TITLE: Snooping On Space Pictures

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STUDIES IN INTELLIGENCE

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Highlights of our scientists' success in intercepting and reconstructing the video from Soviet spacecraft.

SNOOPING ON SPACE PICTURES

Henry G. Plaster

Lunik III's pictures of the far side of the moon in October 1959 excited the world and proved that the Soviets had then the technology to aim a camera in space by remote control, command it to take pictures, automatically develop the film on board the spacecraft, and finally scan the fixed film electronically and transmit fair-quality pictures back to earth from lunar distances. Since then they have employed real-time (i.e., concurrent, "live") television systems in some of their earth-orbiting vehicles to monitor the behavior of dog and human passengers, and they have used in some of their Cosmos satellites a delayed transmission system somewhat similar to that of Lunik III.

A fascinating and extremely important aspect of the U.S. intelligence effort devoted to these video systems is the work of engineering analysis in "breaking out" the pictures contained in the radio transmissions. The process has a trial-and-error aspect like cryptanalysis: since both the horizontal and vertical sweep periods are unknown variables, there are an infinite number of possible combinations. The engineer usually begins by trying to synchronize the vertical axis by hand while synchronizing the horizontal sweep electronically. It requires hours of experimentation with the oscilloscope controls for sweep speed, filtering, and focus, displaying and redisplaying sometimes as little as two seconds worth of recorded data, to get results.

The results of this technical analysis have been valuable to intelligence consumers, and the successful effort deserves general recognition. It has involved special Elint collection techniques, new approaches to signal analysis, feedback to assist in subsequent collection, and intelligence interpretation of the pictures for the consumers.

Lunar Surface Video

The very weak signals returning to earth from Lunik III could not be picked up by standard Elint collection facilities and equipment.

Through the cooperation of the University of Manchester in England, therefore, use of the 250-foot radiotelescope at Jodrell Bank was obtained. The Soviets announced that pictures of the far side of the moon were taken between 0330 and 0410Z (Greenwich Mean Time) on 7 October 1959. Jodrell Bank succeeded in getting a signal on the announced frequency of 183.6 megacycles between 1410 and 1445Z that date. A ten-hour lag behind the actual picture-taking is not excessive: the film first had to be developed, and then the electronic scanning and transmission had to wait until rotation of the earth brought the Soviet deep-space station in the Crimea into position to pick up the signal.

The graduate students working for Sir Bernard Lovell at Jodrell Bank, however, in recording their intercept, narrowed the receiver bandwidth so far, in order to increase the signal-to-noise ratio, that they "clipped off" much of the video information. Confirmation that the Lunik III pictures released by the Soviets (See Figure 1) were valid thus rested on a single poorly recorded intercept from which it could be judged only that the picture was more likely of a test pattern than of the moon. The signal bandwidth, however, was compatible with the parameters announced by the Soviets, and on the basis of technical extrapolation it could be concluded that the Soviet lunar pictures were authentic.

Spacecraft Passengers Televised

Sputniks 5 and 6, launched respectively on 19 August and 1 December 1960, both transmitted signals on 83 megacycles which were initially reported by field Elint operators and later confirmed through detailed analysis to be video transmissions. Soviet announcements that the dog passengers on these satellites were being watched while in orbit by means of a "radio-television" system spurred on analytical efforts to demodulate this new type of signal, and before long CIA technical analysts did succeed in producing pictures from Sputnik 6's recorded signals. (See Figure 2.) These substantiated the Soviet claim of having developed a special television transmission system which could provide instantaneous reporting on the behavior of animal or human passengers aboard a Soviet spacecraft.

More important to intelligence in early 1961, however, was the establishment of a capability to determine as soon after launch as possible whether the Soviets had successfully orbited the first man in space, a feat they were expected to attempt at any moment. The

FIGURE 1. Soviet-released photograph of the far side of the moon taken by Lunik III.

FIGURE 2. Demodulated video from Sputnik 6 showing face and forelegs of a canine passenger.

National Security Agency undertook to design and produce special field collection equipment that would present oscilloscope pictures while the transmission was being received. Several such sets were produced on a priority basis, and the first two were sent to Elint sites in Alaska and Hawaii.

Demodulation of video transmissions from Sputnik 9 (9 March 1961) and Sputnik 10 (25 March 1961) substantiated the Soviet announcements that each of these single-orbit flights carried a dog passenger. Then on 12 April 1961 Sputnik 11 was launched, and 83-megacycle transmissions were detected twenty minutes later as the spacecraft passed over Alaska. Only 58 minutes after launch NSA reported that reliable real-time readout of the signals clearly showed a man and showed him moving. Thus before Gagarin had completed his historic 108-minute flight, intelligence components had technical confirmation that a Soviet cosmonaut was in orbit and that he was alive (See Figure 3).

Earth/Cloud Pictures from Orbit

In March 1962, after several failures, the Soviets launched the first satellite in what they referred to as the "Cosmos series." They announced the purpose of the new project to be scientific data collection, including study of "the distribution and formation of cloud patterns in the earth's atmosphere."

