provide the psychiatrist with a staff of five enlisted medical personnel, a ward tent and 20 cots as part of the Clearing Company of the division's 104th Medical Battalion. By 18 June, 12 days after the division entered combat, the Combat Exhaustion Section had doubled in size, and was attempting to treat 50 patients. From 21 June—10 July admissions averaged 8 to 12 per day. Then on 11 July the division began its major push to seize the road junction at St. Lo. Over the following eight days 501 combat exhaustion cases were admitted. By 14 July the division commander realized that drastic steps had to be taken to handle the sudden influx of patients and authorized another expansion of the Combat Exhaustion Section, to a medical staff of 15, a kitchen staff and accommodations for 250 patients. By the time the 29th Division was committed to operations at Brest it had had considerable experience in handling and treating combat exhaustion.

However, most revealing for the purposes of this study of urban combat is the statistical analysis of combat exhaustion prepared by MAJ Weintrob as an appendix to his report on combat exhaustion. He divided his survey into a four-week period (from the invasion on 6 June—9 July) and five two-week periods, ending on 17 September (effectively the end of division operations in the city of Brest).

During the entire period a total of 1,822 combat exhaustion cases and 14,503 non-fatal battle casualty cases (wounded-in-action) were admitted for a total of 16,325 non-fatal battle casualties over 14 weeks. A total of 1,033 combat exhaustion cases were returned to duty, of which 291 were later readmitted for combat exhaustion.[2] Thus,

[1] NARA RG 407, Entry 427, ETO Theater Historian, Combat Interviews, Box 24035, Folder 84, 29th Infantry Division.

[2] Statistics on WIA returned to duty are incomplete.

combat exhaustion represented 11.16 percent of the total non-fatal casualties (wounded and exhaustion) for the entire period of the Normandy and Brittany Campaigns.

However, during the Battle for Brest the incidence of combat exhaustion cases (and battle casualty cases) was dramatically lower than during any other period of the campaign. From 4—17 September – a period that encompasses the brutal fighting for the fortified line outside Brest, the fighting in the suburbs, and the fighting in the central city itself – there were only 75 cases of combat exhaustion admitted in the division and 1,582 cases of non-fatal battle casualties. Thus, combat exhaustion made up only 4.53 percent of the non-fatal battle casualties during the Battle for Brest, about 40 percent of the average for the entire campaign.

In fact, the peak incidence of combat exhaustion actually occurred some weeks prior to the Battle for Brest. During the period 23 July—6 August there were 552 combat exhaustion cases admitted and they constituted 15.53 percent of the total non-fatal battle casualties admitted.[3] Furthermore, in his analysis MAJ Weintrob made no association with (or mention of) urban combat operations and combat exhaustion. Rather, he quite convincingly found a direct correlation between the number of poorly trained and oriented replacements assigned to the division, and the incidence of combat exhaustion. During the entire period it was found that 694 of the combat exhaustion cases admitted were replacements or 38.09 percent.

Non-battle Casualty Experience in Other Divisions in Urban Combat

Although less precise, an analysis of the casualty experience of the other divisions involved in the urban engagements studied in this report tend to reinforce the view that urban combat is not necessarily a more stressful form of combat. In these cases daily or periodic data for combat exhaustion admissions could not be found. However, the daily sick reports of the divisions are available and reinforce the impression gained from the 29th Division combat exhaustion study. [4]

During the Battle for Brest from 1—18 September, the US 2nd Infantry Division, which was most closely involved in the battle in the urban areas of the city, reported a total of 980 battle casualties (KIA, WIA and MIA, see the previous section analyzing battle casualties). That was an average of 54.44 battle casualties per day. Also, there were 608 sick casualties reported for an average of 33.78 per day, with a peak of 54 reported on 5 September. For the period when the division was battling through the fortified outskirts of the city (1—9 September) the number of sick per day averaged 41. For the period of fighting in the built up area outside the city wall (10—14 September) the number of sick per day averaged 28.4, with a peak of 40 reported on 12 September. For the final fighting in the city center (15—18 September) the number of sick per day averaged 24.25, with a peak of 29 on 17 September.

The daily divisional sick rate (number sick divided by divisional strength) reveals the same pattern. Overall, the rate averaged 0.239 percent-per-day, with a peak of 0.376 on 5 September. For the period 1—9 September the average was 0.289 percent-per-day, for 10—14 September it was 0.200 percent-per-day, with a peak of 0.282 on 12

[3] Non-fatal battle casualties admitted in the period were 3,002 for a total of 3,554 including the combat exhaustion cases.

[4] Sick cases were also referred to as DNBI or disease and non-battle injuries, a category that at the time included what were known as neuro-psychiatric cases or combat exhaustion.

September, and for 15—18 September it was 0.174 percent-per-day, with a peak of 0.208 on 17 September.

The US 1st Infantry Division experience at Aachen (8—21 October 1944) shows somewhat more variation. The division suffered a total of 1,180 battle casualties during the two-week period (see the previous section) and 625 casualties from sickness, an average of 44.6 per day, and an average rate of 0.344 percent-per-day. On 16 October during the fighting in the city center, the peak number and rate of sick casualties was reported as 66 or 0.465 percent-per-day. During the fighting to encircle the city, in the conurban areas to the east and northeast (8—12 October), the average daily sick were 43.6 or 0.312 percent-per-day. During the following nine days (13—21 October) the average daily sick were 51.2 or 0.362 percent-per-day.

It could be assumed that the increased sick during the nine-day long battle in the city of Aachen was at least partly as a consequence of an increase in the incidence of combat exhaustion. However, if so there is no mention of such in the divisional G-1 or medical reports. In fact, the monthly G-1 summaries of the 1st Division for September, October and November all make note of an increased sick rate during the month. For September when the daily sick averaged 29.2, it was noted that "near the end of the month there was an increase noted in the sick rate. This was attributed to the fact that the leading elements of the Division were in foxholes close to a determined enemy, and the weather was very cold and rainy." For October, when the daily sick averaged 42.1, it was noted that "there was an increase in the sick rate due to the weather which was unfavorable with rain and cold wind for the greater part of the month." For November, when the daily sick averaged 71.3, it was noted that "weather was highly unfavorable, and despite the early issuance of overcoats and overshoes, the sick rate showed a marked increase."[5]

Unfortunately, no comparable daily sick data has been found for the Canadian and British units engaged at the Channel ports in September 1944. Only fragmentary and aggregate sick data appears to be available for the German and Soviet units engaged at Kharkov in 1943.

Conclusion

There appears to be little justification for the assumption that combat in an urban environment is any more stressful than in any other environment. The evidence from the experience of the 2nd and 29th Divisions is that the incidence of sickness and combat exhaustion may actually decrease in an urban environment. The contradictory evidence

[5] 1st Infantry Division, Office of the A.C. of S., G-1, Report of Operations, dated 1 October, 1 November and 1 December 1944 as found in NARA RG 407, Entry 427, 301-1, June 1944 to 31 December 1948, Box 5672. Overall, expected sick rates for September are 0.210 percent, for October 0.240 percent and November 0.27 percent, by this criteria the 1st Division experience in November, when it was not engaged in major urban operations, was very high indeed (see Dupuy, *Attrition*, page 57, for average sick rate experience by month for US divisions in the ETO).

from the 1st Division experience appears likely to have been as a result of the extremely poor weather conditions found in the fall of 1944.

Overall, it appears that the assumption that combat in an urban environment is more stressful than other environments is at best unsupported and may in fact be contradicted.

LOGISTICAL EXPENDITURES IN URBAN OPERATIONS, CASE STUDIES

As far as the logistical burden of urban operations is concerned, it has been asserted that

> *In addition, the requisite force concentrations and the higher tempo of operations mean that foodstuffs, water, and ammunition are consumed more rapidly than they would be elsewhere.*[1]

Like most of the assertions regarding urban warfare in Glenn's and many other papers referenced in this study, this declaration of fact is unsupported by any of the data we have been able to find from actual urban operations.

An actual analysis of expenditures – when they are known – in the urban engagements examined, show little evidence that it is higher than that experienced in combat outside an urban environment.

Ammunition Expenditure in the Battle for Brest

The actual amounts of ammunition planned for and actually expended in the battle for Brest were laid out in the extensive after action reports of the VIII Corps artillery.[2] The initial fire plan called for a reserve of three units of fire in the corps ASP (ammunition supply point) before the operation began. This request was denied by corps headquarters, which required an estimate based upon a set, ten-day plan of operations. The corps artillery then forecast a need for 345,200 rounds of artillery ammunition based upon 'knowledge of the difficulties of supply for an operation so far removed from the sources of supply and on the lack of communication facilities to supply agencies."[3] When the operation began, initial stocks of ammunition were actually limited to at most one and one-half units of fire, and only for a few calibers. The scale of the limitations imposed by the logistical constraints may be better understood if it is realized that if **every** artillery piece concerned had had one and one-half units of fire available at the start, only 45,162 rounds would have been available.[4] Nevertheless, the corps artillery successfully prosecuted the attack, expending in the end a total of 421,763 rounds from 22 August to 19 September, an average of 14,544 rounds per day.

That expenditure, although it appears large, was actually unremarkable. During the course of the entire European Campaign in World War II the average number of rounds expended by the two most common artillery pieces, the 105mm M2 and 155mm M1 Howitzer, for units in an attack posture, were 241.6 rounds-per-gun-per-day and 160.6 rounds-per-gun-per-day respectively.[5] The actual expenditure in the VIII Corps attack on Brest averaged 78 and 43 rounds-per-gun-per-day respectively, about one-third

[1] Glenn, *Heavy Matter*, page 12.
[2] Report on the Artillery with the VIII Corps in the Reduction of Brest, 22 August—19 September 1944, NARA RG 407, Entry 427, 208-ART-0.3 to 208-ART-0.7, August 1944, Box 4090.
[3] *Ibid.*
[4] Based upon the unit of fire data as given in the VIII Corps Artillery reports.
[5] J. Duncan Love, *Artillery Usage in World War II (2 Vols.),* ORO-T-375, April 1959.

to one-quarter the normal experience, and not dissimilar from the average expenditure found for all postures (attack, movement and static) during the European Campaign, which was 86.6 and 38.6 rounds-per-gun-per-day respectively.

The experience of the 1st Division artillery in the Battle for Aachen was also similar to the average found for all postures in the Love Study.[6] The average daily expenditure for the division's 66 howitzers was:

8 October	77.65
9 October	65.39
10 October	55.36
11 October	102.70
12 October	66.62
13 October	35.65
14 October	35.20
15 October	133.06
16 October	40.47
17 October	39.18
18 October	60.44
19 October	79.79
20 October	34.05
21 October	(report missing)
Average	63.50

The two 'peak' days, 11 and 15 October, warrant some additional investigation. On 11 October the VII Corps historical report noted that the 1st Division artillery,

> *Worked in close support with fighter-bomber groups of the IX TAC [Tactical Air Command] throughout the period to give Aachen a heavy pounding…and the Div Arty fired 63 missions on the city. A heavy concentration [apparently 10 missions] was fired on an enemy counter-attack against the 3rd [evidently meant to be 1st] Bn, 18th Inf…other missions fired were 60 [or 50, the number was overtyped in the original] harassing, 33 vehicle, 18 tank, 7 mortar and machine gun, and 20 miscellaneous.*[7]

From this account it appears that somewhere between 191 and 211 missions were fired in support of the 1st Division, of which only about one-third were fired into the city. All of the missions fired into the city were preparatory or destructive in nature, since no attacks were made on that day into the city.

On 15 October the situation was somewhat more ambiguous. The VII Corps report noted that,

[6] See the "History of the VII Corps for the period 1—31 October 1944. Based upon the Love averages for all postures, the average rate for the 54 105mm and 12 155mm howitzers would be 77.87 rounds-per-day and for an attack posture it would be 226.87 rounds-per-day.
[7] Ibid.

1st Division: Division artillery was extremely active during the period due to the several enemy counter-attacks. Fired 255 missions as follows: 95 counter-attack, 60 tank, 37 personnel, 14 mortar and machine gun, 7 vehicle, 4 counter-battery, and 7 miscellaneous…[8]

The strongest German counterattack on 15 October was directed against the 16th Infantry, which was entirely engaged in the open countryside east of the city. However, it was stated that the 3rd Battalion, 26th Infantry fighting in the city received "a counter-attack…[which] caused the loss of several houses east of OBSERVATORY HILL."[9]

Overall, the evidence appears to be that the expenditure of artillery ammunition in urban operations was no more than that in other operations. In the two cases where extensive data is available, Brest and Aachen, it appears that the expenditure was actually **less** than the average expenditure rates for all postures and was about **one-third** to **one-quarter** the average expenditure rates expected for an attack posture.

Expenditure Rates for Other Types of Ammunition

It is also possible to compare the expenditure rates for other types of ammunition (small arms, mortar and antitank guns), as well as artillery ammunition, between a division engaged in urban operations and a division engaged in non-urban operations. In this case we will compare the experience of the US 2nd Infantry Division during the Battle of Brest with that of the US 90th Infantry Division during the Normandy Campaign.

The average daily expenditures for the 2nd Division for the period 24 August—20 September 1944 (28 days) and for the 90th Division for the period 1—31 July 1944 (31 days) were:

	2nd Division	90th Division
Small Arms		
Cal. 30 Carbine	1,441.07	7,251.52
Cal. 30 Ball, 5 clip[10]	1,553.57	9,855.23
Cal. 30 Ball, 8 clip[11]	22,050.29	27,885.90
Cal. 30 Ball, MG	16,491.07	30,382.90
Cal. 45 Ball[12]	3,578.57	2,611.39
Cal. 50 MG	12,620.71	2,627.39
Rocket, AT HE[13]	41.68	42.71
Grenade, Hand, frag.[14]	423.29	512.06
Adapter, Grenade Proj.[15]	77.93	17.19

[8] Ibid.
[9] Ibid.
[10] For the Browning Automatic Rifle or BAR, the standard squad light automatic weapon.
[11] For the M1 Rifle, the standard rifle issued to infantrymen.
[12] For the M1911 Pistol and the M1 and M3 submachine guns.
[13] For the 2.35" 'Bazooka' antitank rocket launcher.
[14] The 2nd Division also noted the expenditure of 449 offensive (concussion-type) grenades (16.04 per day) and 1,053 smoke and colored-smoke grenades (37.61 per day). The 90th Division did not record expenditures for these types.
[15] This adapter allowed standard hand grenades to be launched from the standard M1 Rifle. In addition, the 2nd Division reported expending 2,508 antitank rifle-grenades (89.57 per day). The 90th Division did not record expenditures for this type.

Grenade, Rifle, Smoke, W.P.	16.29	74.52
Mortars		
60mm	826.71	511.77
81mm	1,367.04	2,209.55
AT Gun		
57mm	65.07	65.48
Artillery		
105mm How, M3	408.25	450.77
105mm How, M2	1,896.84	2,577.81
155mm How, M1	471.82	346.81

A few comments appear warranted. The consumption pattern for small arms is interesting. It is generally assumed (and on occasion remarked in the after action reports and lessons learned) that carbines and submachine guns are preferred weapons for urban combat.[16] However, although the consumption of Cal. 45 ammunition by the 2nd Division at Brest was 1.37 times higher than that of the 90th Division, the consumption of Cal. 30 Carbine ammunition was 5.03 times lower than that of the 90th Division! But it should be remembered that the carbine at this time was a substitute for the pistol and that neither the carbine nor the submachine gun was a priority item of issue in the infantry table of equipment.[17] It appears likely that the difference in expenditures may be more a factor of different numbers of weapons being available in the two divisions.

The consumption of machine gun ammunition also appears perfectly explicable. The greater range and penetrative capability of the Cal. 50 round over the Cal. 30 round likely made it more desirable as a weapon to interdict the streets of Brest.[18] However, in non-urban operations the excessive weight of the Cal. 50 machine gun itself made it less desirable, especially in mobile operations, a situation which did not pertain to the essentially static situation at Brest. Note that the overall consumption of machine gun rounds is about the same in both cases.

The consumption pattern for grenades don't appear to be radically different in the two cases either, except possibly in the case of rifle grenades. However, again it appears that the availability of a particular type of weapon or ammunition may have been just as significant as the tactical advantage one type had over another in the urban environment.[19]

The consumption of mortar ammunition is also perfectly reasonable, there appears to be little difference between the urban and non-urban case. The higher consumption of

[16] In the report "Fighting in Cities" VIII Corps noted that the "most effective weapons in close-in city fighting were found to be the BAR, the submachine gun, and the automatic carbine." NARA RG 407, Entry 427, 208-0.3.0 to 208-0.10, Box 3960.

[17] At this time the infantry regiment was not authorized any submachine guns, but 293 pistols, 836 carbines and 1,990 rifles.

[18] "Fighting in Cities" noted that due to limited fields of fire machine guns offered little support for advancing troops and were used only to interdict enemy movement across streets.

[19] "Fighting in Cities" noted that hand grenades were "essential" in urban fighting and that rifle grenades were "extensively" used.

60mm mortar ammunition was likely from their noted use as an extemporaneous rifle grenade by wiring the shell to the M1 grenade projector adapter.[20]

Nothing else of significance may be deduced from this comparison, although it further reinforces the assumption that artillery ammunition expenditure rates are not excessive in urban warfare. Overall, it appears that the best evidence is that ammunition expenditure in an urban environment varies somewhat from that in a non-urban environment, but that the variation is a matter of type and degree rather than quantity.

Other notable expenditures recorded by the 2nd Division but unfortunately, not by the 90th Division were the following:

5,050 pounds of TNT
1,331 pounds of demolition blocks
600 pounds of cratering explosive
5,770 feet of prima-cord
2,600 feet of time fuse
600 fuse lighters
2,530 electric blasting caps
350 non-electric blasting caps
50 Bangalore torpedoes

However, although significant in number, the total weight of these items was probably considerably less than 5 tons, a fraction of the 3,735 tons of ammunition reported expended by the 90th Division during July.

Consumption of Food and Water

The assumption that fighting in an urban environment somehow increases the consumption of basic items like food and water is somewhat mystifying to say the least.[21] Unfortunately, no exact measure of food and water consumption in the urban combat cases examined was found. However, there was **no** explicit mention of problems with food or water supply found in the narratives of **any** of the urban engagements, **nor** was there **any** mention of specific problems with food or water supply in **any** of the extensive 'lessons learned' reports associated with these engagements. In this case the absence of any specific information is taken as a refutation of the assumption.

[20] See "Fighting in Cities," ibid.

[21] The assumption that water consumption increases in a desert combat environment or that the consumption of hot food increases in a cold-weather environment (if conditions allow) is perfectly reasonable and may be supportable. However, the assumption that an urban environment increases consumption of food and water appears both unreasonable and unsupportable.

OTHER FACTORS IN URBAN COMBAT, CASE STUDIES

Time Requirements in Urban Combat

One thing that became immediately obvious at the beginning of this study was that most previous studies had badly confused the urban **campaign** with the actual urban **engagement**. That is, as is so common in the study of combat, the scale of the engagement in question became muddled.

As a simple example, the Brest Campaign can be defined as lasting somewhere between 24 and 31 days. However, the actual battle within the confines of the city of Brest lasted at the most some nine days, and at the least some six days. In effect, between 25 and 29 August 1944 attacks were made to develop the German fortified defenses well outside the city. Then, from 30 August to 10 September a continuous series of intense and bloody engagements were fought to bring the American forces to the outskirts of the city (in effect, to the edge of the conurban area of Brest). What can properly be termed "street fighting" or "urban warfare" began on 10 September and continued into the evening of 14 September. In that period, the outskirts of the city, up to the old city fortification wall, were seized. There then followed a brief pause through 15 September and extending to the evening of 17 September as the inner city was bombarded by American air and artillery and the attackers contemplated the best method of breaching the old, but still formidable, city wall. On the evening of 17 September the final attack was executed, which breached the city wall and forced a capitulation of the city garrison on the following day, shortly after noon.

Similar experiences and timetables were discovered in the other cases. In the Channel Ports battles proper (Le Havre, Boulogne and Calais) the actually fighting within the environs of the "city" rarely lasted longer than a day, although fighting for the fortified outskirts usually required between two to four days. In the case of Cherbourg, the fighting inside the city itself also took little more than a day, although again the fortified lines outside the city took considerably greater time and blood to subdue.

Finally, in the case of the largest urban area studied in Phase I of this report, Aachen, two days, 8 and 9 October 1944 were consumed by two battalions of the 26th Infantry of the 1st Division in securing the industrial suburbs southeast of the city.[1] The actual "city" fighting did not begin until 1100 hours 12 October 1944 when the 26th Infantry began driving into the city center, even though the Aachen Campaign itself had begun with the XIX Corps attack north of the city on 2 October. After noon on 21 October the German garrison surrendered the city. Thus, the largest city also took the longest time to clear, between 10 and 12 days. However, by a large margin the forces committed to the final battle for the city were also the smallest of all the cases examined, two reinforced battalions compared to elements of ten battalions in the case of Brest and of 12 battalions in the case of Cherbourg. In the Channel Ports battles the circumstances varied a little (extensive "street fighting" evidently only occurred at Le Havre and Boulogne, there was little at Calais). Apparently between six and nine battalions were

[1] Which was quite literally on the wrong side of the tracks, the area south and southeast of the Aachen-Cologne-Munich-Frankfurt railway line, including the railway station and train yards of Rothe Erde, a heavily industrialized section of the city.

utilized to clear Le Havre and elements of some three battalions were utilized to clear Boulogne and its immediate environs.

