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MILITARY MANOEUVRES IN SYNCHRONOUS ORBIT

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1. INTRODUCTION

On 6 March 1982 the US Air Force launched a satellite into synchronous orbit from Cape Canaveral. Although the USAF did not disclose its mission, identifying it only as "Operations 8701," its true purpose was soon apparent. It had been launched by a Titan 3C, and only two USAF programmes use this vehicle: communications satellites of the Defense Satellite Communications System (DSCS), and early warning satellites of the Defense Support Program (DSP). In the past the USAF has always identified DSCS flights explicitly at the time of launch, so the lack of any announced mission pointed to a DSP flight. Subsequent analysis of the orbital elements of the satellite and its associated objects confirmed this [1].

Routine replacement of failing satellites has been a feature of the DSP for some years, but this launch was to be the start of a complex set of manoeuvres involving a total of three satellites and lasting nearly ten weeks.

2. DSP EARLY WARNING SATELLITES

The role of the DSP early warning satellites is to detect enemy ballistic missiles in their first few minutes of flight and warn of an impending attack [2]. To do this they are equipped with infrared sensors, which detect the high temperature exhaust gases produced by a rocket engine. In order to maintain an around-the-clock watch, DSP satellites are stationed in synchronous orbit, nearly 36,000 km above the equator.

When the DSP system first reached operational status, in 1972, there were two orbital stations. One was over the Indian Ocean, to watch for attack by land-based missiles, and the other over the western coast of South America, to watch for attack by missiles launched for submarines in the Eastern Pacific and Western Atlantic. Since then DSP satellites have been launched to replace those nearing the ends of their lives, and to expand the system to three orbital stations. As the range of submarine-launched ballistic missiles has increased, the areas of the oceans from which they could be launched and still hit the United States have grown. The South American station has therefore been replaced by two stations, one to monitor the Pacific Ocean and one for the Atlantic Ocean. The full DSP system now consists of satellites positioned over the central Indian Ocean (about 70°E), over Brazil (about 70°W) and over the eastern central Pacific (about 135°W) [3].

3. THE LAUNCH OF 1982-19A

The launch of 6 March 1982 received the international designation 1982-19; it was the fourteenth DSP satellite to reach orbit, and its path to its operational station followed the standard pattern for American synchronous orbit payloads. Following a due-east launch from Cape Canaveral the spacecraft, still attached to the last stage of its launcher, entered a low parking orbit, with a period of 90 minutes and an inclination of 28½°. After three-quarters of an orbit, as the vehicle crossed the equator moving northwards, the engine of the last stage ignited for what was to be a major burn, adding 2.5 km per second to its orbital velocity, and dramatically changing the shape of its orbit. The point where the burn was made became the new perigee, and the new apogee was positioned over the equator on the other side of the Earth, at an altitude of 35,500 km. The craft's period in this orbit was about 630 minutes, but it completed only half an orbit in this path before a second major burn was made, adding another 1.8 km per second to its velocity, circularising the orbit and reducing its inclination to just a few degrees. Its job done, the last stage was then separated from the spacecraft.

Satellite 1982-19A was now in a 35,521 by 35,600 km orbit, inclined at 1.98°. The orbit was not exactly synchronous; such a path would have a period of 1436.1 minutes, whereas that of 1982-19A had a period of 1424.6 minutes (see Fig. 1). The result of this discrepancy was to cause the satellite to drift eastwards, at a rate of 2.92° per day. The rationale behind the drift was the fact that the technique just described means that the satellite reaches synchronous altitude after 1¼ orbits of travel, about six and a half hours after launch. At this time the spacecraft would be 90° east of its point of launch, but the Earth would have rotated 100° towards the east by this time, so the point of insertion of the spacecraft into synchronous orbit would be 10° *west* of the launch site, that is at a longitude of about 90°W. For 1982-19A the figure was, in fact, 92.4°W (see Fig. 2), placing it over the Galapagos Islands, 1,350 km off the coast of Ecuador. Its easterly drift then allowed it to be moved, over a period of days, to its required orbital station. Before that was reached, however, a second satellite became involved in the exercise.

