US MILITARY ACTIVITES IN SPACE - 1985

Anthony Kenden

1. INTRODUCTION

The US Department of Defense (DoD) achieved two important, but much delayed, milestones in 1985 - the first all military flight of the Space Shuttle, and the first ASAT intercept of a target satellite. The Shuttle mission was, in fact, the first of two in the year. One carried the prototype of a large new intelligence-gathering satellite, and the other placed a pair of advanced communications satellites in synchronous orbit. The ASAT intercept had to be made with an old satellite rather than the specially-developed ITV, but it worked perfectly.

The biggest disappointment of the year was in the field of photo reconnaissance, where the first launch failure since June 1973 left the US strategic monitoring capability dangerously weak. The Leasat programme also had its problems. One satellite had to be repaired in space before it could be boosted into synchronous orbit, and a second failed soon after reaching synchronous orbit. The SDS communications system was augmented by a launch in 1985, as were the Transit and Navstar navigation satellite networks. Two key research and development satellites were also launched during the year.

A total of 14 defence payloads were launched in 1985, down from 17 in 1984, but continuing the upward trend from the low levels of 1981 and 1982. The year was notable in being the first in which more DoD payloads were launched on NASA vehicles than DoD vehicles. This is a reflection of the military's increasing use, and dependence on, the Space Shuttle.

This paper reviews the DoD's activities in space in 1985, and follows two earlier reviews covering 1983 and 1984 [1,2]. The activities are divided into nine principal categories, with the status at the start of the year and events during the year discussed for each. Orbital data is included for those vehicles for which it has been released. A table at the end of the review gives details of all DoD payloads launched during 1985.

2. PHOTO RECONNAISSANCE

The Big Bird and "close look" programmes appear to have come to an end in 1984, and photo reconnaissance is now carried out exclusively by the KH-11 class. At the start of 1985 there were two KH-11 satellites in orbit, as follows:

Photo Reconnaissance Satellites at 1 January 1985

Satellite	Months in Orbit
1982-111A	25
1984-122A	1

It was suggested in the 1984 review that 1984-122A was the first of the advanced version of the KH-11 spacecraft, but so far the only clue that might confirm this is its orbit. According to the submission to the UN 1984-122A was launched into a 300km by 650km orbit, which is somewhat higher than previous KH-11s. Visual observations of 1982-111A and 1984-122A showed that by mid June 1985 they were both in high orbits, with perigees around 295km and apogees around 680km.

The mission duration record for the KH-11 class stood at 1177 days at the beginning of 1985, a figure which 1982-111A would not reach until 6 February 1986. KH-11 satellites operate in pairs, so with two in orbit it did not appear likely that there would be any photo reconnaissance launches in 1985.

It was, therefore, something of a surprise when 1982-111A was de-orbited on 13 August, after only 1000 days in space. Following the standard pattern its replacement was launched 15 days later, on 28 August. Just under four minutes after liftoff disaster struck. One of the two engines of the Titan core's first stage shut down, 45 seconds ahead of schedule. The other engine continued to burn for its planned duration, but the velocity provided was insufficient, and the satellite ended up in the Pacific Ocean [3].

The spacecraft and launcher were worth over $150 million [4], but more significant was the loss of strategic monitoring capability. Only seven KH-11s have been launched in nine years, and with such a low production rate it is very unlikely that there would be a back-up vehicle available. In any case, the launcher itself was not cleared for use again until late December [5]. However, a replacement mission in 1986 must be expected. As a result of the launch failure the US achieved only 590 mission days in space with photo reconnaissance satellites during the year, compared with 1035 days in 1984.

3. EARLY WARNING

Missile early warning is carried out by Defense Support Program (DSP) satellites in synchronous orbit. The system requires three operational satellites, stationed at 70°W, 134°W and 69°E, plus a number of in-orbit back-ups. The status of the system at the start of 1985 was not completely clear, due to three unexplained launches in 1984 and a lack of orbital data.

The three launches all involved Titan 34D/Transtage vehicles, but their missions have never been revealed. The first appears to have suffered a Transtage failure, leaving its payload stranded in a useless orbit. The second appears to have been its back-up. The second and third launches successfully placed payloads in synchronous orbit. One report suggested that the first launch carried a DSP satellite [6], and this would imply that the second did as well. Given this, the third launch most probably carried a Chalet ELINT satellite.

Orbital data is no longer published for early warning satellites, so it is not possible to tell directly whether a satellite is operational, a back-up, or retired. At the last occasion when orbital data was available (June 1983) there were five operational or back-up spacecraft. The only successful launch of an early warning satellite since then has been the second Titan 34D/Transtage in 1984. It is therefore assumed here that there are still five usable spacecraft, with the 1984 launch replacing the oldest working satellite. Their status would then be:

Early Warning Satellites at 1 January 1985

Satellite	Months in Orbit
1977-07A	95
1979-53A	67
1981-25A	45
1982-19A	34
1984-37A	8½

There were no early warning satellite launches in 1985, and now it seems that the next flight will be the first to go on the Shuttle, on mission 71-B in December 1986.

4. ELECTRONIC INTELLIGENCE (ELINT)

4.1 The Subsatellite Programme

Routine monitoring of communications and radar is performed by small ELINT subsatellites ejected from photo reconnaissance satellites. They use two types of circular orbit, one at 600km to 700km altitude, and the other at 1300km to 1400km.