In terms of size these cities were all fairly similar, each covered an urban area of some four to five square kilometers, with a larger, conurban area enclosing them. In terms of civilian population, Aachen was the largest, with a prewar population of 162,000, Brest was about 75,000, Cherbourg about the same, while the Channel port cities populations were all smaller than 75,000. The wartime civilian population remaining in each at the time of the battles was apparently between 15,000 and 25,000.[2]

Tactical Lessons Learned in Urban Combat

Typically it was remarked in the "lessons learned" from urban combat in Cherbourg, Brest and Aachen that an entire rifle company, suitably reinforced, was required to assault a width of front equivalent to a city block.[3] This appears reasonable in the first two cases, where an adequate number of battalions were available. However, in the case of Aachen this "lesson" appeared to have been ignored.

The inner city of Aachen (east of the Aachen-Antwerp and north of the Aachen-Cologne railway lines) covered an area of about five square kilometers. The southern and eastern approaches to the city, facing the attacking 26th Infantry, extended for two kilometers or more. Accepting this, it may be worthwhile questioning how the six rifle companies of the 26th Infantry were capable of successfully assaulting the city?

Quite simply, it appears that the method adopted utilized simple tactics, adapted to the specific problems associated with urban warfare. Economy of force, mass, establishing a base of fire and fire superiority, and maneuver were the principles that were followed. This was achieved by dividing the attack into manageable "bite-size" chunks. The two battalions of the 26th Infantry attacked specific objectives, usually with a two-company, two-block front, and sought to isolate sections of the city (the operation to clear Rothe Erde was an example). Once a manageable "chunk" was isolated from the rest of the city, tanks, tank destroyers, machine guns, and direct fire artillery were emplaced to interdict movement across streets and the "chunk" was then systematically reduced into smaller and smaller pieces. Defensive strongpoints were reduced by direct fire weapons, often self-propelled 155mm guns firing at ranges of less than 200 meters, rather than by assault, whenever possible, so as to reduce friendly casualties.

It appears that the few times that this methodology did not work as well was in those cases where the German strongpoints were centered in non-urban terrain (or where the strong point was in single large buildings surrounded by open or wooded park land). Thus, the climactic battle for the city was the assault of the world-famous spa complex (the Kurhaus, or Spa House, and the Palast, or Palace, Hotel and their associated gardens, woods and outbuildings) on the Quellenhof, or Spring Hill. It is obvious from the accounts of the fighting that the greater fields of fire in the relatively more open area around the spa and the better observation granted by the hill and the five-story tall hotel far outweighed any advantages found in the built-up sections of the city.[4]

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[2] It is difficult to find accurate figures for the "urban" population of these cities.

[3] The size of a block varied, especially in the older sections of European cities, but we will assume an average width of about 100 meters was typical.

[4] See especially the narrative *26th Inf. – Battle of Aachen – 8—21 Oct 44*, in the 1st ID ETO Combat Interviews, NARA RG 407, Entry 427, Box 24012 (which is rather misleadingly titled *Clearing Area South of the Rail Road Tracks*, since it actually covers the entire 26th Infantry fight for the city).

This systematic approach required careful planning, coordination and execution. It also required that the city be effectively isolated from the main German defense line, an object that was achieved by the attack of the XIX Corps and the 18th Infantry of the 1st Division.[5] The only drawback was that it was time consuming, but in the case of Cherbourg and Brest, where very similar methodology was used, the availability of additional troops shortened the time required.

Supporting Weapons in Urban Combat

In the tactical system adopted by the US Army for urban combat in the ETO, armored fighting vehicles (tanks and tank destroyers mostly, but also half-track personnel carriers, self-propelled antiaircraft multiple-gun carriages and self-propelled 155mm guns) were never committed to an assault down an unsecured street. Instead, they were utilized as mobile reinforcing firepower, for the interdiction of German movement, for the destruction of strongpoints, and to cover (by their bulk and armor) the movement of friendly forces across streets whenever it was absolutely necessary.[6] The threat posed to armor by even extemporized infantry AT weapons was well understood by US forces, as was the danger posed by the short ranges commonly encountered in street fighting.

Although indirect artillery and mortar fires, as well as air attacks, were heavily utilized in the assault of urban areas, it was recognized at the time to have serious limitations. First, the artillery and mortar fuses commonly utilized tended be impact-fused or to have very limited delay times. As a consequence, it was common for rounds to explode soon after impact, usually on a roof, with little effect on troops sometimes three or more floors below. The debris falling into streets was a hazard to infantry, but since the open street was rarely if ever used by exposed infantry it rarely had an effect. A more serious consequence of the fallen debris was the blocking of roads to vehicles, even tanks, which were providing fire support for the attack. As a result, artillery was judiciously used, usually in direct fire, mortars were often utilized for smoke and for close and accurate harassing fire, and air support, which could be very destructive, but which was also notoriously inaccurate, was only infrequently used.[7]

Other favored weapons for urban combat were the submachine gun, the flame-thrower (both vehicle-mounted and man-packed), hand and rifle grenades, and the infantry antitank rocket launcher, the “Bazooka.”

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[5] Although the city was not completely isolated until 16 October (and even then small parties were able to infiltrate and ex-filtrate the city), it was effectively isolated by 10 October. Perhaps 300 infantry reinforcements slipped into the city after that.

[6] American forces learned early in the fighting at Cherbourg that advancing infantry down urban streets was akin to suicide. Rather, infantry advanced through buildings, using shaped charges prepared by engineers to blow a hole through intervening walls, and stayed off streets unless it was absolutely unavoidable. The same methodology was learned by Canadian troops (who termed it “mouse-holing”) in the Battle of Ortona, Italy in December 1943 and was also practiced by the Germans and Russians in the Battle of Stalingrad in the fall of 1942 (although both the Germans and Soviets appeared to forget, ignore, or simply not have the time for the lesson later in the war).

[7] Artillery and air support were heavily used in the bombardment of Aachen on 10—12 October following the expiration of the surrender ultimatum, but it was only sparingly after the infantry assault on the city began on 12 October.

Armor Losses in Urban Combat

It is fairly easy to determine the daily losses (which include destroyed, battle damaged, broken down, and mired vehicles) of tanks in these engagements, but determining the exact circumstances for each loss is more difficult and proved to be impossible within the budgetary and time limitations of this project. That being said, it is notable that, similar to personnel casualties, there is little that was remarked at the time regarding armor losses in urban areas. In fact, without exception, there is no specific mention of any US tank losses in urban terrain, in any of the major examples we studied (Cherbourg, Brest and Aachen).

In the case of Cherbourg, it appears that possibly two medium and one light tanks were destroyed and 9 medium and one light tanks were damaged (battle damaged, broken down and mired) between 19 and 29 June 1944. Both light tanks were reported lost in an ambush on the night of 20/21 June, well before the urban area was reached. The daily loss pattern of the eleven medium tanks are unknown and, given that the fighting in the built-up area only lasted for about two of those eleven days, it is stretching assumptions to believe that the urban fighting was responsible for a disproportionate number. In any case, the US First Army medium tank, average loss rate for the period, which only included those tanks written off as destroyed, was 0.94 percent-per-day, while the light tank loss rate was 0.42 percent-per-day.[8] The comparable rates for the armor units of First Army involved in the assault in Cherbourg were 0.20 percent-per-day for the medium tanks and were 0.27 percent-per-day for the light tanks (that is, for the single light tank we know was destroyed outside the city). Even if all of the losses (destroyed, damaged, broken down, and mired) to armor units in the Cherbourg operation are counted, the average loss was only 1.10 percent-per-day for medium tanks and 0.53 percent-per-day for light tanks, only fractionally higher than the First Army rate for destroyed tanks only.

In the case of Brest, it is known that one attached British Churchill flame-thrower tank was destroyed and two were damaged, but in the assault on one of the outlying fortresses, Fort Montbery. They were not utilized in, nor lost in, the assault on the city or any of its surrounding villages. The only other known armor losses for the battle are the 13 medium tanks lost (destroyed, damaged, broken down, and mired), of which only two are known to have been destroyed, and which were **also** lost in the battles for the fortified **outer** defense ring outside the city. Thus, the known armor losses in the urban combat at Brest were effectively none.

The armor loss incurred by the 1st Division during the assault on Aachen is somewhat more difficult to resolve. The attached 745th Tank Battalion lost (destroyed, damaged, broken down, and mired) seven medium tanks and one light tank on 8 October. Six of the mediums were lost in the assault by the 18th Infantry to encircle the city, none of which were apparently lost in "street fighting" or the attack of what could be termed urban terrain.[9] Another 21 tanks of the battalion were lost (destroyed, damaged, broken down, and mired) from 14—19 October 1944 during the engagements in which there was

[8] From 6 June to 1 July a total of 187 were lost of an average 764 medium tanks operational and 44 of an average 406 light tanks operational. See *The Historical Combat Effectiveness of Lighter-weight Armored Forces*, *The Dupuy Institute*, McLean, VA, 6 August 2001) Appendix X.

[9] The six lost were four from the 2nd Platoon, B Company (one mired, three mined and one hit by artillery fire) and two from the 3rd Platoon (one mechanical and one mined). The five lost to enemy action were all lost well south of the town of Verlautenheide, on the road south running through the Aachen-Cologne Railway underpass.

urban or conurban terrain present. But none of these can be directly attributed to losses in Company C of the 745th, which was the only tank company attached to the 26th Infantry combat team utilized in the capture of the city. Rather, most, if not all of them, appear to have been lost in A and B Company of the battalion, attached to the 16th Infantry and 18th Infantry respectively, which were engaged in the encirclement of the city and the defensive battles against the German counterattacks to relieve the city.

The 745th Tank Battalion suffered a total of 28 tanks lost (destroyed, damaged, broken down, and mired), 8—21 October. During this time the operational average strength of the battalion was 66.23 tanks, meaning that the average loss was 3.02 percent-per-day.[10] This is over three times the loss rate found at Cherbourg, where the combined average for medium and light tank losses (destroyed, damaged, broken down, and mired) was 0.95 percent-per-day, which represents a significant increase. However, the average First Army armor loss rate during the period of the Battle of Aachen, for totally destroyed tanks only, was 0.41 percent-per-day (6—12 October), 0.18 percent-per-day (13—20 October) and 0.12 percent-per-day (21—28 October), and approximate average of 0.24 percent-per-day for the entire 23 days. That was much **lower** than the average 0.76 percent-per-day loss during the longer 26-day period covering the Battle of Cherbourg (6 June—1 July). In any case it remains impossible to state with any confidence that the apparent higher rate of losses at Aachen were caused by the urban terrain. Finally, in the last stages of the battle, 18—21 October, it was noted that the two tank companies of the 3rd Armored Division that were attached to the 26th Infantry especially to facilitate the completion of the operational, suffered no tank losses (and possibly no personnel losses either).

Unfortunately, we have only been able to discover very limited accounts of British and Commonwealth armor losses in the operations to secure the Channel Ports. However, it does not appear that they were excessive, and may have been very minor. At Boulogne it was only noted that four tanks were lost in the minefields surrounding the city. There does not appear to be any information available regarding armor losses at Calais or Le Havre, but it is doubted that they could have been very severe. In any case, the limited number of losses combined with the large numbers used would probably translate into a very low rate of loss.

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[10] Although high, this loss rate is not unusual. The British 11th Armoured Division in Operation GOODWOOD (18—20 July 1944) in Normandy, which was not involved in urban combat, suffered an average tank loss rate (to all causes) of 24.13 percent-per-day. The other two divisions involved in the operation, the Guards and 7th Armoured Divisions, suffered 15.73 and 72.9 percent-per-day losses, respectively. The US 4th Armored Division, in 30 combat days during November and December 1944, none of which could be considered "urban combat," suffered an average tank loss rate of 2.64 percent-per-day, the 6th Armored Division in the same period and same conditions, averaged 1.64 percent-per-day. See Dupuy, *Attrition*, pp. 80-90, for a complete discussion of armor loss rates in combat.

Overall, it does not appear that the armor loss rates encountered in cities were any more severe or intense than those incurred in non-urban operations, and probably varied between about 0.76 and about 3.02 percent-per-day. For the US forces this appears to have been mostly a result of the judicious use that was made of tanks in built-up areas, for the Commonwealth forces in the Channel Ports operations, it appears to be at least partly a consequence of the massive superiority of armored vehicles they enjoyed.

THE IMPACT OF URBAN TERRAIN ON OPERATIONS

The primary result of urban terrain, according to the data derived from the analysis, is to reduce advance rates significantly, reduce casualties to some extent and, as a result, to extend the duration of combat. Fundamentally, combat in urban terrain will simply take longer than in non-urban terrain. While the operational effects of this will be discussed in more depth in the second phase of this study, this difference has some effects that we can already see.

For the effects of urban terrain on operations, two scenarios need to be considered. The first is when the urban terrain can be bypassed and the second when it cannot. Those cases where the urban terrain can be bypassed are the most common. To create a situation where it cannot be bypassed means that the city would have to stretch indefinitely to the left and right, or that the flanks of the city would be solidly anchored on otherwise impassable terrain. These conditions, even with the increased urbanization found in the world, is hard to come by and usually only occurs on islands or peninsulas.

Therefore, the vast majority of urban terrain encountered will be flanked by non-urban terrain. Operations in these non-urban flanks will potentially advance at a pace two to four times that of the urban operations (assuming that forces are distributed evenly across the battlefield). Therefore, under normal circumstances the urban area will by bypassed on one or both flanks and will be threatened with envelopment within a few days of an operation beginning.[1] Furthermore, as the attacker is usually aware that quicker progress can be made outside the urban terrain, then the tendency is to weigh one or both flanks and not bother to attack the city until it is enveloped. This will, of course, result in either the defender withdrawing from the urban terrain, which is what traditionally has occurred, or an assault and eventual mop-up operation by the attacker of the enveloped defenders. This has been the consistent pattern in the past, and will likely continue to be so in the future for those cases where urban terrain, regardless of its increased size or density, has non-urban flanks.

On the other hand, it is possible that one could encounter a situation where the urban terrain could not be bypassed or securely enveloped. The most notable example of such a scenario would be in South Korea, where Seoul, anchored to the west (left flank) by the sea, extends for some 25 kilometers inland and is then flanked east (right) by a substantial mountain range. While this is an important case for US defense planning purposes, it is one of the few hot spots in the world where this situation is found. An examination of an atlas shows few other cities in the world that cannot by bypassed or enveloped.

This apparently is the primary reason why there are so few examples of urban combat to be found. Examining the list of operations found in Appendix V, only two cases come to mind. The first is Shanghai in 1932, where the Japanese made an amphibious landing onto the Chinese mainland and then had to fight their way into the city. The only other significant example may be Stalingrad in 1942, where the city paralleled a broad river that the Germans were not well positioned or prepared to cross. Still, Stalingrad was not an objective that the Germans were forced to take, and the operation there became very much

[1] Assuming of course that the attacker is in fact capable of successful offensive operations of any kind.

influenced by a political desire to take the city, a desire that vastly exceeded its military and economic value.

Many of the other urban battles on the list tend to be cases where the city became partially or completely enveloped before being taken (including Kharkov, Hue and the second Russian occupation of Grozny). This has been the norm in the past, and will probably remain the norm in the future.

Finally, there are two cases on the list where the attacker suffered serious armor losses in taking cities. These are the first battle of Grozny in 1995 and the Battle for Suez City in 1973. These two examples are often cited as support assumption that armor losses in cities are high, when in fact our data shows the opposite to be true. These are the only two major examples of excessive armor losses in taking a city (although there are certainly some others). In both of these cases, the reason for making a quick armor strike was fundamentally political. In the case of Suez City it was a strike attempting to seize the city by coup-de-main after a cease-fire had already been agreed. This was for the sake of strengthening the Israeli post-war negotiating position and was not done for firm military reasons, since the war had effectively ended![2]

The first attack on Grozny was also politically motivated, with the Russian Army under considerable political pressure to resolve the Chechen issue quickly. Unlike the Suez City battle, which was over in a few hours, the Grozny operation lasted for several days. It was an incompetent waste of armor and soldier's lives in an attempt to fulfill a politically driven timetable.

While these two examples provide a firm warning against sending armor into cities without proper reconnaissance and infantry support, the same can be said of sending armor into any terrain without support. **These two examples (and Stalingrad) may be better used to quantify the impact of political agendas on casualties, than to quantify the effects of urban areas on casualties.**

[2] The rationalization that the attack was intended to complete the isolation of the Egyptian Army on the east bank of the Suez Canal is specious in the extreme. They were already effectively isolated, capturing the city was simply another potential bargaining chip at the peace table.

CHANGES IN TECHNOLOGY AND POSSIBLE IMPACT ON URBAN WARFARE

Since the data used for this analysis is from combat that occurred over 50 years ago, one needs to consider what changes have occurred in the world that may change the results of such an analysis. There are at least three changes that have occurred that may be easily identified. They are changes in technology, that make weapons more accurate, lethal, faster, better protected or more flexible. A second is changes in the environment, which may make cities larger, higher or denser. And, finally, changes resulting in a revolution or evolution in warfare created by the synergistic effects of changes in technology, particularly within information and communications systems.

Changes in Weapons Technology

While weapon technologies have improved, it is difficult to think of a single technological development that somehow has changed the nature urban combat. If one assumes rough technological parity between opposing forces, which was the case in our World War II cases, then urban fighting between forces with rough technological equality does not appear to be significantly different, outside of a possible revolution in military affairs (which is discussed below).

Still, there is an overall tendency in modern combat to disperse, engage at greater ranges and make greater use of cover and concealment and mobility. While the urban environment provides considerable cover and concealment, it also brings opposing forces into what are sometimes very close ranges. The modern capability to deliver devastating and accurate firepower to an area affects the urban environment. The larger bomb loads, larger bombs, fuel-air explosives, multiple-launch rocker systems and other weapon systems that can deliver sudden and accurate devastation will still force armed forces to remain dispersed, concentrating only briefly when needed to execute an operation. The modern battlefield is expected to be somewhat more fluid and dispersed than that of World War II, and as such, one may discover that the urban fight will often transition into and from urban terrain with greater frequency. The use of conurban terrain to establish a series of strongpoints may also be more limited, since these strongpoints are more vulnerable. With more fluid operations and increased dispersion, it is difficult to say whether armed force in the future will spend more or less time holding, defending and fighting in urban terrain.

Nearly all the combat operations involving the US military in the last 55 years has been against opponents that were technologically inferior, and in some cases, noticeably so. Our World War II data does not examine combat between forces with a radical technological difference. The application of widely disparate technology has not been analyzed in this report.

Changes in the Nature of Cities

First and foremost, cities are much larger on average than they were in the mid-twentieth century. However, while size may have an effect at the operational level, the data analyzed in this study is clearly division-level, effectively tactical combat. In effect, for this analysis, a larger city would simply imply a larger engagement without changing the nature of the engagement. As such, this does not affect the results of the analysis.

The average density of cities may also have changed, but TDI has not measured this. Densities of building per square meter might have some effect on the analysis, but it is uncertain to what extent. The increasing density of cities caused by the increasing height and area of buildings is fairly insignificant. Most urban combat appears to occur at, or very near, ground level. It is unlikely that a 30-story building would be defended by ten times as many troops as a three-story building, and it is just as unlikely that ten times the number of troops would be required to attack it. The fact that the linear density of troops did not change noticeably between the different World War II non-urban, conurban, and urban terrain cases in the data base does not support the idea that an increase in the density of urban terrain will result in a significant increase in the linear density of troops.

The urban environment measured in this study were well-established French and German towns and cities. The buildings tended to be well constructed with considerable use of masonry, brick, stone and other durable and resistant materials. There is little reason to believe that modern urban constructions are more solidly or strongly built, and it appears that the opposite may in fact be true.[1] Therefore, we do not feel that changes in size, density, height or construction techniques in modern cities obviate or significantly modify this analysis.

In the last fifty years the size, extent and number of "shanty towns" in many Third World cities has changed. These areas tend to contain insubstantial structures and are often of relatively low density compared to more developed areas of cities. They also tend to consist mostly of low-lying structures. None of our combat examples occurred in urban terrain that is comparable. Still, since these shanty town areas are of lower density, lower height and often of insubstantial construction than the examples analyzed, there is little reason to believe that differences in fighting in them is any more significant than the differences already measured between non-urban and urban terrain. It would appear that the difference would be less significant than the difference between non-urban and urban terrain that we measured, although the degree is uncertain. Therefore, we are comfortable with stating that the changes in urban terrain over time have not had a significant impact on the results found in this study.

Changes in Warfare, Revolution or Evolution?

Many have postulated that there has been, or we are on the verge of, a revolution in warfare created by the synergistic effects of increased weapons accuracy, improved intelligence (including targeting information) and improved and widespread communications. Recent US operations have increased this perception due to our opponents being technologically inferior, not particularly well-trained or simply incompetent, while the US has enjoined air supremacy and the luxury of having their opponents "outgunned." The data used in this study is between forces that are relatively similar in technology and competency. There are no real-world examples in the last 25 years of combat between armed forces with similar levels of advanced technology and military competence.

[1] Modern concrete and steel “high-rise” construction techniques do not appear to be very resistant to blast effects, as was seen in the destruction of the Alfred P. Murrah Federal Building in Oklahoma City in April 1995. The more recent destruction of the World Trade Center Towers in New York City highlight other obvious problems associated with modern building design.

Still, there certainly have been changes in these areas, and this may have some impact on or may even obviate the data presented in this report. However, to date this "revolution" has been one-sided, with only the US fully exploring and developing the systems, training and management required for execution of this revolutionary new style of warfare.[2] As such, it is difficult to determine how much of the effect of the "revolution" seen is the result of fighting technologically inferior foes and how much is due to "revolutionary" effects of new technologies. The enemy forces we have engaged with these new systems have had little counter-measure capability, and have mostly resorted to dispersal and hiding to protect themselves. Eventually, we may encounter a competent opponent with equivalent technology, but this does not appear to be something that the US will have to face anytime in the next two to three decades. Quite simply, as the only superpower, and with the second through sixth richest nations of the world as strong allies, the US will not face an opposing force with the economic power to develop a modern technologically advanced army capable of fighting the US on equal terms. As such, any discussion of the revolution in military affairs fundamentally refers to a one-sided revolution.

