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The Soviet Earth Resources Satellite Program

An Intelligence Assessment

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Information available as of 1 April 1980 has been used in preparation of this report.

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June 1980

The Soviet Earth Resources Satellite Program [redacted]

Overview

In monitoring earth resources by satellite, Soviet systems provide multispectral photography [1] of better resolution than that of the US Landsat scanning system, but the data are more limited in quantity and generally are not as timely. The better resolutions are useful for all earth resources applications but are particularly important for estimating crop acreages in regions of the world where fields are small. [redacted]

In contrast to the multispectral scanner approach used by the United States, the Soviets have emphasized manned and unmanned multispectral photography in their earth resources satellite program. This approach has required less sophisticated data processing and recording equipment—two program areas in which the Soviets traditionally have been weak—but the quantity of data is limited by the amount of film aboard each satellite, and the data are, for the most part, not as timely. The Soviets are expected, however, to continue to emphasize the photographic approach at least through the middle 1980s because a suitable multispectral scanner system is unavailable. [redacted]

The Soviets' manned program, based on photographic and data processing systems developed by the East Germans, successfully provides multispectral photography with resolutions of 10 to 20 meters—resolutions that are considerably better than the 80-meter resolution of the US Landsat system. [redacted]

The unmanned earth resources photography system, based on the same or a very similar camera system, was used by the Soviets in 1979 to supplement the manned system in what probably was their first large-scale effort to monitor crops throughout the growing season, as well as to determine the feasibility of using such data to estimate agricultural production. Information on the results of this experiment has been unavailable, but the Soviets probably have found the results quite useful. [redacted]

The multispectral scanner currently used by the Soviets has a resolution capability of 250 to 300 meters, considerably below that of the US Landsat. The Soviet scanner, therefore, is inadequate for some types of earth resources studies—for example, those related to forestry and agriculture.

[1] Multispectral sensing involves the acquisition of data simultaneously in several bands of the electromagnetic spectrum. When the signals recorded in the multiple bands are analyzed in conjunction with each other, more information about the sensed area becomes available than if only a single band were used or if multiple bands were analyzed independently. [redacted]

We believe that the Soviets are developing a new multispectral scanning system with a 30-meter resolution, but it probably will not be available before 1983 at the earliest. Furthermore, data processing problems are expected to plague the Soviets and probably will delay further the operational deployment of the new system [redacted]

In a significant step for their oceanographic research program, the Soviets began launching oceanographic research satellites in 1979, but the fairly routine complement of sensors aboard did not compare with the complex payload of the US Seasat satellite. One of the two 1979 satellites, Intercosmos 20, was developed jointly by the USSR and several CEMA countries and represented the continuing trend by the Soviets to cooperate more fully with CEMA allies. Intercosmos 20 can relay data from remote earth installations, such as ocean buoys, to central receiving facilities. Cosmos 1151, launched early in 1980, reportedly has an active radar system—probably a scatterometer—to measure the magnitude of the waves. [redacted]

In the UN debate on how earth resources satellite data should be handled, the Soviets have proposed that data with resolutions better than 50 meters should not be made available to third countries without the consent of the sensed state. This proposal is attractive to some developing countries that are uneasy with the US policy of allowing anyone to purchase data from Landsat. [redacted]

Despite the high resolution of their photographic data, the Soviets probably cannot compete seriously with the US in supplying data and data systems to developing countries until the new Soviet multispectral scanner system is available, since their photographic data are limited both in quantity and timeliness. When the new system is in use, the Soviets' competition probably will include not only the United States but also several other countries. [redacted]

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The Soviet Earth Resources Satellite Program [redacted]

Introduction

Almost from the beginning of the space era, the Soviets have been interested in the remote investigation of the earth and its environment from spacecraft. Although early space missions were devoted largely to measurements of the space environment, the Soviets very early in their space program began to develop meteorological satellites. Other branches of the Soviet earth sciences soon began to realize the potential of remote sensing from space. This Soviet interest paralleled that of the United States and probably was stimulated by the US development of the Earth Resources Technology Satellite (ERTS—later renamed Landsat), which began in the mid-1960s. [redacted]