Cosmos 4 of the series, launched on 26 April 1962, transmitted signals, identified initially only as "a new data transmission system," in the frequency band between 162 and 175 megacycles, one not previously used in Soviet space operations. CIA technical specialists mounted an effort to demodulate these signals and similar ones from Cosmos 7, launched on 28 July 1962. Through rigorous analysis they established many of the signal parameters, but no identifiable pictures could be produced. Though recorded by a number of Elint collection sites, the signals were of insufficient quality for picture reconstruction because the general-search equipment used was not suitable for recording a highly complex wide-band, frequency-modulated video signal. From the unrecognizable pictures that were achieved it was nevertheless concluded that a camera or cameras on board these Cosmos vehicles were taking photographs, probably of cloud formations, that these photographs were developed by an on-board film processer, and that the fixed film was subsequently scanned electronically and the signals transmitted to ground-based receivers in the Soviet Union.

FIGURE 3. Demodulated video from Sputnik 11 showing movements of Gagarin.

Cosmos 9, launched on 27 September 1962, the third Cosmos vehicle to transmit video signals, was the first from which recognizable pictures could be reproduced. Since cloud cover was readily identifiable in a series of six pictures, CIA geophysics and electronics specialists consulted representatives of the National Meteorological Satellite Center of the U. S. Weather Bureau, the organization which processes the Tiros weather satellite photographs. Through photogrammetric analysis of the pictures, Cosmos 9 was adjudged to be an experimental weather satellite, stabilized about three axes, earth-oriented, and carrying a camera system with provision for delayed readout from the film. NASA was briefed on these findings prior to the 5 December 1962 signing of its agreement with the Soviet Academy of Sciences on cooperative space research and the exchange of data from meteorological satellites. The findings were also presented to a December 1962 meeting of technical representatives of the intelligence community, including some from the Jet Propulsion Laboratory working under an intelligence contract.

In direct consequence of this latter presentation, JPL technical experts embarked on a detailed study of all intercepts of the Cosmos video transmissions, making use of the most sophisticated electronic and photographic equipment available. By the following May they had succeeded in breaking out three overlapping pictures each composed of sixteen subframes which had been transmitted in sequence. (That they had been transmitted by electronically scanning the fixed film, as in Lunik III, was confirmed by their showing readily recognizable emulsion impurities.) Two of these pictures clearly showed Lake Van in Turkey (See Figures 4 and 5), and thus the entire land area in the pictures, where free from cloud cover, could be identified and the camera's field of view thereby defined. The wide-angle (85°) lens employed was such as would be expected in a meteorological satellite and not suitable for military reconnaissance. To achieve with this lens a military reconnaissance resolution on the order of twenty feet, the film would have to be five feet wide, a technological impossibility at present.

After Cosmos 15, launched on 22 April 1963, the Soviets orbited no further Cosmos vehicles with video transmissions, though they have launched and recovered more than a dozen that are believed to have had reconnaissance cameras aboard. On the basis of the stage of development manifested by the four that did transmit video, NASA was again briefed concerning Soviet weather satellite capa-

FIGURE 4. Cosmos 9 photo transmitted 30 September 1962 on 165 megacycles, showing clouds and surface features of the Turkish landscape.

FIGURE 5. Map of approximate area pictured in Figure 4.

bilities prior to the formal implementation on 16 August 1963 of its agreement with the Soviet Academy of Sciences regarding cooperative space programs. This agreement called for a regular exchange of data from meteorological satellites beginning in the second half of 1964, preceded by occasional exchange of experimental data during the first half of the year. It set as an objective pictures covering an area at least a thousand kilometers square with a resolution initially of 2.5 kilometers, ultimately of one kilometer.

No further flight testing of the video system having occurred since the spring of 1963, it became increasingly obvious as time passed that the Soviets were not going to be able to meet their 1964 commitments. As flown, the camera system identified through the video transmissions could not have met them: the 85° lens would need an altitude of 280 nautical miles to produce the required area coverage. At this altitude, however, the Cosmos system could transmit photos with an average resolution of at least 1800 feet, considerably better than the 3280 feet ultimately aimed at in the agreement.

This information plus an estimate of the characteristics to be expected in the initial "operational" Soviet weather satellite was passed along to NASA in advance of the May 1964 discussions in Geneva on further implementation of the meteorological agreement. Although the formal "memorandum of understanding" resulting from these discussions does not specify a new date for beginning the exchange of data, the Soviets informally agreed to aim for early 1965.

Future Prospects

When the exchange of data from meteorological satellites begins, anticipatedly in 1965, it will be up to the intelligence community to establish that the cloud pictures the Soviets give us are as complete and as good as what they receive from their satellites. After the initial determination, periodic spot checks will be required.

Real-time television signals will undoubtedly be transmitted from future Soviet manned spacecraft. TV pictures of Soviet cosmonauts' movements would be of great help to us in assessing pilot participation in rendezvous and docking operations. The activity of passengers in future Soviet orbital space stations will probably be monitored through live TV cameras, and U. S. intelligence will be in a position to check on it at the same time by operating readout devices at Elint sites peripheral to the USSR.

Future Soviet lunar and planetary probes will probably use a technique of picture taking and delayed electronic scanning and transmission. For manned lunar missions, some sort of picture transmission system will undoubtedly be employed, probably one with more advanced techniques.

Constant upgrading of collection equipment and continued analysis of transmitted video signals will ensure that U. S. intelligence will remain in as favorable a position for assessing future Soviet space efforts as it has enjoyed so far.