The question remains, how will these changes affect the urban fight? First, increased weapon accuracy by itself will not revolutionize fighting in urban terrain. What will make the difference is the ability to observe, target and communicate enemy locations. This is an area where urban terrain has a potentially significant degrading effect. It is more difficult to observe and identify targets in urban terrain and as a result conducting precision strikes against them is more difficult. Added to that, built-up areas also give targets easily accessible hard cover.

This may make urban terrain a preferred battleground area, especially for the lower technology force. While this can have a significant operational impact on combat, this particular phase of the study does not address that issue. This study has focused on the effects of urban terrain, as compared to non-urban terrain, in seven major areas of interest:

1. **Force Ratios**. There is no reason to assume that the force ratios in urban warfare engagements will change as a result of a revolution in military affairs. They are driven almost invariably by the result of the operations and the conditions of combat, and are fundamentally not terrain specific.
2. **Mission Success (Outcome)**. There is no reason to assume that the outcome in urban warfare engagements will change as a result of a revolution in military affairs. The results are driven almost invariably by the conditions of combat, and are fundamentally not terrain specific.
3. **Casualty Rates**. These may also decline relative to casualty rates in non-urban terrain, due to the relatively better cover and concealment found in urban as opposed to non-urban terrain.
4. **Armor Loss Rates**. These may not change as much due to the urban terrain. As the key for protection is cover and concealment, this may be better obtained in wooded areas with substantial usable overhead cover than in the more exposed streets of a city, especially something like a shantytown.
5. **Duration of Combat (Time)**. Duration of combat may change to the extent that advance rates change, but may change even more, becoming relatively slower than

[2] It may also be said that the US apparently has been the only nation to fully accept the cost of deploying these new systems and technologies.

advance rates in non-urban terrain. This is because it may be easier for targets in urban terrain to find cover and concealment relative to non-urban terrain. As a result, with potentially more time required to identify and target the enemy, the differences in duration of combat in urban terrain as opposed to non-urban terrain may become more marked.

6. **Advance Rates**. These may change, but there is no reason to believe that they will change more quickly or faster than those in non-urban terrain. Since these are "opposed advance rates" they are relatively unaffected by changes in technology and are mostly affected by the conditions of combat.
7. **Linear Density**. This may be affected for the same reasons discussed under the duration of combat. Fundamentally, as weapons accuracy and effectiveness goes up, so does dispersal. As forces in urban terrain may be better protected against enemy systems, then we may see a greater disparity between linear density of forces in urban versus non-urban terrain.

All these changes are relative to changes in non-urban terrain. One would expect to see even more reduced casualty rates, increased linear density and more extended duration of combat in urban terrain. This may conspire to make the urban environment the terrain of choice for the lower-technology defender (or the lower-technology attacker for that matter), especially for infantry forces.

This still begs the question of how to maintain operational control of the areas outside the city and keep the urban area from being isolated, as has been usually the case. If anything, a revolution in military affairs points towards the ability to even more effectively and quickly isolate a city. This leaves most urban warfare scenarios as mop-up operations, where the defenders are isolated, and where the technologically advanced attackers conduct the pace of operations at a rate of their own choosing. While these mop-up operations can be particularly difficult and painful for the individual soldier, militarily it is still an operation that will be invariably resolved in the favor of the attacker.

As a result it does not appear that the actual effects of a revolution in military affairs, if one truly exists, will change significantly the intensity or nature of urban combat, except in those cases where the city cannot be isolated. As was pointed out in the previous section, because of geography, this is a very rare occurrence.

FINAL COMMENTS

One must stress that our analysis here is focused on division-level operations. The urban operations the US has been involved in during the last 25 years have not been division-level operations. Fundamentally, the operations conducted in Panama City and Mogadishu were battalion-level or smaller urban operations. As such, the lessons that are drawn from them, while useful for the individual soldier or small-unit leader, are not immediately and directly applicable to division-level operations. This may be part of the reason that the conclusions of this study differ from those in other studies.

There is a tendency in the most recent studies to lump together lessons from small-unit actions, large-unit engagements and campaign-level operations, without differentiation. The same applies to the tendency to lump together lessons from conventional warfare, with guerrilla warfare and small-scale contingency operations. There is also a tendency not to separate those events that were heavily driven or influenced by political motivations from those that were not. This leads to much confusion over exactly what lessons apply to what situation, and the universality of each lesson to the future. *The Dupuy Institute* feels that more rigor is needed, insuring that studies only draw conclusions for based upon the level of combat that the data is derived from.

The tendency for recent studies to rely only on individual case studies is also troublesome. They tend to pull examples from whatever case proves their point. Unfortunately, with a proper selection of cases, one can prove any point wished. This rather exclusive reliance on case studies runs the danger of drawing the wrong conclusions. These efforts need to be seriously supplemented with more rigorous analysis.

Finally, about halfway through the preparation of this study, the United States became involved in a contingency operation in Afghanistan, primarily providing air support to one faction in an on-going civil war. One notes that this conflict has also been devoid of extensive or serious urban fighting, even though it is a moderate-sized conventional war. To date, the reported urban fighting consisted of two incidents, both of which took place in Mazar-el-Shariff. One was against forces that either would not surrender or were not given the opportunity or any incentive to surrender, and the other was a very bloody prison riot. In most other cases, the fighting primarily occurred outside, around and in front of cities.

A Final Editorial Comment

The Dupuy Institute is extremely uncomfortable with the current quality of analysis displayed in the operations research community regarding this subject. We have explored this in some detail in Appendix VII of this report. Three things particularly disturb us:

- The analysts inability to separate hypothesis from statements of fact.
- Their inability to conduct analyses according to a simple hierarchy of combat (battalion-level, division-level, army-level, tactical or operational, engagements, battles or campaigns).
- Their inability to define the nature of the combat operations they analyze (conventional war, guerilla war or small scale contingency).

CONCLUSIONS

The Effect of Urban Terrain on Outcome

The data appears to support a null hypothesis, that is, that the urban terrain had no significantly measurable influence on the outcome of battle.

The Effect of Urban Terrain on Casualties

Overall, any way the data is sectioned, the attacker casualties in the urban engagements are less than in the non-urban engagements and the casualty exchange ratio favors the attacker as well. Because of the selection of the data, there is some question whether these observations can be extended beyond this data, but it does not provide much support to the notion that urban combat is a more intense environment than non-urban combat.

The Effect of Urban Terrain on Advance Rates

It would appear that one of the primary effects of urban terrain is that it slows opposed advance rates. One can conclude that the average advance rate in urban combat should be one-half to one-third that of non-urban combat.

The Effect of Urban Terrain on Force Density

Overall, there is little evidence that combat operations in urban terrain result in a higher linear density of troops, although the data does seem to trend in that direction.

The Effect of Urban Terrain on Armor

Overall, it appears that armor losses in urban terrain are the same as, or lower than armor losses in non-urban terrain. And in some cases it appears that armor losses are significantly lower in urban than non-urban terrain.

The Effect of Urban Terrain on Force Ratios

Urban terrain did not significantly influence the force ratio required to achieve success or effectively conduct combat operations.

The Effect of Urban Terrain on Stress in Combat

Overall, it appears that urban terrain was no more stressful a combat environment during actual combat operations than was non-urban terrain.

The Effect of Urban Terrain on Logistics

Overall, the evidence appears to be that the expenditure of artillery ammunition in urban operations was not greater than that in non-urban operations. In the two cases where exact comparisons could be made, the average expenditure rates were about one-third to one-quarter the average expenditure rates expected for an attack posture in the European Theater of Operations as a whole.

The evidence regarding the expenditure of other types of ammunition is less conclusive, but again does not appear to be significantly greater than the expenditures in

non-urban terrain. Expenditures of specialized ordnance may have been higher, but the total weight expended was a minor fraction of that for all of the ammunition expended.

There is no evidence that the expenditure of other consumable items (rations, water or POL) was significantly different in urban as opposed to non-urban combat.

The Effect of Urban Combat on Time Requirements

It was impossible to draw significant conclusions from the data set as a whole. However, in the five significant urban operations that were carefully studied, the maximum length of time required to secure the urban area was twelve days in the case of Aachen, followed by six days in the case of Brest. But the other operations all required little more than a day to complete (Cherbourg, Boulogne and Calais).

However, since it was found that advance rates in urban combat were significantly reduced, then it is obvious that these two effects (advance rates and time) are interrelated. It does appear that the primary impact of urban combat is to slow the tempo of operations.

This in turn leads to a hypothetical construct, where the reduced tempo of urban operations (reduced casualties, reduced opposed advance rates and increased time) compared to non-urban operations, results in two possible scenarios.

The first is if the urban area is bounded by non-urban terrain. In this case the urban area will tend to be enveloped during combat, since the pace of battle in the non-urban terrain is quicker. Thus, the urban battle becomes more a mopping-up operation, as it historically has usually been, rather than a full-fledged battle.

The alternate scenario is that created by an urban area that cannot be enveloped and must therefor be directly attacked. This may be caused by geography, as in a city on an island or peninsula, by operational requirements, as in the case of Cherbourg, Brest and the Channel Ports, or by political requirements, as in the case of Stalingrad, Suez City and Grozny.

Of course these last three cases are also those usually included as examples of combat in urban terrain that resulted in high casualty rates. However, all three of them had significant political requirements that influenced the nature, tempo and even the simple necessity of conducting the operation. And, in the case of Stalingrad and Suez City, significant geographical limitations effected the operations as well. These may well be better used to quantify the impact of political agendas on casualties, rather than to quantify the effects of urban terrain on casualties.

The effects of urban terrain at the operational level, and the effect of urban terrain on the tempo of operations, will be further addressed in Phase II of this study.

FUTURE DEVELOPMENT

It is expected that *The Dupuy Institute* will began work on the second phase of this contract shortly. This work has already been described in this report in **Study Plan**, page 8 and 9. When these two phases are completed, we will have conducted an analysis of urban combat at the division-level based upon at least 92 urban and conurban cases compared to 140 non-urban cases. We will have conducted an analysis of urban combat at the army-level based upon 49 operations, or which a half-dozen will include significant urban terrain.

There is more work that can be done. First, adding more examples can increase the statistical robustness of the non-urban engagements. The nearest and quickest source of this data is to complete the assembly of 71 additional Kursk engagements. In addition, more cases need to be added to the Normandy and Breakout and Pursuit campaign non-urban engagements. The records are available, but they must be researched and analyzed. More data can also be added from the Ardennes Campaign, where TDI has already gathered considerable data.

However, we have already reached the limit of the urban and conurban engagements that can be derived from the battles we have researched. To obtain more urban engagements will require additional research in different urban operations. A list of candidates is provided in Appendix V. Of those, the two most promising, because of data availability and for the ability to test them to existing non-urban engagements (the Kursk engagements) are from Stalingrad, August 1942—February 1943 and Novorossisk, September 1943. TDI would very much like to examine Stalingrad in depth and has already ensured access to the archives of both sides. While Kharkov was a larger city than Stalingrad (based upon pre-war population figures), the Battle of Stalingrad saw a much more extended period of urban fighting. Since it is the example that is regularly used in other studies of urban warfare, it is one that we should also address.

A minor downside to Stalingrad is that many of the German units involved did not survive the battle, and so they were not present at the later, non-urban, Battle of Kursk. On the other hand, some of the Soviet units that fought at Stalingrad also fought at Kursk. *The Dupuy Institute* would recommend that the Stalingrad data be supplemented with the 71 additional Kursk engagements and a selection of non-urban engagements in and around Stalingrad in 1942.

Beyond assembling a more robust collection of data for analysis, there are a number of major issues not address in Phase I or II this study. They include:

- FIGHTING IN OTHER TYPES OF URBAN TERRAIN
  1. Suburban
  2. Shantytown
- FIGHTING AROUND URBAN TERRAIN
  1. Approach
  2. Proximity
  3. Exit
  4. Mop-up
- BATTALION-LEVEL COMBAT

- ARE THERE MEASURABLE ADVANTAGES OR DISADVANTAGES TO THE ATTACKER OR DEFENDER
    1. Are firepower differences degraded in the city?
    2. Is artillery less effective in the city?
    3. Is air power less effective in the city?
    4. Is the defender disadvantaged in the city?
- FREQUENCY AND NATURE
    1. Types of combat.
    2. Measurement of city density in a theater versus days of urban combat.
    3. How much of a city is fought over, and how much is shelled into oblivion?
- OTHER QUESTIONS
    1. Pace of operations.
    2. Ammunition consumption.
    3. Measure the effects of ROE on combat (civilian casualties versus military casualties, both friendly and enemy).
    4. Are larger or smaller reserves maintained in a city fight?
- POST-WWII URBAN ENGAGEMENTS
    1. Budapest, 1956
    2. Jerusalem, 1967
    3. Hue, 1968
    4. Saigon, 1968
    5. Quang-Tri, 1972
    6. Suez City, 1973
    7. Grozny, 1995

All these tasks and questions are ones that *The Dupuy Institute* feels that it could address fairly completely and with solid research. It may also be possible to address some of the other statements listed in Appendix VII, Recent MOUT Literature.

Appendix I

Normandy and Breakout and Pursuit Engagements (Nonurban)

Engage-ment Number	Engagement	Start Date	Duration (in Days)	Attacker Force Name	Defender Force Name	Winner	Outcome	Terrain	Attacker's Total Strength
41010	St. Lo	11-Jul-44	8	US 29th Inf Div (+)	Ger 352 Inf Div (elms), 3d Para Div (elms)	A	Attack Advances	RM	18228
41020	Mortain	07-Aug-44	6	Ger XLVII Pz Corps	US 30th Inf Div (+)	D	Failed Attack	RM	25497
41030	Mortain I	07-Aug-44	1	Ger Elms 1st SS and 2nd PD	US 117th Inf (-) (+), 30th ID	D	Failed Attack	RM	8150
41040	Mortain II	07-Aug-44	1	Ger Elms 2nd SS PD and 17th SS PGD	US 120th Inf (-) (+), 30th ID	D	Failed Attack	RgM	8500
41050	Chartres	16-Aug-44	1	US 7th Armd Div	Ger First Army (-)	draw	Failed Attack	RM	15646
41060	Seine River	23-Aug-44	3	US XX Corps	Ger First Army (-)	A	Defender Penetrated	RM	40619
41070	Melun	23-Aug-44	3	US 7th Armd Div	Ger 48th Inf Div (-)	A	Defender Penetrated	RM	17232
41080	Metz	13-Sep-44	1	US XX Corps	Ger First Army (-)	D	Failed Attack	RM	60794
41090	Arracourt	19-Sep-44	4	Ger 111th and 113th Pz Bdes (+)	US CCA, 4th Armd Div (+)	D	Failed Attack	RM	7500
41101	Brest, Approach to the City	26-Aug-44	8	US VIII Corps	Ger Brest Garrison	A	Attack Advances	RM	51806
41102	Brest, Seizing the Outskirts	03-Sep-44	7	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	RM	54712
41201	Boulogne I	17-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	RM	27973
41207	Boulogne, Mopping Up	23-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Other	RM	27973
41301	Calais I	25-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	Attacker	Attack Advances	RM	31512
41302	Calais II	26-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	Attacker	Attack Advances	RM	31512
41303	Calais III	27-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	Attacker	Attack Advances	RM	31512
41501	Le Havre I	10-Sep-44	1	UK I Corps	Ger Le Havre Garrison	Attacker	Attack Advances	RM	47059
41601	Cherbourg I	21-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Attack Advances	RM	48645
41602	Cherbourg II	22-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Attack Advances	RM	46765
41603	Cherbourg III	23-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Attack Advances	RM	46287
41604	Cherbourg IV	24-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Defender Penetrated	RM	45460

Appendix I

Normandy and Breakout and Pursuit Engagements (Nonurban)

											Armor Loss Statistics:			
Attacker's Total Casualties	Defender's Total Casualties	Attacker's Mission Accomp-lishment	Defender's Mission Accomp-lishment	Distance Advanced Per Day (in km)	Attacker's Casualties % per Day Day	Defender's Casualties % per Day	Total Strength Ratio	Total Casualty Ratio	Attacker Front Width (in km)	Attacker Men/km of Front	Attacker's Total Armor Losses	Defender's Total Armor Losses	Attacker's Armor Losses % per Day	Defender's Armor Losses % per Day
2777	2350	7	5	1	1.90	3.92	2.43	1.18	12	1519.00	13		2.08	
4800	2673	3	7	1	3.14	1.61	0.92	1.80	9	2833.00	100		9.42	
700	400	3	6	0.8	8.59	10.81	2.20	1.75	2	4075.00	5	0	10.00	
375	600	4	7	4	4.41	13.04	1.85	0.63	3	2833.33	4	0	13.33	0.00
113	579	5	5	6	0.72	6.95	1.88	0.20	5	3129.20	7		2.28	
234	906	8	3	12.7	0.19	2.01	2.71	0.26	45	902.64	21	3	1.48	2.63
99	362	6	4	7.3	0.19	2.01	2.87	0.27	5	3446.40	21		2.54	
359	210	3	7	0	0.59	0.53	1.54	1.71	25	2431.76	0		0.00	
779	119	3	6	-0.8	2.60	0.62	1.56	6.55	10.4	721.15	87	25	17.26	5.12
2715	9126	6	4	0.25	0.66	2.97	1.35	0.30	73	709.67	4		0.42	
2329	9978	6	4	0.3	0.61	4.86	1.87	0.23	25	2188.48	9		1.07	
148	485	7	3	2	0.53	4.92	2.84	0.31	12	2331.08				
12	977	7	0	0	0.04	100.00	28.63	0.01	12	2331.08				
29	325	7	4		0.09	3.50	3.39	0.09						
116	1216	8	4		0.37	13.56	3.52	0.10						
66	146	6	4		0.21	1.88	4.07	0.45						
77	1764	7	4		0.16	15.21	4.06	0.04			37		6.78	
284	165	7	4	2.8	0.58	0.58	1.72	1.72	28.8	1689.06	2		1.24	
795	286	6	4	1.4	1.70	1.02	1.67	2.78	30.8	1518.34	2		1.26	
1274	1393	6	4	1.6	2.75	5.01	1.67	0.91	31.6	1464.78	2		1.27	
567	1880	7	4	3.6	1.25	7.12	1.72	0.30	41.2	1103.40	2		1.29	

Appendix II

Cherbourg, Brest, Paris, and Channel Ports Engagements (Urban)

Engage-ment Number	Engagement	Start Date	Duration (in Days)	Attacker Force Name	Defender Force Name	Winner	Outcome	Terrain	Attacker's Total Strength	Defender's Total Strength
42103	Brest, Suburbs I	10-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	CONURBAN	57714	19337
42104	Brest, Suburbs II	11-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	CONURBAN	59014	18193
42105	Brest, Suburbs III	12-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	CONURBAN	61831	16342
42106	Brest, Suburbs IV	13-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	CONURBAN	61702	15738
42107	Brest, Suburbs V	14-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	CONURBAN	61041	15343
42108	Brest, the City I	15-Sep-44	1	US VIII Corps	Ger Brest Garrison	DRAW	Limited Action	URBAN	61026	14350
42109	Brest, the City II	16-Sep-44	1	US VIII Corps	Ger Brest Garrison	DRAW	Limited Action	URBAN	60717	13446
42110	Brest, the City III	17-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Attack Advances	URBAN	60538	11504
42111	Brest, Capitulation	18-Sep-44	1	US VIII Corps	Ger Brest Garrison	Attacker	Defender Penetrated	URBAN	60173	9319
42112	Brest, Mopping Up	19-Sep-44	3	US VIII Corps	Ger Brest Garrison	Attacker	Other	URBAN/RM	59082	1612
42202	Boulogne II	18-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	URBAN/RM	27973	9366
42203	Boulogne III	19-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	URBAN/RM	27973	7036
42204	Boulogne IV	20-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	URBAN/RM	27973	5859
42205	Boulogne V	21-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	CONURBAN	27973	3931
42206	Boulogne VI	22-Sep-44	1	Cdn 3 Div (-)(+)	Ger Boulogne Garrison	Attacker	Attack Advances	CONURBAN	27973	2309
42304	Calais IV	28-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	draw	Attack Advances	CONURBAN	31512	7603
42305	Calais V	29-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	Attacker	Defender Penetrated	CONURBAN/RM	31512	7568
42306	Calais VI, Capitulation	30-Sep-44	1	Cdn 3rd ID (+)	Ger Calais Garrison	Attacker	Other	URBAN	31512	6887
42401	Occupation of Dieppe	01-Sep-44	1	Cdn 2nd ID	Ger Dieppe Garrison	DRAW	Limited Action	URBAN	16300	358
42502	Le Havre II	11-Sep-44	1	UK I Corps	Ger Le Havre Garrison	Attacker	Defender Penetrated	URBAN	47059	9836
42503	Le Havre III, Capitulation	12-Sep-44	1	UK I Corps	Ger Le Havre Garrison	Attacker	Other	URBAN	47059	4554
42605	Cherbourg V	25-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Attack Advances	CONURBAN	45398	24521
42606	Cherbourg VI	26-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Attack Advances	URBAN	46194	20488
42607	Cherbourg VII, Capitulation	27-Jun-44	1	US VII Corps	Ger Cherbourg Garrison	Attacker	Other	URBAN	46373	9795
42701	Liberation of Paris	25-Aug-44	1	US V Corps	Ger Paris Garrison	Attacker	Defender Penetrated	URBAN	29895	2500