4. REPOSITIONING 1981-25A

The twelfth DSP satellite, 1981-25A, was launched on 16 March 1981, and was positioned soon afterwards in the Western Atlantic station. Launch vehicle errors mean that a satellite can never be placed in a precisely synchronous orbit, and even if one could, perturbations due to asymmetries in the Earth's gravitational field, plus the effects of the Sun and Moon, mean that such a satellite would tend to drift slowly off station, forcing it to use its onboard manoeuvring system to send it back to its desired station. During the year from its launch to that of 1982-19A, 1981-25A had been drifting back and forth between longitudes 68°W and 72°W; at the moment of 1982-19A's launch it was in a 35,771 by 35,788 km orbit, with a period of 1435.7 minutes. Positioned over 70.9°W it was drifting slowly eastwards, at a rate of 0.08° per day.

1982-19A's insertion into near-synchronous orbit came in the early hours of 7 March (GMT), and one can conclude

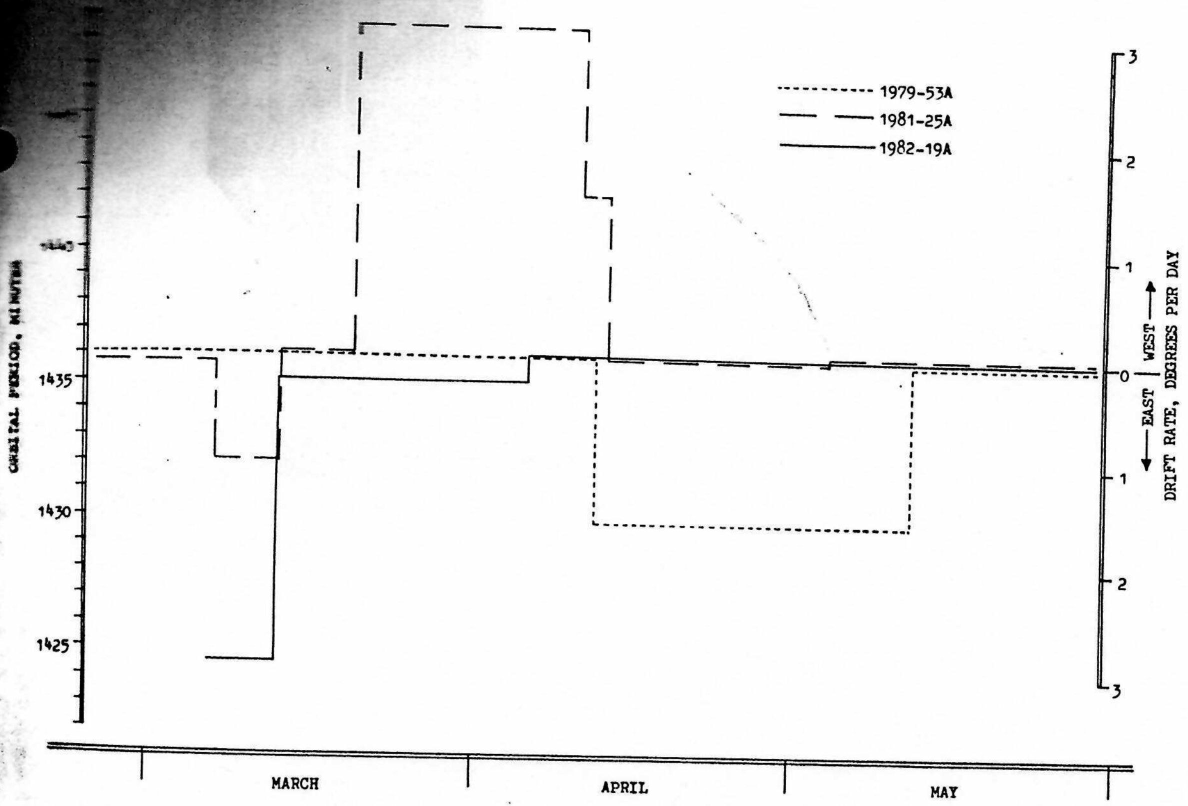

Fig. 1. Orbital periods and drift rates of the early warning satellites.