The subsatellites do not manoeuvre, and have relatively long lives before decaying from orbit. Because of this there is no simple way of telling whether a subsatellite is operational. Previous reviews considered only those which had been in orbit less than five years to be operational. Their status at the start of 1985 would thus be:

ELINT Subsatellites at 1 January 1985

Satellite	Orbit	Months in Orbit
1980-52C	high	54
1982-41C	low	32
1983-60C	high	18
1984-65C	low	6

Since 1972 all ELINT subsatellites have been launched with Big Birds, and with the end of this programme it is not clear what vehicle will carry them. The obvious choice would be the KH-11s, but to date none have done so. It is, of course, possible that the launch failure of 28 August carried an ELINT subsatellite, but other than that there were none in 1985.

4.2 Synchronous Orbit Programmes

Other ELINT activities are carried out from synchronous orbit, and the particular roles of the programmes involved became much clearer during 1985. The Rhyolite programme used relatively small satellites to monitor telemetry from Soviet and Chinese missile tests. Three test launches were made between 1970 and 1972, followed by four operational ones between 1973 and 1978. A single test satellite of a follow-on programme called Argus was launched in 1975, but full-scale development was never approved.

The Chalet class was originally intended to monitor communications rather than telemetry, and the first such satellite was launched in 1978. In 1979 the design was modified to enable telemetry to be picked up as well, and launches of modified spacecraft were made in 1979 and 1981. A third modified Chalet was apparently launched on a Titan 34D/Transtage in 1984 (see section 3).

A report in early 1985 stated that of the eight ELINT satellites in synchronous orbit, only three were still active [7]. The figure of eight must refer to the four operational Rhyolites and four Chalets, so the ones that were still functioning may be assumed to be the most recent three (i.e. the modified Chalets), thus:

ELINT Satellites at 1 January 1985

Satellite	Months in orbit
1979-86A	63
1981-107A	38
1984-129A	½

No Chalet satellites were launched in 1985, and indeed it seems possible that no more will be launched. The reason for this lies in the first DoD Shuttle mission, and the payload it carried.

After many delays, Shuttle mission 51-C lifted off at 14:50 EST on 24 January 1985. The DoD had gone to great lengths to keep details of the mission secret, admitting only that it would carry a "national security" satellite to be boosted to synchronous orbit by an Inertial Upper Stage (IUS).

Despite the DoD's efforts, a month before the flight the Washington Post was able to report that the payload was a large new ELINT satellite, able to monitor signals across most of the radio spectrum. It also revealed that the satellite itself had cost the vast sum of $300 million [8]. The role of the satellite had, in fact, been deduced by a number of observers, and in the 1984 review it was argued that it would be the first Aquacade satellite.

By all accounts the flight of 51-C went off fairly smoothly, with the IUS/satellite combination released 16 hours after liftoff, and ignition of the IUS lower stage 55 minutes later. The mission ended a day earlier than planned, due to bad weather at the landing site. It had lasted just over three days.

Two weeks after the flight it was reported that 51-C's payload was code named Magnum, but all indications are that it is a derivative of the Aquacade design. The DoD did have one surprise in store, however. The normal flight profile for the IUS is for the lower stage to insert the IUS/satellite combination into transfer orbit and then separate. The upper

stage places the satellite in synchronous and then separates from it.

On 25 April the DoD submitted to the UN the following orbital data for mission 51-C (no data was released for the Shuttle itself, object A):

1985-10B (payload):	28.4°,	341-34670km,	612.3min
1985-10C (rocket body):	28.3°,	335-15554km,	284.3min
1985-10D (rocket body):	28.4°,	337-34675km,	612.2min

It is quite common for DoD submissions to list the transfer orbits of satellites which end up in synchronous orbit, but the fact that there were separated objects in the orbits stated means that a different flight profile from normal must have been used.

What must have happened was the IUS lower stage placed the IUS/satellite stack in an intermediate orbit and then separated, appearing as object C. The upper stage raised this to a standard transfer orbit and separated, appearing as object D. Insertion into synchronous orbit must have been performed by a motor on board the satellite, otherwise there would have been an object E in synchronous orbit.

It is interesting to note that on-board motors for synchronous orbit insertion are very rarely used on DoD satellites, but almost always used on civilian satellites. Calculations based on this orbital data show that the Magnum satellite had a mass of about 6.8 tonnes with its motor fully fuelled, reducing to around 3.6 tonnes in synchronous orbit. This makes it the largest object ever placed in synchronous orbit, and about three times the size of a Chalet spacecraft.

Finally, in October, the DoD released orbital data for the Shuttle itself. This showed it in a 332km by 341km orbit, inclined at 28.4° and with a period of 91.3 minutes, similar to civilian missions which have placed payloads in synchronous orbit.

5. OCEAN SURVEILLANCE

Ocean surveillance is carried out by clusters of subsatellites in 1100km orbits, under a programme with the code name White Cloud. Six successful launches had been made by the start of 1985, each involving a cluster of three subsatellites.

Analysis of the relative positions of their orbital planes leads to the conclusion that the first two clusters were no longer active (see figure 1 of the 1984 review), so the programme's status as the year began was:

Ocean Surveillance Satellites at 1 January 1985

Satellite	Subsatellites	Months in orbit
1980-19A	C, D, G	58
1983-08A	E, F, H	23
1983-56A	C, D, G	19
1984-12A	C, D, F	11

White Cloud clusters are launched by refurbished Atlas E missiles, and it was reported that the DoD planned five of these launches from Vandenberg AFB in 1985 [9]. The most obvious way that this figure could be made up was a Navstar, a NOAA satellite for NASA, the long awaited Geosat, a DMSP and a White Cloud. In addition, the oldest active White Cloud had been in orbit for nearly five years, and must have been nearing the end of its useful life. Despite this no such launch took place.

