the main satellites suggests that the fourth generation satellites are de-orbited and allowed to decay, rather than having a large re-entry vehicle for recovery.

6. ACKNOWLEDGEMENTS

The writer would like to thank the Goddard Space Flight Center for the issue of *Two-Line Elements*, without which the calculations presented here could not have been under- ... Establishment for the monthly *Table of Earth Satellites* and Mr. G. E. Perry and Mr. J. O. Dahlberg of the Kettering Group for unpublished data which allowed the checking of recovery time formula noted in Section 3.

REFERENCES

1. Phillip S. Clark, "Aspects of the Soviet Photoreconnaissance Satellite Programme," *JBIS*, 36, 169-184 (1983).
2. Phillip S. Clark, "Soyuz Missions to Salyut Stations," *Spaceflight*, 21, 259-263 (1979).

JBIS 36, 191 (1983)

CORRESPONDENCE

After Discoverer

Sir, With the start of military Shuttle flights and the information of USAF Space Command, much is being made of the 'militarisation' of space. Military domination of space is nothing new, though; the Department of Defense was putting three times as many payloads into orbit as NASA in the early 1960's, and it is probably true to say that the missions of many of these early secret satellites are more mysterious than recent classified launches.

In November 1961, when the DoD lowered a cloak of secrecy on military space programmes, there were two types of imaging reconnaissance satellite in development. The first of these was Discoverer, which returned its film to Earth in a reentry capsule, and was being developed for the 'close look' mission of obtaining detailed photographs of specific targets. There were 38 Discoverer launches between 1959 and 1962, mostly experimental in nature. The second type of satellite had three announced launches under the Samos programme, and used radio to transmit back its pictures rather than returning them physically to the ground. It was to be used for lower resolution 'area survey' mapping missions. Both types of satellite continued to be used after 1961, but can we identify which particular satellites were which?

For a given satellite we usually know the launch vehicle, the orbit, and the length of time spent in orbit; for instance, the RAE Table of Earth Satellites provides a useful compilation of such information [1]. Discoverer and Samos were launched by Thor Agena and Atlas Agena respectively, but several studies of the USAF programme [2, 3] suggest that in early 1962 the projects switched launchers, so that the Atlas Agena launches were the recoverable satellites. While this seems to fit with the fact that these satellites had lower orbits and shorter lifetimes, information available in the open literature seems to contradict the idea.

The Discoverer satellites often carried scientific experiments in addition to their military payloads, and this practice was continued on the later, classified, launches. A list of some of the known scientific payloads on such satellites has appeared in *Spaceflight* [4]. In particular, Discoverers 29 and 36, among others, carried nuclear emulsions to detect energetic protons in the radiation belts; they were carried in the reentry capsule under the heat shield and were recovered and examined for charged particle tracks. These experiments continued after the classification of the spy satellites, and published results allow us to identify the recoverable payloads. One paper [5] contained a list of such satellites with launch dates and lifetimes before recovery (Table 1) and two others [6, 7] contain graphs from which launch dates in the period 1962-5 may be measured. Several other papers, principally in the *Journal of Geophysical Research*, explicitly refer to particular recoverable satellites. In every case the satellite in question is a Thor Agena launch; I have found no reference in the scientific literature to any Atlas Agena recovery. In addition, two early Thor launches, 1962 σ 1 and 1962 $\alpha\upsilon$ 1, are stated to have been recoverable satellites and not electronic intelligence missions as earlier believed.

TABLE 1.

Satellite	Launch date	Time before recovery
Disc. 29	1961 Aug 30	2.11 days
Disc. 36	Dec 12	4.07
1962 σ 1	1962 May 15	4.11
1962 ϕ 1	May 30	3.10
1962 $\alpha\gamma$	Jun 27	4.09
1962 $\alpha\theta$	Jul 28	4.08
1962 $\alpha\kappa$	Aug 2	4.09
1962 $\alpha\sigma$	Aug 29	4.07
1962 $\alpha\chi$	Sep 17	1.10
1962 $\beta\epsilon$	Oct 9	4.11
1962 βo	Nov 5	4.08
1962 $\beta\phi$	Dec 14	4.08
1963-07A	1963 Apr 1	3.08

Unless the scientific papers mentioned have been published with falsified data, many of the Thor Agena satellites in the period 1962-5 were of the recoverable type. Indeed, it seems likely that all the Thor launches (except ferrets) were recoverable, and the Atlas were non-recoverable. Can we reconcile this with the short lifetimes of the Atlas satellites? Is it possible that the successful development of recovery techniques led to a decision to equip the radio-transmission satellites with recovery capsules to supplement quick-look data with higher quality images as early as 1962 rather than in 1971 with Big Bird? What happened in 1966 when Thor

Agena and Atlas Agena were replaced by Thorad Agena and Titan 3B Agena? It is possible that more clues lie hidden in the scientific journals, but it is likely that any speculations on the spy satellites of this era will remain uncertain until and unless the USAF decide to declassify some of the early history of their role in space.

