US MILITARY SATELLITES, 1983

ANTHONY KENDEN
Teddington, Middlesex, England.

This paper reviews US military satellites launched in 1983. The first part describes the programmes in operation as the year began and gives details of all the functioning spacecraft they involved. It also considers what launches could have been predicted for the year at that time. The second part discusses the events in space of 1983 and is concerned for the main part with the missions launched during the year.

1. INTRODUCTION

The US Department of Defense entered 1983 with about 60 satellites in operational use. They ranged from a weather satellite that had been in space for just 11 days to a navigation satellite that had been in daily use for over 15 years. Some programmes were in fine shape, with a full complement of prime satellites, backed-up by in-orbit spares, while others were sorely in need of replenishment.

1983 would see eight military space launches, covering a wide range of missions. While all these appear to have been completely successful there were also some disappointments. What had been planned as the first all-DoD Shuttle flight was first re-oriented and then cancelled and launches to synchronous orbit for at least one other programme were put off until 1984.

2. MILITARY SPACE PROGRAMMES AND THEIR STATUS AT THE END OF 1982

The activities of the US military services can be divided into eight categories of operational programmes, and research and development. The following sections describe the categories in turn and show what launches could be predicted for 1983 as 1982 drew to a close.

2.1 Photo Reconnaissance

Photo reconnaissance programmes have accounted for more launches than any other item in the entire US space effort; by the end of 1982 there had been 265 launches in support of photo reconnaissance programmes, amounting to over 30% of the whole US total.

Initial development efforts started in the late 1950's and the first test satellite, Discoverer 1, was launched in February 1959. Eighteen months later a great step forward was taken when Discoverer 14 completed the first fully successful mission, culminating in the mid-air recovery of a capsule containing reconnaissance photographs taken from space. Two parallel operational programmes followed, one producing high resolution views of small areas ("close look"), and the other providing low resolution coverage of large areas ("area survey"). These two programmes continued throughout the 1960's, averaging nearly 20 launches a year between them, but in 1971 a new type of photo reconnaissance spacecraft was introduced. Known as Big Bird, it combined the two functions of the earlier programmes and in its wake the area survey missions were phased out and the close look missions reduced in frequency [1].

Big Bird was the mainstay of photo reconnaissance activities for five years until the most recent class of satellite, the KH-11, was introduced. Photo reconnaissance operations are now carried out to a regular pattern. Two KH-11 satellites, whose useful lives are measured in years, are kept in orbit all the year round to carry out routine day-to-day observation. The imagery they produce has only moderate resolution, so when more detailed views are required a Big Bird or close look satellite is launched. These supplementary flights average about one a year, alternating between the two types of vehicle. Big Bird flights last six to seven months, giving high resolution coverage; close look flights provide even better resolution, but last only three to four months [2].

All three types are de-orbited at the end of their missions, so it is a simple matter to determine what operational satellites there are at any given time by looking at those in orbit. At the end of 1982 the only photo reconnaissance satellites in orbit were the two KH-11s (Table 1).

TABLE 1. KH-11 Satellites at 31 December 1982.

	Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
1981-85A	276	471	97.0	92.0	16
1982-111A	268	474	97.0	92.0	1½

1981-85A and 1982-111A were the fourth and fifth KH-11 satellites, and the lives of their predecessors were 25, 38 and 33 months respectively. It was something of a surprise when the third KH-11 was de-orbited after only 33 months in space, but an analysis of its orbital behaviour suggested that it suffered some sort of failure (probably in June 1982). One would therefore expect the trend of increasing lifetimes set by the first two craft to be continued by 1981-85A and 1982-111A, with the former operating until the summer of 1984 and the latter into the autumn of 1985. In other words, no KH-11 launches seemed likely for 1983.

A supplementary mission, on the other hand, did seem likely in 1983, following the pattern of previous years. In 1980 there had been a Big Bird mission, in 1981 a close look, in 1982 a Big Bird, and so the obvious candidate to fly in 1983 was a close look satellite.

Having said this, reports in the press had stated that two Titan 34Ds would be launched from Vandenberg AFB in 1983 [3]. The Titan 34D launcher is produced in two variants, an East Coast version and a West Coast version. The East Coast version is intended to take over the role of the Titan 3C, sending payloads to synchronous orbit from

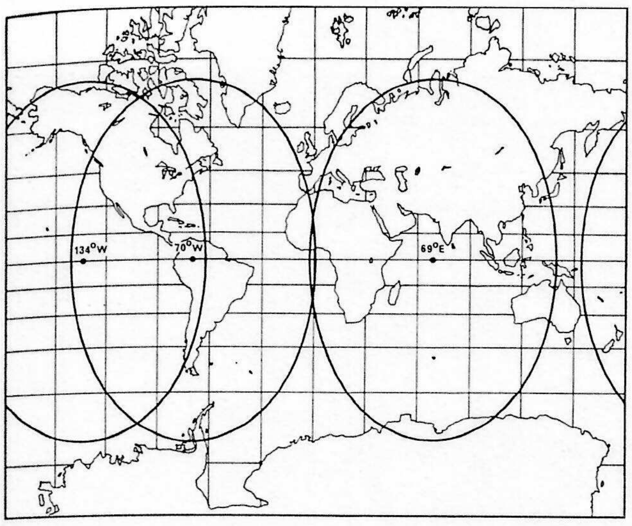

Fig. 1. DSP satellite coverage.

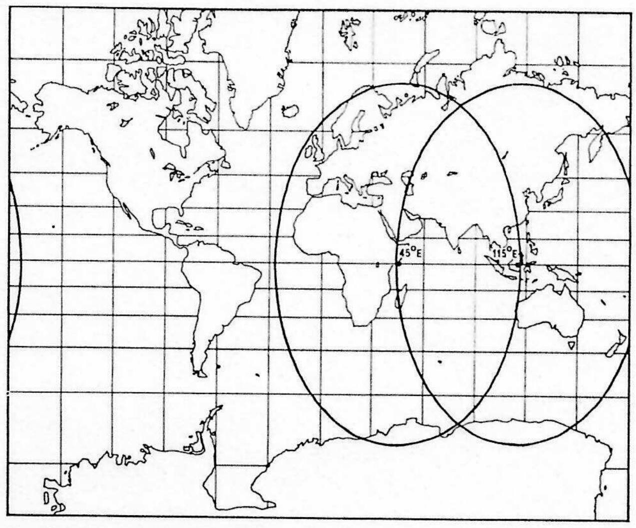

Fig. 2. Rhyolite satellite coverage.

Cape Canaveral. The West Coast version is to take over the role of the Titan 3D, sending payloads to low polar orbits from Vandenberg. As of the end of 1982, only one Titan 34D had been launched, and this was an East Coast version, but it had been stated that no test launches were planned – all flights would carry operational payloads [4].

The only payloads that had used the Titan 3D had been Big Birds and KH-11s, so presumably the payloads for the two reported Titan 34D launches in 1983 would be vehicles of these classes. A Big Bird payload for one flight seemed understandable, producing a repeat of 1979, when both a close look and a Big Bird were orbited, but just what payload the other launch would carry was not at all clear.

2.2 Missile Early Warning

Missile early warning satellites have the same ancestry as photo reconnaissance satellites, but their early efforts were much less successful. Severe problems were experienced with the first few test missions and the programme was cut back to a research and development effort in 1962.

The search for solutions was ultimately successful and the first launch of a new programme incorporating them came in August 1968. Known as Program 949, this was primarily a proof-of-principle project and the full operational programme followed two years later. This latter programme is now referred to as the Defense Support Program (DSP) and it centres on the use of large satellites deployed in synchronous orbit [1].

DSP satellites initially occupied two stations in synchronous orbit, one over the Indian Ocean to watch for ICBM launches and one over South America to watch for SLBM launches. However, during the 1970's the Soviets introduced a new class of SLBM which had a much longer range, so that the submarines carrying it could operate further from the US coastline. To counter this, the South America DSP station was replaced by two stations, one over the West Atlantic and one over the East Pacific [2]. Figure 1 shows the areas that are visible from the three standard DSP stations.

