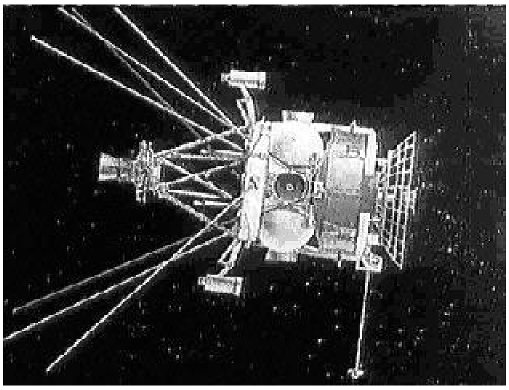
# Simulated war in space - Soviet ASAT tests

*Sven Grahn*

### Contents



## Abstract



The flight profiles of Soviet ASAT tests are examined closely revealing that targets sometimes used stabilized ground tracks to simplify test conditions. In order to achieve high closing rates the difference in orbital periods between target and interceptor needed to be high. Therefore low orbit targets were attacked from "in front and above", while high orbit targets were attacked from "behind and below". Target telemetry was discovered as an intruder in the 144-146 MHz radio amateur band! This transmitter on the target probably also broadcast signals supporting a miss distance indicator. The control law near the target was designed to reduce the rotation of the line-of-sight to the target to zero. Fast and slow approaches were tried. A multiple intercept attempts by the same interceptor

was performed.

(Photo credit for picture of interceptor: Videokosmos)

## Preface

Historical accounts and the record of flights show that the Soviet Union initiated a program to develop an anti-satellite capability very early in the space age. Initial propulsion system tests were performed in 1963 and 1964 under the *"Polyot"* cover name (strangely enough the *"Kosmos"* cover was not used). As described in (**5**) a period of rivalry between different design bureaux then followed. However, considerable priority must have been given to this project in view of the extremely high launch rate of U.S. reconnaissance satellites in the 1960's. This strong U.S. emphasis on space reconnaissance was probably interpreted by the Soviet leadership as signs of U.S. war preparations. To achieve an anti-satellite (ASAT) capability must have been seen to be more important than competing with the U.S. to land a man on the Moon. Thus, at the end of the 1960's an aggressive series of of ASAT flight tests started.

The analysis of Soviet ASAT tests presented here is not intended to replace other excellent works on this subject, such as (**5**) and (**6**), but rather to complement these works and add some new dimensions to the analysis. Orbital data for the relative motion plots below have been obtained from NASA's Orbital Information Group and, when such data were missing, from my own archives and those of Mr Geoff Perry. The software used to generate the plots is an as yet unpublished version of my mission analysis software SMX (Space Mission eXpert).

## Polyot - propulsion flight tests?

Development of the Soviet ASAT system, IS (Istrebitel Sputnikov, "fighting satellite") began in 1961 in the design bureau of Vladimir Chelomei. It was originally intended to be launched with Chelomei's UR-200 rocket, but since its development lagged, the first tests of the IS were made with a launch vehicle based on Korolev's R-7 rocket. (It was called 11A59 and has been described as a two stage version of Vostok 11A57 and was capable of putting about 1400 kg into a 300 km orbit. Eventually the UR-200 rocket was cancelled and the Tsiklon rocket developed in the Ukraine became available. The first tests of the IS were called Polyot.

Polyot 1 was launched from Baikonur at about 0850 UT on 1 November 1963. It transmitted FSK-PDM telemetry signals on 19.945 MHz that were picked up by observers in the West. The Sohio Research Lab in Cleveland tracked Polyot 1 on revolution 3,4,5,11,12, and 13 (**11**). The transmitter seemed to have ceased operating on 3 November. In a telegram dated 2 November 1963 TASS gave the initial orbit to be 339-592 km, but no inclination was announced. The final orbit was given by TASS as 343-1437km, i = 58 92 degrees from which the spacecraft decayed in 1982.

Polyot 2 was launched from Baikonur at about 0920 UT on 12 April 1964. The orbit was announced by TASS on 13 April as 310-500km at 58.06 deg, which is the final orbit. The corresponding Western figures are 303-479 km. The initial orbit was measured by Western sensors to be 242-485 km at i = 59.92 degrees. Thus, perigee was raised and the inclination was changed by 1.86 degrees. Such a plane change required a delta-v of 250 m/s, which required about 125 kg of propellant (if the spacecraft weighed 1400 kg at ignition). It transmitted FSK-PDM telemetry on 19.895 MHz. The Sohio Research Lab in Cleveland again picked up signals and reported that they went silent on 15 April 1964 (**12**). The spacecraft decayed in 1966.

At the time these two launches were certainly not associated with the ASAT program. they were seen as manoeuvring tests in preparation for manned rendez-vous and docking operations. TASS called both satellites "manoeuvring spacecraft" in news releases. The three-year interval until testing resumed also confused observers.

## Kosmos 185 - the test series kicks off?

Somewhat lost in the excitement surrounding the Kosmos 186/188 docking between two Soyuz ships, the ASAT test series kicked off with the launch of Kosmos 185 on 27 October 1967 (**5**). Of course, no announcement was made as to the character of this spacecraft. TASS gave the orbit to be 522-888 km at 64.1 deg inclination. Western sensors detected an orbit at 519-871 km. According to another source (**13**) the craft was briefly tracked at a much lower altitude, then reached the final orbit.

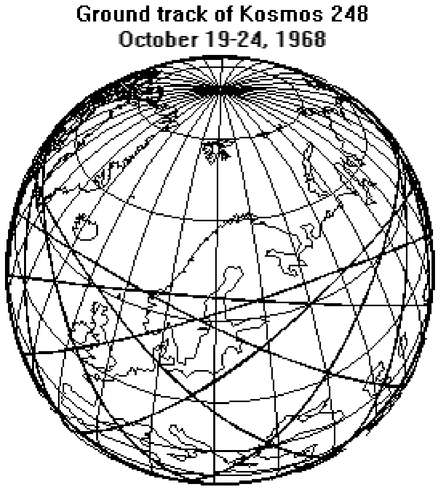
# Kosmos 217 - the first target

At about 1600 UT on 24 April 1968 Kosmos 217 was launched from Baikonur. TASS announced the orbit to be 396-520 km at 62.2 degrees inclination. Western sensors found the satellite in an orbit at 144-262 km, i = 62.24 degrees, and there was no separated rocket stage. So it seems that TASS announced the intended orbit, not the actual orbit. This is highly interesting, since I have always been very impressed by the accuracy of the orbits given by TASS. If the TASS orbits were based on pre-launch plans, they are even more impressive. So, Kosmos 217 did not enter its intended orbit and the subsequent launch of an interceptor was cancelled.

**Test Nr 1(1968): The first intercept - Kosmos 248 is the target**

## The Kosmos 249 intercept, 20 October 1968

This test took place in October 1968 and used Kosmos 248 as the target. The launch of Kosmos 248 around 0420 UT on 19 October 1968 was very similiar to that of Kosmos 217 in that no rocket stage was left in orbit and the orbital parameters (476-543 km, i = 62.25 deg) were extremely close to those announced for Kosmos 217 (but never achieved).