6. WEATHER MONITORING

The Defense Meteorological Satellite Program (DMSP) uses a pair of satellites in sun-synchronous orbits to monitor global weather conditions. The first and second vehicles of the Block 5D-2 version were operating at the start of 1985:

Weather Monitoring Satellites at 1 January 1985

Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Months in Orbit
1982-118A	813	825	98.7	101.3	24
1983-113A	813	832	98.7	101.4	13

The two satellites were providing complementary coverage, with 1982-118A making its observational passes at about 6:20 local time and 1983-113A at about 10:10.

As noted above, a DMSP mission in 1985 would tie in with the DoD's plans for Atlas launches. The DoD had also said that they planned to launch the fourth Block 5D-2 vehicle in 1986 [10], suggesting that the third would go in 1985. In spite of this there were no DMSP launches during the year.

7. COMMUNICATIONS

7.1 Defense Satellite Communications System

The Defense Satellite Communications System (DSCS) provides high volume, high data-rate links between large, fixed ground stations. It entered 1985 with a full complement of four prime and four back-up vehicles in orbit:

DSCS Satellites at 1 January 1985

Name	Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Station	Months in Orbit
Prime							
II-12	1978-113B	35,776	35,793	2.8	1435.9	60°E	72
II-13	1979-98A	35,778	35,791	2.0	1435.9	175°E	61
II-14	1979-98B	35,781	35,793	2.1	1436.0	12°W	61
III-1	1982-106B	35,769	35,802	0.0	1435.9	135°W	26
Back-Up							
II-4	1973-100B	35,781	35,795	6.4	1436.1	66°E	132
II-8	1977-34B	35,782	35,792	4.0	1436.0	180°E	91
II-11	1978-113A	35,778	35,787	2.8	1435.8	130°W	72
II-15	1982-106A	35,782	35,788	0.6	1435.9	15°W	26

It had originally been planned to phase out the DSCS II spacecraft and replace them with DSCS IIIs, which have much greater jam resistance and survivability. The first DSCS III was launched with the fifteenth DSCS II in October 1982, and at that time it was intended that the second DSCS III and the sixteenth (and last) DSCS II should follow within a year. The DSCS II/III launches use Titan 34D/IUS boosters, but subsequent flights, involving pairs of DSCS IIIs, would employ the Shuttle. Back in 1981 the DoD had set the first DSCS III Shuttle mission for mid 1985 [11].

The high reliability of the spacecraft in orbit, plus the availability of in-orbit spares, caused the second Titan 34D/IUS mission to be postponed. An official of General Electric, manufacturer of DSCS III spacecraft, stated in June 1985 that it would go as soon as a launch vehicle became available [12], but this too seems to have been put back. The Shuttle date, however, was retained, and it was this that eventually got off the ground first, as mission 51-J, the second all-military flight.

Shuttle 51-J was launched on 3 October and, unlike mission 51-C, Two Line Orbital Elements were released for it. They showed it initially in a 28.5°, 469km by 476km orbit. By rev 7 this had been raised to 476km by 515km, a new altitude

record for the Shuttle. It landed after four days, having dispatched two satellites to synchronous orbit with the help of an IUS.

No elements were issued for the payloads or the IUS stages, and to date no submission to the UN containing them has been made. However, with a payload mass of only 2.1 tonnes a standard flight profile can be expected. The eight DSCS spacecraft which were in operation at the start of 1985 were still on their same stations at its end, implying that the new vehicles had not yet been brought into service.

There was a Titan 34D/IUS on the pad at Cape Canaveral in the late summer [13], but by the end of the year there had been no sign of the DSCS II/DSCS III launch. The DoD has currently scheduled two Shuttle flights from Cape Canaveral in 1986 and three in 1987. While one of the 1986 flights seems certain to be a DSP, and one of the 1987 flights is for SDI, it seems likely that at least one of the others will carry another pair of DSCS IIIs. In this case the value of a DSCS II/DSCS III launch seems very limited, and it may well have been cancelled completely.

7.2 Fleet Satellite Communications Program

The Fleet Satellite Communications Program (FLTSATCOM) programme is for communications between mobile users, mainly ships of the US Navy. Five spacecraft were launched, but the last, intended as an in-orbit spare, was damaged during booster separation. The other four spacecraft continue to function, and their status is given below:

FLTSATCOM Satellites at 1 January 1985

Name	Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Station	Months in Orbit
F-1	1978-16A	35,776	35,793	3.3	1435.9	100°W	83
F-2	1979-38A	35,738	35,838	2.0	1436.0	72°E	68
F-3	1980-04A	35,781	35,790	2.0	1435.9	23°W	59
F-4	1980-87A	35,775	35,800	1.2	1436.0	172°E	50

The first satellite in the second batch of vehicles had been scheduled for launch in December 1985, but during the year this was put back, presumably because of the continued good performance of the ones in orbit. The launch date for FLTSATCOM 6 is now April 1986.

7.3 Leasat Programme

The Leasat programme resulted from a directive from Congress in 1977 that if the US Navy wished to augment its first batch of FLTSATCOM satellites, it must do this by leasing channels rather than procuring actual spacecraft. This decision was reversed in 1981, when the second batch of FLTSATCOMs was approved, but by this time the Leasat programme had been started.