By the end of 1982 there had been ten DSP launches, but only five of the satellites remained in operational service. Just which satellites are operational at any particular time can be deduced from their orbital behaviour. A satellite in synchronous orbit is subject to perturbations caused by the irregular shape of the Earth and the attractions of the Sun and the Moon. The effect is to make the satellite drift off station and every couple of months a small manoeuvre is required to nudge it back to its desired position. It is now the practice of the US Air Force whenever a synchronous orbit satellite has completed its useful life it is ejected out of that orbit so as not to interfere with other operational satellites. Monitoring the locations and drift rates of these satellites provides a simple indicator of their status.

The DSP satellites that were operational at the end of 1982 consisted of three primes and two in-orbit backups as shown in Table 2.

TABLE 2. DSP Satellites at 31 December 1982

	Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Station	Months in Orbit
Prime						
1977-07A	35,779	35,797	4.4	1436.2	69°E	71
1981-25A	35,777	35,790	0.5	1436.0	134°W	21
1982-19A	35,769	35,796	1.3	1435.9	70°W	10
Back-Up						
1976-59A	35,775	35,799	4.9	1436.2	75°E	78
1979-53A	35,727	35,848	0.9	1436.2	85°W	43

No figures have been published for the design lifetimes of the DSP satellites, but comparison with contemporary vehicles would suggest about five years (i.e. 60 months). Whatever the actual value, 1976-59A and 1977-07A must have been approaching the ends of their useful lives at the end of 1982 and replacement launches seemed to be imminent. However, 1982-19A had used the last Titan 3C launcher [5] and any subsequent launches would have to use the East Coast version of the Titan 34D. Besides the two West Coast Titan 34Ds to be launched in 1983 that have already been mentioned, there were reports of one, or possibly two, East Coast launches in 1983. The one definitely planned launch would carry two communications satellites but no payload had been inidicated for the second. In fact, there are only two possible candidates for such a launch: a DSP satellite or a Chalet ELINT satellite (see Section 2.3). At the end of 1982 there was no obvious preference for one or the other of these programmes so a DSP launch in 1983 appeared to be a reasonable possibility at that time.

2.3 Electronic Intelligence (ELINT)

Electronic intelligence satellites, sometimes referred to as ferrets, made their debut in 1962, with the first in a series of missions characterised by medium altitude, long life circular orbits. A year later a complementary effort began in which small subsatellites were deployed in similar orbits after ejection from photo reconnaissance satellites. Both programmes continued at a steady pace until 1971, when the last launch dedicated wholly to an ELINT mission took place. Although the subsatellites continued to appear, the satellite flights seemed to have come to an end.

At just about this time the role of carrying ELINT subsatellites was being taken over by the Big Birds, so it was suggested that with the change-over a new class of subsatellite was introduced which performed the missions of both the earlier subsatellites and the dedicated satellites [1]. At the end of 1982 a total of 11 ELINT subsatellites remained in orbit, three of the earlier class and eight of the Big Bird-related class. There is no way of telling whether a particular subsatellite is still functioning from its orbital data alone, as the craft do not manoeuvre during operations or de-orbit at the end of their lives. However, their instruments probably do not function for more than an average of about five years, and at the end of 1982 there were just four subsatellites with ages less than this figure. In the absence of any other indications, these can be considered to be the operational craft at the year's end (Table 3).

TABLE 3. ELINT Subsatellites at 31 December 1982

	Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
1978-29B	574	586	95.8	96.3	57
1979-25B	548	554	95.8	95.7	45
1980-52C	1324	1329	96.6	112.2	30
1982-41C	693	699	96.0	98.7	8

Any modern Big Bird launch can be expected to carry one or possibly two ELINT subsatellites and, as has been noted earlier, a Big Bird flight in 1983 appeared a strong possibility.

In 1979 reports started appearing of a new dedicated class of ELINT satellite code-named Rhyolite, which had consisted of four launches between 1973 and 1978. Unlike the standard ELINT craft, whose object was to monitor radio and radar traffic, Rhyolite was intended to intercept telemetry from Soviet missile tests. The Rhyolite satellites operated from synchronous orbit, following launch by Atlas-Agena vehicles, and these two facts had led observers to classify them at the time as a continuation of the Program 949 early warning series. Now it was clear they had a different role.

The reports indicated that two of the satellites were primes and two were back-ups. After the fourth launch the Atlas-Agena pad at Cape Canaveral was de-activated and no further launches could be made [2]. Very little other data on Rhyolite have come to light and the satellites' orbital data are extremely sketchy, having never appeared in the standard sources. Table 4 gives their reported positions [6] but it has not been possible to verify them. Figure 2 shows the areas they cover if these positions are correct.

TABLE 4. Rhyolite Satellites at 31 December 1982.

	Station	Months in Orbit
Prime		
1973-13A	45°E	118
1977-38A	115°E	67
Back-Up		
1977-114A	?	61
1978-38A	?	57

Since the satellites are never listed in the *Two Line Orbital Elements* it is not possible to determine whether they are station-keeping or drifting and thus whether they are operational or retired. The times that they had been in orbit by the end of 1982 indicated that some, if not all, should have been due for replacement. No more Rhyolite launches could have been expected so any replacements would have to come as part of another programme. The most likely choice for this was a programme with the code name Chalet, details of which are now only beginning to emerge.

The origins of Chalet are obscure but appear to be related to an earlier programme known as Argus. In June 1975 a Titan 3C placed a satellite in synchronous orbit and observers immediately labelled it a DSP early warning satellite. It is now clear that this was the prototype Argus satellite whose job was to eavesdrop on microwave transmissions, particularly long-distance telephone calls [7]. It was reported that funds for an operational Argus programme were refused, as they were on two later occasions [6, 8]. What happened next is not certain, but the most likely explanation is that plans for Argus were revised or modified in some way and given the new name Chalet. In this form they finally found approval and the programme went ahead [9, 10]. One thing is certain; a second launch was made in June 1978 to be followed by a third the next year and a fourth in 1981.

Sparse orbital data have been published for the Argus/Chalet satellites and there have been no reports of their orbital stations. A reasonable estimate, given their mission, would be in similar slots to those of the Rhyolites (Table 5).

TABLE 5. Argus/Chalet Satellites at 31 December 1982

	Months in Orbit
1975-55A	90
1978-58A	55
1979-86A	39
1981-107A	14

There is no way of telling which are operational but their ages at the end of 1982 suggested that a launch in 1983 might have been required. Past launches had used Titan 3Cs so any launch in 1983 would have to use a Titan 34D. As noted earlier, there was a good chance of a Titan 34D launch to synchronous orbit in 1983, for whichever (Chalet or DSP) had the greater need.

2.4 Ocean Surveillance

The expansion of the Soviet Navy in the mid-1960's led the US Navy to consider using satellites to keep track on the movements of ships at sea. Formal studies started in 1968 and a mission to test the techniques involved was flown in December 1971. Also during 1971 the USN started using data from USAF photo reconnaissance satellites but in 1973 the whole effect underwent a major re-direction. Two projects emerged, code named White Cloud and Clipper Bow.

White Cloud was to be the technically simpler project, using passive radio to listen in to transmissions from target ships. Each satellite was to deploy a set of small subsatellites, equipped with receivers. By measuring the small differences in the arrival times of signals at the various subsatellites, the locations of the transmitting ships could be deduced. Clipper Bow was to employ the more complex technique of active radar to locate ships, similar to NASA's Seasat of 1978. In the interim, while the projects were being developed, the burden of ocean surveillance would be carried by aircraft, principally the U-2.

The first White Cloud was launched on 30 April 1976 and in the weeks that followed three subsatellites were released. A second launch in December 1977 created a similar cluster in an orbital plane 120° away from the first and a third launch in March 1980 completed the set.

The programme then suffered a serious setback; a launch into an orbital plane very close to that of the first cluster failed when its booster veered off course in December 1980. This was the second mishap involving an Atlas F in little over six months, so a detailed investigation of the status of the vehicle was called, but it seemed certain that a replacement launch would be made as soon as this was complete [2]. In the event, no launch came, although other Atlas F launches were resumed, and by the end of 1982 it was beginning to look as if White Cloud had been abandoned.

The orbits used by the White Clouds are at high altitude where the effects of atmospheric drag are negligible and the spacecraft do not make any obvious manoeuvres. In addition, it appears that the subsatellites are connected by fine wires. Therefore, there is no means of telling whether a particular satellite cluster is active from its orbital data alone. Furthermore, there has been no indication whether the fourth launch was to replace a failing cluster or to provide an in-orbit spare. Orbital data for all three clusters are in Table 6.