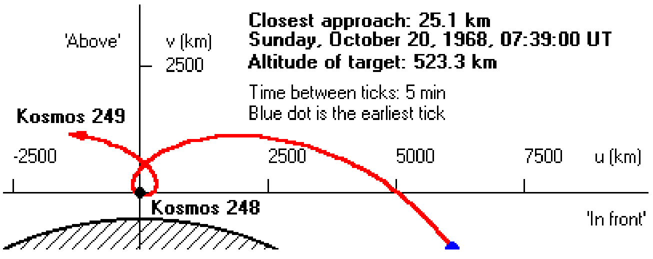



An interesting feature of the orbit of Kosmos 248 is that it had a **"stabilized ground track"**, i..e the ground track repeated itself on the globe every day (See figure on the right). A repeating pattern orbit is described by four parameters:

- N, the number of full revolutions per day, i.e. integer part of the mean motion,
- M: Suppose the reference ground track on the reference day is called $M_o$. Then suppose that the ground track after a number of days does not match that of rev $M_o$, but of $M_o$+M.
- Q: The number of integer days until the ground track is synchrozised.
- i, the inclination of the orbit.

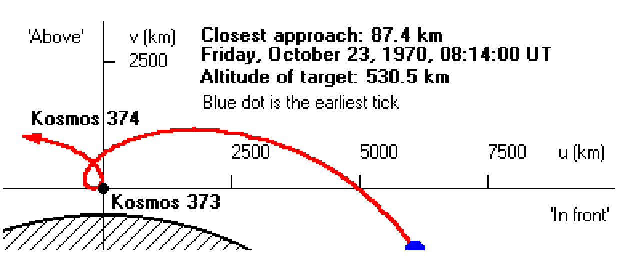
Kosmos 248 was in a N=14, M=1, Q=1, i=62.25 degree orbit (abbreviated 14,1,1,62.25$^o$). A simplified theory gives the mean altitude of this "ground-track stabilized" orbit as 508.35 km while the mean altitude of Komsos 248 was 509.25 km!

Kosmos 249 was launched around 0400 UT on 20 October 1968 and initially entered a transfer orbit with 104.7 km perigee and 138.2 km apogee. On the first revolution the orbit had changed to 502 km perigee and 1639 km apogee. On revolution 2 the intercept orbit had been established with perigee at 489 km and apogee at 2167 km. So, Kosmos 249 "attacked" Kosmos 248 from "in front" and "above". According to Russian sources the interceptor repeatedly approached the target. No orbital data to support this claim exists. Russian sources also say that it was blown up to test the destruct charge. Indeed, 109 fragments were detected in orbit by Western sensors (6). Kosmos-252 was launched on 1 November 1968 and approached Kosmos 248 in a manner highly reminiscent of that of Kosmos 249. After the intercept the main piece of Kosmos 252 was in an orbit between 531 km and 2149 km. There were 139 fragments left in orbit after the intercept.(5)




# Test Nr 2 (1970): Kosmos 373 is the target

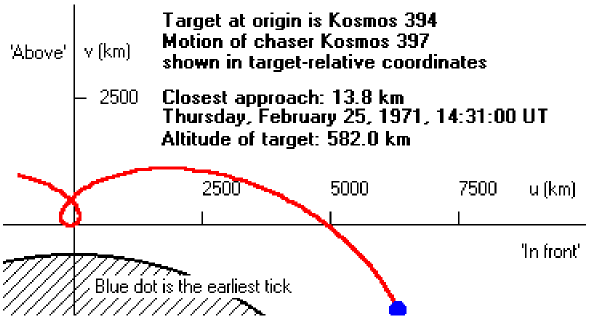
The second intercept test, using Kosmos 373 as a target, was a virtual repeat of the first test, except that the



inclination was raised slightly from 62.3 degrees to 62.9 degrees. The target, Kosmos 373, launched on 20 October 1970, was again put into an orbit with a stabilized ground track. This permitted the use of almost identical flight profiles for the two interceptors - clearly a simplifying condition, but not a very good simulation of real targets. The orbital parameters were initially 474-542 km with a nodal period of $T_n$=94.77 min. In preparation for the second interceptor its orbit was raised slightly to 460-563 km with a nodal period of $T_n$=94.83 min. The first interceptor Kosmos 374 was launched at around 0445 UT on 22 October 1970 and followed a flight profile very similar to those flown by Kosmos 249 and 252, i.e. it attacked the target "from in front" and "from above". An intermdiate orbit at 530-1053 km was detected by radars in the West. The figure below shows that the target was approached shortly after 0800 UT on 23 October, 1970 along an intercept orbit at 529-2132 km altitude.

Kosmos-375 was launched on 30 October 1970 to perform an intercept very similar to those flown by all previous interceptors. An intermediate orbit at 566-994 km, quite similar to the intermediate orbit of Kosmos 374, was detected by Western sensors. The intercept orbit of Kosmos 375 was 525-2098 km.

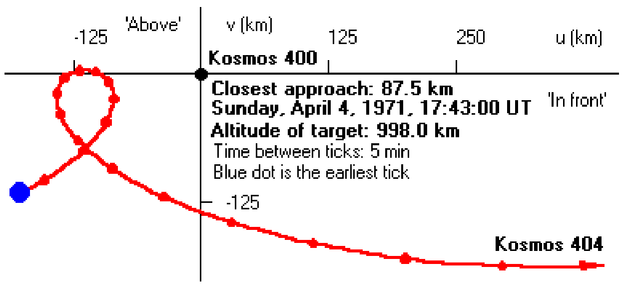
## Test Nr 3 (1971): Kosmos 394 - a new type of target is destroyed by first interceptor




Kosmos 394 was launched from Plesetsk on 9 February 1971 into 572-614 km orbit (average altitude 593 km) inclined at 65.84 degrees. It turns out that this orbit is extremely close to an orbit that has a ground track that repeats every four days with the parameters (N,M,Q,i)=(14,3,4,65.8) and an average altitude of about 592 km. Therefore, the launch of an interceptor could occur at four day intervals if a specific phasing between the target and interceptor was sought. In fact the interceptor was launched after 4 x 4 days=16 days! According to (**5**) the target was of a new type designated DS-P1-M developed by the Yangel design bureau in the Ukraine. It was much lighter than the inital series of targets and was launched by Kosmos-3M rockets (11K65M).

The launch of Kosmos 397 interceptor took place on 25 February 1971, much longer after the launch of the target than previous interceptors. The initial orbit had a 65.1 degree inclination which was changed to the 65.84 degrees inclination of the target. The intercept took place about 1431 UT the same day as can be seen from the graph below. The interceptor performed the final approach along an orbit at 575-2200 km. Eighty-two (82) fragments were later discovered in the elliptical orbit (**6**). In summary, this intercept is relatively similar to previous tests. No second inteceptor was launched, indicating that the target was indeed destroyed?

## Test Nr 4 (1971): Kosmos 400 target simulates U.S. Transit Navsats?

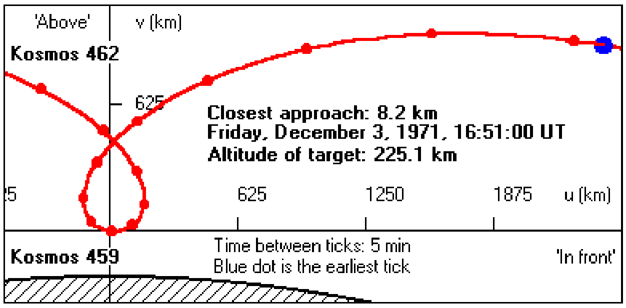



Kosmos 400 was launched from Plesetsk on 19 March 19871 into an orbit at 987-1002 km with 65.85 degrees inclination. This orbit is highly reminiscent of the orbits of US Navy Transit navigation satellites that were used to help U.S. missile submarines determine their location. Maybe the intention was to simulate an attack on such a U.S. space assset?