The Soviets had several space systems that they could have adapted easily for their earth resources satellite. The first of these was the Meteor weather satellite system developed during the early 1960s. The Meteor spacecraft is stabilized about three axes and thus would appear to make an ideal platform for a multispectral scanning system similar to that used in Landsat or for a photographic system with onboard processing similar to that used to provide photographs of the far side of the moon. [redacted]

The Soviet manned space program also offered excellent platforms on which to fly earth resources experiments. Earth observations from orbit are a natural thing for cosmonauts to do, and such observations provide valuable information on earth resources, as well as giving a good cover for military-related activities, such as testing sensors during missile launches. The active Soviet photoreconnaissance program also provided a good means for carrying out earth resources observations. The fact that the Soviets were proceeding with all these approaches became evident as the earth resources program developed. [redacted]

Manned Photographic Program

Although the Soviet manned space program has placed a high priority on earth observations from the early 1960s, the beginning of multispectral (usually referred to as "multizonal" by the Soviets) photography of the earth's surface came with the launch of Salyut 1 on 19 April 1971. On 7 June, Soyuz 11 docked with Salyut 1, and the crew began carrying out photographic observations a few days thereafter. The crew of Soyuz 11 perished as they returned to earth, but the photographic data were returned and studied by Soviet scientists. Salyut 1 carried both fixed and hand-held cameras. Besides photographing the earth, some of these cameras were used simultaneously to photograph the stars in order to locate accurately earth features on the photographs. [redacted]

Salyut 1 also carried a spectrophotometric experiment that was a continuation of work begun during the group flight of Soyuz 6, 7, and 8 in October 1969. This experiment was used to determine the brightness of various types of underlying surfaces in different parts of the spectral range from 0.4 to 0.7 micrometer (μm). The carefully prepared experiment of Soyuz 6, 7, and 8 involved simultaneous ground and aircraft observations for ground truth (to establish the accuracy of the satellite measurements) and was clearly related to the development of the multispectral camera. [redacted]

The deaths of the Soyuz 11 cosmonauts resulted in a standdown of the Soviet manned program until 1973, when Salyut 2 (never manned) was launched on 3 April. Soyuz 12—launched on 27 September 1973—continued the development of the manned photographic earth resources program with the inclusion, for the first time in space, of a multispectral camera. A major difference between this camera and that of Salyut 1 was that it provided simultaneous photographs in nine different bands, whereas the Salyut 1 camera could operate in only one band at a time. The newer camera had nine lenses with synchronous shutters actuated by a common control mechanism. The camera reportedly had a focal length of 44 millimeters (mm), a frame size of 24 mm by 32 mm, and three cassettes for the nine lenses. The nine spectral bands used were 0.05 to 0.1 μm in width and were centered at 0.42, 0.47, 0.54, 0.59, 0.63, 0.65, 0.68, 0.73, and 0.80 μm. [redacted]

Soyuz 13 was launched in December 1973 with the same type of camera as used on Soyuz 12. These flights were important steps in the development of the Soviet earth resources program and demonstrated the effectiveness of multispectral photography for purposes of cartography, geology, and vegetation studies. This photography provided Soviet scientists with information about oil- and gas-bearing structures, previously unknown faults, and shallow sources of fresh ground water in desert regions, thus confirming to the Soviets the potential of remote sensing. These data not only were of immediate use to the Soviet economy but also were used to determine optimal wavelengths and wavelength combinations to be utilized in future earth resources studies. [redacted]

Salyut 3, launched in June 1974, again provided earth photography that reportedly was used for the solution of "important national and economic problems." Salyut 3 photographs were said to help define 67 oil- and gas-bearing structures—including some underwater structures—and a number of intersections of large faults that were of interest in prospecting for valuable minerals. Salyut 3 also apparently continued the spectrophotometric observations carried out on Salyut 1. The observations, however, apparently were not a progressive step in the development of the multispectral photographic capability; more probably, they provided a convenient scientific objective for what was primarily a military mission. [redacted]