TABLE 6. White Cloud Satellites at 31 December 1982.

	Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
976-38A	951	1264	64.4	107.4	80
1976-38C	946	1269	63.4	107.4	
1976-38D	945	1271	63.4	107.4	
1976-38J	951	1265	63.4	107.4	
1977-112A	1038	1177	63.4	107.5	61
1977-112D	1035	1182	63.4	107.4	
1977-112E	1035	1182	63.4	107.4	
1977-112F	1037	1180	63.4	107.4	
1980-19A	1088	1127	63.5	107.4	34
1980-19C	1076	1140	63.5	107.4	
1980-19D	1076	1140	63.5	107.4	
1980-19G	1087	1129	63.5	107.4	

Whether any White Cloud launches could be expected in 1983 depended, of course, on whether the programme was still active or not. If it were, then at least one launch, to carry out the mission of the 1980 failure, could be expected. If it had been abandoned, then presumably the USN would continue to use aircraft for ocean surveillance, supplemented by data from photo reconnaissance satellites.

Meanwhile, design work on Clipper Bow continued. It had been planned to make the first launch in 1983, but the DoD decided not to go ahead with full development in 1979 and the next year the project was finally cancelled. In its place was created the Integrated Tactical Surveillance System (ITSS), which is to be a much more ambitious programme, involving the Air Force, Army and Marines as well as the Navy. Continuing development of ITSS was approved in May 1982, with the first launch several years away [11].

2.5 Nuclear Explosion Detection

The original role of nuclear explosion detection satellites was to keep watch for any tests carried out in space, in contravention of the Nuclear Test Ban Treaty of 1963. Satellites were launched in pairs into circular orbits at around 100,000 km in a programme named Vela. The first pair was launched in October 1963 and their payloads consisted of X-ray and gamma-ray detectors and neutron counters. The third pair, launched in July 1965, also carried ultraviolet sensors and visible light flash detectors called bhangmeters which enabled them to detect explosions in the Earth's atmosphere as well as in space.

By all accounts the Vela satellites performed remarkable well, exceeding their intended lifetimes and detection capabilities by a sizeable margin. A second generation of larger spacecraft was introduced in 1967 and they carried instruments to detect the intense electromagnetic pulse produced by a nuclear explosion, in addition to the standard Vela payload. The sixth and final pair was launched on 8 April 1970 and these were to be the last satellites wholly dedicated to detecting nuclear explosions. In future sensor packages for this would be flown "piggyback" on other mission satellites.

The first class of satellite to carry such a package was the DSP early warning satellites. It has not been revealed at which point in the DSP programme this began, but early in 1974 the Secretary of the Air Force commented that "these warning satellites have the capability to detect nuclear explosions above the ground and ultimately will replace current satellites which monitor the atmospheric nuclear test ban treaty" [12].

A year after this statement work started on a more sophisticated programme of nuclear explosion detection packages with the title Integrated Operational Nuclear Detection System (IONDS). These packages would be carried by Navstar satellites when they became operational and would include spacecraft-to-spacecraft data links to enable readouts from any part of the world to be viewed in real time. The mission of IONDS, however, will extend far beyond monitoring the Test Ban Treaty. Its primary function is to detect and locate nuclear explosions in time of war and to provide attack and damage assessments during protracted conflict [13, 14].

A prototype IONDS package was flown on the sixth Navstar in April 1980 and operational versions are to enter service with the eighth launch [15] (see Section 2.8).

In the meantime, the Vela satellites have soldiered on, far beyond their intended lives. Designed to operate for a minimum of 18 months, the last four spacecraft were reported to be still functioning in 1980 [16]. In December 1983 an advert for TRW, the manufacturer of the Vela spacecraft, was published in which it was claimed that three of them were still operating [17]. Orbital data for the last four Velas are given in Table 7, and it is clear that at least three of these were in use at the end of 1982.

TABLE 7. Vela Satellites at 31 December 1982.

Name		Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
Vela 9	1969-46D	88,877	131,805	57.8	6614.2	163
Vela 10	1969-46E	84,080	138,638	58.1	6700.9	163
Vela 11	1970-27A	105,044	117,700	56.9	6702.0	152
Vela 12	1970-27B	104,023	118,859	56.9	6707.9	152

2.6 Weather Observations

Military interest in weather satellites goes back to the

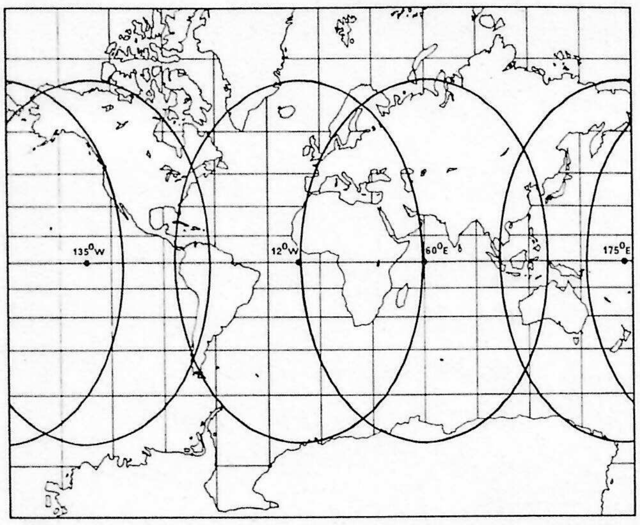

Fig. 3. DSCS satellite coverage.

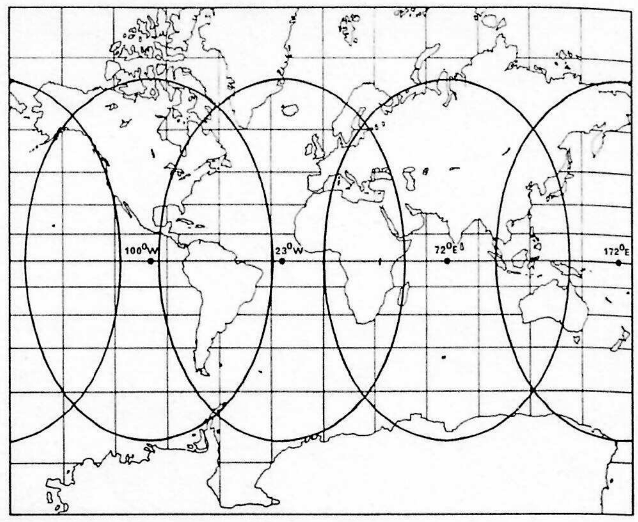

Fig. 4. FLTSATCOM satellite coverage.

earliest experimental flights carried out by NASA. The requirements of the civilian and military users eventually diverged and separate programmes were set up. The main aim of the civilian meteorologists is to gather weather data over the whole globe so that the overall processes that influence the weather can be understood and better forecasts produced. The military users, in contrast, are interested in detailed veiws of selected areas and they also want to examine the data in as near real time as possible. Their uses for this information are two-fold; firstly, to assist in the selection of targets for photo reconnaissance satellites, to ensure that they did not waste precious film on scenes obscured by clouds and, secondly, to support fleet and battle commanders in their daily operational planning.

The first military weather satellite was launched on 19 January 1965 but it was only in 1973 that the DoD officially acknowledged the existence of the programme, which became known as the Defense Meteorological Satellite Program (DMSP). Launches continued at the rate of about two per year, with periodic improvements when new versions or "blocks" were introduced. The complete DMSP system consists of two satellites in moderate altitude, Sun-synchronous orbits, with one making its northbound equator crossings at about 06:30 local time, and the other at about noon [18].

In recent years, however, the programme has been dogged by launch and equipment failures and for a period of almost two years it was virtually inoperable, leaving the DoD to rely on data from civilian weather satellites [19]. This situation was partially rectified by the launch of the first of a new generation of DMSP satellites, referred to as Block 5D-2, on 21 December 1982, and a launch in 1983 to provide the second of a pair required by the full system seemed at that time to be a strong possibility. The one working satellite was crossing the equator at about 06:15 local time, suggesting that if there was a launch in 1983, it would be a "noon satellite." The orbital data of the one working satellite at the end of 1982 are given in Table 8.

TABLE 8. DMSP Satellites at 31 December 1982.

	Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
1982-118A	811	823	98.7	101.2	⅓

2.7 Communications

The DoD and US military services have such a large and wide ranging requirement for satellite communications that there are now three separate programmes for this in operation, known as DSCS, FLTSATCOM and AFSATCOM.