Appendix II

Cherbourg, Brest, Paris, and Channel Ports Engagements (Urban)

											Armor Loss Statistics:			
Attacker's Total Casualties	Defender's Total Casualties	Attacker's Mission Accomp-lishment	Defender's Mission Accomp-lishment	Distance Advanced Per Day (in km)	Attacker's Casualties % per Day Day	Defender's Casualties % per Day	Total Strength Ratio	Total Casualty Ratio	Attacker Front Width (in km)	Attacker Men/km of Front	Attacker's Total Armor Losses	Defender's Total Armor Losses	Attacker's Armor Losses % per Day	Defender's Armor Losses % per Day
281	1144	7	4	0.8	0.49	5.92	2.98	0.25	25	2308.56	0		0.00	
222	1851	6	5	0.1	0.38	10.17	3.24	0.12	25	2360.56	0		0.00	
117	604	6	5	0.2	0.19	3.70	3.78	0.19	25	2473.24	0		0.00	
202	395	6	5	0.2	0.33	2.51	3.92	0.51	25	2468.08	0		0.00	
250	993	6	4	0.1	0.41	6.47	3.98	0.25	25	2441.64	3		2.34	
434	904	5	5	0	0.71	6.30	4.25	0.48	25	2441.04	0		0.00	
288	1942	5	5	0	0.47	14.44	4.52	0.15	25	2428.68	0		0.00	
265	2185	6	4	0.2	0.44	18.99	5.26	0.12	25	2421.52	0		0.00	
168	7707	7	4	0.6	0.28	82.70	6.46	0.02	25	2406.92	0	13	0.00	100
154	7103	8	2	0	0.09	146.88	36.65	0.02	5	11816.40	0		0.00	
130	2330	7	3	1.5	0.46	24.88	2.99	0.06	12	2331.08				
163	1177	7	3	1.5	0.58	16.73	3.98	0.14	12	2331.08	4		1.67	
104	1928	7	3	2.5	0.37	32.91	4.77	0.05	12	2331.08				
91	1622	7	3	1.5	0.33	41.26	7.12	0.06	12	2331.08				
46	1332	7	3	0.5	0.16	57.69	12.11	0.03	12	2331.08				
43	35	6	6	0	0.14	0.46	4.14	1.23						
65	681	8	2		0.21	9.00	4.16	0.10						
53	6887	8	0	0	0.17	100.00	4.58	0.01						
4	358	6	6	27	0.02	100.00	45.53	0.01	1	16300.00				
283	5282	8	4		0.60	53.70	4.78	0.05						
97	4554	8	3		0.21	100.00	10.33	0.02						
873	4033	7	4	1.7	1.92	16.45	1.85	0.22	10.4	4365.19	2		1.30	
535	10693	7	3	1.2	1.16	52.19	2.25	0.05	8	5774.25	2		1.32	
457	9795	7	0	0.2	0.99	100.00	4.73	0.05	2.4	19322.08	1		0.67	
42	2500	8	1	15	0.14	100.00	11.96	0.02	23	1299.78	0	2	0.00	100

Appendix III

Westwall, Lorraine and Ardennes Engagements (Nonurban)

Engage-ment Number	Engagement	Start Date	Duration (in Days)	Attacker Force Name	Defender Force Name	Winner	Outcome	Terrain	Attacker's Total Strength	Defender's Total Strength
43010	Westwall	02-Oct-44	6	US XIX Corps	Ger LXXXI Corps	A	Attack Advances	RM	32283	19632
43020	Schmidt	02-Nov-44	12	US 28th Inf Div (+)	Ger LXXIV Corps (-)	D	Failed Attack	RM/RgM	20493	20250
43030	Schmidt I	02-Nov-44	4	US 112th Inf (+), 28th ID	Ger LXXIV Corps (-)	D	Failed Attack	RM/RgM	6200	5025
43110	Foret de Chateau-Salins	10-Nov-44	2	US 4th Armd Div (+)	Ger XIII SS Pz Corps (-)	A	Attack Advances	RM	43587	11185
43120	Morhange	13-Nov-44	3	US CCB, 4th Armd Div (+)	Ger 11th Pz Div (-) (+)	A	Attack Advances	RM	25881	7555
43130	Bourgaltroff	14-Nov-44	2	US CCA, 4th Armd Div (+)	Ger 11th Pz Div (-) (+)	A	Attack Advances	RM	10348	6519
43140	Baerendorf I	24-Nov-44	2	US CCB, 4th Armd Div (-)	Ger Pz Lehr Div (-) (+)	A	Attack Advances	RM	7935	5366
43150	Baerendorf II	26-Nov-44	1	US 4th Armd Div	Ger Pz Lehr Div (-)	A	Attack Advances	RM	15871	6999
43160	Burbach-Durstel	27-Nov-44	3	US 4th Armd Div (+)	Ger Pz Lehr Div (+)	A	Attack Advances	RM	16232	6713
43170	Sarre-Union	01-Dec-44	2	US 4th Armd Div (+)	Ger 25th Pz Gr Div (-) (+)	A	Attack Advances	RM	19773	6044
43180	Singling-Bining	06-Dec-44	1	US 4th Armd Div (-) (+)	Ger 25th Pz Gr Div (-) (+)	draw	Attack Advances	RM	15224	5044
43201	Our River North	16-Dec-44	2	Ger LVIII Pnz Corps	US 112th Inf (+), 28th ID	A	Attack Advances	RgW	16000	5740
43202	Diekirch	16-Dec-44	4	Ger LXXXV Corps	US 109th RCT, 28th Infantry Division	A	Attack Advances	RgM	33415	5200
43203	Schnee Eifel North I	16-Dec-44	1	Ger 18th VGD (-) (+)	US 14th Cav Grp (+)	A	Defender Penetrated	RM	14300	2050
43204	Schnee Eifel North II	16-Dec-44	4	Ger 18th VGD (-) (+)	US 422nd Inf (+), 106th ID	A	Defender Surrounded	RgW	12800	4150
43205	Schnee Eifel South	16-Dec-44	1	Ger 62nd VGD (+)	US 424th Inf (+), 106th ID	A	Failed Attack	RgW	11000	4300
43206	Our River Center	16-Dec-44	3	Ger XLVII Pnz Corps	US 110th Inf (-) (+), 28th ID	A	Defender Penetrated	RgW	43800	5340
43207	Dillengen	16-Dec-44	3	Ger 276th Volksgrenadier Division	US 9th Armored Division (-)	D	Attack Advances	RgM	9320	3887
43208	Sauer River	16-Dec-44	2	Ger 212th VG Div	US 12th Inf Rgt, 4th Inf Div (+)	A	Attack Advances	RgM/RM	10000	8634
43209	Krinkelt-Rocherath II	17-Dec-44	3	Ger 12th SS PnzD (-) (+)	US 38th Inf (-) (+), 2nd ID	D	Failed Attack	RB/RM	9100	6600
43210	Bastogne	18-Dec-44	3	Ger XLVII Pz Corps (elms)	US 10th Armd Div (-) (+)	D	Attack Advances	RM	36678	4849
43211	Bastogne I	19-Dec-44	1	Ger XLVII Panzer Corps (-)	US 101st Airborne Div (+)	D	Attack Advances	RM	39444	22755
43212	Bastogne II	20-Dec-44	1	Ger XLVII Panzer Corps (-)	US 101st Airborne Division (+)	D	Attack Advances	RM	39258	21835
43213	Bastogne III	21-Dec-44	1	Ger XLVII Panzer Corps (-)	US 101st Airborne Division (+)	D	Attack Advances	RM	25094	21793
43214	26th ID Attack I	22-Dec-44	1	US 26th Infantry Division (+)	Ger 915th VGR + Elms Fuehrer Grenadier Bde	A	Attack Advances	RgW	13298	9000

Appendix III

Westwall, Lorraine and Ardennes Engagements (Nonurban)

											Armor Loss Statistics:			
Attacker's Total Casualties	Defender's Total Casualties	Attacker's Mission Accomp-lishment	Defender's Mission Accomp-lishment	Distance Advanced Per Day (in km)	Attacker's Casualties % per Day Day	Defender's Casualties % per Day	Total Strength Ratio	Total Casualty Ratio	Attacker Front Width (in km)	Attacker Men/km of Front	Attacker's Total Armor Losses	Defender's Total Armor Losses	Attacker's Armor Losses % per Day	Defender's Armor Losses % per Day
1477	3616	5	4	1.3	0.76	3.07	1.64	0.41	12.5	2582.64	79	49	4.22	12.96
3683	3000	3	8	0.4	1.50	1.23	1.01	1.23	9.5	2157.16	47		4.30	
1096	850	4	7	0.85	4.42	4.23	1.23	1.29	1.7	3647.06	21	10	11.93	4.17
720	446	6	5	2.1	0.83	1.99	3.90	1.61	16.6	2625.72	8	3	1.23	7.50
1006	197	6	4	2.2	1.30	0.87	3.43	5.11	7.7	3361.17				
185	141	7	6	1	0.89	1.08	1.59	1.31	11.3	915.75		8		25.00
58	224	6	4	0.5	0.37	2.09	1.48	0.26	3.5	2267.14	4	4	1.89	6.67
56	233	6	5	5	0.35	3.33	2.27	0.24	11.3	1404.51	4		1.90	
110	216	6	5	1.3	0.23	1.07	2.42	0.51	11.3	1436.46	10		1.58	
234	129	7	5	1.3	0.59	1.07	3.27	1.81	4.5	4394.00	3	2	0.63	4.35
155	121	5	5	1.4	1.02	2.40	3.02	1.28	3.6	4228.89	13	3	6.16	16.67
770	196	6	5	2	2.41	1.71	2.79	3.93	4	4000.00	20	3	12.82	37.50
1237	500	5	4	2.25	0.93	2.40	6.43	2.47	13.5	2475.19	6	1	6.25	1.67
50	125	8	2	4	0.35	6.10	6.98	0.40	6	2383.33	2	7	4.00	20.59
200	3535	8	2	1.5	0.39	21.30	3.08	0.06	1	12800.00	2	0	0.42	
200	300	6	5	2	1.82	6.98	2.56	0.67	9	1222.22	7	0	26.92	
900	3300	6	5	3.25	0.68	20.60	8.20	0.27	12	3650.00	43	59	6.76	26.94
824	350	4	5	1.33	2.95	3.00	2.40	2.35	6.5	1433.85		2		0.84
268	134	5	4	3.2	1.34	0.78	1.16	2.00	14.5	689.66	2	3	25.00	3.75
900	720	3	7	0.3	3.30	3.64	1.38	1.25	3	3033.33	41	13	11.29	13.13
3000	1151	5	7	5	2.73	7.91	7.56	2.61	12	3056.50	50	103	4.64	22.59
186	888	4	5	5	0.47	3.90	1.73	0.21	12	3287.00	13	60	6.60	31.91
166	32	4	5	7.6	0.42	0.15	1.80	5.19	16.2	2423.33	28	1	16.09	0.78
185	150	6	8	5.8	0.74	0.69	1.15	1.23	13	1930.31	3	3	3.75	2.36
27	56	7	2	19.6	0.20	0.62	1.48	0.48	8.5	1564.47		4		12.50

43215	Bastogne IV	22-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	D	Failed Attack	RM	11971	21638
43216	4th AD Attack I	22-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (+)	A	Attack Advances	RgM	13275	8100
43217	80th ID Attack I	22-Dec-44	1	US 80th Infantry Division (+)	Ger 352d Volksgrenadier Division (-) (+)	A	Defender Penetrated	RgW	16618	11018
43218	26th ID Attack II	23-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier (-) (+)	A	Attack Advances	RgW	13412	8944
43219	Bastogne V	23-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	D	Limited Attack	RM	11806	20474
43220	4th AD Attack II	23-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (+)	D	Attack Advances	RgM	13465	7881
43221	80th ID Attack II	23-Dec-44	1	US 80th Infantry Division (+)	Ger 352d Volkgrenadier Division (-)(+)	A	Defender Penetrated	RgW	16568	10750
43222	4th AD Attack III	24-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (+)	D	Failed Attack	RgM	13465	7725
43223	Bastogne VI	24-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	D	Limited Attack	RM	11641	20211
43224	Celles	24-Dec-44	5	US 2d Armored Division (+)	Ger 2d Panzer Division (+)	A	Defender Penetrated	RM	18351	14202
43225	80th ID Attack III	24-Dec-44	1	US 80th Infantry Division (+)	Ger 352d Volksgrenadier Division (-) (+)	A	Defender Penetrated	RgW	15197	10000
43226	26th ID Attack III	24-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier Brigade (+)	D	Attack Advances	RgW	13286	8779
43227	26th ID Attack IV	25-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier Brigade (-) (+)	A	Attack Advances	RgW	13148	8444
43228	4th AD Attack IV	25-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (+)	D	Attack Advances	RgM	14500	6486
43229	Bastogne VII	25-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	D	Failed Attack	RM	15571	20036
43230	Verdenne	25-Dec-44	3	US 84th Infantry Division	Ger 116th Panzer Division	A	Defender Penetrated	RM	17548	14400
43231	80th ID Attack IV	25-Dec-44	1	US 80th Infantry Division (+)	Ger 352d Volksgrenadier Division (+)	A	Attack Advances	RgW	14984	12747
43232	4th AD Attack V	26-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (+)	A	Defender Penetrated	RgM	14225	8658
43233	26th ID Attack V	26-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier Brigade (+)	A	Attack Advances	RgW	16165	7618
43234	80th ID Attack V	26-Dec-44	1	US 80th Infantry Division (-) (+)	Ger 79th Volksgrenadier Division (-) (+)	A	Attack Advances	RgW	14835	10886
43235	Bastogne VIII	26-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	D	Failed Attack	RM	14689	20120
43236	4th AD Attack VI	27-Dec-44	1	US 4th Armored Division (+)	Ger 5th Parachute Division (-) (+)	A	Defender Penetrated	RgM	14125	7021
43237	Stalemate on the Sure I	27-Dec-44	1	US 80th Infantry Division	Ger 79th Volksgrenadier Division (-) (+)	DRAW	Limited Attack	RgW	14459	10400
43238	Bastogne IX	27-Dec-44	1	Ger 26th Volksgrenadier Division (+)	US 101st Airborne Division (+)	DRAW	Limited Action	RM	14524	19930
43239	26th ID Attack VI	27-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier Brigade (-) (+)	A	Attack Advances	RgW	15949	7600
43240	Bastogne Corridor I	27-Dec-44	1	US 35th Infantry Division (+)	Ger 5th Parachute Division (elms))	A	Defender Penetrated	RgW	16258	3800

113	862	6	8	1	0.94	3.98	0.55	0.13	44	272.07	1	0	2.56	0
1	219	6	4	17.8	0.01	2.70	1.64	0.00	12.8	1037.11	37	0	12.63	0
27	268	8	5	17.7	0.16	2.43	1.51	0.10	8.9	1867.19				
73	165	7	4	3.2	0.54	1.84	1.50	0.44	8.5	1577.88	2	7	1.92	25.00
44	251	6	8	2.5	0.37	1.23	0.58	0.18	44	268.32	4	2	10.53	1.61
6	156	5	6	4.3	0.04	1.98	1.71	0.04	9	1496.11	14	1	5.47	6.67
209	747	6	4	2.4	1.26	6.95	1.54	0.28	8.9	1861.57	2	13	2.22	25.49
101	1239	5	6	2.4	0.75	16.04	1.74	0.08	11.4	1181.14	8	4	3.27	28.57
22	179	6	8	0	0.19	0.89	0.58	0.12	44	264.57	0	3	0.00	2.46
243	1590	9	4	2.4	0.26	2.24	1.29	0.15	13.5	1359.33	27	82	1.09	14.14
176	149	6	4	2.7	1.16	1.49	1.52	1.18	14.6	1040.89	11	1	12.50	2.63
99	335	5	6	1.8	0.75	3.82	1.51	0.30	13.6	976.91		2		9.52
72	110	7	5	5.4	0.55	1.30	1.56	0.65	12	1095.67	8		7.69	
125	2028	5	6	0	0.86	31.27	2.24	0.06	16.6	873.49	4		1.70	
639	70	5	8	0	4.10	0.35	0.78	9.13	26	598.88	18	2	19.78	1.68
582	931	6	4	0.5	1.11	2.16	1.22	0.63	8.5	2064.47	8	16	2.81	10.67
156	181	6	5	0.9	1.04	1.42	1.18	0.86	19.6	764.49	1		1.28	
73	1037	8	5	8	0.51	11.98	1.64	0.07	16.6	856.93	3		1.36	
101	18	8	5	2	0.62	0.24	2.12	5.61	10	1616.50		5		12.20
463	466	6	5	1.2	3.12	4.28	1.36	0.99	20	741.75				
103	183	4	7	0	0.70	0.91	0.73	0.56	26	564.96	3		4.11	
44	1102	6	5	4	0.31	15.70	2.01	0.04	8	1765.63	6		2.71	
357	364	5	5	0	2.47	3.50	1.39	0.98	22	657.23				
4	89	5	5	0	0.03	0.45	0.73	0.04	25	580.96	1		1.43	
48	473	6	5	0.5	0.30	6.22	2.10	0.10	14.1	1131.13	6	3	5.94	8.33
39	231	7	4	6.6	0.24	6.08	4.28	0.17	10	1625.80				

43241	Stalemate on the Sure II	28-Dec-44	1	US 80th Infantry Division (+)	Ger 79th Volksgrenadier Division (+)	DRAW	Limited Attack	RgW	14384	10000
43242	Bastogne Corridor II	28-Dec-44	1	US 35th Infantry Division (+)	Ger 5th Parachute Division (-)	A	Attack Advances	RgW	16173	3500
43243	4th AD Attack VII	28-Dec-44	1	US 4th Armored Division (+)	Ger Group Luettwitz	A	Defender Penetrated	RgM	13918	10900
43244	26th ID Attack VII	28-Dec-44	1	US 26th Infantry Division (+)	Ger Fuehrer Grenadier Brigade (-)	A	Attack Advances	RgW	15897	9500
43245	26th ID Attack VIII	29-Dec-44	1	US 26th Infantry Division (+)	Ger 9th Volksgrenadier Division (-)(+)	A	Attack Advances	RgW	15828	13800
43246	Stalemate on the Sure III	29-Dec-44	1	US 80th Infantry Division (+)	Ger 79th Volksgrenadier Division (+)	DRAW	Limited Attack	RgW	15445	10000
43247	4th AD Attack VIII	29-Dec-44	1	US 4th Armored Division (+)	Ger Group Luettwitz	A	Attack Advances	RgW	13880	10628
43248	Bastogne Corridor III	29-Dec-44	1	US 35th Infantry Division (+)	Ger 5th Parachute Division (-)	A	Defender Penetrated	RgW	16114	6100
43249	167th VGD Attack I	30-Dec-44	1	Ger 167th Volksgrenadier Division (-) (+)	US 4th Armored Division (+)	D	Attack Advances	RgM	21250	13893
43250	Stalemate on the Sure IV	30-Dec-44	1	US 80th Infantry Division (+)	Ger 79th Volksgrenadier Division (+)	DRAW	Limited Attack	RgW	15216	9900
43251	26th ID Attack IX	30-Dec-44	1	US 26th Infantry Division (+)	Ger 9th Volksgrenadier Division (+)	D	Attack Advances	RgW	15656	10300
43252	Lutrebois I	30-Dec-44	1	Ger 1st SS Panzer Division (-)	US 35th Infantry Division (+)	D	Attack Advances	RgW	19105	14000
43253	26th ID Attack X	31-Dec-44	1	US 26th Infantry Division (+)	Ger 9th Volksgrenadier Division (+)	D	Failed Attack	RgW	15537	9600
43254	Stalemate on the Sure V	31-Dec-44	1	US 80th Infantry Division (+)	Ger 79th Volksgrenadier Division (+)	DRAW	Limited Attack	RgW	15876	9800
43255	167th VGD Attack II	31-Dec-44	1	Ger 167th Volksgrenadier Division (+)	US 4th Armored Division (+)	A	Failed Attack	RgM	21192	13860
43256	Lutrebois II	31-Dec-44	1	Ger 1st SS Panxer Division (+)	US 35th Infantry Division (+)	DRAW	Failed Attack	RgW	18875	13800
43257	Bastogne XXVI (Foy)	13-Jan-45	1	US 101st Airborne Div (+)	Ger 340th Volksgrendadier Div (+)	A	Attack Advances	RM	12600	7905
43601	Aachen 1st ID Attack I	08-Oct-44	1	US 1st ID +	Ger 246 VGD (-)	A	Defender Penetrated	RM	19145	6316
43801	Aachen 30th ID Attack I	02-Oct-44	1	US 30th ID +	Ger 183 VGD +	Attacker	Attack Advances	RM	19679	5137