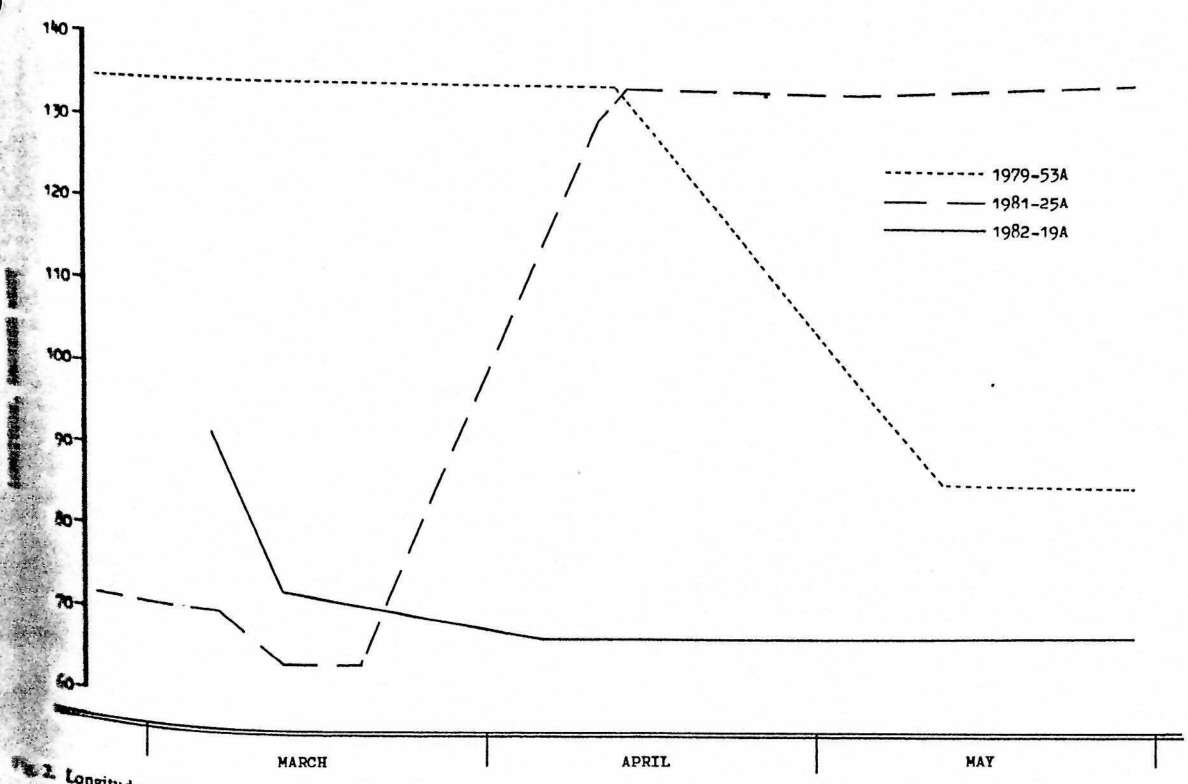

Fig. 2. Longitudes of the early warning satellites.

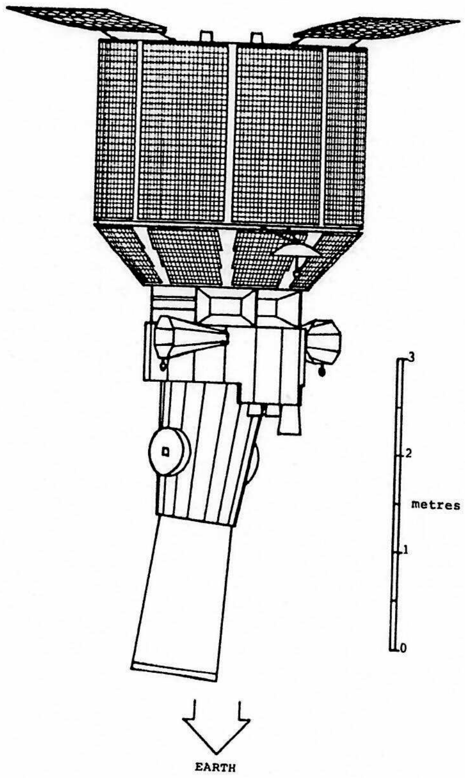

Fig. 3. Defense Support Program Satellite.

that its performance was quickly checked out because within 16 hours, 1981-25A, the satellite it was to ultimately replace, was manoeuvred. Its new orbit ranged from 35,636 to 35,778 km, giving it a period of 1432.0 minutes and a drift rate of 1.02° east per day.

Six days later, on the afternoon of 13 March, 1982-19A was manoeuvred. Its orbit was raised to 35,733 by 35,803 km, increasing its period to 1435.2 minutes and cutting its drift rate by a factor of 12, to just less than a quarter of a degree per day. It was by now only a few degrees away from its desired orbital station, at 73.3°W. Just about four hours later 1981-25A was manoeuvred for a second time, resetting its orbit to 35,776 by 35,800 km. It was now orbiting over a point 64.6°W with virtually no easterly or westerly drift. The net effect of 1981-25A's two manoeuvres had been to shift it 6° to the east, presumably to reduce the chances of radio interference with 1982-19A.