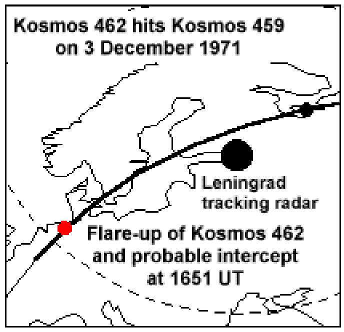
Kosmos 404 was launched around 1420 UT on 4 April 1971 and approached Kosmos 400 sometime between 1745 and 1800 UT on 4 April. The approach took place from "below" along a 803-1010 km orbit. This was the first approach from below. About 12 hours after the approach (around 0930 UT on 5 April 1971) the interceptor was commanded to maneuver down into a 169-799 km orbit when it passed over ground stations on the Soviet Pacific coast. This orbit had changed to the 126-661 km when NORAD determined its orbit at 1140 UT 6 May 1971. With such a low perigee Kosmos 404 decayed soon afterwards. The figure below shows a large miss distance, but in all probability, the interceptor orbit used to generate this graph is not accurate. During these intercept tests, Western sensors often had little time to refine the orbital parameters.

## Test Nr 5 (1971): Kosmos 462 hits a simulated photorecon satellite and is observed from the ground

The Kosmos 459 target was launched from Plesetsk on 29 November 1971 into a 223.2 - 260.2 km orbit maybe simulating a low-orbit photo reconnaissance satellite. The Kosmos 462 interceptor was orbited on 3 December. It entered a higher orbit (231.4-1655) km than its target. On its second orbit around the earth the interceptor approached its target from "in front" and "above" as the figure below shows.




The figure shows that Kosmos 462 missed Kosmos 459 by only 8.2 km at 1651 UT, but we now know that there was an intercept, so the orbit of Kosmos 462 needed only to have been adjusted very little in relation to the one which forms the basis of the figure below.

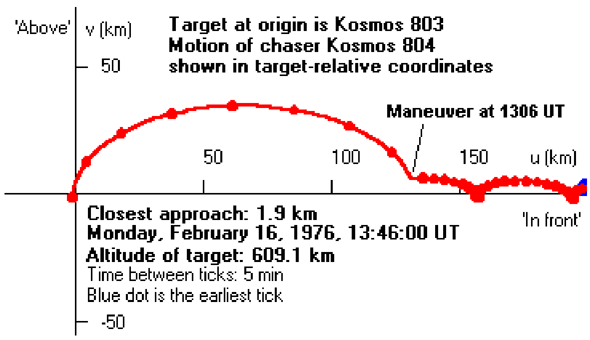



Interestingly, in May 1973, I received a call from UFO enthusiasts in southern Sweden. They reported that on 3 December 1971 observers in Sweden's southernmost county, Skane, and in Copenhagen had observed a bright object in the sky coming from the southwest that suddenly flared up abruptly at 1651 UT (see figure below). The flare lasted about 20 seconds and then gradually faded.

The RAE Table of Earth satellites gives the time of closest approach between Kosmos 459 and Kosmos 462 as Dec 3.70, i.e. 1650 UT and our analysis here shows the intercept to have taken place at 1651 UT! It is interesting to note that Kosmos 462 entered eclipse at 16:51:22 . It seems that the UFO-ists observed the intercept and destruction of the target and the interceptor!

## Test Nr 6 (1976): Second generation tests start with an unusual very slow approach to Kosmos 803

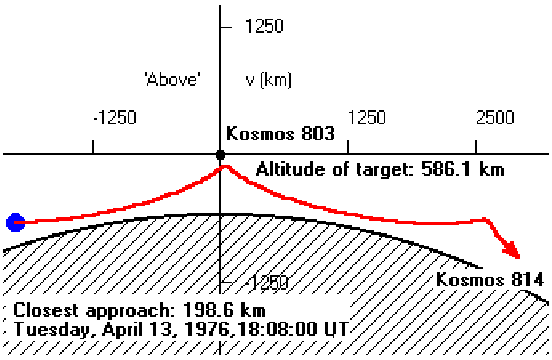
There was a five-year long break in ASAT testing after the failure of the target Kosmos 521 launched in September 1972. This lull in testing was due to the fact that the Strategic Arms Limitation Treaty was signed between the Soviet Union and the U.S. in May 1972. The launch of Kosmos 521 was not stopped by the signature of the Treaty, but its failure must have "come in handy" when the decision was taken to discontinue testing. According to (5) the purpose of the Kosmos 521 target was to test modifications to the interceptor design.




However, in 1976, a new generation of interceptors had been designed and testing resumed (5). A new type of target had also been developed, called IS-P. The first such target, Kosmos-803 was launched 12 February 1976 into an orbit at 554-618 km and 65.85 degrees inclination. This orbit was similar to that of earlier targets, in particular that of Kosmos 394. Its ground track was not stabilised. The first interceptor, Kosmos-804, was launched 16 February 1976 and followed an entirely new approach! First it entered the typical low-perigee "transfer orbit" (149-703 km, i=65.15 deg, at

08:19:35 UT). Then the orbit was matched relatively well to the target orbit (561-619 km, i=65.86 deg, at 09:53:35 UT ) providing a slow approach to Kosmos 803 (as can be seen on the right in the figure below. Then, at about 1306 UT the final half-orbit approach was performed quickly along an 530-623 km, 65.75 deg orbit. Upon reaching the target - "from above" (!) - there was a braking maneuver and the interceptor **rendez-voused with the target (see picture of motion)** and maintained a 556.3-615.3 km, 65.86 deg orbit for more than 3 hours (until about 1610 UT).

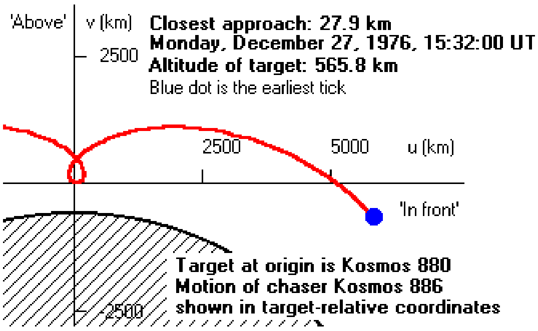
Kosmos 814 was launched on 13 April 1976 - almost two months after the first interceptor. Only one set of orbital parameters is available and it shows an approach to the Kosmos 803 "from below". The orbital paarmeters of this element set are 117-480 km at 65.1 degree inclination. This is the initial "transfer" orbit and a as can be seen from the figure below amaneuver had to follow to bring the interceptor reasonably close to the target.




## Test Nr 7 (1976): Tests continue with Kosmos 839 target in new type of orbit

Kosmos 839 was launched as a target into a new - very unusual - type of orbit on 9 July 1976. It entered an orbit at 984-2098 km, 65.86 degrees. No orbital data that shows an intecept are available, only the initial orbit of the Kosmos 843 interceptor launched on 21 July 1976 into a 131-341 km orbit at 65.1 degrees inclination. According to (**5**) this test was a success. This may have been the first in a series of "pop-up" intercepts where the interceptor re-entered immediately after the intercept. However, no independent confirmation of this hypothesis exists.