Twelve photographic systems of different types reportedly were aboard Salyut 4, launched in December 1974. Solar observations—rather than earth resources investigations—appeared to be the main mission of this spacecraft. Nevertheless, Salyut 4 carried wide-format mapping cameras—the KATE-140 and the KATE-500—as well as a multizonal photographic system, designated the FMS. The KATE-140 camera has a 140-mm focal length and a 180-mm frame format and has been used again extensively on Salyut 6. Little is known about the KATE-500; it probably had a function similar to that of the KATE-140. The "500" designator probably indicates a 500-mm focal length, since the "140" designator in the KATE-140 is the same as its focal length. One frame of the KATE-140 camera covers approximately [illegible],000 square kilometers of the earth's surface and is especially useful for determining relative and absolute altitudes of various points thereon. [redacted]

The FMS camera system consisted of four cameras operating in three spectral ranges: 0.5 to 0.6, 0.6 to 0.7, and 0.7 to 0.85 μm. Ground processing of these photographs included the use of false color to highlight various types of ground surfaces. The pictures reportedly were used to discover and map large faults and other geological features—particularly over inaccessible mountainous regions of the Pamirs and the Caucasus—and to analyze forest and water resources. In addition, the operation of the FMS photographic system aboard Salyut 4 provided important data for the development of the MKF-6 multizonal camera, which was tested aboard Soyuz 22 in September 1976. [redacted]

Salyut 5, launched in June 1976, had a military-related mission similar to that of Salyut 3, but—as in Salyut 3—the photographic experiments reportedly were also used for earth resources purposes. [redacted] The Soviets report that 65 million square kilometers were surveyed, including the region of the Southern Urals, Aral Sea, Altay mountain system, and the Dzhugarskiy and Alatou spurs of the Pamirs and Tien Shan mountain ranges, as well as portions of the Indian, Pacific, and Atlantic Oceans. [redacted]

Based on the results of the earth resources information collected from their many manned flights through Salyut 3, the Soviets concluded that they needed a multispectral camera with better capabilities than any they had available. This led to the development of the MKF-6 camera—a development that was to be carried out jointly by the Institute of Space Research in Moscow and Karl Zeiss in Jena, GDR. In reality, however, the new photographic system was developed almost entirely by Zeiss, based upon specifications provided by the Soviets. The Soviets also installed the camera on the spacecraft and integrated it with the subsystems of the spacecraft. [redacted]

The Soviets first approached the GDR about the development of this camera early in 1973; in 1974 an agreement was reached on the specifications that included operating the camera in wavelengths between 0.48 to 0.84 μm, using bandwidths of 0.04 to 0.10 μm. This agreement marked a new phase in the expanding cooperative space efforts between the Soviets and the East European countries. Heretofore, the East Europeans had built instrumentation to fly on Intercosmos satellites, but nothing on the scale of the MKF-6, which is the primary instrument for the Soviets' earth resources program. [redacted]

Besides the MKF-6 camera, the GDR also designed the multispectral projector designated the MSP-4. The MSP-4 is designed to provide high-resolution, synthesized color pictures from four black-and-white photos taken in different wavelengths. The MSP-4 also is a complex optical instrument that can provide color images with a fivefold enlargement. By combining light filters and varying the intensity of illumination of the initial (black and white) photographs, synthesized images can be produced in both natural and false color. [redacted]

Soyuz 22, with the MKF-6 camera aboard, was launched in September 1976, manned by a crew of two Soviet cosmonauts. After a flight of eight days, the camera and exposed film were recovered with the spacecraft. A somewhat modified camera, designated the MKF-6M, has been used extensively on Salyut 6. A reserve electronic bloc reportedly was added to the modified camera, and a thinner film probably was used so that 220 meters of film per cassette could be carried instead of the 110 meters used in Soyuz 22. [redacted]

Soyuz 22 reportedly provided more than 2,000 pictures of the earth's surface, with each frame covering an area of about 19,000 square kilometers. Thus, a total of 40 million to 50 million square kilometers were surveyed during the eight-day flight. Special test areas were established in the GDR, Bulgaria, and the USSR, and these areas were photographed repeatedly in conjunction with simultaneous ground and surface observations. These simultaneous observations should have provided good ground truth data to assist in analyzing the satellite photographs. [redacted]