162	29	5	5	0	1.13	0.29	1.44	5.59	22	653.82				
19	64	6	4	3.4	0.12	1.83	4.62	0.30	8.6	1880.58	1		3.23	
46	272	6	4	2	0.33	2.50	1.28	0.17	8	1739.75	1		0.47	
104	579	7	5	3.7	0.65	6.09	1.67	0.18	8.5	1870.24	7	3	6.93	9.09
120	122	6	5	1.4	0.76	0.88	1.15	0.98	10	1582.80	2	3	2.08	6.82
165	121	5	5	0	1.07	1.21	1.54	1.36	22	702.05				
73	278	6	5	1.5	0.53	2.62	1.31	0.26	8	1735.00	2		0.90	
87	71	7	4	5.7	0.54	1.16	2.64	1.23	15	1074.27	1		3.33	
58	28	3	5	2.3	0.27	0.20	1.53	2.07	8	2656.25		7		3.50
92	107	5	5	0	0.60	1.08	1.54	0.86	22	691.64				
128	646	5	6	1.8	0.82	6.27	1.52	0.20	10.3	1520.00				
240	126	4	6	2	1.26	0.90	1.36	1.90	5	3821.00	16	2	34.78	5.41
179	423	5	6	0	1.15	4.41	1.62	0.42	8	1942.13				
33	29	5	5	0	0.21	0.30	1.62	1.14	22	721.64				
4	89	6	5	0	0.02	0.64	1.53	0.04	8	2649.00				
314	450	6	6	0	1.66	3.26	1.37	0.70	5	3775.00		1		2.63
105	315	7	5	1	0.83	3.98	1.59	0.33	5.8	2172.41	0	0	0.00	0.00
150	359	7	4	3	0.78	5.68	3.03	0.42	12	1595.42	6	1	5.56	16.67
315	103	7	5	1.3	1.60	2.01	3.83	3.06	1.8	10932.78	1	0	0.89	0.00

Appendix IV

Aachen Engagements (Urban)

Engage-ment Number	Engagement	Start Date	Duration (in Days)	Attacker Force Name	Defender Force Name	Winner	Outcome	Terrain	Attacker's Total Strength	Defender's Total Strength
44102	Aachen 1st ID Attack II	09-Oct-44	1	US 1st ID +	Ger 246 VGD (-)(+)	A	Attack Advances	RM/CONURB	19259	5957
44103	Aachen 1st ID Attack III	10-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	RM/CONURBAN	19032	6981
44104	Aachen 1st ID Attack IV	11-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Limited Attack	RM/CONURBAN	18906	6408
44105	Aachen 1st ID Attack V	12-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Limited Attack	CONURBAN/U	18960	6278
44106	Aachen 1st ID Attack VI	13-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	14264	6241
44107	Aachen 1st ID Attack VII	14-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	19293	5816
44108	Aachen 1st ID Attack VIII	15-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	19269	9229
44109	Aachen 1st ID Attack IX	16-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	19275	8982
44110	Aachen 1st ID Attack X	17-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	19219	9082
44111	Aachen 1st ID Attack XI	18-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	20662	8628
44112	Aachen 1st ID Attack XII	19-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	20686	8205
44113	Aachen 1st ID Attack XIII	20-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Attack Advances	U/CONURBAN	20657	7954
44114	Aachen 1st ID Attack XIV	21-Oct-44	1	US 1st ID (+)	Ger 246 VGD (-)(+)	Attacker	Other	U/CONURBAN	20365	6960
44302	Aachen 30th ID Attack II	03-Oct-44	1	US 30th ID +	Ger 183 VGD +	Attacker	Attack Advances	RM/CONURBAN	19297	9360
44303	Aachen 30th ID Attack III	04-Oct-44	1	US 30th ID +	Ger 49 ID +	Draw	Attack Advances	RM/CONURBAN	23813	9025
44304	Aachen 30th ID Attack IV	05-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Attack Advances	RM/CONURBAN	22585	10749
44305	Aachen 30th ID Attack V	06-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Limited Attack	RM/CONURBAN	32173	14274
44306	Aachen 30th ID Attack VI	07-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Attack Advances	RM/CONURBAN	32118	15943
44307	Aachen 30th ID Attack VII	08-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Attack Advances	RM/CONURBAN	31800	18467
44308	Aachen 30th ID Attack VIII	09-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Attack Advances	CONURBAN	32208	17107
44309	Aachen 30th ID Attack IX	10-Oct-44	1	US 30th ID +	Ger 49 ID +	Attacker	Attack Advances	CONURBAN	32279	16533

Appendix IV

Aachen Engagements (Urban)

											Armor Loss Statistics:			
Attacker's Total Casualties	Defender's Total Casualties	Attacker's Mission Accomp-lishment	Defender's Mission Accomp-lishment	Distance Advanced Per Day (in km)	Attacker's Casualties % per Day Day	Defender's Casualties % per Day	Total Strength Ratio	Total Casualty Ratio	Attacker Front Width (in km)	Attacker Men/km of Front	Attacker's Total Armor Losses	Defender's Total Armor Losses	Attacker's Armor Losses % per Day	Defender's Armor Losses % per Day
104	137	7	5	1	0.54	2.30	3.23	0.76	12	1604.92		2		40.00
69	313	7	5	0.8	0.36	4.48	2.73	0.22	12	1586.00				
65	130	7	5	0.2	0.34	2.03	2.95	0.50	12	1575.50				
72	337	7	5	0.2	0.38	5.37	3.02	0.21	12	1580.00		6		46.15
54	425	7	5	0.5	0.38	6.81	2.29	0.13	12	1188.67		0		0.00
71	317	6	5	0.5	0.37	5.45	3.32	0.22	12	1607.75	1	7	0.97	46.67
77	247	6	5	0.2	0.40	2.68	2.09	0.31	12	1605.75	7	2	6.25	4.65
112	200	7	5	0.6	0.58	2.23	2.15	0.56	12	1606.25	0	6	0.00	11.11
58	454	7	5	0.6	0.30	5.00	2.12	0.13	12	1601.58	7	4	6.67	8.33
103	423	7	4	0.8	0.50	4.90	2.39	0.24	12	1721.83	1	14	0.75	22.95
122	251	6	4	0.4	0.59	3.06	2.52	0.49	12	1723.83	5	5	3.76	10.64
100	994	7	4	0.5	0.48	12.50	2.60	0.10	12	1721.42	0	0	0.00	0.00
36	1564	8	0	0.3	0.18	22.47	2.93	0.02	12	1697.08	0	7	0.00	15.91
215	335	6	5	1.3	1.11	3.58	2.06	0.64	2.5	7718.80	3	9	2.70	14.75
284	528	6	6	0.7	1.19	5.85	2.64	0.54	7	3401.86	8	7	2.66	12.07
199	496	7	5	2.25	0.88	4.61	2.10	0.40	8	2823.13	25	11	8.39	24.44
442	524	6	5	1.8	1.37	3.67	2.25	0.84	11	2924.82	30	4	6.11	11.76
157	1394	7	5	3	0.49	8.74	2.01	0.11	18	1784.33	12	1	2.66	2.00
257	1360	7	5	2.1	0.81	7.36	1.72	0.19	20	1590.00	9	4	2.05	8.70
114	574	6	5	1.5	0.35	3.36	1.88	0.20	22	1464.00	3	0	0.70	0.00
112	134	6	5	1	0.35	0.81	1.95	0.84	24	1344.96	1	1	0.23	2.13

APPENDIX V. Examples of Urban Combat

Possible Sources for Combat Data in Cities (assumption: you need two sided archival data to be worthwhile):

	Battle	**Date**	**Sources**
1.	Shanghai	1932	Japanese sources may be good Chinese sources are unknown
2.	Warsaw	1939	Excellent German data Polish data unknown
3.	Rostov	1941	Good to Excellent German data Good USSR data is accessible
4.	Hong Kong	1941	Maybe good British sources Maybe good Japanese sources
5.	Dieppe	1942	Excellent German sources Excellent Canadian sources
6.	Sevastopol	1942	Good to Excellent German data Good USSR data is accessible
7.	Stalingrad	1942	Good to Excellent German data Good USSR data is accessible
8.	Kharkov (twice)	Feb-March 1943	Good to Excellent German data Good USSR data is accessible
9.	Kharkov	Aug 1943	Good to Excellent German data Good USSR data is accessible
10.	Novorossisk	1943	Good to Excellent German data Good USSR data is accessible
11.	Warsaw ghetto	1943	Good to Excellent German data Jewish data is probably weak
12.	Warsaw uprising	1944	Mediocre to Good German data Polish data probably not good
13.	Brest	1944	Mediocre to Excellent German data Excellent US data
14.	Cherbourg	1944	Mediocre to Excellent German data Excellent US data
15.	St. Malo	1944	Mediocre to Excellent German data Excellent US data
16.	Dunkirk	1944	Mediocre to Excellent German data Good to excellent Canadian/UK data
17.	Le Havre	1944	Mediocre to Excellent German data Good to excellent Canadian/UK data
18.	Boulougne	1944	Mediocre to Good German data Good to excellent Canadian/UK data

19.	Aachen	1944	Mediocre to Good German data Excellent US data
20.	Metz	1944	Mediocre to Good German data Excellent US data
21.	Manila	1945	Excellent US data Japanese data is probably weak
22.	Budapest	1945	Mediocre to Good German data Good USSR data is accessible
23.	Iassy	1945	Mediocre to Good German data Good USSR data is accessible
24.	Leipzig	1945	German data is limited Good USSR data is accessible
25.	Berlin	1945	German data is limited Good USSR data is accessible
26.	Jerusalem	1948	Israeli data may be accessible Jordanian data may be accessible
27.	Inchon/Seoul	1950	Excellent US data NKA data is not available
28.	Budapest	1956	Soviet data may be accessible. Hungarian data may be accessible.
29.	Jerusalem	1967	Archival data is not available
30.	Hue	1968	Excellent US Data Vietnamese data may be accessible
31.	Saigon	1968	Excellent US Data Vietnamese data is probably poor
32.	Quang-Tri	1972	Unknown ARVN data NVA data may be accessible Certainly some US data
33.	Suez City	1973	Archival data is not available
34.	Beirut	1982	Excellent US Data Israeli Data may not be available Phalangist, PLO, etc. data may not be available.
35.	Panama	1989	Excellent US Data Panamanian data unknown
36.	Monrovia	1990	Archival data probably does not exist for all three sides.
37.	Mogadishu	1992-93	Excellent US data Little opposing force data
38.	Grozny	1994-5	Archival data not available
39.	Grozny	1996	Archival data not available
40.	Grozny	1999	Archival data not available.

APPENDIX VI. Database Analysis, Tables

Table 1. Distribution of Outcome by Force Ratio in the Data Sets

	I	II	III	IV	V	VI	VII
Channel	4.25			1.85	4.16		4.58
Ports	4.52			2.25	4.78		4.73
	45.53			2.98	6.46		10.33
				2.99	11.96		36.65
				3.24			
				3.78			
				3.92			
				3.98			
				3.98			
				4.14			
				4.77			
				5.26			
				7.12			
				12.11			
Normandy &			0.92	1.35			28.63
Pursuit		1.54	1.67				
			1.56	1.67			
			1.85	1.72			
			1.88	1.72			
			2.20	1.87			
				2.43			
				2.71			
				2.84			
				2.87			
				3.39			
				3.52			
				4.06			
				4.07			
Aachen		2.25		1.72			2.93
		2.95		1.88			
		3.02		1.95			
				2.01			
				2.06			
				2.09			
				2.10			
				2.12			
				2.15			
				2.29			
				2.39			
				2.52			
				2.60			
				2.64			
				2.73			
				3.23			
				3.32			
Westwall, 0.73	0.58	0.55	1.15	1.22	3.08		
Lorraine	0.58	0.73	1.15	1.28			
& Ardennes		1.39	0.78	1.16	1.29		
		1.44	1.01	1.18	1.51		
		1.54	1.23	1.31	1.52		
		1.54	1.37	1.36	1.54		
		1.62	1.38	1.36	1.64		
			1.53	1.48	2.01		
			1.62	1.48	2.64		
			1.74	1.50	3.03		
			2.56	1.51	4.28		
				1.52	6.98		
				1.53	8.20		
				1.56			

	I	II	III	IV	V	VI	VII
				1.59			
				1.59			
				1.64			
				1.64			
				1.67			
				1.71			
				1.73			
				1.80			
				2.10			
				2.12			
				2.24			
				2.27			
				2.40			
				2.42			
				2.79			
				3.02			
				3.27			
				3.43			
				3.83			
				3.90			
				4.62			
				6.43			
				7.56			

Table 2. Distribution of Outcome by Force Ratio and Terrain Type

Rolling, Mixed	0.73	0.58	0.55	1.15	1.22		28.63
		0.58	0.73	1.16	1.29		
			0.78	1.35	3.03		
			0.92	1.48	6.98		
			1.01	1.59			
			1.23	1.59			
			1.38	1.64			
			1.54	1.67			
			1.56	1.67			
			1.88	1.72			
			2.20	1.72			
				1.73			
				1.80			
				1.87			
				2.27			
				2.42			
				2.43			
				2.71			
				2.84			
				2.87			
				3.02			
				3.27			
				3.39			
				3.43			
				3.52			
				3.83			
				3.90			
				4.06			
				4.07			
				7.56			
Rugged, Mixed			1.53	1.53	1.28		
			1.74	1.64	1.64		
			1.85	1.71	2.01		
				2.24			
				2.40			
				6.43			
Rugged, Wooded		1.39	1.37	1.15	1.51	3.08	
		1.44	1.62	1.18	1.52		
		1.54	2.56	1.31	1.54		

I	II	III	IV	V	VI	VII
	1.54		1.36	2.64		
	1.62		1.36	4.28		
			1.48	8.20		
			1.50			
			1.51			
			1.52			
			1.56			
			1.67			
			2.10			
			2.12			
			2.79			
			4.62			

Table 3. Distribution by Force Ratio, Exchange Ratio and Outcome

Channel Ports, Brest and Paris

Force Ratio	Exchange Ratio	Outcome
1.85	0.22	IV
2.25	0.05	IV
2.98	0.25	IV
2.99	0,06	IV
3.24	0.12	IV
3.78	0.19	IV
3.92	0.51	IV
3.98	0.14	IV
3.98	0.25	IV
4.14	1.23	IV
4.16	0.10	V
4.25	0.48	I
4.52	0.15	I
4.58	0.01	VII
4.73	0.05	VII
4.77	0.05	IV
4.78	0.12	V
5.26	0.12	IV
6.46	0.02	V
7.12	0.06	IV
10.33	0.02	VII
11.96	0.02	V
12.11	0.03	IV
36.65	0.02	VII
45.53	0.01	I
8.07	0.17	Average
4.33	0.07	Weighted Average

Normandy & Pursuit

0.92	1.80	III
1.35	0.30	IV
1.54	1.71	III
1.56	6.55	III
1.67	2.78	IV
1.67	0.91	IV
1.72	1.72	IV
1.72	0.30	V
1.85	0.63	III
1.87	0.23	IV
1.88	0.20	III

Force Ratio	Exchange Ratio	Outcome
2.20	1.75	III
2.43	1.18	IV
2.71	0.26	V
2.84	0.31	IV
2.87	0.27	V
3.39	0.09	IV
3.52	0.10	IV
4.06	0.04	IV
4.07	0.45	IV
28.63	0.01	VII
3.55	1.03	Average
2.02	0.52	Weighted Average
Aachen		
1.72	0.19	IV
1.88	0.20	IV
1.95	0.84	IV
2.01	0.11	IV
2.06	0.64	IV
2.09	0.31	IV
2.10	0.40	IV
2.12	0.13	IV
2.15	0.56	IV
2.25	0.84	II
2.29	0.13	IV
2.39	0.24	IV
2.52	0.49	IV
2.60	0.10	IV
2.64	0.54	IV
2.73	0.22	IV
2.93	0.02	VII
2.95	0.50	II
3.02	0.21	II
3.23	0.76	IV
3.32	0.22	IV
2.43	0.36	Average
2.29	0.25	Weighted Average
Westwall, Lorraine & Ardennes		
0.55	0.13	III
0.58	0.18	II
0.58	0.12	II
0.73	0.56	III
0.73	0.04	I
0.78	9.13	III
1.01	1.23	III
1.15	1.23	IV
1.15	0.98	IV
1.16	2.00	IV
1.18	0.86	IV
1.22	0.63	V

Force Ratio	Exchange Ratio	Outcome
1.23	1.29	III
1.28	0.17	V
1.29	0.15	V
1.31	0.26	IV
1.36	1.90	IV
1.36	0.99	IV
1.37	0.70	III
1.38	1.25	III
1.39	0.98	II
1.44	5.59	II
1.48	0.26	IV
1.48	0.48	IV
1.50	0.44	IV
1.51	0.30	IV
1.51	0.10	V
1.52	1.18	V
1.52	0.20	IV
1.53	2.07	IV
1.53	0.04	III
1.54	1.36	II
1.54	0.86	II
1.54	0.28	V
1.56	0.65	IV
1.59	1.31	IV
1.59	0.33	IV
1.62	1.14	II
1.62	0.42	III
1.64	0.41	IV
1.64	0.07	V
1.64	0.00	IV
1.67	0.18	IV
1.71	0.04	IV
1.73	0.21	IV
1.74	0.08	III
1.80	5.19	IV
2.01	0.04	V
2.10	0.10	IV
2.12	5.61	IV
2.24	0.06	IV
2.27	0.24	IV
2.40	2.35	IV
2.42	0.51	IV
2.56	0.67	III
2.64	1.23	V
2.79	3.93	IV
3.02	1.28	IV
3.03	0.42	V
3.08	0.06	VI
3.27	1.81	IV
3.43	5.11	IV
3.83	3.06	IV
3.90	1.61	IV
4.28	0.17	V
4.62	0.30	IV
6.43	2.47	IV

Force Ratio	Exchange Ratio	Outcome
6.98	0.40	V
7.56	2.61	IV
8.20	0.27	V
2.13	1.18	Average
1.69	0.63	Weighted Average

Comparing Similar Force Ratios

Force Ratio	Exchange Ratio	Outcome	Source
1.71	0.04	IV	Ardennes
1.72	1.72	IV	Normandy
1.72	0.30	V	Normandy
1.72	0.19	IV	Urban A
1.73	0.21	IV	Ardennes
1.74	0.08	III	Ardennes
1.80	5.19	IV	Ardennes
1.85	0.63	III	Normandy
1.85	0.22	IV	Urban C
1.87	0.23	IV	Normandy
1.88	0.20	III	Normandy
1.88	0.20	IV	Urban A
1.95	0.84	IV	Urban A
2.01	0.11	IV	Urban A
2.01	0.04	V	Ardennes
2.06	0.64	IV	Urban A
2.09	0.31	IV	Urban A
2.10	0.40	IV	Urban A
2.10	0.10	IV	Ardennes
2.12	5.61	IV	Ardennes
2.12	0.13	IV	Urban A
2.15	0.56	IV	Urban A
2.20	1.75	III	Normandy
2.24	0.06	IV	Ardennes
2.25	0.84	II	Urban A
2.25	0.05	IV	Urban C
2.27	0.24	IV	Ardennes
2.29	0.13	IV	Urban A
2.39	0.24	IV	Urban A
2.40	2.35	IV	Ardennes
2.42	0.51	IV	Ardennes
2.43	1.18	IV	Normandy
2.52	0.49	IV	Urban A
2.56	0.67	III	Ardennes

Average Force Ratio	Average Exchange Ratio	
2.11	0.36	Urban (15 cases)
2.04	1.11	Non-urban (19 cases)

Force Ratio	Exchange Ratio	Outcome	Source
2.60	0.10	IV	Urban A
2.64	1.23	V	Ardennes
2.64	0.54	IV	Urban A
2.71	0.26	V	Normandy
2.73	0.22	IV	Urban A
2.79	3.93	IV	Ardennes

Force Ratio	Exchange Ratio	Outcome	Source
2.84	0.31	IV	Normandy
2.87	0.27	V	Normandy
2.93	0.02	VII	Urban A
2.95	0.50	II	Urban A
2.98	0.25	IV	Urban C
2.99	0.06	IV	Urban C
3.02	1.28	IV	Ardennes
3.02	0.21	II	Urban A
3.03	0.42	V	Ardennes
3.08	0.06	VI	Ardennes
3.23	0.76	IV	Urban A
3.24	0.12	IV	Urban C
3.27	1.81	IV	Ardennes
3.32	0.22	IV	Urban A
3.39	0.09	IV	Normandy
3.43	5.11	IV	Ardennes
3.52	0.10	IV	Normandy
3.78	0.19	IV	Urban C
3.83	3.06	IV	Ardennes
3.90	1.61	IV	Ardennes
3.92	0.51	IV	Urban C
3.98	0.14	IV	Urban C
3.98	0.25	IV	Urban C
Average Force Ratio	**Average Exchange Ratio**		
3.22	0.27	Urban (15 cases)	
3.17	1.40	Non-urban (14 cases)	

Force Ratio	Exchange Ratio	Outcome	Source
4.06	0.04	IV	Normandy
4.07	0.45	IV	Normandy
4.14	1.23	IV	Urban C
4.16	0.10	V	Urban C
4.25	0.48	I	Urban C
4.28	0.17	V	Ardennes
4.52	0.15	I	Urban C
4.58	0.01	VII	Urban C
4.62	0.30	IV	Ardennes
4.73	0.05	VII	Urban C
4.77	0.05	IV	Urban C
4.78	0.12	V	Urban C
5.26	0.12	IV	Urban C
6.43	2.47	IV	Ardennes
6.46	0.02	V	Urban C
6.98	0.40	V	Ardennes
7.12	0.06	IV	Urban C
7.56	2.61	IV	Ardennes
8.20	0.27	V	Ardennes
Average Force Ratio	**Average Exchange Ratio**		
4.98	0.22	Urban (11 cases)	
5.78	0.84	Non-urban (8 cases)	

Table 4. Distribution by Force Ratio and Advance Rate

Force Ratio	Advance Rate	Source
1.15	1.4	Ardennes
1.15	5.8	Ardennes
1.16	3.2	Ardennes
1.18	0.9	Ardennes
1.31	1.5	Ardennes
1.35	.25	Normandy
1.36	1.2	Ardennes
1.36	2.0	Ardennes
1.48	0.5	Ardennes
1.48	19.6	Ardennes
1.50	3.2	Ardennes
1.51	1.8	Ardennes
1.52	1.8	Ardennes
1.53	2.3	Ardennes
1.56	5.4	Ardennes
1.59	1.0	Ardennes
1.59	1.0	Ardennes
1.64	1.3	Ardennes
1.64	17.8	Ardennes
1.67	1.4	Normandy
1.67	1.6	Normandy
1.67	3.7	Ardennes
1.46	3.58	Average (22 cases)
1.71	4.3	Ardennes
1.72	2.1	Urban A
1.72	2.8	Normandy
1.73	5.0	Ardennes
1.80	7.6	Ardennes
1.85	1.7	Urban C
1.87	0.3	Normandy
1.88	1.5	Urban A
1.95	1.0	Urban A
2.01	3.0	Urban A
2.06	1.3	Urban A
2.09	0.2	Urban A
2.10	0.5	Ardennes
2.10	2.25	Urban A
2.12	0.6	Urban A
2.12	2.0	Ardennes
2.15	0.6	Urban A
2.24	0.0	Ardennes
2.25	1.2	Urban C
2.27	5.0	Ardennes
2.29	0.5	Urban A
2.39	0.8	Urban A
2.40	1.33	Ardennes
2.42	1.3	Ardennes
2.43	1.0	Normandy
2.52	0.4	Urban A
2.07	2.59	Average, Non-urban (12 cases)
2.10	1.23	Average, Urban (14 cases)

Force Ratio	Advance Rate	Source
2.60	0.5	Urban A
2.64	0.7	Urban A
2.73	0.8	Urban A
2.79	2.0	Ardennes
2.84	2.0	Normandy
2.98	0.8	Urban C
2.99	1.5	Urban C
3.02	1.4	Ardennes
3.23	1.0	Urban A
3.24	0.1	Urban C
3.27	1.3	Ardennes
3.32	0.5	Urban A
3.43	2.2	Ardennes
3.78	0.2	Urban C
3.83	1.3	Ardennes
3.90	2.1	Ardennes
3.92	0.2	Urban C
3.98	0.1	Urban C
3.98	1.5	Urban C
3.30	1.76	Average, Non-urban (7 cases)
3.28	0.66	Average, Urban (12 cases)
4.14	0.0	Urban C
4.62	3.4	Ardennes
4.77	2.5	Urban C
5.26	0.2	Urban C
6.43	2.25	Ardennes
7.12	1.5	Urban C
7.56	5.0	Ardennes
12.11	0.5	Urban C
6.20	3.55	Average, Non-urban (3 cases)
6.68	0.94	Average, Urban (5 cases)
3.30	.96	Urban Average (31 cases)
2.24	3.02	Non-urban Average (44 cases)

APPENDIX VII. Recent MOUT Literature

The Dupuy Institute is a late arrival to the study of urban warfare, not due to a lack of interest, but rather due to a lack of funding. We have found four significant studies that precede our work. Three are readily available via the Internet.