## Test Nr 8 (1976): Rerun of an earlier test scenario - Kosmos 880 is the target



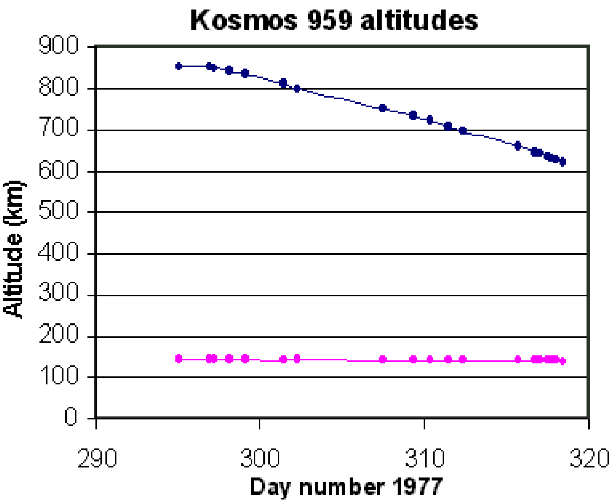

Kosmos 880 was launched on 9 Dec 1976 into a n orbit at 560-617 km i = 65.85 deg - an orbit very similar to that of Kosmos 394. Therefore the interceptor launch could be expected at four-day intervals starting from the target launch. This indeed happened and Kosmos 886 was launched on 27 Dec 1976. It first entered an intermediate orbit at 533-1267 km. The interceptor approached the target along an orbit at 596-2297 km , i=65.84 deg. The closest approach occurred at 1532 UT and the orbital data indicate that the intercept was indeed successful.

According to (6) this test involved the fragmentation of the interceptor and (6) also suggests that *"the resumption of tests may have been timed to coincide with the SALT talks but it is also possible that this fragmentation test was staged to impress the Carter Administration."*

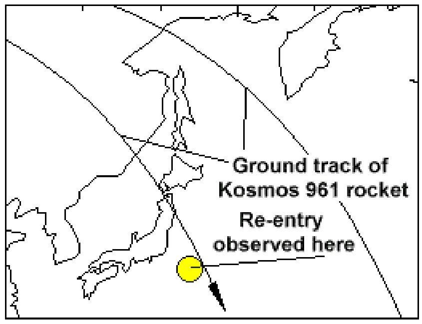
## Test Nr 9 (1977): Two "pop-up" intercepts against Kosmos 909?

Kosmos 909 was launched on 19 May 1977 into a 991-2107 km, 65.87 deg orbit. This was an orbit almost identical to that of the Kosmos 839 orbit. Again no orbital data except the initial transfer orbit (149-506 km, 65.1 deg) of the Kosmos 910 interceptor (launched 23 May 1977) are available. Therefore, this intercept has again been regarded as a "pop-up" intercept where the interceptor re-entered immediately after the intercept. However, again, no independent confirmation of this hypothesis exists. The same scenario repeated itself when Kosmos 918 was launched on 17 June, 1977. The transfer orbit of the interceptor was 128-244 km, i=65.1 deg.

# Test Nr 10 (1977): A "pop-up" test against Kosmos 959 gives rise to UFO reports in Japan



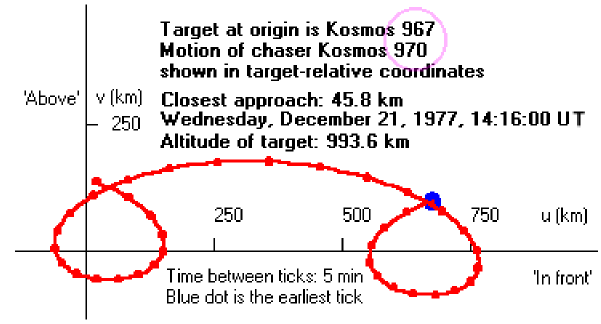

On 21 October 1977, Kosmos 959 was launched into a low elliptical orbit (145-854 km, 65.84 deg). This orbit was surprisingly stable despite the extremely low perigee (see figure on the right). It lasted 40 days in orbit. Seven days after the launch of the target, Kosmos 961 employed the "pop-up" profile, passed close to Kosmos 959 and re-entered burning up over the Pacific Ocean (36 N, 143 E, (**9**)) and giving rise to numerous UFO reports in Japanese newspapers (**8**). The initial orbit of Kosmos 961 was as 130-248 km (65.1 deg) and the intercept orbit given in (**9**) as 269-1421 km.



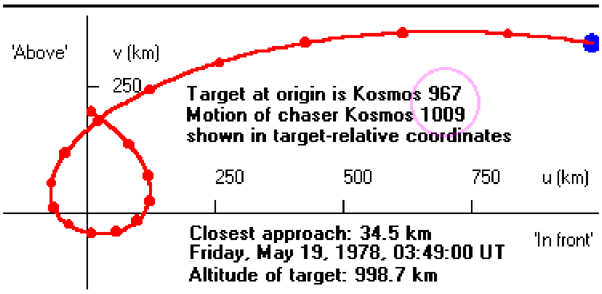

# ASAT target telemetry on 144-146 MHz detected by radio amateurs

In the mid-to-late 70's radio amateurs began noting intruders on their 2-meter band (**1**,**2**). Wide band buzzing sounds were picked up from around 144 MHz all the way up to 146 MHz. Many little carriers were spread over the 144-146 MHz frequency band. When listening to the signals in FM mode it sounded like a buzz with a few hundred Hertz frequency. The signal showed doppler shift, so it obviously came from a satellite. The signals were picked up for about 15-20 minutes each time. They were first noted in 1974 (**4**). In 1979 the Naval Research Laboratory identified the latest batch of signals from these "intruders" to come from Kosmos 909 (launched on 19 May 1977) and Kosmos 967 (launched on 13 Dec 1977). The signals that radio amateurs picked up in 1974 must have come from the target satellite Kosmos 521, launched in May 1972. As we shall see, the frequency 145.0 MHz (+/- 1 MHz) continued to be used for ASAT targets until the tests ended. It is very strange that Soviet engineers picked this frequency for the ASAT target telemetry. The 144-146 MHz band is used by thousands of radio amateurs around the world and is the worst possible frequency band to use if one wants to hide a particular transmission. It is difficult to imagine that the intrusion into the amateur band was made on purpose - but - who knows? This is still a most bizarre feature of these tests.

# Test Nr 11 (1977): A "slow approach" test against Kosmos 967




Kosmos 967 launched on 13 Dec 1977 into 964-1005 km, 65.83 deg, very similar to that of Kosmos 400 back in 1971. Kosmos 970 was launched on 21 December 1977 into an intermediate orbit at 158-744 km, 65.1 deg. Kosmos 970 intercepted Kosmos 967 around 1416 UT on 21 Dec 1977 along an orbit at 949-1149 km (i=65.85 deg). This was a relatively slow approach - sometimes called a co-orbit intercept. The interceptor was commanded to self-destroy (**5**), but not near the target, since the target was used once again.

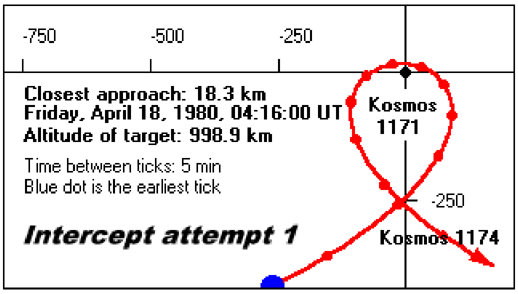


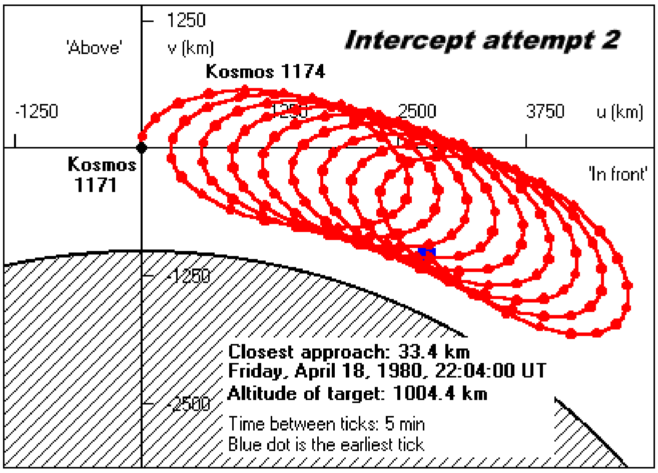

The second interceptor launch against Kosmos 967 was delayed by a record amount of time - more than five months. Thus, Kosmos 1009 was launched on 19 May, 1978 and also approached the target rather slowly along an orbit at 966-1363km i = 65.87 deg. the closest approach took place at