The experiment aboard Soyuz 22 proved to be very successful, and the activity on Salyut 6 took on more of an operational—rather than experimental—mode. According to Ya. Ziman, who heads the earth resources program for the Institute for Space Research, 90 percent of the Salyut 6 photographs were obtained to fulfill requirements of the national economy, and only 10 percent for scientific purposes. Earth resources photography was a major portion of the overall mission, with both the KATE-140 mapping camera and the MKF-6M being used extensively during manned portions of the flight. During the first manned phase (10 December 1977 to 16 March 1978) of Salyut 6, the cosmonauts probably took about 3,000 frames with the MKF-6M, while in the second manned phase (16 June to 2 November 1978), 4,900 photographs reportedly were taken by the MKF-6M and KATE-140 cameras combined. [redacted]

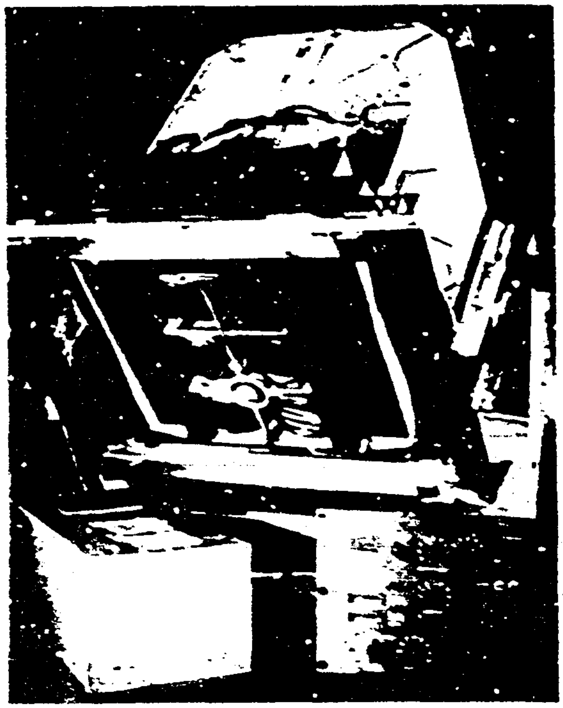
Salyut 6 photography was concentrated on certain geographical areas, including the Caspian Sea and the regions along the route of the Baykal-Amur railroad, as well as on areas that would be affected by the planned diversion of northern rivers. Photographs from Salyut 6 reportedly are being sent to more than 400 Soviet facilities having work under way in many scientific disciplines. [redacted]

Salyut 6 photography is being used by geologists to look for structures that show potential for oil, gas, and mineral deposits. New faults discovered in various tectonic regions of the world will contribute to a better understanding of faulting and its relationship to earthquakes. Hydrologists and glaciologists are finding the data useful for calculating water resources.

These data will contribute to a new atlas of snow and ice resources that the Soviets are compiling at the request of UNESCO. In the area of oceanography, the Soviets are using Salyut 6 photography to study shallow shelf zones where many reserves of minerals and petroleum are located. Salyut 6 photography also is used extensively in agriculture and forestry. [redacted]

Despite the wealth of information in the press and popular science publications about applying these data, little has appeared as yet in the scientific literature. Furthermore, Soviet scientists have presented few papers based on Soyuz 22 or Salyut 6 photography at scientific conferences. Part of this delay could be due to normal lag time in getting scientific papers published, but normal lag time would not account for the three years that have elapsed since the flight of Soyuz 22. Some of this delay probably is due to the data processing problems that so often hamper the timely dissemination of scientific analyses in the Soviet space program. [redacted]

The MKF-6 Multizonal Camera Figure 3



[redacted]

The MKF-6 camera has become a major factor in the Soviet earth resources program and probably will remain so for some time. While the Soviets eventually may design or purchase an improved camera, the MKF-6 probably will be used for at least the next five years. Similarly, we believe, the Soviets will continue