The first two Leasats were launched in 1984, and they were deployed as follows at the start of 1985:

Leasat Satellites at 1 January 1985

Name	Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Station	Months in Orbit
L-2	1984-93C	35,777	35,797	3.2	1436.0	105°W	4
L-1	1984-113C	35,727	35,846	3.4	1436.0	15°W	2

The Shuttle schedule at the start of the year showed Leasat 3 on mission 51-D in March and Leasat 4 on 51-I in August. Mission 51-D actually took off on 12 April, and Leasat 3 was ejected from the Shuttle's payload bay 23 hours later, to become object 1985-28C. Within a few minutes it was clear that something major was wrong, for there were no signs of life from the satellite.

Leasat spacecraft are unique in that they are not powered up until the moment of release from the Shuttle, when a small lever is meant to be triggered. It was thought initially that the lever had not been triggered, and attempts were made to snag it using a "flyswatter" attached to the remote manipulator arm. Soon it was realised that this was not the cause of the failure, and the spacecraft had to be abandoned in its 315km by 460km parking orbit.

During the summer plans were drawn up to rescue Leasat 3 on mission 51-I, which would also carry Leasat 4 into orbit. The spacecraft design was modified to allow the event sequencer to be commanded from the ground, in case of a repeat of Leasat 3's problem. There was no question of bringing Leasat 3 back to Earth, because it was loaded with 5½ tonnes of rocket propellant. Instead, a bypass unit would be fixed to the satellite while it was held in the payload bay, and then it would be released again.

Mission 51-I was launched on 27 August and Leasat 4 was ejected two days later. Its motors worked according to plan, placing it, after five burns, in an orbit of 35,447km by

35,870km, inclined at 3.7°. Within a few days it was on station at 178°E. Meanwhile the dramatic rescue of Leasat 3 was unfolding. The satellite was captured and the bypass unit attached during an EVA on 31 August, and spun up and released during a second EVA on the next day.

Leasat 3 responded immediately to commands from the ground, but it would not be possible to fire its motors until they had thawed out, a process that was expected to take around eight weeks. No sooner had Leasat 3 been brought back to life than problems appeared with Leasat 4. Check out and testing of the satellite began on 4 September, a day after reaching synchronous orbit. Two days later its communication system failed, and despite repeated efforts from ground controllers the satellite could not be brought back to life, and it had to be written off as a total loss [14].

Leasat 3's motors thawed out as hoped, and they were fired on 27 October, raising the orbit to 35,604km by 36,067km. It had been intended to station Leasat 3 at 77°E, but when Leasat 4 failed it was decided to put Leasat 3 in its slot. Leasat 3 was actually stationed 4° to the west of Leasat 4, presumably to avoid radio interference. Testing was planned to last a month, and then the satellite would ready for the Navy to use. This would allow Hughes Communications Inc, the owners of the satellites, to meet their first contract milestone, which called for three operational satellites by 30 November 1985.

The second milestone, four operational satellites by 31 March 1986, would not be met due to the failure of Leasat 4. A fifth spacecraft had been built as a spare, and when the initial troubles developed with spacecraft number 3 it was decided to launch Leasat 5. A date was set towards the end of the year, but the failure of Leasat 4 made Hughes delay this until the cause was found and corrected. Leasat 5 is now scheduled to go on mission 61-L in November 1986.

7.4 Satellite Data System

The Satellite Data System (SDS) provides critical communications links to strategic forces operating in polar regions and data relays for the Satellite Control Facility.

The DoD is very reluctant to talk about this programme, and the barest orbital data is released. The analysis in the 1984 review showed that only two spacecraft were needed for a full system, but it seems that at least one in-orbit spare is maintained. Taking the active satellites as those less than five years old gives the status of the system as:

SDS Satellites at 1 January 1985

Satellite	Months in Orbit
1980-100A	48
1981-38A	44
1983-78A	17
1984-91A	4

The tenth operational SDS satellite was launched on 8 February, to become object 1985-14A. Data submitted to the UN showed it in an orbit of 400km by 39,700km, inclined at 63° and with a period of 712.2 minutes.

The DoD reportedly had only five Titan 3B launch vehicles left in mid 1983 [15], and 1985-14A used the fourth since then. This would imply that just one more SDS will be launched on an expendable booster.

8. NAVIGATION

8.1 Navy Navigation Satellite System

The Navy Navigation Satellite System was in its twenty first year of operation at the start of 1985. It consisted of a set of five satellites, as follows:

Transit and Nova Satellites at 1 January 1985

Name	Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Months in Orbit
Transit O-13	1967-48A	1067	1095	89.7	106.9	211
Transit O-20	1973-81A	891	1137	90.0	105.5	134
Transat	1977-106A	1063	1105	89.8	107.0	98
Nova 1	1981-44A	1084	1272	90.0	109.0	43
Nova 2	1984-110A	1155	1201	90.1	109.0	2½

The early Transits were built by the Applied Physics Laboratory of Johns Hopkins University, but the final batch of 15 were produced by RCA. Of the RCA vehicles only three had been launched by the start of 1985 (O-18, O-19 and O-20), because of the high reliability of the satellites in orbit. The rest were in storage. However, the Scout booster programme had been running down for some time, and the Navy decided in 1983 to launch the remaining ones and store them in orbit. The Scout's performance would allow two satellites to be launched on each booster, and the programme was christened Stacked Oscars on Scout (SOOS). The first launch was planned for 1985 [16].

The first SOOS launch came on 3 August, placing Transit O-24 in a 1005km by 1262km orbit and O-30 in a 1004km by 1262km orbit. Both orbits were inclined at 89.8° with periods of 108.0 minutes, and in a plane midway between Nova 1 and Nova 2. Although it had been originally planned to put the two satellites in storage, O-30 joined the operational set. O-24 was put in standby mode, however, transmitting on a maintenance frequency only.