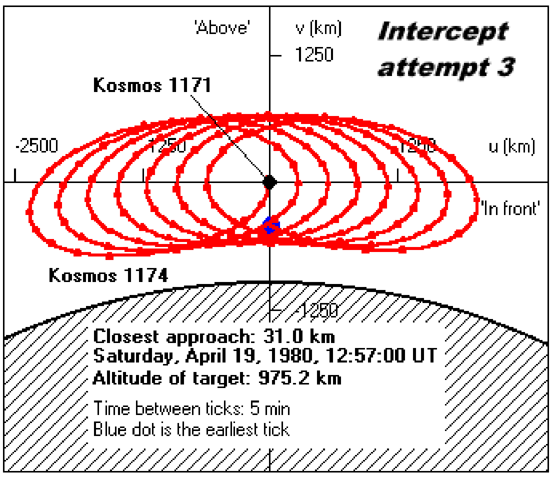
0349 UT. According to (5) the interceptor was de-orbited using its own engine over the Western Pacific after 0.17 days in orbit. The re-entry was near 10 N, 147 E.

The Kosmos 967 target remained in orbit waiting for the second intercept for an unusually long time and this is the satellite reported in (1). This satellite was reported to have transmitted **in the autumn of 1979(!)**. In (1) it was indicated that the transmitter on 145 MHz was not always active, but at intervals of two months. The ascending node rotated 24 hours in local time in about 6 months. This could affect the time when transmissions were heard. Obviously the transmissions from the target satellites were heard frequently by radio amateurs, since complaints were wide-spread. However, Soviet interference on radio wave-bands was not uncommon in those days. Many of us remember the so-called "woodpecker" Soviet experimental shortwave "over-the-horizon"-radar that spread the most horrendous interference all over shortwave bands, so this bandwidth-limited and time-limited intrusion on the 2-meter band pales in comparison!

## Test Nr 12 (1980) - three intercept tries!




Test nr 12 commenced with the launching of Kosmos 1171 into the typical approximately circular target orbit at 1000 km on 3 April 1980. According to (5) the following interceptor launch was made to test the ability of an interceptor to perform after a long period of storage. When Kosmos 1174 was launch on 18 April 1980 a drama in space unfolded displaying new capabilities of the Soviet ASAT system. When the initial intercept failed, the interceptor was maneuvered to perform two more intercept attempts. the table below shows that the futile attack on Kosmos 1171 lasted 1.5 days.

| Event | Date | Time (UT) | Remarks |
|---|---|---|---|
| Launch | 18 Apr 1980 | 0055 | 131-432 km, 65.18 deg |
| 1st manuever | " | 0212 | 363-1026 km, 65.83 deg |
| **Intercept attempt 1** | " | 0416 | Miss distance 18.3 km |
| 2nd manuver | " | 0625 | 380.2-1660.7 km, 66.11 deg |
| **Intercept attempt 2** | " | 2204 | Miss distance 33.4 km |
| 3rd manuver | 19 Apr 1980 | 0035 | 379.9-1659.4 km, 66.13 deg |
| **Intercept attempt 3** | " | 1257 | Miss distance 31.0 km |

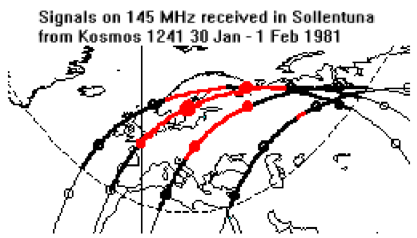
The first intercept attempt was performed from "below and behind" on rev. 2 of the interceptor, and took place over northern Russian near the city of Surgut .

The attempt failed and orbital data seem to indicate a miss distance of tens of kilometres. However, ground controllers recouped quickly from this setback, and commanded a manoeuvre that brought the interceptor back to the target 16 hours later off the Californian peninsula. This time the approach was made from "in front" but the interceptor approached from above along the radius vector.

Again the interceptor missed the target and again ground control, extremely quickly commanded another manoeuvre. This must have been a quick-reaction effort, since the failed intercept occurred at 2204 on 18 April 1980 and the manoeuvre took place at 0035 on 19 April 1980. The pass over the Soviet Union when the manoeuvre could have been commanded took place at 2310-2330 UT on 18 April! Anther slow approach was performed taking about 12 hours to complete, resulting in another missed intercept at 1257 UT on 19 April 1980 over the Pacific near Samoa.

This disappointing test ended on 20 April 1980 when the interceptor was commanded to destroy itself. An interesting feature of this test is the wide separation of the intercept points. Two of them were definitely out of range of Soviet tracking means, since it seems improbable that Soviet space engineers could have planned the second and third intercept attempt and placed tracking ships at those location. Rather, the target and the interceptor itself must have recorded data to show the results of the approach and this data was read out when passing over Soviet ground stations.

## Test Nr 13 (1981): Kosmos 1241 - I finally pick up target telemetry on 145 MHz




| | |
|---|---|
| 30 Jan 1981 | 0408.20-0409.00 UT |
| | 0548.55-0555.10 UT |
| 31 Jan 1981 | 0811.25-0814.00 UT |
| 1 Feb 1981 | 0650.35-0702.05 UT |

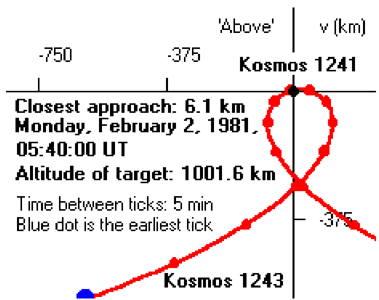
With Kosmos 1241 I was finally able to pick up signals from an ASAT target. Signals on 145 MHz was picked up from my home in Sollentuna, Sweden on 30 and 31 January and 1 February 1981 (See map). On 21 January 1981 this target had been inserted into the typical 977-1011 km orbit at 65.8 degrees inclination - very similar to that of the previous target.

It was natural to assume that the upcoming interceptor would be launched at the same orbital phasing as Kosmos 1174 had in relation to Kosmos 1171. The previous target had a northbound equator crossing longitude (NBECL) of 40.71 E (319.29W) when the interceptor was launched. Kosmos 1241 would get close to this longitude on 2 February 1981 when its NBECL was 318.9 W.

In this way, I was able to be prepared for the launch of the interceptor. Since the target passed over Sweden early in the morning, I did not need to take the morning off from work. As soon as I picked up the target signal on 145 MHz at 0345.39-0356.35 UT I switched the discone antenna to another receiver with which I tuned across the 55-260 MHz range. Since satellites launched by the Tsiklon booster usually transmitted on 166 MHz, I was not overly surprised to find typical PPM-AM telemetry on this frequency at 0358.20-0402.40 UT.

This was indeed exciting! An interceptor had in all probability been launched! Would its signals appear at the same time as those from the target on the following revolution - normally the intercept revolution? I must say I held my breath an hour and a half later. The target telemetry appeared faithfully at 0530.10 UT and the 166 MHz signal started at 0531.40 UT. The two signals grew in strength and faded out almost simultaneously at 0544.56 (target) and 0544.50 (interceptor) at 2 degrees elevation.

An interceptor, Kosmos 1243, had indeed been launched early in the morning and the closest approach took place at 0540 UT well within view of my station.