View of the Pamir Mountains Taken With the MKF-6 Figure 2

[redacted]

[redacted]

to use their manned spacecraft as a major input to the overall earth resources program. Tied to the manned program, earth resources observations receive more attention than they would if they were carried out aboard unmanned spacecraft. This fact can be of importance to the Soviets if they wish to overcome their late start and to compete with Western nations in providing satellite earth resources data to lesser developed countries. Also, the use of photographic data—as opposed to that of a multispectral scanner—does not tax Soviet data-processing capabilities so severely. On the other hand, earth resources observations aboard manned spacecraft normally have to compete with other experiments, and currently—with the exception of Soyuz 22—the Soviet manned spacecraft do not provide data much beyond 52° north or south latitude. Under current operational procedures, the manned program also does not provide data on a near-real-time basis. This often is not a serious detriment, but it could be in certain instances, such as monitoring crop conditions. The manned system could provide more timely data if the crews were rotated more frequently or if recoverable capsules were used as has been done on the military Salyuts.[redacted]

Unmanned Photographic Program

With the launch of Cosmos 771 in September 1975, the Soviets began a new phase of their earth resources satellite program (table 2).[redacted] The new series—now called ERPHO—have [redacted] flight duration, and spacecraft in common with most high-resolution photoreconnaissance satellites; they also are recovered in the same

Table 2

Launches of Unmanned Photographic Earth Resources Satellites

	Launch Date	Apogee (km)	Perigee (km)	Period (min.)	Inclination (degrees)
Cosmos 771	25 Sep 75	248	215	88.9	81.3
Cosmos 820	21 May 76	256	214	88.8	81.3
Cosmos 912	26 May 77	257	219	89.0	81.4
Cosmos 948	2 Sep 77	265	217	89.0	81.4
Cosmos 1010	23 May 78	256	218	89.0	81.4
Cosmos 1033	3 Oct 78	268	223	89.1	81.4
Cosmos 1099	17 May 79	274	224	89.2	81.4
Cosmos 1105	8 Jun 79	281	223	89.2	81.4
Cosmos 1108	22 Jun 79	272	224	89.1	81.3
Cosmos 1115	13 Jul 79	283	222	89.1	81.4
Cosmos 1123	21 Aug 79	296	221	89.1	81.4
Cosmos 1127	5 Sep 79	300	226	89.4	81.4
Cosmos 1102	25 May 79	288	222	89.2	81.4
Cosmos 1106	12 Jun 79	284	222	89.1	81.4
Cosmos 1118	27 Jul 79	273	222	89.1	81.4
Cosmos 1122	17 Aug 79	260	218	89.1	81.4

[redacted]

manner. Instead of the normal photoreconnaissance cameras, however, they carry five or six lower-resolution cameras. [redacted]

[redacted]