8.2 Navstar Global Positioning System

The Navstar programme had six operational satellites at the start of 1985, arranged in two orbital planes 120° apart. The spacing between satellites within the planes was approximately 45°. Their orbital data was as follows:

Navstar Satellites at 1 January 1985

Name	Satellite	Perigee (km)	Apogee (km)	Incl (°)	Period (min)	Months in Orbit
First Plane						
Navstar 4	1978-112A	20,078	20,285	63.2	718.0	73
Navstar 8	1983-72A	19,904	20,462	62.8	718.0	18
Navstar 9	1984-59A	20,029	20,335	62.6	718.0	6½
Second Plane						
Navstar 3	1978-93A	20,100	20,265	64.0	718.0	75
Navstar 6	1980-32A	19,913	20,452	63.8	718.0	56
Navstar 10	1984-97A	19,955	20,410	63.3	718.0	4

The final Block I spacecraft was scheduled for launch in August, but did not actually leave the pad until 9 October. It was placed in a 543km by 20,710km orbit, which was circularised 33½ hours later to 19,570km by 20,526km. Three days later the spacecraft's groundtrack was stabilised by lowering the orbit to 19,821km by 20,538km, inclined at 63.4° and with a period of 717.9 minutes. The satellite was positioned in the same plane as Navstars 4, 8 and 9, becoming the new "lead" vehicle, 42° ahead of Navstar 4.

Future Navstars will be of the larger Block II design, and will be launched on the Shuttle. The first is scheduled for mission 71-A in January 1987.

9. ANTI-SATELLITE (ASAT)

The US anti-satellite (ASAT) system entered flight testing in 1984. The first test, on 21 January, was to demonstrate the operation of the F-15/missile combination, and no Miniature Vehicle (MV) homing head was carried. The test was a success. The second test, on 13 November, did carry an MV, and was intended to prove the operation of its tracking and guidance systems. It was aimed at a star, and the only public indications at the time were that it was a success.

In 1985 a General Accounting Office (GAO) report revealed that the test had been only partially successful. It later emerged that cryogenic lines carrying coolant to the MV's infra-red sensor had not retracted properly. Subsequent ground tests verified that this was caused by improper preparation of the missile [17].

The third test would be the first against an actual target. A special satellite, known as the ITV (Instrumented Test Vehicle), had been developed for use as the ASAT target. It consisted of a 2m diameter balloon which could vary its reflectance to match Soviet satellites. Pairs of ITVs were to be launched on Scout boosters. The test had been delayed many times, but was planned for March as 1985 began.

The delays continued during the year, and the GAO report, released on 14 June, recorded that there were still 30 "technical concerns" with system, 16 with the missile and 14 with the target [18]. On 3 July the DoD announced that the test had been postponed indefinately, because of technical difficulties with the target.

Six weeks later, on 20 August, the Pentagon announced that the test would be made against an old satellite instead of the ITV, and the same day President Reagan gave formal notification to Congress of the test. Congress required 15 days' notice of the test, and this would allow it to take place from 4 September onwards.

The target chosen for the test was the Solwind satellite, launched on 24 February 1979. Also designated P78-1, this satellite was part of the Space Test Program, but was now no longer active, although it was transmitting. It was in a 516km by 546km orbit, inclined at 97.6°. For the test a pass over the Western Test Range off the coast of California was required, and on 4 September it would make one in the early afternoon. If all went as planned, the intercept would be at 13:43 PDT (20:43 GMT).

It had been thought initially that the notification period would expire at midday on 4 September, but during the period the DoD's legal experts concluded that it would not expire until midnight. The test on 4 September was therefore scrubbed [19]. Solwind's groundtrack repeated every nine days, so it was rescheduled for 13 September. On this day everything went as planned, and the DoD described the test as "flawless".

The F-15 carrier aircraft took off from Edwards AFB at 12:34 PDT and flew to a point over the WTR approximately 400km off the Californian coast. Solwind crossed the Equator at 118°W at 13:33 PDT, travelling slightly west of due north. Launch occurred at an altitude of 11,600m, while the F-15 was in a 60° to 65° climb and flying at just under Mach 1.0. The launch conditions were critical to the success of the test, requiring the pilot to fly a predetermined trajectory to a high degree of accuracy [20]. Intercept took place, it was announced, at 13:42 PDT.

The DoD has released very little data on the ASAT's flight profile, but it is possible to reconstruct it from known data on the rocket stages it uses, and a few simple assumptions. Photos of the sequence show the missile igniting very soon after launch, and pulling up sharply. At the moment of intercept the target was about 500km off the coast, so the ASAT's climb must have been almost vertical.

The reconstruction is shown in figure 1. According to this, the SRAM first stage fired for 43 seconds, taking the ASAT to an altitiude of 57km and a vertical velocity of 2.4km/sec. The Altair second stage then took over, firing for 29 seconds. Burnout occurred at 112km altitude, with a velocity of 7.2km/sec. Prior to separation the MV was spun up to 20revs/sec to provide stability.

The rest of the flight was essentially coasting, with the MV's bank of 56 solid rockets providing small impulses to correct its path. Impact came just over two minutes after launch, 525km up, above the location 32.4°N, 125.5°W. At this instant the MV was moving upwards with a velocity of 6.7km/sec, while the target was moving horizontally at 7.6km/sec. The relative velocity of impact was 10.1km/sec, and both target and interceptor were destroyed instantaneously. The track of the target satellite is shown in figure 2.