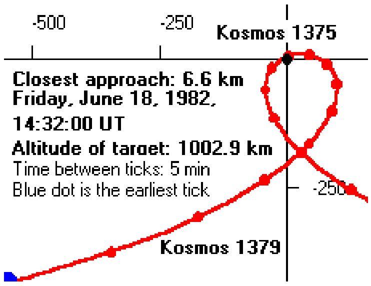


Actually the elevation from Sollentuna at the moment of closest approach (**50** meters according to **5**) occured when the two craft were 35 degrees above my horizon and at a slant range of 1584 km. (see map showing signals 2 February 1981) The interceptor approached the target along an orbit at 296-1016 km, i.e. it appraached from "below and behind". According to (**5**) the explosive charge did not go off as planned and the interceptor was guided to a destructive re-entry into the earth's atmosphere.

A second intercept of Kosmos 1241 was made at about 1645 UT on 14 March 1981 when Kosmos 1258 was launched and approached Kosmos 1241 along an orbit (290-1025 km, 65.82 deg) almost identical to that of Kosmos 1243. The closest appraoch took place at 2014 UT, but the intercept was unsuccessful (**5**).

## Test Nr 14 (1982): The final round of tests!

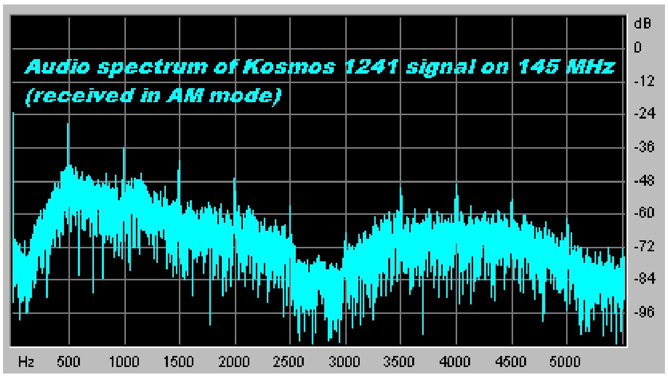
The test in 1982 was designed to evaluate the system performance after storage (**5**). The target, Kosmos 1375 was launched on 6 June 1982 into an orbit very similar to previous targets (980-1013 km, 65.84 deg). Target telemetry was again picked up in by radio amateurs (**3**). I was well aware of the launch opportunity for the interceptor - 12 days after the target as with Kosmos 1243. Indeed Kosmos 1379 was launched at about 1105 UT on 18 June 1982. I had rushed home from work to try to pick up the target and the interceptor. Strangely enough I did not hear the target on 145 MHz, but heard the interceptor telemetry on 166 MHz at 1243.05-1245.10 UT. The closest approach occurred at 1432 UT and was successful (**5**).




With this flight 19 years of testing ended and the system never flew in space again. Presumably it was kept in readiness at Baikonur for quite a number of years, perhaps to be replaced by an air-aunched similar to the U.S. system.

## Some thoughts on target subsystems

The radio signals from Kosmos 1241 deserve some more detailed description. The appeareance of such signals in the 1970's has been noted above. Usually they were described as a "buzzing sound". Whe I picked them up I couod look at them on a small spectrum display unit and it became appaarent that the signals consisted on the normal PPM-AM pulse train, which is nearly inaudible to the "naked ear" because of its high pitch (> 12.5 kHz), and an overlaid series of microsecond pulses with a repetition rate of 500 Hz - an audio frequency that is easily heard (listen to 500 Hz "buzz" from Kosmos 1241). The spectrogramme below shows that the pulse repetition frequency (PRF) is exactly 500 Hz. The peaks at multiples of 500 Hz are probably generated by the non-linearities of the reproduction chain for this recording.



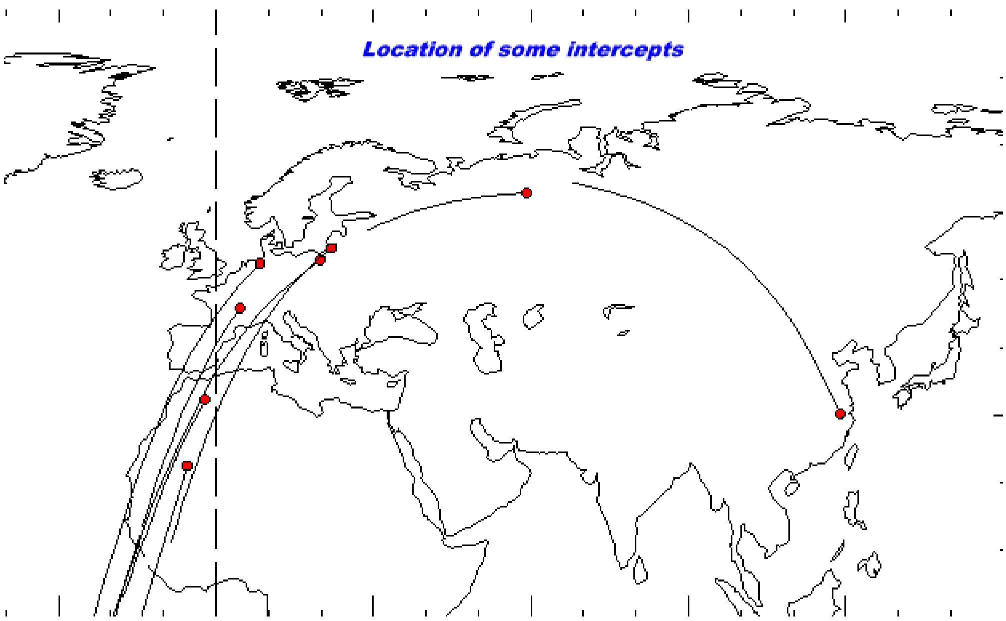

What could possibly be the purpose of such a train of pulses? The most obvious is that of a radar to determine the miss distance of the interceptor. The maximum range corresponding to a PRF of 500 Hz is 300 km. But, the 145 MHz signal was apparently transmitted by an omni-directional antenna. Could we really expect a skin track radar based on such a low gain antenna to work? In all probability it could not work out to 300 km, but then maybe at closer range. But if intended for a closer range, why not raise the PRF? Another alternative is that the interceptor carried a transponder that picked up the 145 MHz signal (if I could, it could) and sent it back to the target on another frequency. This is the principle of a radar transponder and it might very well have worked at distances up to 300 km. (When the target passed overhead at 1000 km range the signal was indeed very strong when received on my lousy discone. Imagine being at 30 km range - then the signals would have been almost ten times stronger.


It could be interesting to compare the few known facts about the Soviet ASAT target satellite with the equally meagre information about the target developed for the U.S. ASAT program in the 80's. The ASAT vehicle that was carried under an F-15 fighter was supposed to have attacked two targets launched by a Scout rocket from Wallops Island. The targets were indeed launched but never used (the Solwind satellite was used instead). The only information about their technical details has been gleaned from a publicity brochure published by LTV (**10**) . The two Instrumented Target Vehicles (ITV) were launched by the same Scout (S-207) on 12 December, 1985 (into a 319-768 km, i = 37.1 deg orbit). The spacecraft contractor was Avco Systems Division (Wilmington, Mass) and each spacecraft weighed 81.6 kg. The central body dimensions were 0.46 m in diameter and 1.07 m in length. The diameter of the balloon was 1.83 m. Only ITV2 deployed its balloon.