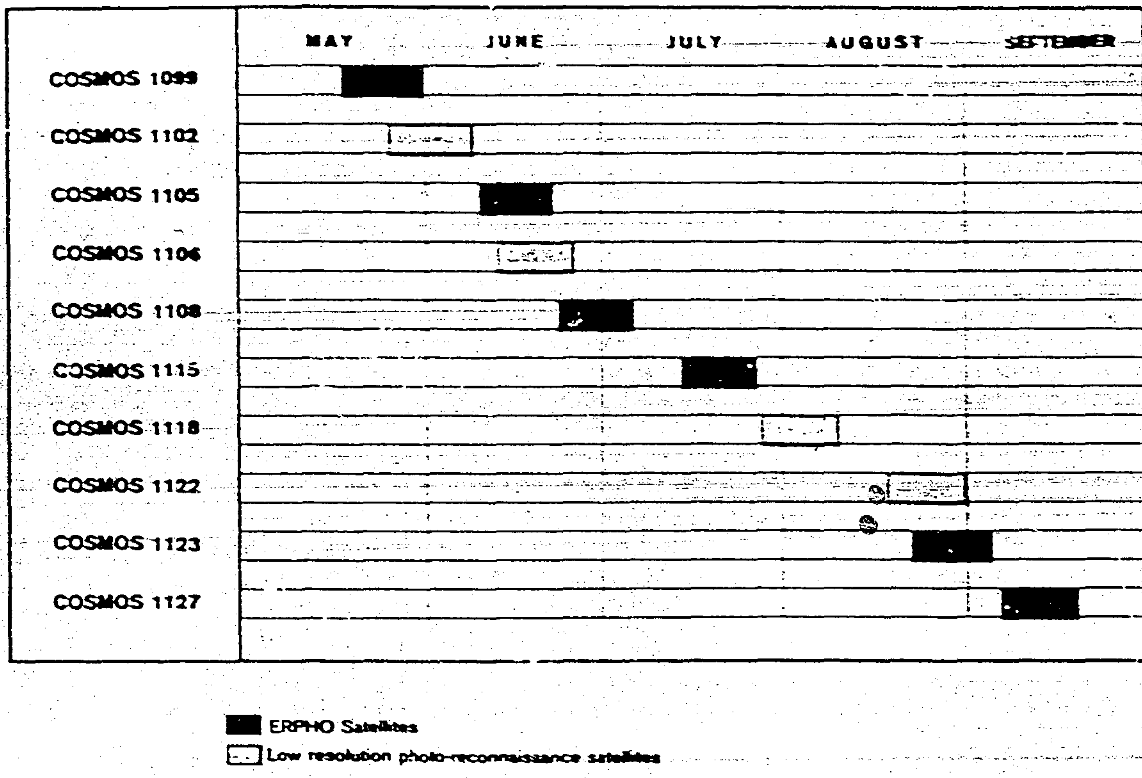
The cameras aboard the ERPHO satellites probably are multispectral and are similar or identical to the MKF-6 cameras used on the manned flights. Development of the MKF-6 camera reportedly did not begin until 1974, however, and the camera probably would not have been far enough along in its development at the time of the Cosmos 771 flight. In any case, the resolution of the two systems is assessed to be similar.

All the ERPHO satellites have been launched into orbits with about 81° inclinations. A notable feature of the launch schedule from 1975 through 1978 was the launch of one satellite in the spring and another in the fall. The near-81° inclinations provide the Soviets with coverage of the total USSR land mass, a[illegible]e spring and fall launches could indicate an interest in the sowing and harvesting of crops, as well as in other phenomena, such as the freezing and thawing of waterways and the amount of snow cover. Other types of earth resources investigations—such as geological features—probably could have been carried out equally well during other seasons of the year. [redacted]

The most interesting feature of the ERPHO program took place from May-September 1979, when six of these satellites were launched along with four regular low-resolution photoreconnaissance satellites that, the Soviets stated, had earth resources missions. The launches provided the Soviets with almost continuous coverage during this period (figure 3). The facts that

Summer 1979 Earth Resources Experiment

Figure 3



[redacted]

Table 3

Launches of Unmanned Satellites Each With a Multispectral Scanner System

	Launch Date	Apogee (km)	Perigee (km)	Inclination (Degrees)	Period (Minutes)
Meteor 1/18	9 Jul 74	905	875	81.2	103
Meteor 1/25	15 May 76	908	866	81.2	102
Meteor 1/28 (Meteor Priroda)	29 Jun 77	685	602	98	97.5
Meteor 1/29	25 Jan 79	656	623	98	97.4
Meteor 2/1	11 Jul 75	903	871	81.2	102
Meteor 2/2	7 Jan 77	932	893	81.3	103
Meteor 2/3	14 Dec 77	906	872	81.2	102
Meteor 2/4	1 Mar 79	908	857	81.2	102
Meteor 2/5	31 Oct 79	904	877	81.2	103

[redacted]

the period of activity embraced the sowing-through-harvesting phases of the crop season and that the coverage was nearly continuous are highly indicative that the driving factor for this operation was primarily agricultural. The ERPHO satellites would provide information on the status of crops, whereas the low-resolution photoreconnaissance satellites would provide information primarily on the status of field work. [redacted]