REFERENCES

1. "The RAE Table of Earth Satellites," D. G. King-Hele *et al*, Macmillan press, 1981.
2. P. J. Klass, "Secret Sentries in Space," Random House, 1971.
3. A. Kenden, *Spaceflight*, 20, 243 (1978).
4. J. Powell, *Spaceflight*, 21, 515 (1979).
5. R. Filz, H. Yagoda, E. Holeman, "Space Research IV," p. 642 (1963).
6. R. Filz, E. Holeman, *JGR*, 70, 5807 (1964).
7. R. Filz, *JGR*, 72, 959 (1967).

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Performance of the Onboard Timer of 1981-39A, Cosmos 1267

Sir, Shortwave telemetry on a frequency of 19.953 MHz from Cosmos 1267 was frequency-shift-keyed (f.s.k.) pulse-duration modulated (PDM) in the manner of its predecessor, Cosmos 929. Moreover, as with Cosmos 929, it existed in two distinct modes on a time-sharing basis [1]. Major differences occurred in that signals for both modes were transmitted on the same pair of frequencies and the duration of each mode was reduced from 30 minutes to 10 minutes. The shortened duration ensured that each mode was observed during passes over the Soviet Union and, usually, over an individual ground station but use of the same pair of frequencies made precise determination of the time of mode change more difficult.

Figures 1a and 1b show the first seven words of the telemetry frame in each mode. It will be seen that in mode A (in operation at the beginning of the mission) words 3, 4 and 5 are all very short and are heard as blips whereas in mode B they are all long. These words serve to distinguish between the two modes.

At 22h 48m 30.1s UT on 7 May 1981, during the 207th revolution, words 4 and 5 were observed to be long whereas word 3 was still the blip of mode A. Clearly this indicated the instant of mode change. Figure 1c shows such a change. Later, changes from mode B to mode A were observed in which words 3 and 4 were long and word 5 was a blip.

On 28 September 1981, during the 2,407th revolution, by which time the spacecraft had rendezvoused and docked with the Salyut 6 space station, word 4 was observed to have a medium duration due to the change of mode occurring during sampling of the telemetered parameter. This is shown in Fig. 1d.

It is convenient to log changes of mode which occur at other times within the frame and are thus not easily determined aurally as the time of word 3 in the first frame following the change. At the beginning of the mission these changes were occurring approximately 8 minutes 30 seconds after each multiple of 10 minutes within the hour. During the mission the time of mode change became progressively earlier and, on 8 May 1982, it was observed to occur at 21h 27m 23.2s. Thus, in one year, the onboard timer lost 67 seconds. Cosmos 929's timer was observed to lose at a rate of 0.116 sec/day [2].

Figure 2 shows that the rate of decrease of Cosmos 1267's timer is not linear but increased as time went by. Nevertheless it was close to manufacturers of quartz timepieces' guarantees of an accuracy of one minute per year.

One further observation of a precise mode change at 06h 17m 13.6s on 18 June showed that the rate of decrease had risen to 0.233 sec/day over the preceding 40 days. The Cosmos 1267-Salyut 7 complex was deorbited on 29 July 1982.

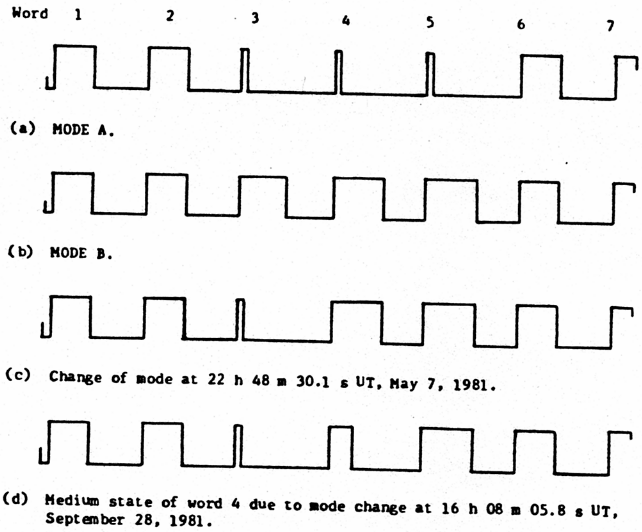

Fig. 1. Telemetry modes of signals on 19.953 MHz from Cosmos 1267.

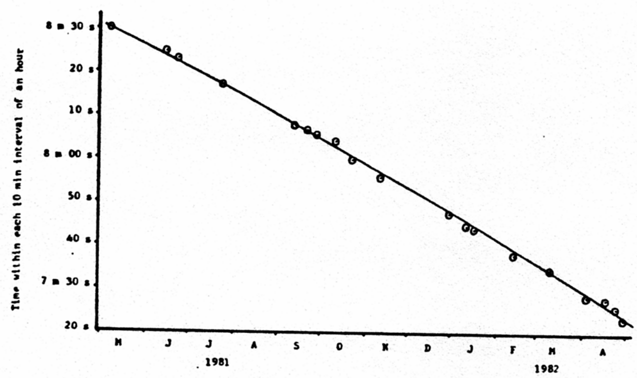

Fig. 2. Time of mode change becomes progressively earlier throughout the mission.

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REFERENCES

1. The Kettering Group, *Spaceflight*, 20, 353-355 (1978).
2. ibid.

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