As can be seen from the figure here the spacecraft central body was encapsulated in a balloon like structure. The balloon surface seemed to have embedded in it something that looks like a an antenna system. The "ramparts"-like structure of the conductor in the balloon skin seems to indicate a rather low frequency - perhaps a VHF frequency not very far from the 145 MHz used by the Soviet ASAT target. probably this was the antenna of the miss distance indicator system. The large structures on the balloon surface would not disturb the radiation pattern of e.g. S-band telemetry antennas on the central spacecraft body.

Another capability of the target must have been to store the scoring data on board for later read-out over ground stations. This is obvious if one looks at the locations of intercepts. Not all took place within easy view of Soviet ground stations or tracking ships as can be seen in the figure below (which shows some of the intercept locations). What kind of data recorder was used? A tape recorder?

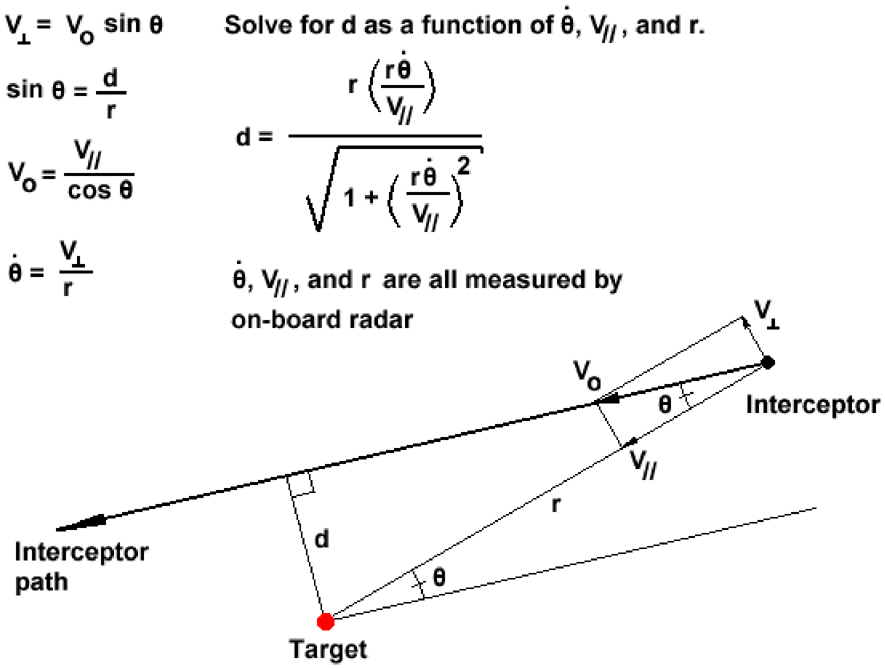
In (**5**) reference is made to manoeuvres by the targets. Kosmos 373 is stated to have manoeuvred twice. Actually, this spacecraft is the only target that shows any signs, albeit weak, of manoeuvring. Maybe the early targets, being derivatives of the interceptor could manoeuvre, while the later models, being much smaller, probably could not.




## Control law near target

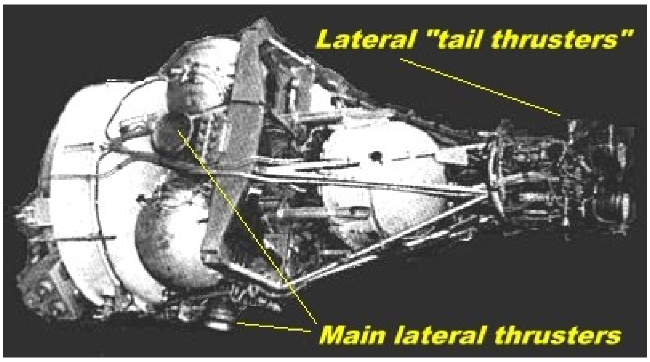
When the interceptor approaches close to the target the time until closest approach is much less than the orbital period of each of the objects. Under such conditions the relative motion of the objects does not exhibit "Keplerian" effects. Actually, the motion takes place as if in a gravity-free environment. This simplifies the guidance of the interceptor. The interceptor approaches the target either along the local horizontal plane or along a line perpendicular to this plane. The interceptor can then point its radar (and its own longitudinal axis) accordingly. The frequency of the radar was probably chosen so that a relatively broad search beam was created.  The diameter of the radar dish is about 2 meters, so if the carrier frequency of the radar was 1 GHz the beamwidth of the radar antenna was about 10 degrees.

As can be seen from the formulas below the miss-distance (d) can be estimated and the sideways course-correction impulse computed by observing range, range-rate, and angular motion of the interceptor relative to the target. In order to obtain good angular motion data the interceptor needs to be well stabilised with low angular body rates. As can be seen the miss-distance (d) is brought to zero if the angular motion of the interceptor relative to the target (the motion of the line-of-sight) is eliminated by a sideways velocity impulse. This is the reason for the four lateral thrusters seen on the interceptor.




***Intercept geometry and kinematics***

The thrust vectors of these thrusters go through the centre-of-gravity for an average fuel loading. For the cases when they do not, small lateral thrusters near the longitudinally mounted engine at the apex of the lattice structure opposite the radar antennas are used. They counteract the torque generated by the c.o.g offset. In this way these small thrusters resemble the function of the tail rotor of a helicopter. The picture below shows the Polyot propulsion test vehicle on which these small "tail" thrusters as well as the main terminal phase lateral thrusters can be seen. The picture is provided courtesy and copyright of Mark Wade.

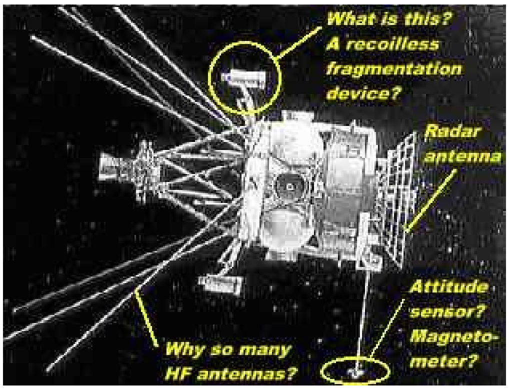



After initial corrections the rotation of the line-of-sight needs to be measured again to check if ithe initial course correction was sufficient. Thus, the control law for ensuring intercept is simple: **"Reduce the rotation of the line-of-**

**sight to the target to zero."** This control law is also used for rendezvous operations when the range and range rate are also eventually zeroed (7). So, the interceptor radar needs to be able to determine the angular position of the target. This is the classical function of a tracking radar. Either the interceptor had a rotating feed or a monopulse sensor.

In Western reports about the Soviet ASAT tests reference was often made to an optical guidance system for the interceptor (5) starting with Kosmos 967. However, Russian sources never mention such a guidance scheme. As can be seen from the analysis above, an optical sensor could not derived the value for the sideways impulses since the range-rate was difficult to estimate. Why did Western intelligence refer to optical guidance? Because they failed to detect the radar signals from the interceptor?

## A few remarks on the interceptor configuration




The two devices on each side of the interceptor could be some kind of recoilless fragmentation device (bazooka-like), or it could be some kind of target acquisition sensor. The multitude of HF antennas is also a bit strange. The Polyot vehicles carried HF (20 MHz) transmitters, and of course later interceptor could have had such transmitters, but never monitored in the West (because the Russians never announced them?).