After reading these studies, TDI noted that they contained a number of conclusions that when compared to our study appeared correct, a number that were counter-intuitive and a number that appeared to be purely hypothetical. Our work covers much of the same ground as these other studies, but makes more extensive use of hard data taken from the records of real-world engagements. Therefore, it may be useful to look at the conclusions

drawn and the hypothetical statements made in these studies, and compare them with the real-world data that we utilized in our study.

The format utilized in this comparison will be to list each of the salient statements made or conclusions drawn in each previous study and then evaluate them relative to the data presented in this study. Each statement is evaluated as follows:

- **Well Supported**. Our data supports this conclusion, and we agree with it.
- **Supported**. Our data supports this conclusion, but with insufficient weight to give us confidence that it is indisputably correct.
- **Contradicted**. Our data contradicts the conclusion, leading us to question its validity.
- **Strongly Contradicted**. Our data contradicts the conclusion and leads us to believe that it is incorrect.
- **Not Supported**. Our data neither supports nor contradicts this conclusion. This does not mean that we disagree with the conclusion, rather, the data may simply be ambiguous or may be insufficient to draw a conclusion from.
- **Not Examined**. We did not examine this issue in Phase I of this project, and therefore cannot comment on it. This is different from **Not Supported** where we did examine the issue, but could not find sufficient data to support the statement.

Modern Experience in City Combat

The first study is by R. D. McLaurin, Paul A. Jureidini and David S. McDonald, *Modern Experience in City Combat* (Abbot Associates, Inc. March 1987). This is the earliest study of urban combat that we examined, and appears to have been the starting point for the others. It is a study that is based upon testing various hypothesis, and even though we feel the data collection to support it is weak, the analysis appears very insightful. It is a very neatly structured and easy to understand report and is by far the most "scientific" and structured of the four reports examined (all quotations are taken from pages 3—5).

- **Well Supported**

Such an attack is not necessarily overly expensive in casualties or resources, depending upon a number of factors, several of which are not under attacker control. What the city does consume in almost every case is time.

- **Supported**

The results suggest that current doctrine is well-founded in advising attacking American forces to avoid cities where this is feasible.

Isolating and encircling a city, however, may prevent the prolonged battle for control of it from slowing the overall offensive.

In cases where attackers enjoyed a 4:1 advantage or greater in personnel, even major cities did not consume more than two weeks' time on the average.

Defense in a built-up area does not appear to be a better risk than defense on other terrain in terms of ultimately holding the ground.

The 'odds' favoring an ultimate attacker victory do not materially increase on the attacker's force advantage exceeds 2:1.

Further increasing the attacker's force advantage [above 2:1], however, lessens the amount of time needed to seize the city.

In cases where the attacker enjoyed a 4:1 or greater force advantage, even battles for major cities did not consume an average of over two weeks.

Superiority is specific combat areas [i.e. air and armor] does not seem to be significantly related to a successful outcome.

The belief that armor had no role in city fighting is erroneous.

Personnel training and motivation continue to be as important as equipment or force balance factors.

- **Not Examined**

However, defense of cites, especially large cities that an attacker cannot avoid, does appear to offer unique advantages to the defender. A well planned defense, even if cut off, or lacking in air, armor, or artillery weapons, can consume inordinate amounts of the attacker's time. This time can permit the defender to reorganize, re-deploy, or otherwise more effectively marshal resources in other areas.

Despite the relationship between force ratio and combat duration, preparation of the city for defense can offset some of the defensive force ratio disadvantage. Careful planning and construction of defensive positions, kill zones, and obstacles can extend urban combat for several weeks in a major city.

From the attacker's point of view, air and armor superiority appear to be of roughly equal weight, but have very different implications. Control of the air is important for the protection of attacking forces more than for the destructive power than can be unleashed through air attacks. A second important role of air power is to cut off the city from sources

of supply, reinforcement, and evacuation. It appears that the psychological utility of bombing can be great depending on the character of the defending forces and their perceptions and expectations. The psychological effects of aerial bombardment appear to increase to the degree the defenders are surprised by an unanticipated attack or are inexperienced or inadequately trained or organized. Air attack is further demoralizing to defenders who initially hold high expectations of victory.

These cases [of use of armor in city fighting] show that the role of attacking armor is important, particularly at the outer perimeter in operations to isolate a city. The defender may also use tanks on the outer perimeter to delay or prevent isolation. The defender, however, will place greater emphasis on the antitank (AT) missile. Tanks and armored personnel carriers (APCs) have also proven vital to the attacker inside the city as long as they were protected by dismounted infantry. Many cases in World War II and the IDF (Israeli Defense Forces) experience in the 1982 battles in Lebanon illustrate very clearly that armor can be invaluable in cities. U.S. experience in Hue also demonstrates the prominent role armor can play.

Artillery, like armor, has two distinct roles: outside the built-up area to isolate or prevent isolation, and within the built-up area to provide direct-fire support. New tactics and equipment emphasizing the use of self-propelled (SP) artillery in the direct-fire roles (not in itself a new tactic) undergird [sic] the special value of artillery in cities. By contrast, indirect fire support is more problematical. It is apparent that indirect artillery must be concentrated in volume against a small target area to be truly effective. Even so, indirect artillery fire, like air attack, is significant for its psychological impact.

General or relatively unlimited wars are the only situations in which the attacker has extremely favorable advantages over the defender in MOUT. Conversely, if the attacker is subject to any major constraints, the defender has a good chance to win or at least prolong the battle and raise the cost for the attacker. This is true regardless of force balance factors.

Modern weaponry may affect the outcome of future urban combat. It appears that tanks, whose vulnerability in cities was evident even in World War II, are today more vulnerable to a wider range of better AT munitions. At the same time evolution and proliferation of new tank weapons and ammunition give armor more destructive firepower. There is also some evidence that the newest families of air-to ground munitions may be giving the air arm a viable tactical role in MOUT, although it is premature to render any verdict yet. In a unlimited war environment, the attacker may have gains a slight edge, but in a limited war it appears that defender has gained.

The priority for both attacker and defender on the ability to control military operations in highly decentralized circumstances remains the same.

Equally important is the requirement for truly combined arms operations, especially for the attacker. The infantry has long been thought to be the primary combat arms branch in city fighting. It is true that the foot soldier's role is unique and somewhat different in urban areas, but so are those of armor and artillery. Moreover, several of the cases reaffirm the

necessity for the various branches to plan, train, and develop doctrine together. Infantry requires fire support against strongpoints no more or less than armor and SP artillery need protection by infantry.

In general, *The Dupuy Institute* is not much concerned regarding the validity of most of these statements.

Analysis of Casualty Rates & Patterns Likely to Result from Military Operations in Urban Environments

The next study examined is by Colonel (Retd) RA Leitch, MBE RGN, Dr. HR Champion, F.R.C.S. (Edin) F.A.C.S., and Dr. JF Navein MB ChB M.RC.G.P. *Analysis of Casualty Rates & Patterns Likely to Result from Military Operations in Urban Environments* (US Marine Corps Commandant's Warfighters Laboratory, 1997). This study is basically a compilation of other work, often without proper source attribution (unless otherwise indicated, all quotations are from pages 34—36).

- **Strongly Contradicted**

Table 19: Casualty Estimate Profile for Offensive Urban Operations... Based on rates of 30-50 casualties per 1,000 troops per day.

Table 20. Casualty Estimate Profile for Transitional Urban Operations... Based on rates of 15-30 casualties per 1,000 troops per day.

Table 21. Casualty Estimate Profile for Defensive Urban Operations... Based on rates of 10-15 casualties per 1,000 troops per day.

- **Contradicted**

There currently is no existing database on urban-specific casualty rates.

There are a number of high quality sources worldwide that contain considerable data on casualties resulting from urban operations. However, the material is contained within comprehensive databases dealing with generic casualties in broad conflict scenarios. To date, there appears to have been no attempt to extract the relevant data for use in a specific study of urban operations.

- **Not Examined**

Urban operations require physically fit, well-trained, equipped and motivated fighters.

Personnel protective equipment such as helmets, ballistic vests, flameproof clothing and eye protection, appear to substantially mitigate casualty rates if used in urban combat.

Combat is at close range and mainly conducted by small groups of combatants.

Command, Control, and Communications are often very difficult to maintain in urban operations.

Identification, location, and initial treatment of casualties is generally more difficult in urban than in non-urban operations.

Combat units therefore need a high degree of autonomy. This includes self-sufficiency in medical support.
Evacuation is often dangerous, slow, and delayed.

The ability to provide skilled, initial care and to stabilize casualties far-forward is vital in urban operations.

The means of evacuation may often be limited to heavily protected vehicles or stealth movement by foot.

The traditional means of evacuating casualties from far forward by helicopter will often be impossible in urban environments.

Evacuation from safe areas away from the immediate combat zone to definitive care, will often be a lengthy journey and STOL and VSTOL aircraft are key to the mission.

Given the dispersed nature of combat and problematic evacuation, there is a vital need for 'life and limb saving' surgical capability well forward, probably at the traditional Echelon Two level.

The key components of medical support to urban operations are the highest standards of 'buddy aid' for a highly trains medic well forward with the fighting sub-units.

None of the available contemporary literature, studies, or data sources show the impact of injured civilians or POWs on health care resource needs. This is a study area that required detailed future attention.

Although no specific database of urban rates exist, the Kuhn Study has genuine application provided that it was shaped to meet the specific needs of urban operations.

Predicted casualty were still the main tool used to design the shape, size and capability of operational health-care support.

Emerging political and social attitudes regarding the acceptable levels of operational casualties were likely to impact dramatically on the planning of pragmatic casualty rates, which would, in turn, limit the shape, size, and capability of deployed health-care support.

There is a need for a specified planning tool for the development of mission-specific operations health care support.

As with casualty rates, there is no consolidate data source of urban-specific wounded patterns. When comparisons were made between the isolated finding in the existing

literature, there appeared to be conflicting conclusions, particularly over finding on wounding patterns.

The WDMET, held at the Borden Institute, appears to be the best source currently available, although the urban specific data requires extraction. Of the other data sources, the most valuable appear to be the U.K. database on operations in Northern Ireland and the Falklands, the Israeli database from the Lebanon War, the Russian data from Chechnya and Bosnian data.

The campaign by the Israeli Defense Forces in Lebanon has many valuable lessons to be learned and would make an ideal addition to the WDMET data.

The specific wound data from the Battle of Hue requires extraction from the WDMET database.

The Russian campaign in Chechnya and specifically the battle for Grozny has much promise as a specific source of data for urban combat and should be examine further.

The Dupuy Institute finds itself wondering as to the validity of a number of statements in this study, even though we have not specifically examined them. *The Dupuy Institute* also takes exception to the application by this study of the same casualty rate data to Platoon, Company, Battalion and Brigade-level combat. There is a body of literature demonstrating that this is incorrect dating back to the 1970s. This application of a fundamentally flawed methodology produces unrealistic casualty rates. We were also disappointed to make note of the chart on page 11 of their report, which is headed by the statement that,

The Study examined 17 conflicts/operations spanning the period 1939 to 1995... The operations/battles examined are…

This chart was clearly copied, with little or no modification, from one prepared by *The Dupuy Institute* dated 21 May 1997. The TDI version is the direct progenitor of the chart used in Appendix V of this report. No reference is made in the Marine Corps study to *The Dupuy Institute* or to the chart's actual author, Christopher A. Lawrence, as the source of the chart. Furthermore, the Marine Corps version of this chart contains a glaring error, listing Israel as one of the combatants in Mogadishu. Furthermore, the Marine Corps study then goes on to state,

In the event there proved to be little data on casualty rates or wounding patterns for many of the operations and… 3 of the listed operations provide sufficient material to elaborate upon in the Study…

This is a conclusion that is clearly incorrect. The original TDI chart was an analysis of the quality and availability of archival records for the units involved and not a compilation of data itself. Our current study has clearly shown that the records for many of the operations do in fact contain extensive casualty data.

Mars Unmasked: The Changing Face of Urban Operations

The third study we examined was Sean J. A. Edwards, *Mars Unmasked: The Changing Face of Urban Operations* (RAND, MR-1173-A, 2000). (Except where otherwise noted, all quotations are from pages 95—98.)

- **Not Examined**

The manipulation of information is becoming more central to urban operations because of recent technological, political, and social developments.

Because of developments such as these, the support of civilian populations involved in the conflict is even more critical.

Increasingly, the enemy's will to fight can be influenced by civilian affairs, public affairs, PSYOP, management of the media, balanced ROE, and information operations in general.

The presence of noncombatants significantly affected tactics, planning, ROE, and political-military strategy. Noncombatants were present in greater numbers, they played an active role in the fighting, they made ROE more restrictive, and the attracted the media.

Balancing ROE proved to be difficult, especially in the high-intensity case. Constructing and managing flexible ROEs so that they were neither restrictive nor permissive was critical... ROE also affected tactics and prevented the use of armor, artillery, and airpower on occasion.

All belligerents found the media a useful information tool for PSYOP, IO in general, civil affairs, and public affairs.

PSYOP and civil affairs operations proved indispensable in influencing the will of the civilian populations involved.

The failure of political leadership to communicate the national interested at stake in Somalia and Chechnya lowered the public's threshold for casualties.

At the same time, the more "traditional" elements of MOUT – airpower, combined arms, situational awareness, and technology--remained crucial to the outcome of urban battle.

In most cases, defeating the will of the enemy is still best accomplished by killing the enemy. In the last decade, tanks, artillery, and infantry performed this basic roles quite well (albeit under more restrictive political constraints), as they have done since World War II. Traditional factors did not, however, change in any fundamental way in the three urban operations looked at here.

Significant technological improvements in urban operations may be possible in the future. If improvements can be made in the areas of precision fire and C3I, then the use of military

force in urban operations can evolve into a much more flexible operation (even in the face of severe political constraints).
Yet new weapons, equipment, and tactical adjustments are only part of the solution. What is needed, as this case analysis had hopefully shown, is a more comprehensive approach that recognizes the increasing significance of information elements--the media, ROE, noncombatants, PSYOP, PA, and CA.

In future conflicts, it should be anticipated that some U.S. Adversaries will recognize the growing importance of these information elements and leverage them as part of an asymmetric response to American firepower.

Some selected statements extracted not from the conclusions, but rather from the body of the report (pages xi—3) are also interesting:

- **Not Examined**

Cities offer physical cover--three dimensional urban terrain--and political cover--the more stringent rules of engagement (ROE) associated with the presence of noncombatants. Both type of cover limit the effectiveness of U.S. heavy weapons such as tanks, artillery, and airpower. Weaker opponents can use cities to avoid heavy weapons, leverage the non-combatant population, and "even" the odds by fighting infantry-versus-infantry battles only.

Lessons that predate the early 1980s may be irrelevant or less important today, especially because of the larger number of political considerations that have restricted the use of force in more recent urban operations.

Several important elements of urban operations that previous studies have identified--such as situational awareness, intelligence, airpower, surprise, technology, combined arms, and joint operations--are no more decisive today than they were in the past.

In the last decade, technological, social, and political changes have caused the following MOUT elements to become relatively more significant: the presence of the media, the presence of noncombatants, ROE, and information operations tools such as psychological operations (PSYOP), public affairs (PA), civil affairs (CA), and political-military strategy.

Information technology, recent historical precedents, asymmetric responses, and shifting political justifications of the use of force have combined to exacerbate a long-standing geostrategic problem for conventional powers: how to wage restricted urban warfare while keeping casualties below some threshold of public tolerance.

Recent trends indicate that urban operations should focus more on information-relate factors that manipulate the will of the opposing population.

…recent urban operations also showed that many elements of MOUT have not changed in any fundamental way.

Complete situation awareness will remain an elusive goal for some time to come, just as it was in the past.

Airpower proved to be a mixed blessing in recent urban operations because of the presence of noncombatants, ROE, and capable air defense threats. Urban terrain, poor weather, and an inability to precisely engage dispersed infantry with air-to-ground munitions also contributed to the mixed performance of airpower. Airpower was effective in joint operations around the perimeter of small villages and towns that could be isolated, against specific strongpoints that could be pinpointed, and in open area in clear weather.

Urban warfare technologies employed in the 1990s did not differ significantly from technologies available before 1982. Weapons remained essentially the same...

The advantage of surprise was critical to the outcome of all three cases studies, but it was neither more nor less decisive than in the past.

Combined arms teams were essential if friendly casualties needed to be minimized, but they also resulted in more collateral damage and noncombatant casualties.

Command, control, and communication problems continued to plague joint operations.

The likelihood that U.S. military forces will fight in cities in increasing. There are many reasons for this trend: continued urbanization and population growth; a new, post-Cold War U.S. focus on support and stability operations; and a number of new political and technological incentives for U.S. adversaries to resort to urban warfare.

Fighting in cities offers an adversary a way to inflict higher casualties. The presence of non-combatants in urban areas usually requires more stringent rules of engagement (ROE), which prohibit or limit the effectiveness of heavy weapons such as tanks, artillery, and airpower. Adversaries can use cities to avoid these heavy weapons and 'even' the odds of facing U.S. military might by fighting infantry-versus-infantry battles.

Because urban warfare is primarily an infantry fight, it is a form of warfare that lends itself least to the application of advanced technology.

Heavy Matter: Urban Operation's Density of Challenges

The final study is by Russell W. Glenn, *Heavy Matter: Urban Operation's Density of Challenges* (RAND, MR-1239, 2000).

The underlying assumption of this study, which is clearly stated (pages 2—5), is that battlefield densities in urban combat are significantly different from those found in non-urban combat. All of Glenn's analysis flows from that point, and if this assumption does not stand up to scrutiny, then the rest of the study and the conclusions drawn from it, also do not stand up.

The basis for this comparison of urban to non-urban terrain is presented in a chart on page 3. In that chart, Mr. Glenn examines urban densities in five periods, labeled

"Antiquity," "Napoleonic Wars," "U.S. Civil War," "World War II," and "October War." For each, he has from two to five examples of urban combat. From those examples, he calculates urban densities in men-per-square-kilometer and square-meters-per-man. For the non-urban combat data he uses for comparison, he uses figures he drew from Trevor N. Dupuy's *Numbers, Predictions and War*.

TDI has many problems with this approach.