The mission of the Defense Satellite Communications System (DSCS) is to carry high volume, high data-rate traffic between large, fixed ground terminals. An example of this is the large number of routine messages that pass daily between the headquarters of the US forces in Europe and installations in the continental USA. The first phase of DSCS was originally referred as the Initial Defense Communications Satellite Program and it consisted of a number, eventually 26, of small satellites in sub-synchronous orbits. In June 1966 an initial batch of seven satellites was launched on a single booster and the system was declared fully operational in July 1967 [20].

The second phase, known as DSCS II, depends on larger satellites in true synchronous orbits, with a full complement comprising four prime and two back-up spacecraft. The spacecraft were launched in pairs aboard Titan 3C rockets, of which the first were orbited on 3 November 1971. Two launch failures and a series of equipment problems delayed the achievement of the full set of six operational satellites, however, until the flight of the seventh pair, in November 1979 [21]. Figure 3 shows the areas covered by the four prime satellites.

Meanwhile, work on the third phase was gaining momentum. Initiated in 1974, DSCS III was to field still larger spacecraft with improved survivability, resistance to jamming and greater flexibility [22]. The first DSCS III satellite was launched with the 15th DSCS II on the Titan 34D flight of 30 October 1982. At the end of the year DSCS III-1 was in the midst of a period of extensive checkout before being handed over to its user, the Defense Communications Agency, while DSCS II-15 was being moved eastwards at the rate of just under a degree per day to its operational station. As 1982 closed, the orbital data for the DSCS satellites in use are shown in Table 9.

The DSCS II spacecraft have a design lifetime of five years and, as can be seen from Table 9 one of the prime satellites had been in orbit for nearly double that figure and another had exceeded it by eight months. One would therefore have expected a launch in 1983 and indeed press reports indicated that the second DSCS III would be launched with the 16th (and last) DSCS II on a Titan 34D in

TABLE 9. DSCS Satellites at 31 December 1982.

Name		Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Station	Months in Orbit
Prime							
DSCS II-4	1973-100B	35,779	35,797	4.6	1436.2	60°E	108
DSCS II-8	1977-34B	35,779	35,792	2.2	1436.1	175°E	68
DSCS II-11	1978-113A	35,780	35,792	1.1	1436.1	135°W	48
DSCS II-14	1979-98B	35,774	35,798	0.4	1436.1	12°W	37
Back-Up							
DSCS II-12	1978-113B	35,741	35,833	1.4	1436.1	66°E	48
DSCS II-13	1979-98A	35,777	35,791	0.5	1436.0	130°W	37
Being Deployed							
DSCS II-15	1982-106A	35,644	35,776	2.4	1432.2	34°W	2
DSCS III-1	1982-106B	35,727	35,857	2.4	1436.4	127°W	2

the latter part of the year.

The function of the Fleet Satellite Communications System (FLTSATCOM) is to relay moderate volume, moderate data-rate messages between mobile users and, as it name implies, this is mainly for ship-to-ship and ship-to-shore communications for the US Navy. The contract for developing the FLTSATCOM spacecraft was awarded in 1972 [23] and the first was launched on 9 February 1978. The initial part of the programme consisted of placing five spacecraft in synchronous orbit, four as primes and one as an in-orbit spare. The first four launches went without a hitch but the fifth satellite, the spare, was damaged during separation from its booster and is able only to provide limited communication facilities [24]. The coverage achieved by the four prime spacecraft is illustrated in Fig. 4 and data for all five are listed in Table 10.

TABLE 10. FLTSATCOM Satellites at 31 December 1982.

Name		Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Station	Months in Orbit
Prime							
FLTSATCOM 1	1978-16A	35,766	35,808	1.5	1436.2	100°W	59
FLTSATCOM 2	1979-38A	35,739	35,833	0.3	1436.1	72°E	44
FLTSATCOM 3	1980-04A	35,776	35,802	1.3	1436.2	23°W	35
FLTSATCOM 4	1980-87A	35,765	35,807	0.7	1436.1	172°E	26
Back-Up							
FLTSATCOM 5	1981-73A	35,665	35,915	5.5	1436.3	45°W	17

Like the DSCS II satellites, the FLTSATCOM craft have a design life of five years and Table 10 shows that the first was to exceed this in 1983 and the second was to be not far short of it at the end of the year. However, in 1977 Congress ruled that there should be no follow-on spacecraft after the first five but that in future the DoD should lease channels from commercially-owned satellites. A programme called Leasat, to fulfil the role of FLTSATCOM, is under way, but the first launch is was not expected until 1984 [25]. In 1981 Congress reversed its decision, allowing a contract to be awarded for three more FLTSATCOM spacecraft, in addition to Leasat, but the first of these will not be launched until 1985 [26]. Therefore, no launch activity associated with this programme could have been expected for 1983.

The third programme is the Air Force Satellite Communications System (AFSATCOM), whose function is to provide command and control of strategic nuclear forces, with a particular emphasis on retaining its capabilities during time of war. The main feature of its communications traffic is that it should be secure and resistant to jamming; the actual messages relayed are quite short and comparatively low data-rates can be used.

Unlike the other two communications satellite programmes, AFSATCOM does not have its own satellites, but instead uses channels on spacecraft from other programmes. At the present time this is restricted to FLTSATCOM and SDS spacecraft, but DSCS III will in the future carry some AFSATCOM transmissions [21]. At one time it was also planned to equip operational Navstar satellites with a single channel transponder for AFSATCOM, but this was cancelled [27].

Twelve of the 23 channels available on FLTSATCOM spacecraft are used by AFSATCOM [28], and these provide worldwide coverage between latitudes 75°N and 75°S, as can be seen from Fig. 4. For the majority of communications satellite users this would be more than adequate, but for AFSATCOM the lack of coverage over the North Pole would present a serious problem. To provide this trans-polar relay, AFSATCOM uses spacecraft of the Satellite Data System (SDS).

The SDS is one of the most highly classified of all US military space projects. Satellites in this programme use orbits similar to the Soviet Molniyas, with perigees of about 400 km and apogees of about 40,000 km. This gives a period of just under 12 hours and, combined with an inclination of 63.4°, causes the groundtrack to be stabilised in relation to the Earth's surface. Apogee is positioned at the northernmost part of the groundtrack, so that the satellite is able to relay communications over the pole for about eight hours each orbit. Three suitably space satellites can thus provide 24 hours a day coverage.

SDS spacecraft have other functions besides trans-polar relay for AFSATCOM. It was originally planned that they would act as a direct link between photo reconnaissance and early warning satellites while they were over the Soviet Union and their controllers in the United States [29], but this was abandoned for unspecified reasons in 1973 [30]. Instead, they are used to handle communications between the overseas ground stations and the Satellite Test Center in Sunnyvale, California that make up the USAF's Satellite Control Facility. It has been claimed, however, that the SDS spacecraft can act as a direct relay for the KH-11 satellites, owing to the latter's entirely digital imaging format [31]. It is also possible that SDS spacecraft perform ELINT activities, monitoring foreign radar transmissions.

The first satellite launched in the SDS programme were two experimental vehicles, placed in orbit in March 1971 and August 1973. The first operational satellite was launched on 10 March 1975, and the initial network appears to have been completed by the second and third spacecraft, which were launched two months apart in mid 1976. Two more were launched in 1978 and then there was a gap of over two years before the sixth, in December 1980. The seventh came on 24 April 1981.

None of these satellites is ever listed in the *Two Line Orbital Elements* or the *Satellite Situation Report*, so there is no way of knowing which are still in use. Only the last four launches were made within the five years to the end of 1982, so in the absence of any other indicator they will be considered as the operational ones at that time (three prime and one back-up?); their data are listed in Table 11.

If a design life of five years is assumed, then a launch in 1983 seemed to be a strong possibility at the end of 1982,

TABLE 11. SDS Satellites at 31 December 1982.

	Months in Orbit
1978-21A	58
1978-75A	53
1980-100A	25
1981-38A	20

given the ages of two of the satellites, and the critical need to keep a full system in operation.

