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, the satellites were positioned 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 a result of the increased surveillance that has occurred, the areas of the oceans from which the satellites can intercept ballistic missiles has increased, and still the United States has 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 The South American station has therefore been replaced by two stations, one to monitor the Pacific Ocean and one for the Atlantic Ocean.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 space-craft, still attached to the last stage of its launcher, entered a low parking orbit, with a period of 90 minutes and an inclination of 28.5°. After three-quarters of an orbit, as the vehicle crossed the equator moving northwards, the engine of the last stage ignited for what would be a major burn, adding 2.5 km per second to its orbital velocity, and dramatically changing the shape of its orbit. The point when 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, circulating 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 1456.1 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 180 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, however, it was 92.4°W (see Fig. 2), placed it over the Galapagos Islands, 1,350 km off the coast of Ecuador. Its eastward 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 asymmetry 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 on-board manoeuvres 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 35,748 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.
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 forest 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 144.4°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 eastwards 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 fulfilling the Western Atlantic slot, 1981-25A had been moved across to the Eastern Pacific and, after nearly three years in orbit, 1979-53A had been retired. To reduce the risk of 1979-53A interfering with its successor it had been taken out of synchronous orbit and was drifting around the Earth in an easier 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 86.3°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...
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complex series of maneuvers 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 maneuvers, and a total velocity increment of 40 meters per second.

NOTES AND REFERENCES
1. The orbital data used here was all taken from NASA's *Two Line Orbit Element*.
2. This program is the Defense Support Program and its predecessors can be found in two previous works by the author: "Synchronous Orbit Elements" and "Astronomy Fact Book*, June 1977, "Recent Developments in Synchronous Orbit Satellite Programs", *Spaceflight*, January 1982.
3. As described in this article, at the start of 1979 the 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 policy 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 Orbit Elements* (which, although distributed by NASA, are in fact originated by NOAO). 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 Orbit Elements*. The DSP satellites launched in the last three years can be categorized as follows:

1979-53A — Eastern Pacific
1979-53A — no data
1980-25A — Western Atlantic, then Eastern Pacific
1980-25A — no data
1981-25A — Western Atlantic.

The most likely explanation for this is that the launches for which no data are released are rastered 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 solicitous about its ELINT activities, and so may be trying to avoid embarrassment by not acknowledg-

ing the fact that certain DSP satellites end up in the Indian Ocean orbit, carrying out ELINT work.
4. Further details of the topics discussed here may be found in the following:

*Aviation Week and Space Technology*, 23 June 1980;
*Aeronautics and Space Technology*, 26 March 1975;
*Aviation Week and Space Technology*, 23 June 1980;
*Aeronautics and Space Technology*, 26 March 1975;
*Aviation Week and Space Technology*, 16 February 1981;
*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*;

8. CONCLUSIONS

During the months of March, April and May 1982 the USAF launched a new early warning satellite and embarked on s...