- **The use of Trevor Dupuy's dispersion figures for the non-urban examples is a misapplication of Colonel Dupuy's stylized data.**

The data used for the non-urban figures was drawn from Trevor N. Dupuy's *Numbers, Predictions and War*, page 28. The figures presented in that book are fundamentally a theoretical construct to show why weapons lethality has decreased over time even though weapon capability has greatly increased. The reason that 10 square meters per man was used for the ancient figures was because it roughly fit the data and was based upon a "theoretical ancient army." While Dupuy's firepower scores are modified by this "dispersion factor" this has actually no impact on the model use and outcome, it is only a theoretical construct.[1] Since our data in this report utilizes linear kilometers, then multiplying Trevor Dupuy's figures by the depth figures in his book (ranging from 0.15 kilometers for "Ancient Armies" to 67 kilometers for "1973"), provides the following density measurements based upon linear kilometers:

	Men per Square Kilometer	**Men per Linear Kilometer**
Ancient Armies	100,000	14,993
Napoleonic Wars	4,970	12,500
American Civil War	3,883	12,005
WWI	404	4,801
WWII	32	2,000
1973	25	1,667

The figures for linear density for the 91 non-urban examples used in this study range from 265 to 12,800 men-per-linear-kilometer. The average linear density for Normandy data was 2072.20 and for the Ardennes data it was 2,068.95. While our figures compare favorably with Trevor Dupuy's figures, this still does not change the criticism that Glenn's study compared a stylized theoretical construct with actual measured data.

- **The urban and non-urban data clearly come from two entirely different sources that are not directly comparable.**

This second point is related to the first, since Glenn has derived one set of numbers from one source (Dupuy) and has mixed it with data drawn from a second source (of unknown provenance, methodology and veracity). Unless rigorous care is used in mixing

[1] See the article by Christopher A. Lawrence, "Dispersion is Not Played in the TNDM," *International TNDM Newsletter*, Volume I, Number 3, December 1996, page 10, for further explanation.

two different research, measurement and analysis methodologies, then one is bound to induce error in such a study.

- **The number of examples used is extremely small.**

Mr. Glenn utilized a very small number of examples for his measurement. In the case of the World War II data, he used five cases. This makes the data more sensitive to one or two data points skewing the results, either by being an exception, by being a research or measurement error, or by being an error in the secondary sources that were used (it is apparent that Mr. Glenn did not make extensive use of primary sources).

- **A number of cases used did not involve urban combat.**

The four urban examples cited from "Antiquity" are all sieges rather than cases of urban combat. One of the two examples from the "Napoleonic Wars" was not urban combat, although elements of Lannes Corps did defend the granary in the tiny village of Essling. The three "U.S. Civil War" (from 1861-65) urban examples are not from that conflict at all. Two of them are from the Mexican-American War (1846-48) and the third example is from the Zulu War in Africa during 1879. This third example, Rorke's Drift, where 139 defenders held a field fortification incorporating two small buildings, is probably not a good example of "urban warfare."[2] In all fairness though, *The Dupuy Institute* has no problems with the ten examples selected for "World War II" and for the "October War." These do appear to be the real basis of his analysis.

- **There is considerable confusion over scale of combat applied.**

This fifth point is very significant. If one is to compare figures from urban to non-urban combat, than one needs to compare cases that occur between units of roughly the same size. To compare Trevor Dupuy's data for Civil War battles involving thousands of men on each side, to 139 men defending Rorke's Drift is a misapplication of scale. There is some concern, considering the aggregate level of data used for the "World War II" and "October War" examples, that Glenn is comparing a mixture of battalion, brigade, corps and army-level actions with Trevor Dupuy's data, which is all fundamentally derived from division-level engagements.

- **It is unclear how one precisely and accurately measures square kilometers as they relate to the area occupied by units in combat.**

Units in combat usually establish clear left and right flank boundaries and fill the area between the two with units and/or fields of fire. However, the rear boundary of a unit is usually not as well defined, especially in pre-modern wars. Even if a rear boundary is set, it is usually a line drawn on a map and is not based upon the immediate combat situation. Furthermore, even modern units have a strong predisposition to forward deployment, so that even with a theoretical depth of 67 kilometers, most of the personnel and weapon systems are within a few kilometers of the front line. Since most of the examples used have no clear rear boundary, the analyst needs to either assign one (making the measurement extremely imprecise), or use Trevor N. Dupuy's stylized depth figures (turning a precise measurement

[2] If this evident criterion were held to, then virtually every single battle in modern and pre-modern military history could be cited as a case of "urban warfare" since almost every single one included significant combat centered upon a manmade structure.

into an abstract one). TDI has relied upon linear troop density, and believes that this is the only practical form of measurement that can be used. This leaves open the question of how Mr. Glenn managed to determine what the depth was in his urban examples.

- **It appears that there is some gross error in the measurement of density.**

The final, and most important issue, is that TDI remains confused as to what the basis for Glenn's density figures were. Mr. Glenn uses men-per-square-kilometer to provide figures comparable to those of Trevor N. Dupuy. If his figures were based upon the same depths as those of Dupuy, then the linear troop densities would be:

	Men per Square Kilometer	**Men per Linear Kilometer**
Antinquity	16,300	2,445
Napoloeonic Wars	46,400	116,000
U.S. Civil War	11,600	34,800
World War II	1,300	78,000
October War	1,100	73,700

This World War II figure of 78,000 men-per-kilometer is not comparable with our average figure of 4,614 men-per-kilometer in the Channel Ports engagements or the 2,089 men-per-kilometer figure for the Aachen engagements (which one of Glenn's five examples). Accepting the 78,000 men-per-kilometer figure would imply that each linear kilometer of urban terrain was occupied by a corps-sized organization or larger. This is an absurdity quickly disproved by a glance at a map of the urban operations in question.

This leads one to conclude that Glenn's men-per-square-kilometer figure is not based upon the depth calculations of Trevor N. Dupuy. This exacerbates the problem outlined in our second point, which is that Glenn clearly mixed two different and incompatible methodologies that do not parallel each other in methods of measurement. Since Glenn's figures produce absurdly high linear densities, then he either used depth figures far greater then those of Trevor Dupuy (and it is difficult to justify why he would), or he measured something very different from what Trevor Dupuy did.

Glenn may have measured the actual forces committed into a city. He may have been measuring battalion or company-sized units (clearly the case of Rorke's Drift), and compared them to Trevor Dupuy's measurement. If so, he exacerbated the problem outlined in our second point again, and compounded his error by the problem identified in our fifth point, which is that he used mismatched scales of combat. This is then further exacerbated by not knowing how he determined the rear boundary for these company and platoon-sized actions, since there was no comparable data to be drawn from Dupuy for this. Therefore, he exacerbated the problem addressed in our sixth point, which is that measuring densities in square kilometers is extremely nebulous and imprecise exercise.

At this point, it is clear that the figures Mr. Glenn used for measuring the urban examples are not comparable to the figures he used for his non-urban examples. In fact, his troop density figures for the urban examples appear absurdly high for division-level combat. It is obvious that some other, much smaller scale of combat, with an undefined depth, was used by him for his urban examples. **Therefore, his comparison of urban troop densities**

to Trevor N. Dupuy's non-urban troop densities is without validity. And, since this supposed great increase of troop density in urban combat underlies much of his subsequent analysis, then much that follows in his paper is also of questionable validity. They are conclusions drawn from an invalid comparison.

Thus, it is not surprising that many of the conclusions in this TDI study disagree with Mr. Glenn's conclusions. We believe that the difference is fundamentally caused by our more rigorous use of real-world data for *The Dupuy Institute* analysis (all quotations are taken from pages 2—37).

- **Strongly Contradicted**

*Table 1: Battlefield Density Through the Ages: Men per **square** kilometer, World War II, urban terrain is given as 1,300.*

The density of fighters among buildings remained strikingly higher than the norm.

- **Contradicted**

Thus, while tactics promote dispersion on the battlefield, urban architecture allows stacking of capabilities such that it is far more appropriate to consider densities in terms of three dimensions (e.g. cubic kilometers) rather than two.

The multiplicity of threats demand larger numbers of infantrymen to maintain satisfactory force protection levels.

A single urban area can become a "resource magnet: that demands seemingly more than its fair share of manpower and other assets.

In addition, the requisite force concentrations and the higher tempo of operations mean that foodstuffs, water, and ammunition are consumed more rapidly that they would be elsewhere.

The most difficult battlefield transition for a force may well be the one it must undergo as it moves from open ground (whether inside or outside a built-up area) to the dense environs of a city.

As the assault moves forward, the inevitable requirements to clear buildings of enemy combatants, secure them against further enemy infiltration, and evacuate the ubiquitous noncombatants, bring about the severe physical and mental exhaustion that characterized urban combat. These and other factors, quickly drain a force of numbers even in the absence of combat losses.

The three dimensional quality of urban terrain, each level dense with challenges, requires repetition of offensive or defensive tasks on layer after layer, above, at, and below ground level.

A single building can consume battalions.

Lacking very large numbers of soldiers or marines, a leader could quickly find himself unable to meet his combat power requirements.

Reinforcement helps, but it can only delay the inevitable; the constant high density of challenges consumes a force operating in a city.

- **Not Examined**

The number of structures, firing positions, avenues of approach, enemy, noncombatants, friendly force units, key terrain, and obstacles per cubic kilometer, or the number of small-unit engagements, troops movements, and interactions with noncombatants per minute within that space are far greater in cities than in any other environment.

Noise and physical exhaustion increased soldier stress, increasing the attrition of friendly force strength.

Cities grow exponentially, now only outward but also skyward, downward, and inward in the sense that today far more people can be accommodated in a given volume than was previously reusable.

The high density of urban space leads directly to a similarly magnified density of time.

More decisions per unit of time are demanded of military leaders.

A segment of open ground can at most offer firing positions to a handful of enemy; if that ground houses subterranean structures or skyscrapers, it may harbor thousands.

Ground that might support a single avenue of approach in grasslands might have several in a city--some underground, others on the surface, yet others through the upper floors of building interiors--all potential routes for movement or maneuver.

At the same time, the density of obstacles means that traditional tactical operations may be impossible: the high density of buildings, vehicles, and the like has reduced the space available for maneuver.

Density has overloaded his ability to monitor the situation, complicated his target identification, and reduced his engagement to an almost instantaneous act.

Indirect fire, aviation, and air support must meet similar demands for speed and hyper-accuracy.

Such problems are compounded by highly restrictive rules of engagement (ROE) precipitated by high densities on noncombatants, civil infrastructure, and cultural landmarks.

Separately, densities present problems enough; their cumulative negative effects can create a scenario of sensory and capability overload.

This density of potential threats also accelerates both mental and physical exhaustion, which is further fed by the excessive sound levels reflecting off the numerous hard surfaces.

Further, the proliferation of below-ground and elevated firing positions present problems for armored vehicles…
Subterranean passageways, for instance, may threaten a passive force with underground envelopment.

Steps taken to counter the higher densities found in the city may therefore degrade operational flexibility outside the metropolis.

That virtually no doctrine or compilation of historical usage rates [foodstuffs, water, and ammunition] exist for urban contingencies magnifies the need for further study, simulation, and extrapolation from quality exercises.

The densities of targets in built-up areas combine with concentrations of friendly forces and civilians to put a premium on the accuracy and controllable effects of munitions.

While not a zero-sum situation, strict ground force ROE have historically precipitated higher friendly force casualties.

The density of urban targets means that stockpiles of precision weapons will likely be exhausted well before all are addressed.

Further, precision weapons are expensive; barring a dramatic reduction in their price, it will simply be too costly to engage each target with these systems.

A city with shortages of food, water, medicines, or other essentials, still populated by residents and perhaps refugees from the surrounding countryside, poses a logistical problem that might well overwhelm even the most effective military support system.

Control of refugees attempting to leave built-up areas will quickly overtask military police forces that must also perform their doctrinal traffic control, prisoner of war, and other responsibilities.

Medical personnel, always tasked to provide care to friendly force and coalition member combatant casualties, may find large numbers of civilians in need of assistance.

Again drawing on the example of Hue, such movements of groups [of refugees] will inevitably include hostile force members attempting to infiltrate friendly lines or cause disruption to rear area operations.

The high density of noncombatants in cities could result in a force confronted by an enemy to the front and instability in its rear.

The bunching of buildings provides fuel for fires, which can spread to consume major portions of a city and endanger both friend and noncombatant.

Manpower requirements and unit frontages can change dramatically within a very short distance. An organization able to defend hundreds or even thousands of meters of frontage in a large park may be able to defend a sector consisting of only a single building after an advance or withdrawal of a few hundred meters, making force allocation estimates difficult.

Further, the tempo of operations, the ability to communicate, and the suitability of particular weapons systems can all change suddenly.

It is true that the density of streets and other means of transporting people and material is far higher in cities than elsewhere.

The greater density offers little solace for military transporters, however; cites are infamous for traffic that makes it difficult for their populations to move about effectively. Add a military force's oversized vehicles driven by individuals unfamiliar with the area, and the congestion could precipitate a standstill.

If residents are fleeing an enemy, the same gridlock that plagues daily life within an urban area can clog roadways existing a city, the very roadways that may be essential to moving friendly force personnel and material forward.

Isolation of the battlefield is perhaps the most often violated tenet of urban combat. Denying an enemy reinforcements and resupply has often foretold the beginning of his end. Failure to do so can allow a combatant to continue resistance almost indefinitely.

Victory during urban contingencies has often followed a prolonged but eventually successful attempt to cut off a force in a built-up area.

Urban combat is justifiably seen as an equalizer. The superior combat power of U.S. armed forces is in many ways effectively neutralized on city streets, especially when restrictive ROE are in effect.

Superior discipline, training, combined arms and joint cooperation, and leadership will continued to be influential, if not decisive.

Some technological advantages are effectively neutralized; other are not or may suffer only conditional shortfalls.

Though buildings and other obstacles will shield targets on occasion, much urban sprawl consists of structures that are well dispersed and suffer limited if any shielding by adjacent obstacles. Indirect, aviation, or fixed-wing air fire support is in many cases feasible (though the accuracy of such support and the vulnerability of aircraft will be influenced by the sophistication of the adversary's air defense capabilities).

Urban densities may complicate the employment of such support, but proper planning, map analysis, visual reconnaissance, and training can ensure that friendly force fire support superiority is not unnecessarily diminished.
Future weapons, intelligence acquisition, and targeting systems enhancements will help a force maintain an asymmetric advantage… Several such systems should be available within the next decade.

The density of friendly force and noncombatant casualties during urban actions could easily overwhelm military medical resources.

The same factors that disrupt friendly force undertakings can overwhelm the enemy.

The density of activity in a city is a natural cloak for surreptitious actions. Changes in routine are less likely to be noticed, as urban routine is itself often in constant flux.

Density can provide the innovative commander with flexibility…

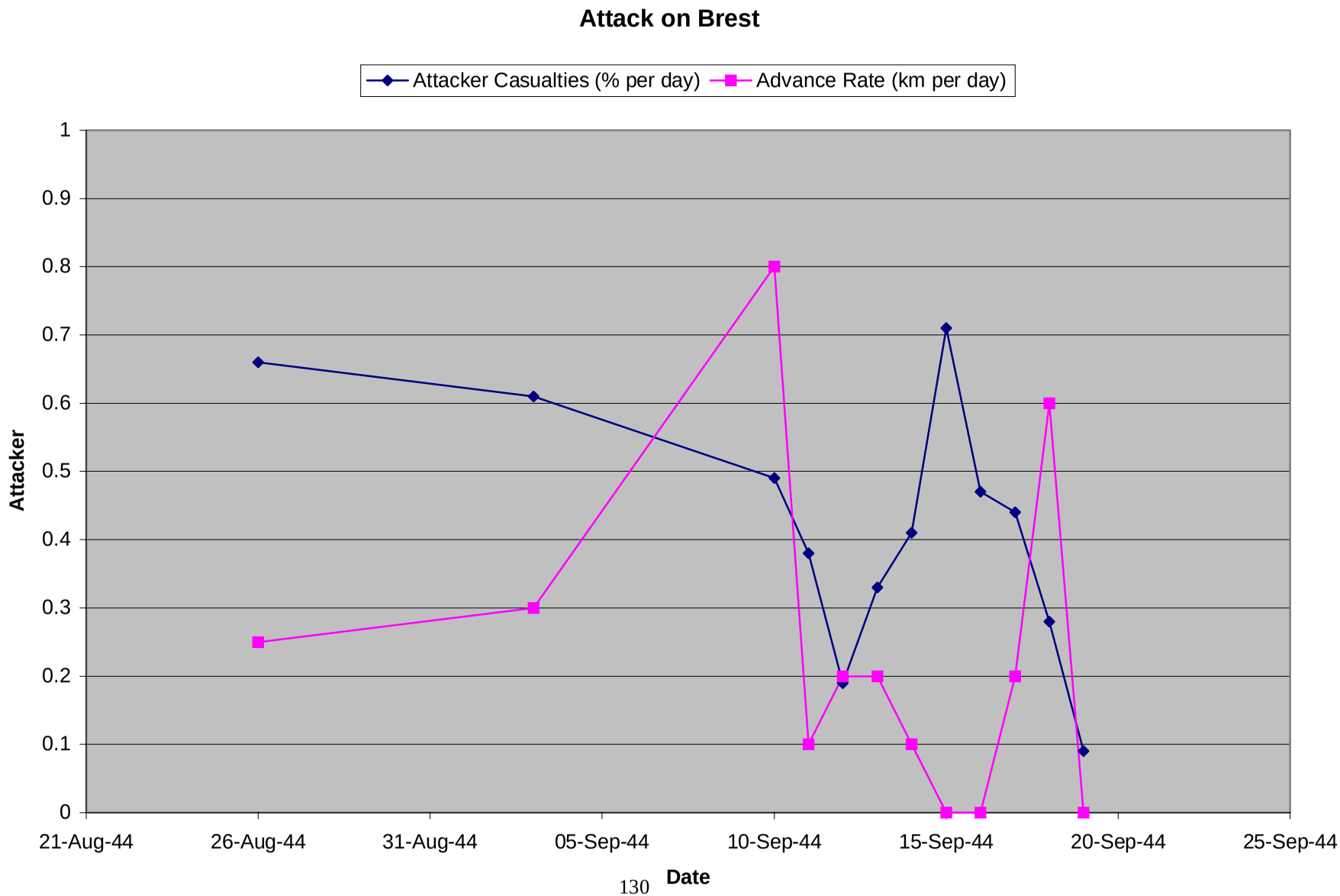
Keys to gaining the upper and on the urban battlefield included decentralized decision-making, good leadership, regular rehearsals, well-conceived drills, and quality training.

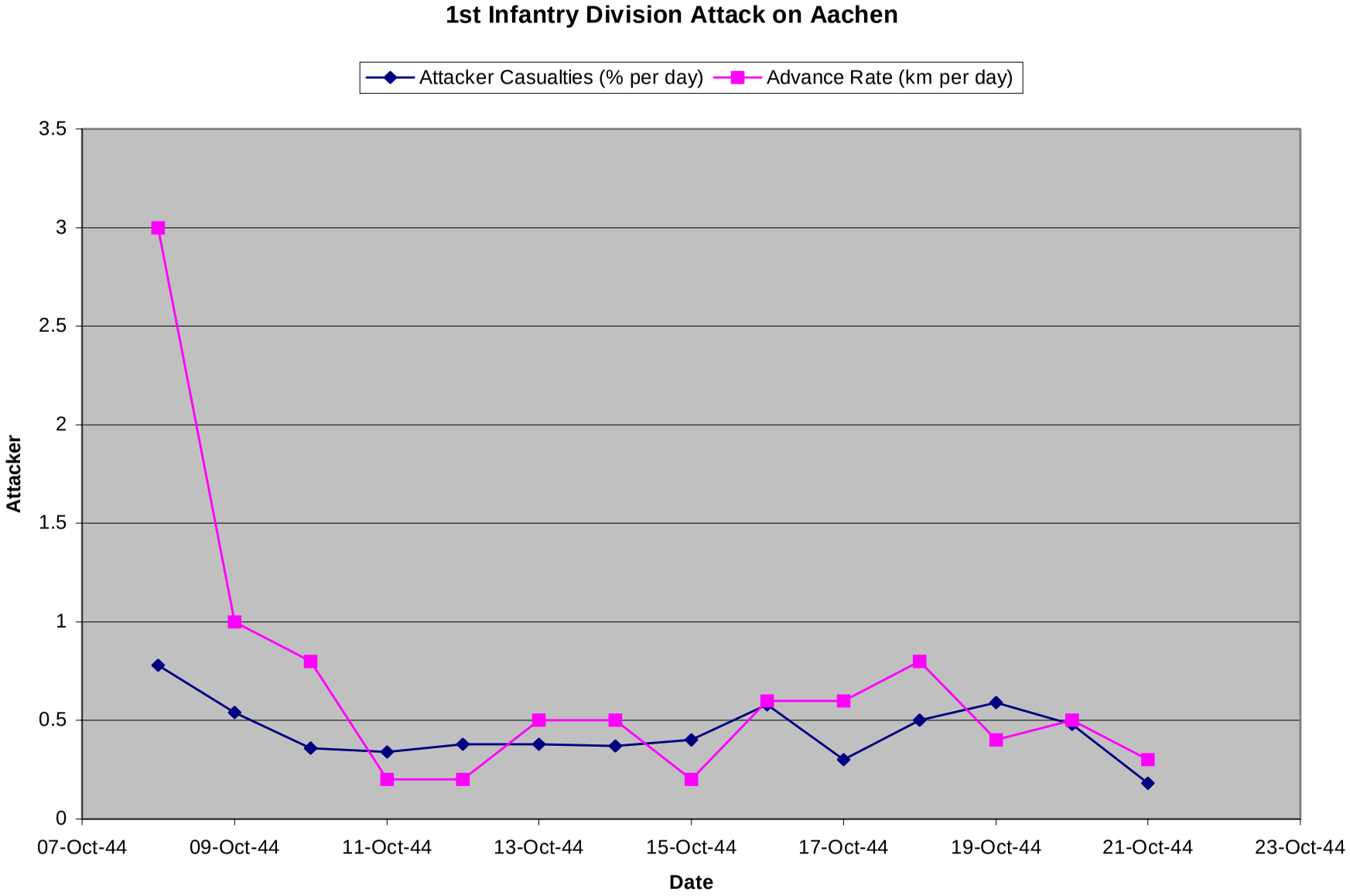
The past is an able guide for the professional who desires to prepare himself for future conflicts.