5. HANDOVER FROM 1981-25A TO 1982-19A

With 1982-19A nearing its planned position, more detailed checking out and testing of its onboard systems could be performed. Apparently all was in good order because, on the afternoon of 20 March, a week almost to the hour after 1982-19A's drift rate was cut, 1981-25A made a large two-burn manoeuvre. The resulting orbit had a perigee of 36,012 km and an apogee of 36,042 km, giving it a period of 1448.4 minutes. The most important result of the manoeuvre, however, was the rate at which it was now leaving its old Western Atlantic slot; it was moving westwards at 3.07° per day. The watch over the Atlantic Ocean had become the responsibility of 1982-19A.

1982-19A maintained its slow drift eastwards for 23 days until, on 6 April, it reached a longitude of 67.9°W. A relatively small manoeuvre at this point changed its orbit to 35,760 km by 35,813 km, with a period of 1436.1 minutes and a drift of less than 0.006° per day. It was at last on station, high over the rain forests of north western Brazil.

6. HANDOVER FROM 1979-53A TO 1981-25A

While 1982-19A had been moving slowly eastwards, 1981-25A was moving westwards, but at a much faster pace. By 10 April it had reached a longitude of 130.0°W, when its orbit was lowered to 35,800 by 36,009 km, halving its drift rate. With 1981-25A now very close to its new orbital station, the satellite it was to replace could be moved. 1979-53A was the tenth DSP satellite launched; following liftoff on 10 June 1979 it went through the standard procedure of parking orbit, transfer orbit and near-synchronous drifting orbit, to end up in the Eastern Pacific station, over a longitude of 134°W. When 1982-19A was launched 1979-53A was in a 35,717 by 35,853 km orbit, with a period of 1436.0 minutes and positioned over 134.4°W. During the early morning of 12 April it made a single-burn manoeuvre, dropping its orbit to 35,611 by 35,718 km, and setting it moving easterwards at a rate of 1.57° per day. Just over a day later 1981-25A stabilised its orbit by lowering it to 35,769 by 35,799 km. Stationed over 133.8°W and with a drift of less than 0.03° per day, it now took over the watch on the Pacific Ocean.

At this point it appeared that the sequence of manoeuvres was complete: 1982-19A was filling the Western Atlantic slot, 1981-25A had been moved across to the Eastern Pacific slot, and, after nearly three years in orbit, 1979-53A had been retired. To reduce the risk of 1979-53A interfering with its successors it had been taken out of synchronous orbit and was difting around the Earth in an easterly direction, completing one revolution in 230 days. It was therefore rather a surprise when, on 12 May, 1979-53A carried out an orbit-stabilising manoeuvre. By raising its orbit to 35,723 by 35,843 km, the satellite's period was increased to 1435.9 minutes and its rate of drift was cut to less than one twentieth of a degree per day. Its subsatellite point was at 86.5°W, 700 km off the coast of Ecuador, a position not used before by the early warning satellites. This does, however, seem to have been the last step in the exercise. No further burns, other than minor ones for station-keeping, have been made.

7. THE REASONS

The previous sections have described the details of the manoeuvres, but they do not give any clue as to their aim. Certainly, they were carefully planned and executed, but what were they intended to achieve? An examination of the recent history of the DSP project gives some insight into this [4].

The US Air Force has been considering expanding the DSP configuration from three orbital stations to five for some time, but no steps have actually been taken to implement this. We can therefore infer that the removal of 1979-53A from its Eastern Pacific slot meant that it was being withdrawn from active service. However, its stabilisation at the new position of 86°W means that it has not been retired completely.

There are three possible roles for 1979-53A in its new position. It is possible that it has been placed in backup status, in a semi-dormant mode but ready to be moved into position and brought into active service should one of the current operational satellites fail. Alternatively, it could be use as a target, to test onboard laser countermeasures. Ever since the laser blinding incidents of 1975 the USAF has been very worried by the prospect that the missile-detecting sensors carried by the early warning satellites may be blinded by ground-based lasers. A report in June 1980 indicated that laser countermeasures had been fitted to the most recent DSP spacecraft, to detect illumination by laser and to protect the satellites' delicate infrared optics against it. Presumably, the spacecraft referred to include 1979-53A, and at its new position it would make an ideal target for the US's laser test facility at Cloudcroft, New Mexico.