2.8 Navigation Satellites

When the first artificial satellite was launched in October 1957, two scientists at the Johns Hopkins University's Applied Physics Laboratory noticed that the signals received from it exhibited a marked Doppler shift as the satellite approached, passed overhead and then receeded. If the orbit of the satellite and its transmission frequency were known, they argued, then the receiver's position could be determined by measuring the Doppler shift. At just this time the US Navy was looking for a way of improving the navigation and position-fixing capabilities of its nuclear submarines and here seemed to be the answer. Thus the Navy Navigation Satellite System, more commonly known as Transit, was born.

Development of Transit began in December 1958 and the first satellite was launched ten months later. The system was declared operational in January 1964 and released for use by the civilian community in 1967 [32].

Although the generation of a position fix requires only one satellite, the system as a whole requires a minimum of four satellites to be operating, so that the times at which no satellite is in view are kept to a minimum. At the end of 1982 there were five functioning Transits, plus the first of an improved version called Nova. The orbital data for these satellites are given in Table 12.

TABLE 12. Transit and Nova Satellites at 31 December 1982.

Name		Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
Transit 0-12	1967-34A	1040	1070	90.3	106.3	188
Transit 0-13	1967-48A	1061	1094	89.7	106.8	187
Transit 0-14	1967-92A	1032	1104	89.2	106.6	183
Transit 0-19	1970-67A	948	1208	90.2	106.8	148
Transit 0-20	*1973-81A*	*888*	*1134*	*90.0*	*105.4*	*110*
Nova 1	*1981-44A*	*1167*	*1189*	*90.0*	*109.0*	*20*

In addition to the spacecraft in orbit, there were 12 Transits and two Novas in storage, to be launched should any of those in orbit fail, or gaps appear in their coverage. The latter situation could arise in the following way; the launcher used is the Scout and the pointing control of its final stage is not particularly precise. As a result, the orbits achieved vary significantly from one launch to the next and so do the rates of orbital precession. These differing rates can mean that the planes of two satellites' orbits drift apart, giving rise to an unacceptably large gap in coverage.

Figure 5 shows the positions of the orbital planes at the end of 1982; it should be compared to the ideal arrangement of four satellites whose planes are separated by 45°. There are two gaps greater than 45° and, while the precessions were causing the large one to decrease, the smaller one was increasing. Therefore, a launch in 1983 seemed a moderate possibility.

It should be noted here that NASA, which carries out the actual launches for the Navy, included in its announced schedule for 1983 two such missions. There were, however, only call-up missions, to be made if required, rather than definite launch intentions. Indeed, each NASA launch schedule for the last several years has included one or two such entries.

In 1964 both the Navy and the Air Force started studying ways of providing more accurate fixes than Transit and ones which would compute altitude as well as latitude and longitude. These efforts were combined in 1973 into an all-service programme entitled the Global Positioning System,

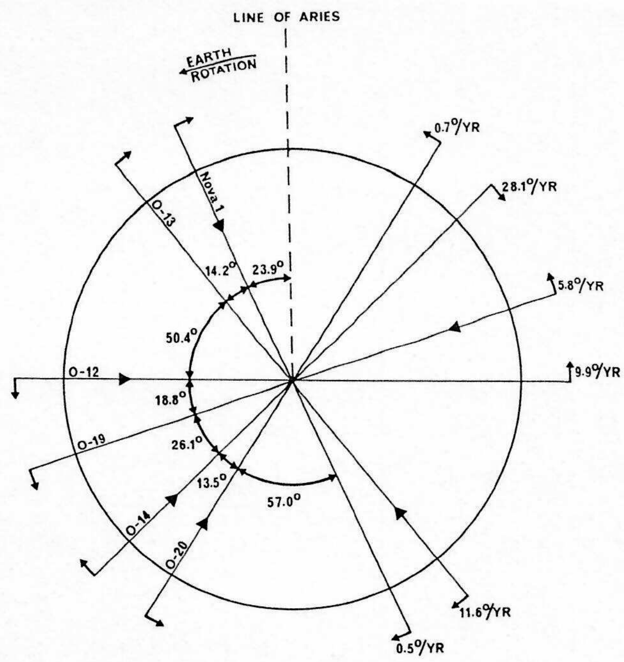

Fig. 5. Orbits of the Transit and Nova satellites on 31 December 1982, viewed from above the North Pole.

now more usually known as Navstar [33]. The principle of Navstar is to use four satellites simultaneously to achieve a three-dimensional fix without requiring the user to have an accurate measurement of time. In this way small, low cost receivers could be produced, making the system attractive to a wide range of potential users.

The orbit eventually chosen for Navstar was circular with a period of just under 12 hours. By using an inclination of 63.4° the groundtrack would be stabilised on the Earth's surface. Originally the full system was to consist of 24 satellites, eight in each of three orbital planes. In spring 1980 this was reduced to 18 satellites, six in each plane, as a means of cutting costs [34], and this was subsequently amended to three satellites in each of six orbital planes, plus three in-orbit spares [35].

The first phase was a long series of tests of the concept and the initial batch of four Navstar satellites was launched in 1978. The first two suffered a series of failures in their on-board clocks and, although they could still be used for some types of testing [36], Navstars 5 and 6 were launched as replacements in 1980. A seventh launch failed shortly after lift-off in December 1981. Data for the six satellites in use at the end of 1982 are given in Table 13.

TABLE 13. Navstar Satellites at 31 December 1982

Name		Perigee (km)	Apogee (km)	Inc (°)	Period (min)	Months in Orbit
Navstar 1	1978-20A	20,095	20,268	63.2	718.0	58
Navstar 2	1978-47A	19,949	20,413	64.0	718.0	56
Navstar 3	1978-93A	20,129	20,234	63.6	718.0	51
Navstar 4	1978-112A	20,109	20,252	63.2	717.9	49
Navstar 5	1980-11A	20,072	20,293	63.8	718.0	35
Navstar 6	1980-32A	19,954	20,409	63.4	718.0	32

In 1982 the DoD revealed that the eighth Navstar, carrying the first operational IONDS package, would be launched in mid-1983 [37].

2.9 Research and Development

The research and development missions form a vital adjunct to the operational programmes described above. They cover a wide range of topics, from investigations of the basic physical processes that influence the space environment, to evaluations of new technological concepts. Initially these missions were carried out by each service independently but in May 1965 they were consolidated into the Space Test Program (STP) and nowadays most R&D missions come under its auspices.

The most recent mission whose spacecraft was still in orbit at the end of 1982 was P78-1, launched in February 1979. The experimental nature of most STP satellites tends to lead to much shorter operating lives than those of operational programme satellites so it did not seem likely that any R&D satellites were still functioning at the year's end.

The amount of information about an R&D mission made public beforehand varies considerably and this was particularly true for missions that were announced for 1983. Reference was made to five flights but the accompanying data ranged from the mere fact that a launch was planned to a detailed mission description.

The first R&D satellite scheduled for 1983 was the US Navy's Geosat, to be launched by an Atlas F in March. The aim was to provide more precise data on the Earth's gravitational field to enable the mathematical model to be used in the Trident 2 missile guidance system to be refined. No details of the intended orbit were released but the fact that the launch was to come from Vandenberg suggested a near-polar orbit [38].

The second payload was again for the US Navy, this time using a modified Transit spacecraft launched by NASA on a Scout rocket. Known as Hilat (for High Latitudes), it was to investigate the distortion produced in radio and radar waves as they pass through auroral plasmas in the Earth's polar regions. This launch was planned for the summer of 1983 [39].

The two Navy missions were to be followed by two for the Air Force. Listed simply as AF1 and AF2, they were to be launched by NASA using Scout rockets from Wallops Island in August and December; no other details were made public [40].

The final R&D flight of 1983, and by far the most publicised, was to be STS-10. This would be the first all-DoD Shuttle flight when it was launched in December, carrying a free-flying satellite designated P80-1 plus an experiment-carrying cradle known as ESS-2. The P80-1 satellite would be released from the Shuttle when it was in a 185 km circular orbit, but this would then be raised to a 740 km circular orbit by a two-stage rocket attached to the satellite. The primary mission of P80-1 would be to test the Teal Ruby sensor, which is to demonstrate the detection of aircraft from space using a staring mosaic infrared array. Also carried on the satellite would be two NASA mercury ion thrusters, an extreme ultraviolet photometer and a Navy stellar horizon atmospheric dispersion experiment [41] (the Navy experiment replaced a laser communications experiment, which was deleted due to lack of funds in August 1982 [42]).