A further interesting figure can be deduced from the reconstruction. If the ASAT had not hit its target it would have reached an altitude of nearly 2800km before starting its descent. This puts an upper limit on the target altitudes for the ASAT, although it may be that the ultimate limit is imposed by the life of the cryogens used to cool the IR seeker. It would take the ASAT 14½ minutes from launch to reach its apogee, and there does not appear to be any active system of cooling in the MV.

Following the test the DoD said that it expected to receive the re-worked ITVs from their manufacturer within a week [21], and the first pair were finally launched, from Wallops Island, on 13 December. One entered an orbit from 313km to 774km inclined at 37.07°, and the other an orbit from 315km to 772km inclined at 37.07°. Each was housed in a cylindrical container, and would only be inflated just before a test. At the time of the launch the ITVs were to be used in tests in the first and second quarters of 1986.

It was, however, to be Congress that had the last say in the matter. On the same day that the ITVs were launched Congress passed an amendment to the DoD's FY86 budget. This prohibited any further testing against objects in space unless the Russians resumed testing of their ASAT. The ban will last until the end of FY86 (i.e. 30 September 1986) [22].

10. RESEARCH AND DEVELOPMENT (R&D)

10.1 Geosat

The US Navy's Geosat satellite is to measure the precise shape of the ocean surface, using a radar altimeter. The aim of this is to produce a better model of the Earth's gravitational field, and as such it will be a continuation of the work started by Skylab and Seasat. Besides basic research in geodesy, this data will be used in generating the guidance programs for the Trident 2 missile [23].

Geosat was initially scheduled for launch in March 1983, but this date slipped, and by the start of 1984 it was set for the following September. The launch did not materialise in 1984, but as 1985 began it appeared imminent. It came, at last, on 13 March. An Atlas E booster placed the 635kg spacecraft in a 760km by 817km, 108.0° orbit, very similar to its predecessor Seasat.

10.2 GLOMR

The second military R&D satellite to be carried into space in 1985 was GLOMR, the Global Low Orbiting Message Relay satellite. Sponsored by the Defense Advanced Research Projects Agency, GLOMR is to test the use of a simple relay satellite to control isolated sensors on the ground and to pass data from them to ground stations in the US.

The stimulus for this was the development by the Russians of techniques for hiding their missile-launching submarines under the polar ice cap, breaking through the ice to launch their missiles. A possible way of keeping track of the submarines would be to place a number of sonar sensors on the ice cap. They would then be interrogated by a relay satellite such as GLOMR at regular intervals [24].

GLOMR was carried aboard Shuttle 51-B when it was launched on 29 April, but could not be ejected from its Getaway Special canister because two switches did not operate [25]. The satellite was brought back to Earth and re-launched on mission 61-A on 30 October. The next day deployment went according to plan, placing GLOMR in a 57.0°, 318km by 330km orbit.

10.3 Teal Ruby

The Teal Ruby satellite, to demonstrate the detection and tracking of aircraft from space, had suffered many delays, but was finally set for the first Shuttle launch from Vandenberg AFB, mission 62-A [26]. In late 1984 the launch was put back

from October 1985 to early 1986, and it is now planned for July 1986.

Footnote: The loss of the Shuttle on 28 January 1986 occurred while this review was being prepared. The launch schedules referred to here are from the latest Shuttle manifest prior to this, and may be expected to change somewhat as a result of the accident.

DEFENSE PAYLOADS LAUNCHED IN 1985

NAME	DATE	LAUNCH VEHICLE	SITE	COMMENTS
1985-10B	24 Jan	Shuttle 51-C/IUS	CC	Magnum
1985-14A	8 Feb	Titan 3B/Agena D	VAFB	SDS
1985-21A	13 Mar	Atlas E	VAFB	Geosat
1985-28C	12 Apr	Shuttle 51-D	CC	Leasat 3
1985-66A " B	3 Aug "	Scout "	VAFB "	Transit O-24 Transit O-30
1985-76D	27 Aug	Shuttle 51-I	CC	Leasat 4
none	28 Aug	Titan 34D	VAFB	KH-11 failure
1985-92B " C	3 Oct "	Shuttle 51-J/IUS "	VAFB "	DSCS III DSCS III
1985-93A	9 Oct	Atlas E/SVS	VAFB	Navstar 11
1985-104B	30 Oct	Shuttle 61-A	CC	GLOMR
1985-114A " B	13 Dec "	Scout "	WI "	ITV 1 ITV 2

REFERENCES

All orbital data used in the review has been derived from NASA's Two Line Orbital Elements unless specified otherwise.

1. A Kenden, "US Military Satellites, 1983", JBIS, February 1985.
2. A Kenden, "US Military Activities in Space - 1984", distributed privately, 1985.
3. Aviation Week and Space Technology, 18 November 1985, p 26.
4. Aviation Week and Space Technology, 9 September 1985, p 15.
5. Aviation Week and Space Technology, 10 February 1986, p 20.
6. Aerospace Daily, 9 February 1984, p 228.
7. The Observer, 27 January 1985.
8. The Washington Post, 19 December 1984.
9. Aviation Week and Space Technology, 18 March 1985, p 115.
10. Defense Electronics, September 1984, p 73.
11. Aviation Week and Space Technology, 7 October 1985, p 24.
12. Aerospace Daily, 10 June 1985, p 218.
13. Aerospace Daily, 5 September 1985, p 19.
14. Aviation Week and Space Technology, 23 September 1985, p 21.
15. Flight International, 23 July 1983.
16. Flight International, 22 October 1983.
17. Aerospace Daily, 23 August 1985, pp 297-8.
18. Status of the U.S. Antisatellite Program, General Accounting Office, June 1985.