The small boom probably holds a magnetometer, but it could be some kind of device working together with the device seen at the lower left part of the picture above - maybe a mirror to work with horizon sensors mounted on the body?. The mesh-type radar antenna is clearly not intended for high frequencies (low surface accuracy), so the assumption made earlier that the carrier frequency is near 1 GHz seems reasonable

## List of launches

**D** = Deorbited after intercept, **F** = Fragmented at target, **S** = Self-destruct after closest approach

| Cat Nr | Int'l desig-nator | Name | Launch date | Incl. | $H_p$ (km) | $H_a$ (km) | End | Remarks |
|---|---|---|---|---|---|---|---|---|
| 683 | 1963-043A | Polyot-1 | 1 Nov 1963 | 58.92 | 343 | 1437 | - | Interceptor engine test. Initial: 339-592 km |
| 783 | 1964-019A | Polyot-2 | 12 Apr 1964 | 58.06 | 303 | 479 | - | Interceptor engine test. Initial: 242-485 km, 59.92 deg |
| 3013 | 1967-104A | Kosmos-185 | 27 Oct 1967 | 64.09 | 518 | 873 | - | Test of interceptor engine only. |
| 3216 | 1968-036A | Kosmos-217 | 24 Apr 1968 | 62.20 | 144 | 262 | - | Injection into final orbit failed |
| 3503 | 1968-090A | Kosmos-248 | 19 Oct 1968 | 62.25 | 476 | 543 | - | |
| 3504 | 1968-091A | Kosmos-249 | 20 Oct 1968 | 62.33 | 489 | 2167 | S | Intermed orbits:105-138 km, 502-1639 km |
| 3530 | 1968-097A | Kosmos-252 | 1 Nov 1968 | 62.32 | 531 | 2149 | F | |
| 4058 | 1969-066A | Kosmos-291 | 6 Aug 1969 | 62.24 | 147 | 548 | - | Wrong target orbit due to engine failure |
| 4590 | 1970-087A | Kosmos-373 | 20 Oct 1970 | 62.93 | 474 | 542 | - | Target orbit raised slightly after 1 w. |
| 4594 | 1970-089A | Kosmos-374 | 22 Oct 1970 | 62.96 | 529 | 2132 | S | Initial orbit:530-1053 km |
| 4598 | 1970-091A | Kosmos-375 | 30 Oct 1970 | 62.80 | 525 | 2098 | S | Initial orbit: 566-994 km |
| 4922 | 1971-010A | Kosmos-394 | 9 Feb 1971 | 65.84 | 572 | 614 | - | New, smaller, type of |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | target. |
| 4964 | 1971-015A | Kosmos-397 | 25 Feb 1971 | 65.76 | 575 | 2200 | F | |
| 5050 | 1971-020A | Kosmos-400 | 19 Mar 1971 | 65.85 | 987 | 1002 | - | First attack from below |
| 5113 | 1971-027A | Kosmos-404 | 4 Apr 1971 | 65.74 | 803 | 1010 | D | Moved to 169-799 km after approach |
| 5625 | 1971-102A | Kosmos-459 | 29 Nov 1971 | 65.83 | 223 | 260 | - | |
| 5646 | 1971-106A | Kosmos-462 | 3 Dec 1971 | 65.88 | 231 | 1655 | F | |
| 6206 | 1972-074A | Kosmos-521 | 29 Sep 1972 | 65.89 | 965 | 1022 | - | Target. TM system failed. (5) |
| 8688 | 1976-014A | Kosmos-803 | 12 Feb 1976 | 65.85 | 554 | 618 | - | New IS-P target (5) |
| 8694 | 1976-015A | Kosmos-804 | 16 Feb 1976 | 65.75 | 530 | 622 | D | "Rendez-voused" with the target |
| 8806 | 1976-034A | Kosmos-814 | 13 Apr 1976 | 65.07 | 117 | 480 | D | No intercept orbit available |
| 9011 | 1976-067A | Kosmos-839 | 9 Jul 1976 | 65.86 | 984 | 2098 | - | |
| 9043 | 1976-071A | Kosmos-843 | 21 Jul 1976 | 65.11 | 131 | 341 | D | No intercept orbit available |
| 9601 | 1976-120A | Kosmos-880 | 9 Dec 1976 | 65.85 | 560 | 617 | - | Similar orbit to Kosmos 394 |
| 9634 | 1976-126A | Kosmos-886 | 27 Dec 1976 | 65.84 | 596 | 2297 | F | Intermed. orbit 533-1267 km |
| 10010 | 1977-036A | Kosmos-909 | 19 May 1977 | 65.87 | 991 | 2107 | - | Very similar to Kosmos 839 |
| 10014 | 1977-037A | Kosmos-910 | 28 May 1977 | 65.10 | 149 | 506 | D | No intercept orbit available. Rocket orbit given here. |
| 10065 | 1977-050A | Kosmos-918 | 17 Jun 1977 | 65.11 | 128 | 244 | D | No intercept orbit available. |
| 10419 | 1977-101A | Kosmos-959 | 21 Oct 1977 | 65.84 | 145 | 854 | - | |
| 10434 | 1977-104A | Kosmos-961 | 26 Oct 1977 | 66 | 269 | 1421 | D | Intercept orbit not confirmed. Initial: 125-302 km. |
| 10512 | 1977-116A | Kosmos-967 | 13 Dec 1977 | 65.83 | 964 | 1005 | - | |
| 10531 | 1977-121A | Kosmos-970 | 21 Dec 1977 | 65.85 | 949 | 1149 | S | Interm. orbit 158-744 km, 65.1 deg |
| 10904 | 1978-050A | Kosmos-1009 | 19 May 1978 | 65.87 | 966 | 1363 | D | Another "slow" approach |
| 11750 | 1980-026A | Kosmos-1171 | 3 Apr 1980 | 65.84 | 967 | 1010 | - | |
| 11765 | 1980-030A | Kosmos-1174 | 18 Apr 1980 | 65.83 | 363 | 1026 | S | Initial: 124-340 km, 65.1;After: 380-1660, 66.1 |
| 12149 | 1981-006A | Kosmos-1241 | 21 Jan 1981 | 65.82 | 977 | 1011 | - | |
| 12160 | 1981-010A | Kosmos-1243 | 2 Feb 1981 | 65.82 | 296 | 1016 | D | Explosive charge failed. |
| 12337 | 1981-024A | Kosmos-1258 | 14 Mar 1981 | 65.82 | 290 | 1025 | D | |
| 13259 | 1982-055A | Kosmos-1375 | 6 Jun 1982 | 65.84 | 980 | 1013 | - | |
| 13281 | 1982-060A | Kosmos-1379 | 18 Jun 1982 | 65.84 | 538 | 1020 | D | |

## References


1. **Branegan, J.** Oscar News, No 27, AMSAT-UK, autumn 1979, p. 33

2. **Sassoon G.T**: "The Best of Oscar News", vol. 1 AMSAT-UK 1980, pp.50-51
3. **Branegan, J**. Oscar News, No 40, AMSAT-UK, January 1983, p. 4
4. **QTC**, January 1979
5. **Mark Wade**'s Encyclopedia Astronautica, **"ASAT"**.
6. **Perry, Geoff**, **"Russian Hunter-Killer Satellite Experiments",** The Royal Air Forces Quarterly, Vol 17, Winter 1977, pp. 328-335.
7. **Lebedev L, Nikitin S, Sokolov V**, "Der Weg zur ersten bemannten Raumstation", FLUG REVUE + flugwelt international, 10/1969, pp.49-60.
8. **Jasani, B.M.**, "Outer Space - Battlefield of the future", SIPRI 1978, p.176
9. The RAE Table of Earth Satellites, 1957-1989, p. 509
10. "Scout satellite accomplishments", LTV Missiles and Electronics Group, Missiles Division, February 1987, p.30
11. "Polyot Maneuvering Claim Questioned", Aviation Week, 11 Nov 1963, p.29.
12. "Polyot 2 launched by Soviet Union", Aviation Week, 20 April 1964.
13. "Cosmos maneuvers", Aviation Week, 26 February 1968.

---

Back to Space History Notes