The two mercury ion thrusters were prototypes of devices that could be used on synchronous orbit satellites for station-keeping, their very low fuel consumption enabling the satellites to stay on station much longer than at present. For the first year of P80-1's operation they would not be used, to avoid contaminating Teal Ruby's optics, and this period would be spent mainly in testing Teal Ruby. The ion thrusters would then be tested in a series of 2,557 firings in 507 days, for an overall mission duration of nearly three years [43].

The ESS-2 cradle, which would remain attached to the Shuttle throughout, would carry five experiments to carry out a range of measurements in the infrared, ultraviolet, X-ray, gamma ray and plasma environments [44].

However, all was not well with Teal Ruby; it had already suffered a series of delays and by the end of 1982 it was becoming clear to project managers that it would not be ready for the planned flight. These problems would come to a head in the course of 1983.

3. THE EVENTS OF 1983

3.1 1983-08: Ocean Surveillance Revived

The first US military space launch of 1983 came at approximately 13:46 GMT on 9 February when an Atlas F was launched from Vandenberg AFB. Receiving the international designation 1983-08A, its cargo entered a 1046 by 1184 km, 63.4° orbit and within the next four weeks seven objects were released from the main payload. This was very similar to the previous ocean surveillance flights; the first produced a total of 11 objects in orbit, while the second and third each produced eight.

The main payload, object A, appears to have manoeuvred six times in its first three weeks in orbit, but it is not certain whether these were true manoeuvres or simply refinements in the orbital model used in the *Two Line Orbital Elements.* Either way, no more orbital changes were apparent after the beginning of March, by which time its orbit was from 1052 km to 1167 km, with a period of 107.47 minutes.

At the time of the launch of 1983-08 all nine subsatellites from the preceeding ocean surveillance missions were in orbits with periods of 107.47 minutes (in fact, their periods all agreed to within 1/20 sec), and it soon became clear that the subsatellites from this mission were objects E, F and H, as they too had exactly this period. Like the main payload, all three subsatellites were in 1052 by 1167 km orbits. Subsequently, the identification of these objects as the subsatellites was confirmed, with designations SSA, SSB and SSC, but it was revealed that object B was also a payload, labelled SSD. Its orbit was from 1046 to 1184 km, with a period of 107.59 minutes, implying that its operation was not connected directly with that of the other subsatellites.

It was thought that 1983-08 was intended to carry out the mission of the December 1980 failure, but the position of its orbital plane leaves some doubt whether this was actually the case. The three earlier ocean surveillance clusters had orbital planes that were more or less evenly spaced, the actual gaps between the planes at the time of 1983-08's launch being 111°, 125° and 124°, and that if the failure had been successful, its plane would have been 5° to the west of 1976-38's. When 1983-08 went into orbit, its plane was 9° to the east of 1976-38's. One possible explanation is that 1983-08's orbital plane was positioned to make the spacings between it and the second and third clusters more even, with the angles between them resulting as 120°, 125° and 115°. However, the whole question of the orbital plane spacings of the ocean surveillance missions would be thrown into confusion later in the year.

3.2 1983-32: A Close Look

In October 1980 the Secretary of the Air Force stated that only four close look photo reconnaissance satellites remained in the inventory and that they would be used only in times of "serious military emergency" [45]. One of the four had been launched in 1981 and a second appeared as 1983-32A. Launched at about 18:45 GMT on 15 April, it entered an orbit of 135 by 311 km at 96.53°. Following the usual pattern for close look satellites, its orbit was Sun-synchronous with its observational passes in the southbound direction, crossing the equator at about 10:30 local time.

After four days, when the satellite's orbit had been allowed to decay without correction, 1983-32A began the daily cycle of decay followed by manoeuvre that typifies the close look craft. Each cycle started with the satellite in a roughly 128 by 268 km orbit, with its perigee lying at 55°N on the southbound pass. After about 24 hours atmospheric drag would have reduced the orbit to 126 by 255 km and precessions would have moved the perigee northwards to 59°N. At this point, which generally came at around 19:00 (GMT), a two-burn manoeuvre would be made to reset the values and a new cycle would begin. Averaged over several cycles, 1983-32A's orbital period was 88.44 minutes and its track separation (i.e. the separation in longitude between successive equator crossings) was 22.11°, which meant that its groundtrack repeated every seven days, which took 114 orbits.

A report from Washington speculated that the mission of 1983-32A was to check on compliance with arms control agreements. The report also gave the first indication of the programme's official, if classified name: KH-9 [46].

For the last ten years satellites of the close look programme have displayed steadily increasing lifetimes, with each staying in orbit longer than its predecessors. 1983-32A carried on this tradition, operating for a total of 128 days before its de-orbit on 21 August.

3.3 Changes to the *Two Line Orbital Elements*

The *Two Line Orbital Elements* are a unique source of data for studying space activities. They are issued daily by NASA but originate at NORAD, as part of its function of monitoring space objects. In has been NORAD's practice to include orbital elements for virtually all spacecraft which are transmitting or operational, whether foreign or American, with the exception of three classes of US military satellite. These are the Rhyolite, the Argus/Chalet ELINT and the SDS communications satellites.

In the *Two Line Orbital Elements* for 15 and 16 June 1983 there were no element sets for any photo reconnaissance or early warning satellites. This continued in subsequent issues. Within a few weeks, ocean surveillance satellites had joined the list of proscribed classes.

3.4 1983-56: The Revival Continues

A second ocean surveillance mission in 1983 came only four months after the first. 1983-56 lifted off at about 23:17 GMT on 9 June, and the first element set released showed it at rev 17 in a 1048 by 1167 km, 63.34° orbit. Only four further element sets were released before NORAD's change of policy came into effect, and these implied a manoeuvre to a 1059 by 1186 km orbit, followed by one to 1063 by 1184 km.

Like its predecessor, 1983-56A released seven objects into orbit, but only two of them were stated to be subsatellites. These were objects C and D, which were given the designations GB1 and GB2. No explanation of the meaning of the ocean surveillance subsatellite designations has ever been given and the mystery is compounded by the fact that each mission seems to use an entirely separate system. The subsatellite names have been as follows:

1976-38:	SSU-1, SSU-2 and SSU-3
1977-112:	SS-1, SS-2 and SS-3
1980-19:	EP-1, EP-2 and EP-3
1983-08:	SSA, SSB, SSC and SSD
1983-56:	GB1 and GB2

Unfortunately, only one element set was released for each subsatellite and both of these showed a 1050 by 1170 km

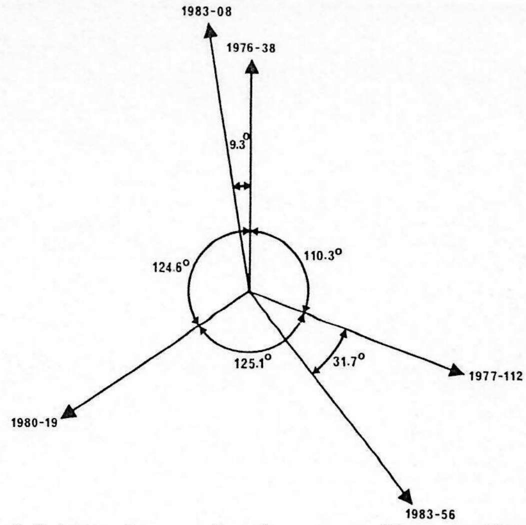

Fig. 6. Relative plane spacing of ocean surveillance satellites, showing how the two 1983 launches do not fit into the pattern of the previous launches.

orbit, with a period of 107.48 minutes, which is in good agreement with the periods of the subsatellites from previous launches. The deployment of two subsatellites rather than three was somewhat unexpected and so was the positioning of 1983-56's orbital plane. As can be seen from Fig. 6, it was 32° to the west of 1977-112 and 151° to the west of 1983-08. It is not clear whether 1983-56 represents part of the existing ocean surveillance system or whether it is the start of a new, and to some degree different, system. This may well be resolved when another launch is made.

3.5 1983-60: The Second Photo Reconnaissance Mission of 1983

The launch of 1983-60 on 20 June was the inaugural flight of the West Coast version of the Titan 34D, taking over the role of launching large reconnaissance spacecraft from the Titan 3D. The Titan 34D's capability to a low orbit is 14½ tonnes, a substantial increase over the Titan 3D's 11 tonnes. Although there was nothing to indicate that 1983-60A was anything other than a standard Big Bird, this increased capability would be used in 1984 to launch the first advanced KH-11 spacecraft, a design that is intended to satisfy photo reconnaissance needs almost to the end of the century.