19. Aerospace Daily, 6 September 1985, p 278.

20. Aviation Week and Space Technology, 7 October 1985, pp 18-9.

21. Aerospace Daily, 17 September 1985, pp 81-2.

22. Air et Cosmos, 4 January 1986, p 31.

23. Aviation Week and Space Technology, 19 July 1982, p 31.

24. Aviation Week and Space Technology, 15 April 1985, pp 14-6.

25. Aerospace Daily, 6 June 1985, p 205.

26. A Kenden, "Tracking Aircraft from Space", Satellite Technology, July 1985.

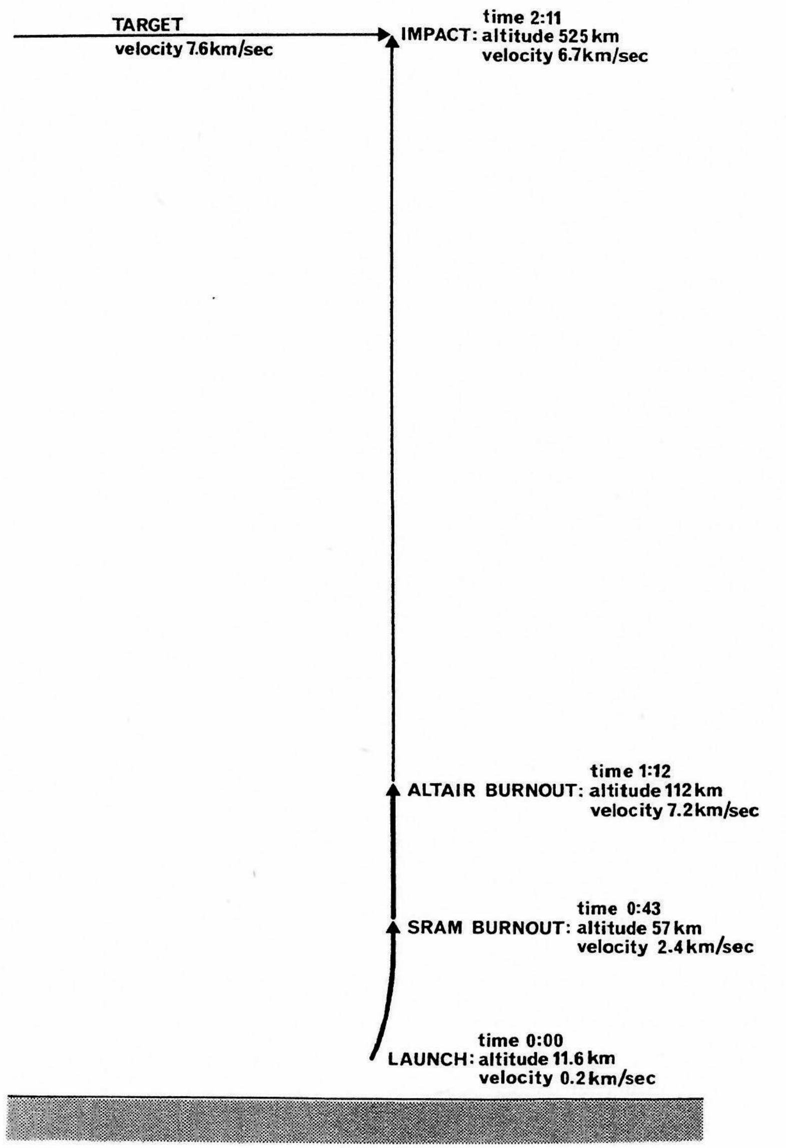


Figure 1: ASAT Flight Profile

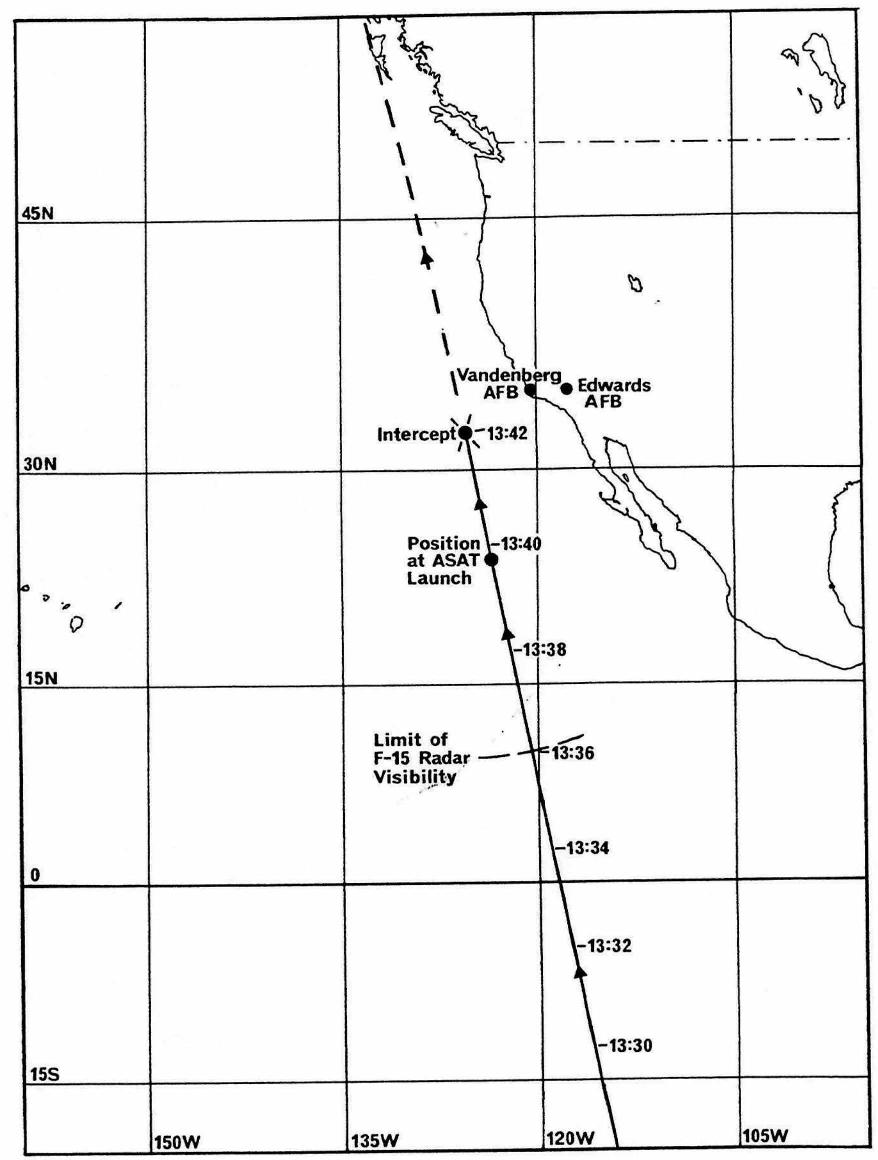
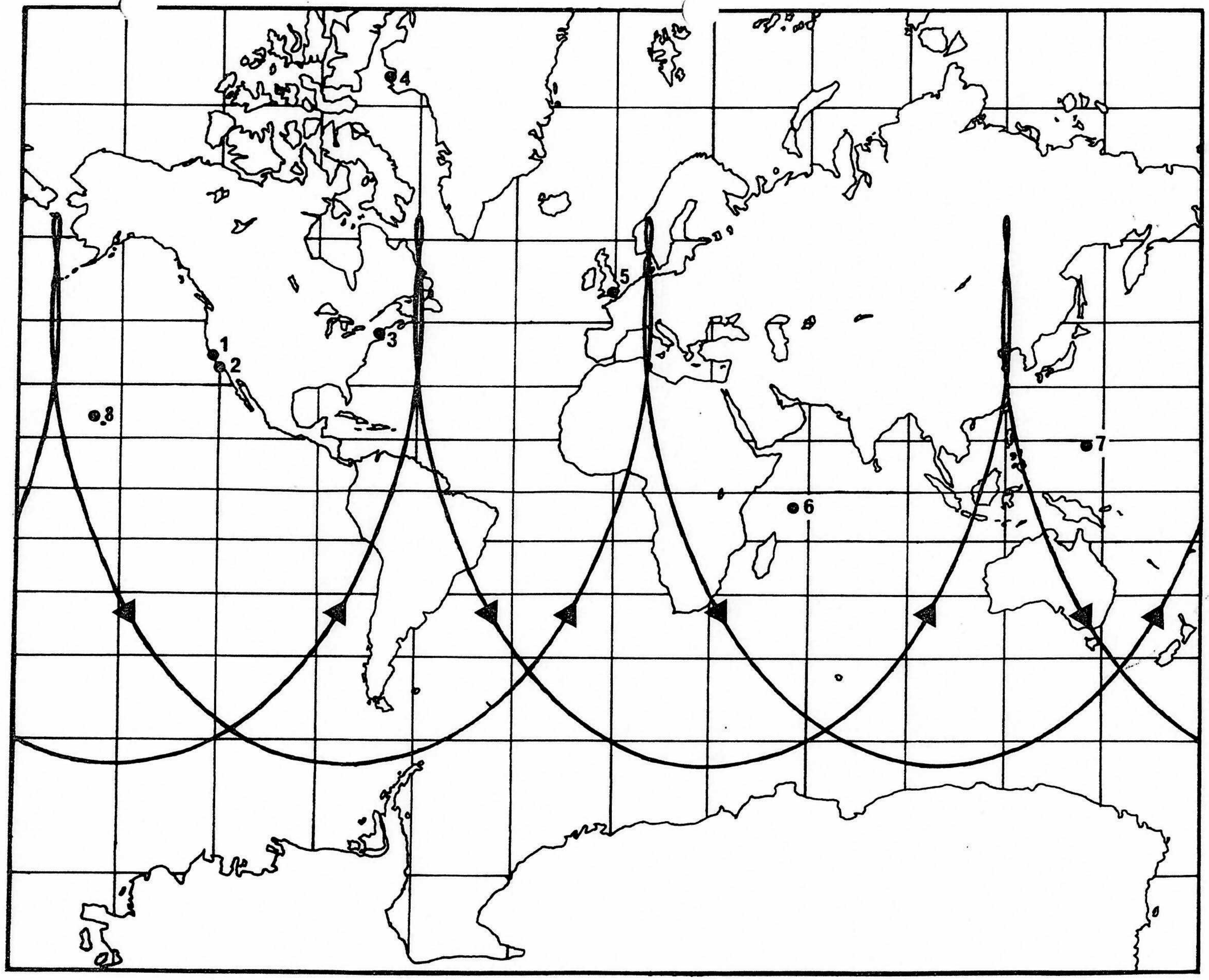


Figure 2: ASAT Target Groundtrack



SCF Stations

1 Sunnyvale
2 Vandenberg AFB
3 Manchester AFS
4 Thule
5 Oakhanger
6 Mahe Island
7 Guam
8 Oahu

Fig 2. Groundtracks of SDS Satellites and Positions of SCF Stations