A third possibility for 1979-53A's role is for testing and calibration of GEODSS. Non-cooperative satellites in high altitude orbits are virtually impossible to track by radar, but high resolution optical systems should be able to pick them out. The GEODSS (Ground-based Electro Optical Deep Space Surveillance) system is a new US project planned to do just this; it will eventually consist of five sites around the world, and the first of these, at White Sands in New Mexico, has been under test since mid-1980. Situated in synchronous orbit over 86°W, 1979-53A would be in a good position for observation by GEODSS. None of these three roles excludes any of the others, so it is of course possible that 1979-53A is performing some combination of them.

With 1979-53A being removed from active service, why was 1982-19A not sent straight to the Eastern Pacific slot to replace it, instead of placing it in the Western Atlantic slot and moving 1981-25A across? An ongoing effort in the DSP programme has been to upgrade the sensors carried on successive satellites. The operational life of DSP satellites is measured in years, and over such periods the performance of their sensors degrades significantly. In addition, new types of Soviet missiles, particularly the solid fuel submarine-launched missiles, have infrared signatures which are not well matched by the capabilities of the DSP sensors. In response the USAF has initiated an evolutionary programme, whereby the abilities of each satellite's sensors are an improvement over its predecessors. Given this, it would appear that 1982-19A was a more able satellite than 1981-25A, which in turn was a more able satellite than 1979-53A. When 1981-25A was launched, it was positioned directly in the Western Atlantic slot; when 1982-19A was launched, it was also sent to the Western Atlantic slot. Apparently, then, the needs of this station are greater than those of the Eastern Pacific. Just why this is so is not clear; it could be related to the SS-20 medium range ballistic missile, which has in recent years been deployed widely in the USSR. Fired against Western Europe, these missiles, which are also solid fuelled, would just be in view of the Western Atlantic DSP satellite.

8. CONCLUSIONS

During the months of March, April and May 1982 the USAF launched a new early warning satellite and embarked on a complex series of manoeuvres to reconfigure the DSP system. One satellite nearing the end of its life was replaced, a second was re-positioned and a third was brought into operational use. In all, the sequence lasted 67 days, required nine orbital manoeuvres, and a total velocity increment of 40 metres per second.

NOTES AND REFERENCES

1. The orbital data used here was all taken from NASA's *Two Line Orbital Elements.*
2. The history of the Defense Support Program and its predecessors can be found in two previous works by the author:
   "U.S. Reconnaissance Satellite Programmes," *Spaceflight*, July 1978.
   "Recent Developments in U.S. Reconnaissance Satellite Programmes," *JBIS*, January 1982.
3. As described in this article, at the start of 1982 the Eastern Pacific station was occupied by 1979-53A and the Western Atlantic station by 1981-25A. However, it is not possible to determine which satellite was in the Indian Ocean station from unclassified sources. This results from a peculiarity in the USAF's policy for releasing information to the public. When some DSP satellites are launched, full data is released and their orbital elements appear frequently in the *Two Line Orbital Elements* (which, although distributed by NASA, are in fact originated by NORAD). When other satellites are launched, in contrast, very little data beyond the announcement of launch is released, and they never appear in the *Two Line Orbital Elements.* The DSP satellites launched in the last three years can be categorised as follows:
   1979-53A – Eastern Pacific
   1979-86A – no data
   1981-25A – Western Atlantic, then Eastern Pacific
   1981-107A – no data
   1982-19A – Western Atlantic.
   The most likely explanation for this is that the launches for which no data are released are stationed over the Indian Ocean, but these satellites also carry out electronic intelligence (elint) duties, monitoring Soviet and Chinese missile tests and satellite launches. The US has always been very reticent about its elint activities, and so may be trying to avoid embarressment by not acknowledging the fact that certain DSP satellites end up in the Indian Ocean slot, carrying out elint work.
4. Further details of the topics discussed here may be found in the following:
   Improvements and upgrades to the DSP system:
   Aviation Week and Space Technology, 20 June 1977.
   Aviation Week and Space Technology, 23 June 1980.
   Aerospace Daily, 23 January 1981.
   Aviation Week and Space Technology, 16 February 1981.
   Laser blinding incidents:
   Aviation Week and Space Technology, 8 December 1975.
   Aviation Week and Space Technology, 5 January 1976.
   GEODSS:
   Aviation Week and Space Technology, 16 June 1980.
   Deployment of the SS-20 missile:
   International Defence Review, June 1981.

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