1983-60A might well have been the last Big Bird: when the Secretary of the Air Force said that there were only four close look craft left, he also said that there were enough Big Birds to last through 1983. With its June launch, 1983-60A could be expected to remain in orbit until the first weeks of 1984, and so follow-on missions seemed unlikely. If 1983-60A was, in fact, the last Big Bird, then the programme would have achieved a notable record; 18 flights in 13 years, every one a success, and reaping between them 6.7 *years* of observation time.

A further point is that between the launch of 1983-60A on 20 June and the de-orbit of 1983-32A on 21 August the US had four photo reconnaissance spacecraft operating in orbit, with each class and each type of coverage represented.

Just one element set was released for 1983-60A, showing the satellite in a 160 by 259 km, 96.45° orbit at rev 2. The launch was made at about 18:45 GMT, so the southbound passes crossed the equator at about 10:30 local time. If 1983-60A followed the standard form for Big Birds, it would have entered a regular three day cycle a few days after launch. The cycle would start with the spacecraft in a 167 by 262 km orbit, with its perigee at 47°N on the southbound pass, but after three days atmospheric drag and precession would have reduced this to a 161 by 244 km orbit, with its perigee at 59°N. A two-burn maneouvre would then restore the values and the cycle would be repeated.

The Big Bird spacecraft, object A, was accompanied into orbit by the upper stage of the Titan vehicle core, which existed as object B for just under two days before it decayed. An ELINT subsatellite, object C, was deployed from the main satellite, but no element sets have been released for it. However, the *RAE Table of Earth Satellites* listed it as being in a 1289 by 1291 km, 111.41 minute orbit.

3.6 1983-63A: Hilat

The Hilat auroral research satellite, described in Section 2.9, was launched on 27 June. Its Scout booster rocket placed it in an orbit from 771 to 837 km, inclined at 82.03° and with a period of 101.02 minutes. Correct operation of the on-board experiments was reported soon afterwards and later in the year the DoD released some imagery taken by one of these in ultraviolet light, showing the aurora spreading across northern Canada [47].

3.7 1983-72A: Navstar 8

Navstar 8 was launched on 14 July by an Atlas F-SVS booster combination from Vandenberg AFB. After separating from the SVS upper stage, Navstar 8 was in a 548 by 20,926 km, 63.00° orbit with a period of 371.39 minutes. A day and a half later, as it was starting its seventh orbit, the satellite's built-in apogee motor fired to raise its orbit to 19,952 by 20,798 km, 62.83°, giving it a period of 725.81 minutes.

Navstar 8's orbital period in its new, circular orbit was somewhat greater than the figure of 718.0 minutes required for a stabilised orbit, but this was quite intentional. Navstar satellites use a technique similar to synchronous orbit satellites for attaining their required orbital positions. By taking up an orbit with a period slightly different from 718.0 minutes, the groundtrack can be made to drift eastwards or westwards at a slow, controlled rate until the desired position is reached, at which point the orbit is adjusted to have a period of 718.0 minutes, thus stopping the drift and stabilising the groundtrack. In Navstar 8's case, its groundtrack was moving westwards at a rate of just under 4° of longitude a day. During rev 18, on 22 July, Navstar 8 reached its required position, and so its orbit was lowered to 19,916 by 20,449 km, thus reducing its period to 717.99 minutes.

The position at which Navstar 8's orbit was stabilised coincided with those of Navstars 1, 4 and 5, and it was then ready to take up its position fixing role.

3.8 1983-78A: The Mystery Satellite

Of all the launches in 1983, of any nationality, 1983-78 had the least public information on it. The launch took place at Vandenberg AFB on 31 July using a Titan 3B launch vehicle and two objects appeared in orbit, both of which were still there at the end of 1983. No orbital data of any kind have been released.

This data, meagre though it may be, is sufficient to deduce 1983-78's mission with a high degree of confidence. Prior to this launch, the Titan 3B booster had been used successfully on 59 occasions, but for only three types of mission. Close look photo reconnaissance launches accounted for 49 out of the total, SDS communications satellites for nine, and there was one unique mission in the previous year, 1982-06. If the launch of 1983-78 had taken place before NORAD changed its release policy, the lack of orbital data would have immediately indicated an SDS mission, as full element sets were always released for close look and the 1982-06 mission, but now more subtle clues would have to be found.

There are two reasons for believing that 1983-78A was not a close look satellite. Firstly, in all the 21 years of close look operations there has never been a single instance of two satellites being in orbit at the time same time, and yet at the time of 1983-78A's launch 1983-32A, which was known for certain to be a close look, was still in operation and would remain so for another three weeks. Secondly, only a small number of close look launches have ever produced more than one object in orbit and, in the few cases that have, the secondary objects have always decayed within a few days of release from the main satellite. Clearly, 1983-78 did not fit this pattern.

Neither did 1983-78 fit the profile for 1982-06. When 1982-06 was launched, two objects appeared in orbit but object B decayed within a matter of hours. Two months after launch three objects were released from object A, followed by a fourth six weeks later. Object A was deorbited after four months in orbit [48].

1983-78 does, however, fit the SDS profile very closely. In each SDS launch, two objects have appeared in orbit at the start of the mission, both of which were long-lived, a pattern exactly repeated by 1983-78. It seems, therefore, almost certain the 1983-78A was the eighth SDS satellite, and it will be recalled that in Section 2.7 it was concluded that an SDS launch in 1983 was a strong possibility.

3.9 1983-113A: DMSP Returns to Normal Service

Almost eleven months after 1982-118A had brought the DMSP programme back into operation, albeit at a reduced level, 1983-113A was launched to restore the full two-satellite service. 1983-113A was launched at about 06:32 GMT on 18 November and went into an orbit ranging from 815 to 832 km with an inclination of 98.74° and a period of 101.43 minutes.

There was one factor, however, relating to 1983-113A's orbit that was puzzling: the local time of its equator crossings. All the standard descriptions of the DMSP system state that one satellite makes its northbound crossings at about 06:30 local time and the other at noon. When 1983-113A was launched 1982-118A was making its crossings at 06:17, but the new satellite made its at 10:10. Examination of earlier launches shows that this has, in fact, occurred before. The first Block 5D1 satellite, 1976-91A, made its crossings at 10:18 local time, while 1979-50A made its *southbound* crossings at 09:56. Presumably, the crossing time of the second satellite in the system has been brought forward to allow more time for analysis of its data before distribution or to improve lighting conditions at the target sites.

3.10 IUS Problems on STS-6

Although the mission of STS-6 to launch the TDRS-A satellite was entirely civilian in nature, it was to have important consequences for more than one US military space programme. This was to be the first time that the Inertial Upper Stage (IUS) was flown on the Shuttle and in the future several military programmes planned to make use of the IUS. There had been only one flight involving an IUS before STS-6 and that was on the Titan 34D flight of October 1982, when the stage had performed flawlessly.

It was during the firing of the IUS upper stage on 5 April that disaster struck: 80 seconds into the 105-second burn all contact with the vehicle was lost. In the next few hours flight