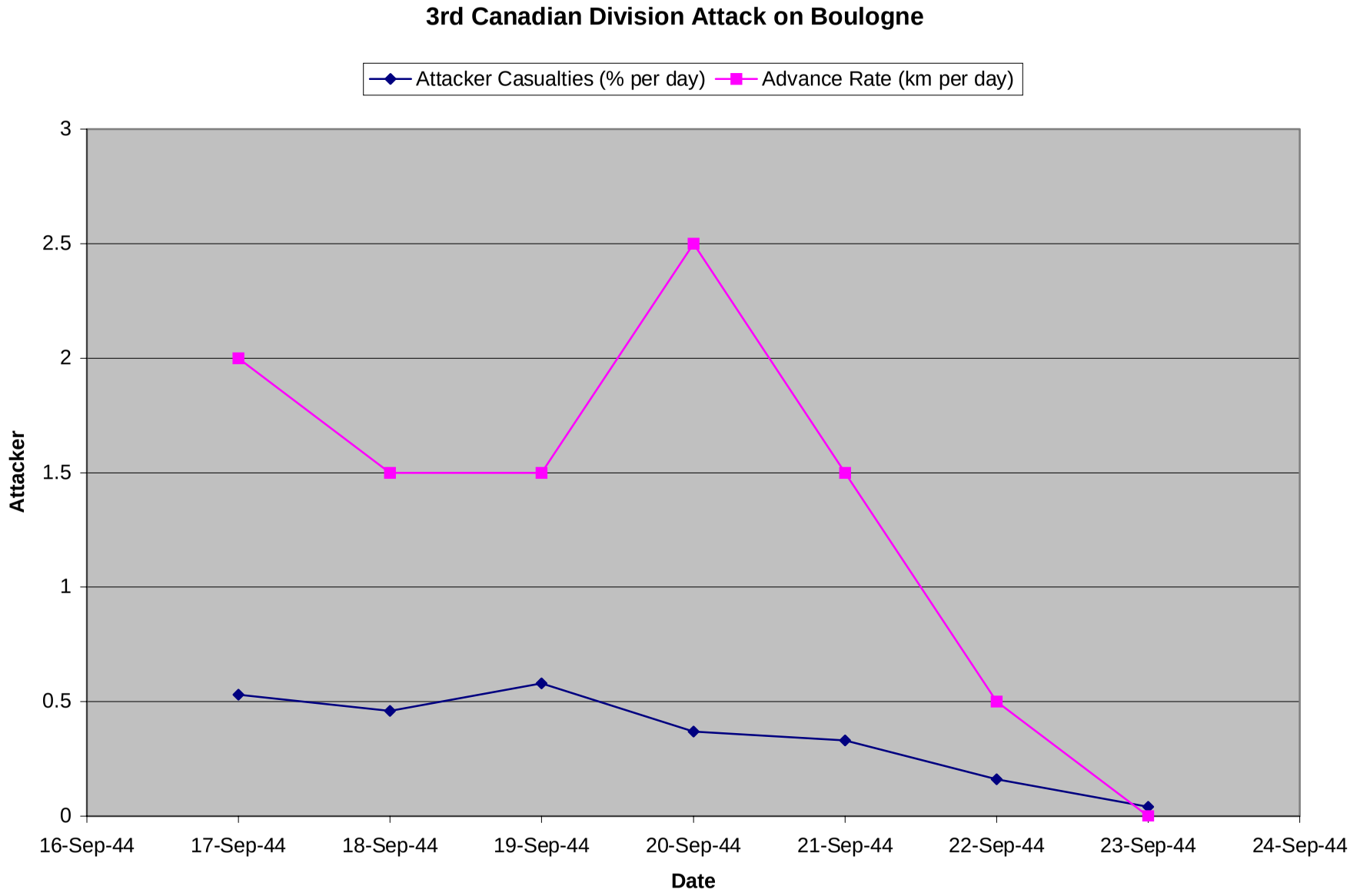
Key cities are much larger and denser than the ones confronted during World War II and Korea.

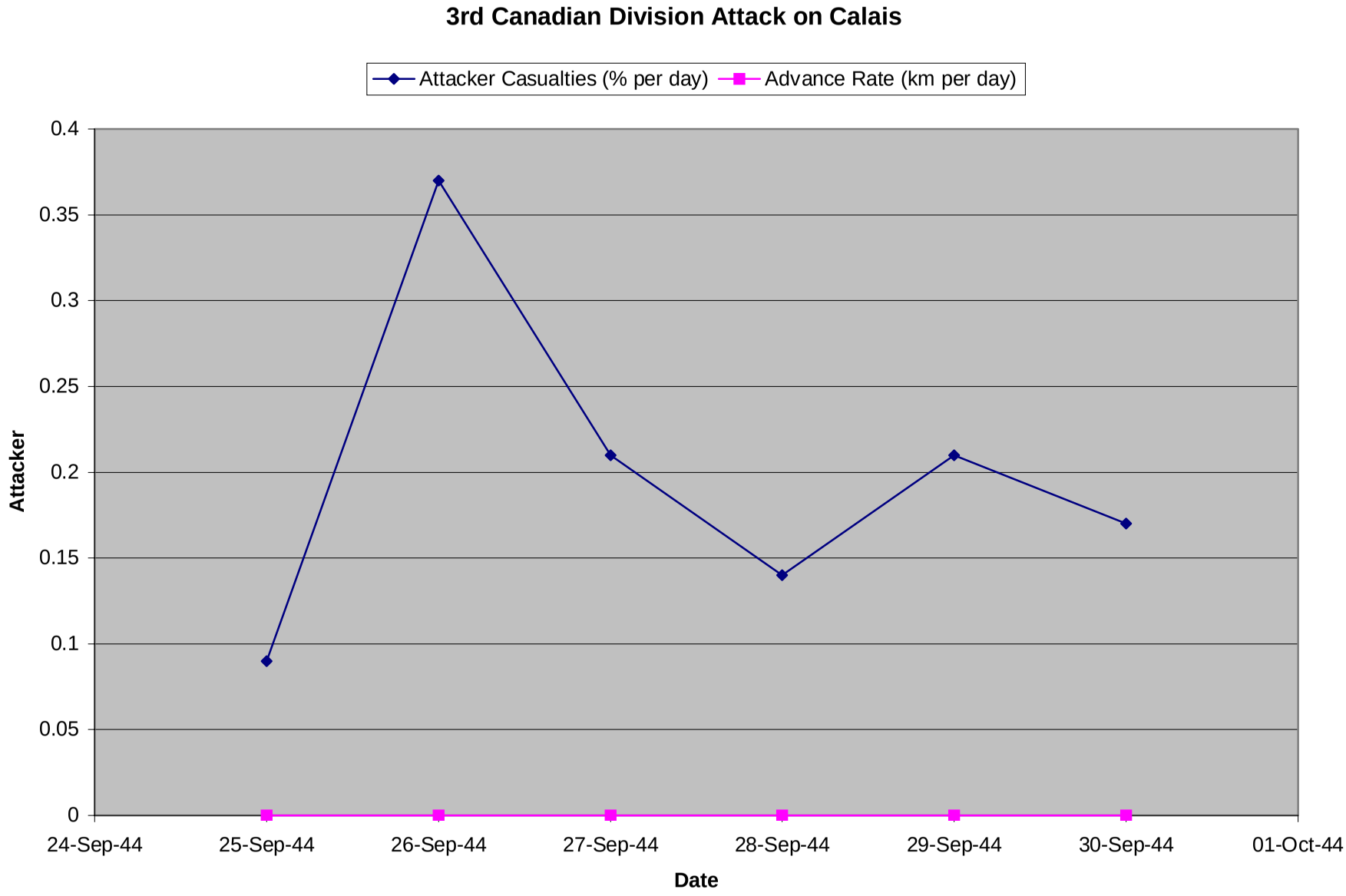
Concerns about friendly force casualties, noncombatant losses, and infrastructure damage have greater influence than they have in the past.

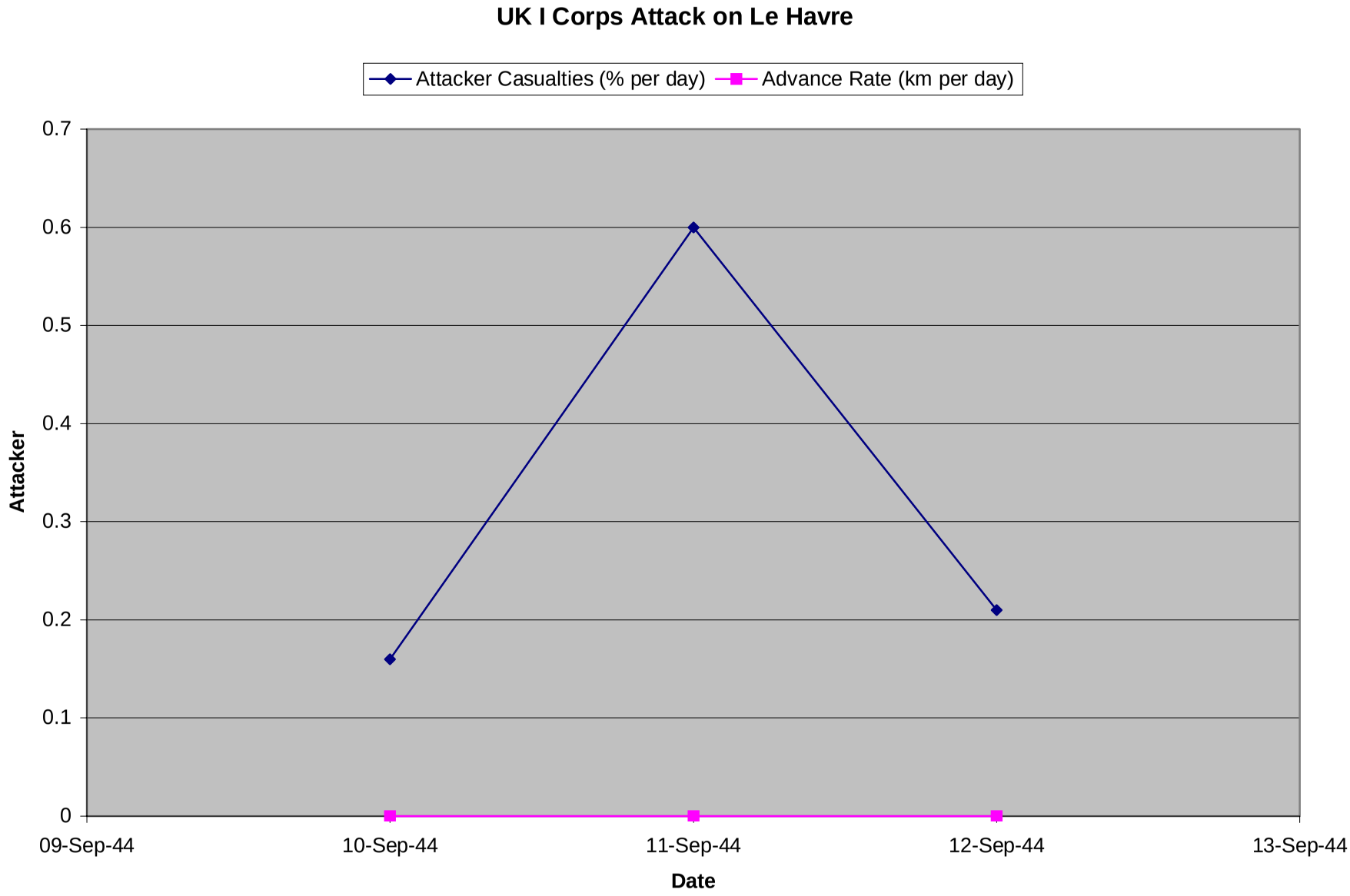
APPENDIX VIII. Case Studies, Casualties and Advance Rates by Day

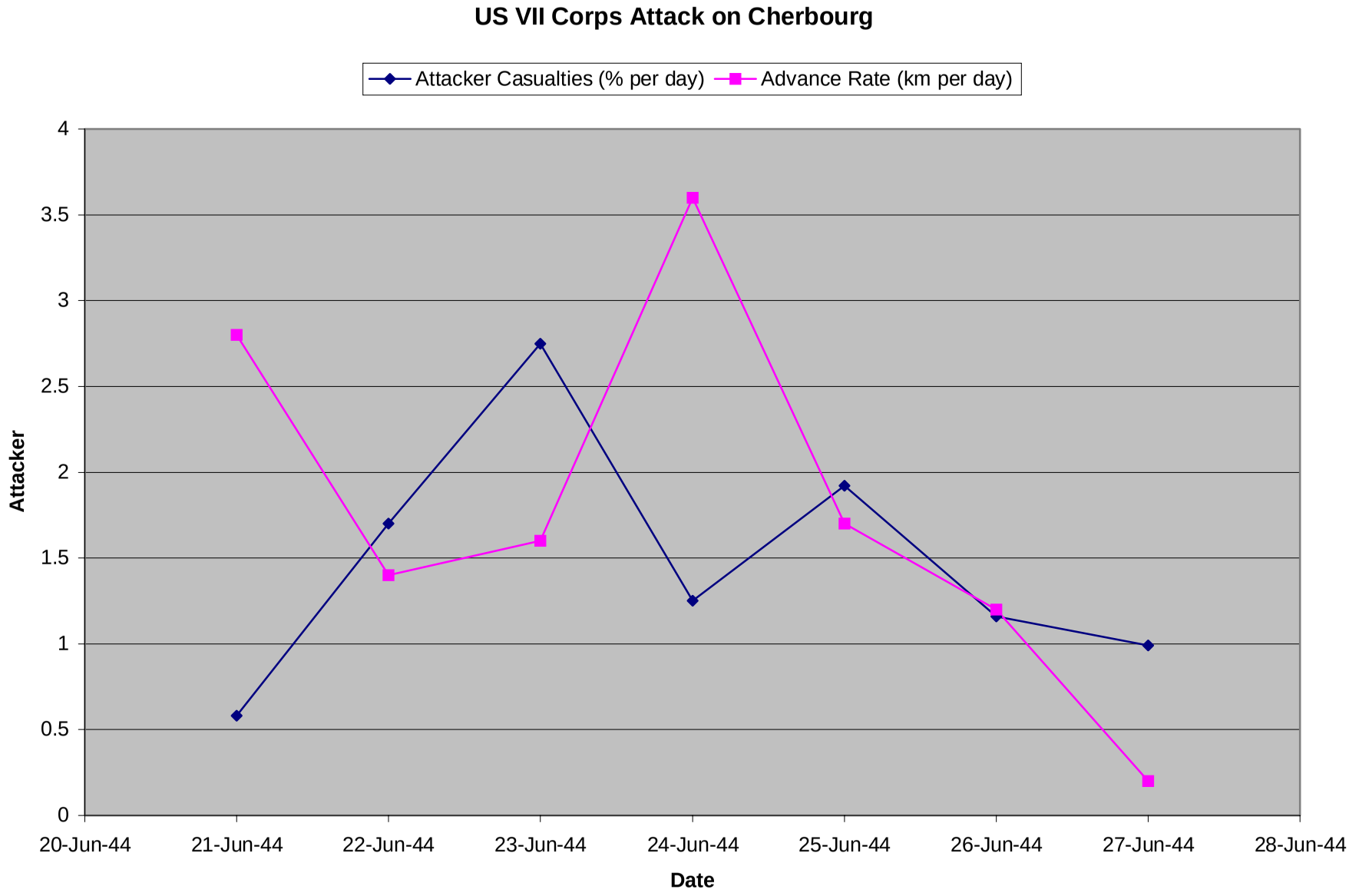


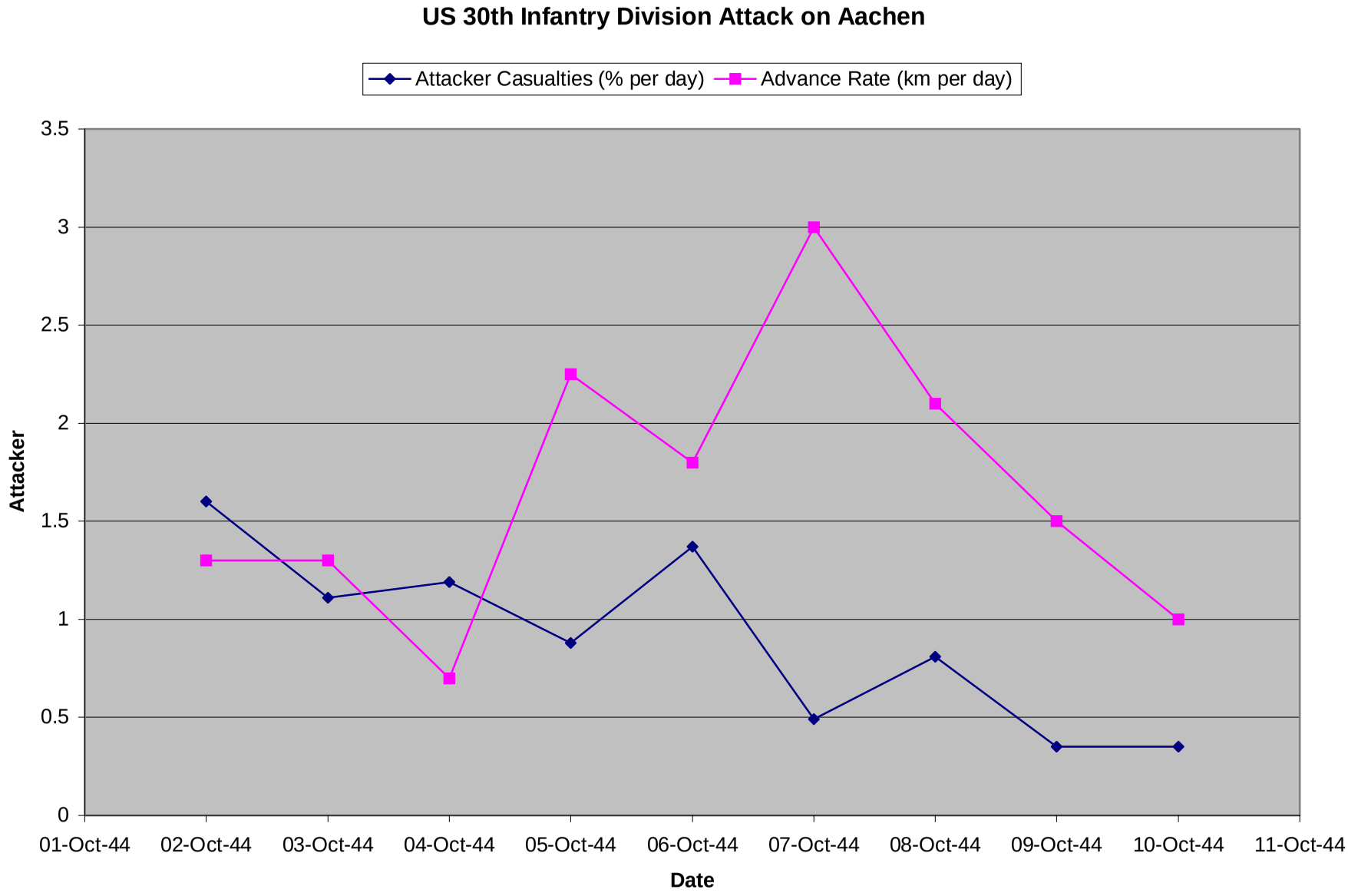

1st Infantry Division Attack on Aachen
Attacker Casualties (% per day)
Advance Rate (km per day)
3.5
3
2.5
2
1.5
1
0.5
0
Attacker
07-Oct-44
09-Oct-44
11-Oct-44
13-Oct-44
15-Oct-44
17-Oct-44
19-Oct-44
21-Oct-44
23-Oct-44
Date


3rd Canadian Division Attack on Boulogne
Attacker Casualties (% per day)
Advance Rate (km per day)
Attacker
3
2.5
2
1.5
1
0.5
0
16-Sep-44
17-Sep-44
18-Sep-44
19-Sep-44
20-Sep-44
21-Sep-44
22-Sep-44
23-Sep-44
24-Sep-44
Date


3rd Canadian Division Attack on Calais
Attacker Casualties (% per day)
Advance Rate (km per day)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Attacker
24-Sep-44
25-Sep-44
26-Sep-44
27-Sep-44
28-Sep-44
29-Sep-44
30-Sep-44
01-Oct-44
Date


UK I Corps Attack on Le Havre
Attacker Casualties (% per day)
Advance Rate (km per day)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Attacker
09-Sep-44
10-Sep-44
11-Sep-44
12-Sep-44
13-Sep-44
Date


US VII Corps Attack on Cherbourg
Attacker Casualties (% per day)
Advance Rate (km per day)
Attacker
4
3.5
3
2.5
2
1.5
1
0.5
0
20-Jun-44
21-Jun-44
22-Jun-44
23-Jun-44
24-Jun-44
25-Jun-44
26-Jun-44
27-Jun-44
28-Jun-44
Date


US 30th Infantry Division Attack on Aachen
Attacker Casualties (% per day)
Advance Rate (km per day)
Attacker
3.5
3
2.5
2
1.5
1
0.5
0
01-Oct-44
02-Oct-44
03-Oct-44
04-Oct-44
05-Oct-44
06-Oct-44
07-Oct-44
08-Oct-44
09-Oct-44
10-Oct-44
11-Oct-44
Date