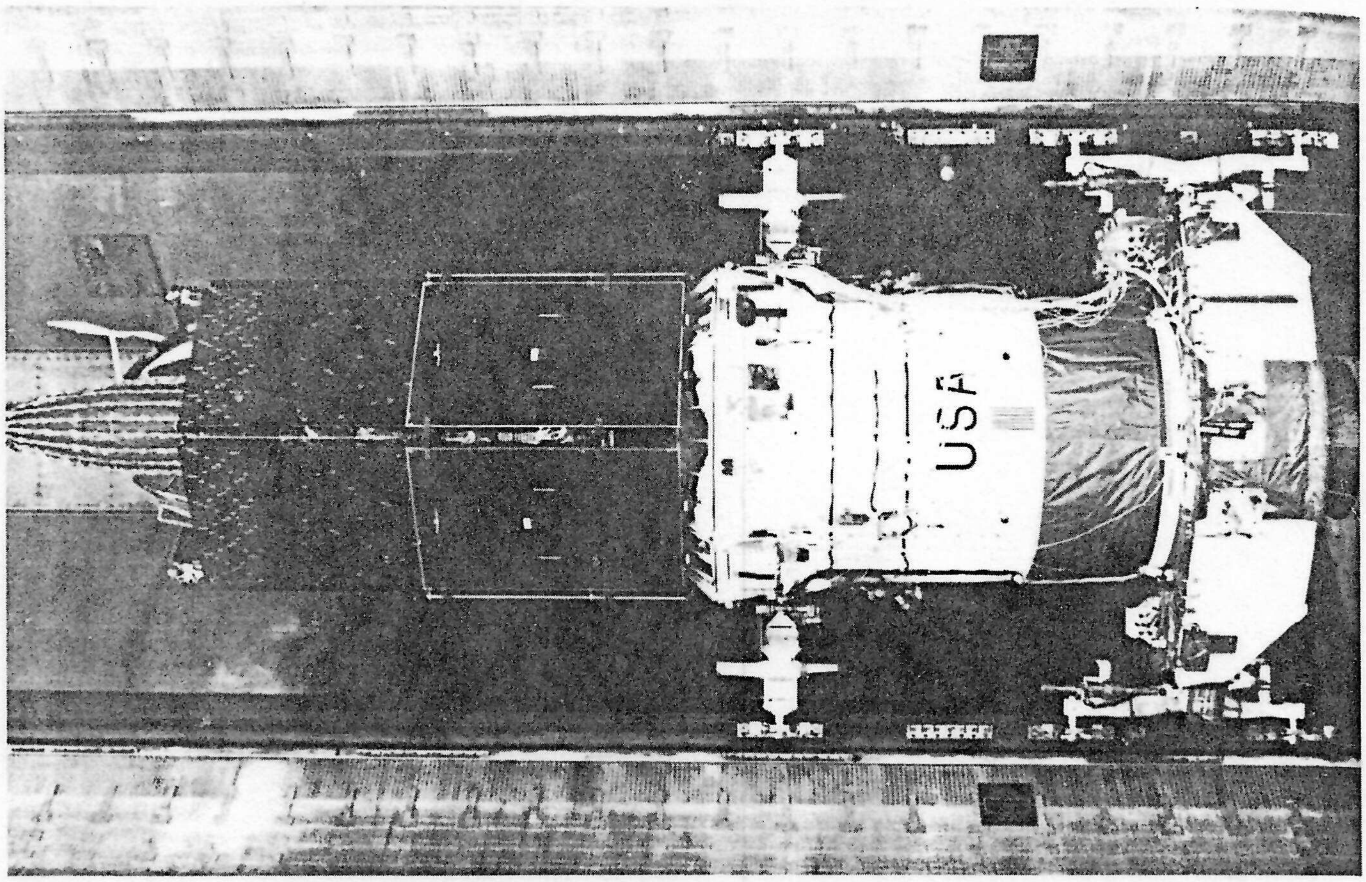

Fig. 7. The Inertial Upper Stage (right) and the TDRS satellite are processed for launch by Shuttle STS-6 in April 1983.

NASA

controllers managed to separate the TDRS-A spacecraft from the IUS, but it was left in a 21,853 by 35,389 km orbit instead of the planned synchronous orbit.

While NASA concentrated on nudging TDRS-A up into its proper orbit, the USAF, who had responsibility for the IUS vehicle, set up a Joint Anomaly Evaluation Board to determine the cause of the failure. As all telemetry had been lost at the instant of failure, the board had little information to work on and finding the fault was to take some months. Understandably, NASA was reluctant to fly any more IUS missions until the anomaly had been cleared, and by the end of April it looked unlikely that TDRS-B would be flown on STS-8, scheduled for August. In mid-May it was reported that NASA was considering a test mission for the IUS with a dummy payload, and STS-10 was suggested as one of the possible candidates [49]. The reference to STS-10 implied that its previously-stated role of carrying the P80-1 satellite (see Section 2.9) had been dropped and this was confirmed in two separate reports a month later. In one, it was stated that the Teal Ruby sensor, which was to form the major part of P80-1, had been experiencing development problems for some time and its launch had been postponed until 1986. In the other, it was stated that STS-10, which was described as carrying a "large national security satellite" to be placed in synchronous orbit by an IUS, had been cancelled, due to uncertainties with the IUS [50]. Although there had been no public confirmation, one must assume that the one or two Titan 34D flights that were to use the IUS in 1983 were also cancelled at this time, and indeed no such launches had been made by the year's end.

By the end of September the fault in the IUS had been narrowed to a breakdown in thermal insulation allowing a doughnut-shaped seal to overheat and burst [47]. In anticipation of a cure being found, NASA's Shuttle schedule for 1984, published on 14 November 1983, included three missions involving IUS stages. These were 41-E for the DoD in July, 41-H for the DoD in September and 51-C, carrying TDRS-B, in December.

3.11 Satellites in Operation at the Start of 1983

Section 2 described the 60 or so satellites that were in operational use at the start of the year and all of them were still in orbit at the end of 1983. Several regularly manoeuvre, either to counter orbital decay or to keep on station, but unfortunately orbital data for some of them are not made public. With the change to NORAD's policy that occurred in June, the number of satellites for which data were not available grew.

Prior to the change in the *Two Lines* the two KH-11 satellites made nine manoeuvres between them, and the fact that they were still in orbit at the end of the year showed them to be still operational. Similarly, the DSP satellites had made a total of five station-keeping manoeuvres by June, and the *Satellite Situation Report* for 31 December 1983 showed them all as having periods of 1436 minutes, indicating that they were still station-keeping, and thus operational, although they might, of course, have moved stations in the intervening period.

One group of synchronous orbit satellites for which full orbital data are available is the DSCS communications satellites, and they show that they performed an impressive sequence of manoeuvres during the year. As 1983 began the four prime satellites were numbers II-4 (stationed at 60°E), II-8 (175°E), II-11 (135°W) and II-14 (12°W). The first event came on 21 January when II-15, which had been drifting eastwards since its launch the previous October, arrived at 15°W and manoeuvred to stop its drift and take up that station, backing-up II-14. Launched with II-15 had been III-1 and it was drifting towards the 130°W station, but at a much lower rate. This particular slot was already occupied by satellite number II-13, so it was manoeuvred on 10 February to send it drifting westwards at almost 1° of longitude per day. DSCS III-1 was stabilised at 130°W in late February, while II-13 continued until it reached 180°W on 3 April, where it was halted.

The extensive checking out of III-1 was completed on 30 April, when it was formally handed over to its user, the Defense Communications Agency [51]. Within a fortnight it had swapped positions with II-11, so that it was now the prime satellite at 135°W and II-11 was the back-up at 130°W. In mid-July a second swap took place, between II-8 and II-13, resulting in II-13 being the prime at 175°E, backed-up by II-8 at 180°. One wonders whether the second swap resulted from the cancellation of the planned launch of DSCS II-16 and III-2, or whether this launch, had it been made, would have triggered yet more changes of station.

In contrast to the DSCS satellites, the FLTSATCOM satellites maintained their synchronous orbit stations without change throughout the year. The only other satellites whose status was clear at the end of 1983 were the two navigational satellite programmes, Transit and Navstar. The fact that the US Navy did not take up the option of either of the Transit call-up launches implies that no replacement spacecraft was needed and that all the spacecraft in orbit at the start of 1983 remained usable throughout the year. Also at the end of 1983, all seven Navstars were still in orbits with periods of 718.0 minutes and their plane spacings had been maintained, implying that they were all operational.

4. CONCLUSIONS

The eight military launches of 1983 produced 15 paylods in orbit. All but one of these, the close look reconnaissance satellite, were still in orbit at the end of the year and apparently functioning satisfactorily.

Photo reconnaissance operations were maintained at a high level during the year, with the four satellites in use accumulating a total of 1053 mission days. The White Cloud ocean surveillance programme, which had begun to appear as if it had foundered, returned to active use and the deployment of a new variant may have started in 1983. After a long period of reduced operation the DMSP weather satellite programme was back to full capacity by the end of the year and routine replacement satellites had been provided for both the SDS communications and Navstar navigation programmes. On the research and development front, only one of the five anticipated launches was actually made, but the nature of RPD work means that schedules are liable to slip and plans are liable to change.

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The orbital data quoted in Section 2 were taken from the 31 December 1982 issue of NASA's *Satellite Situation Report*, which provides data as of 24:00 GMT on that date. The data used in Section 3 were derived from NASA's *Two Line Orbital Elements*. In both sections the RAE's *Table of Earth Satellites* was a useful cross-check.

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