The Large Area Crop Inventory Experiment (LACIE) carried out by the United States between 1974 and 1977 using Landsat data showed that satellite data are very useful in determining wheat acreage, which—in turn—is used to make production estimates before harvesting has started. The Soviets' 1979 activity probably was similar in principle to the LACIE program, although other resources observations probably were also carried out. If the Soviets found these data useful, similar activity may be seen in following years. The Soviet program had the advantage of higher resolution data than the LACIE program; insufficient resolution was considered by US researchers to be one of the biggest weaknesses of the Landsat data, particularly in areas where strip farming effectively reduced field size. This generally is not a problem in the USSR, where fields are large. Data from the ERPHO satellites were not obtained in real-time since the film was not recovered for 13 days and then had to be processed. Overall, however, the Soviets probably found their data useful. [redacted]

Unmanned Multispectral Scanner Program

Soviet development of a multispectral scanner (MSS) for earth resources studies has been based on the Meteor weather satellite program (table 3). Since the beginning of that program in the late 1960s, video data provided by Meteor spacecraft have been studied by scientists—such as geologists and hydrologists—to determine the usefulness of such data in fields other than meteorology. Despite resolutions somewhat poorer than 1 km, the data were found to have some utility in nonmeteorological fields; however, the low resolutions combined with the lack of multispectral characteristics made the data far from ideal for a multidisciplinary earth resources program. [redacted]

Not until the launch of Meteor 1/18 in July 1974 did the Soviets fly a multispectral scanner in space. Meteor 1/25 was launched in May 1976 and Meteor 1/28 in June 1977—both also carried the developmental MSS. Meteor 1/28, however, was in a nominal 650-km orbit instead of the usual 900-km, and its inclination was a sun-synchronous 98° rather than 81°. Both of these changes were indicative of a mission more oriented towards earth resources, since the lower altitude would result in better resolution, and the sun-synchronous orbit would provide data with the same lighting conditions each time a satellite passed over a particular spot on the earth. Meteor 1/28 also was the first satellite to be called by the Soviet press, "Meteor-Priroda" (Nature), indicating that the development and testing stage had been completed or was nearing completion. The Soviets since have launched Meteor 1/29 into a l un-synchronous orbit similar to that of Meteor 1/__ [redacted]

The instrumentation aboard the recent Meteor 1 satellites consists of two multispectral scanners designated the MSU-M and the MSU-S. The MSU-M has a resolution of about 1 km and scans in four spectral ranges; the MSU-S has a higher resolution of 250 to 300 meters but scans in only two spectral regions (table 4). The MSU-M scans at a rate of four lines per second, and the MSU-S, at 48 lines per second. Because of this difference in scanning speeds, two different scanning principles are used—the MSU-M uses an oscillating mirror, and the MSU-S, a rotating reflecting pyramid. [redacted]

The Soviets also have been flying the second generation Meteor 2 satellites since 1975, and at least one MSU-M or MSU-S scanner is used on these satellites. The Meteor 2 satellites continue to be launched into the normal 900-km orbit, while the last two Meteor 1 satellites have been in the lower 650-km orbit. Whether this launch pattern will continue cannot be determined yet, but if it does, it suggests that the Meteor 1 satellites will be used mainly for earth resources studies, while the Meteor 2 satellites have meteorological observations as their primary mission. [redacted]

The resolution of the two scanners used on the Meteor satellites points towards a dual purpose—meteorological and earth resources. The establishment in 1974 of a new data processing center, the State Scientific Research Center for the Study of Natural Resources, (GOSNITsIPR), under the State Committee for

Table 4 Wavelengths (μm)

Meteor Multispectral Scanners

MSU-M (Resolution About 1 km)	MSU-S (Resolution 250 m-300 m)	
	1976	1977
0.5-0.6		
0.6-0.7		
0.7-0.8	0.43-0.73	0.46-0.67
0.8-1.0	0.77-1.02	0.7-0.82

[redacted]

Hydrometeorology and Control of the Natural Environment (GOSGIMET) also is indicative of a dual purpose. This center probably was established to process the MSS data from the Meteor satellites. At the same time, a second data center, the Scientific Research Center—Priroda, was established under the Chief Directorate for Geodesy and Cartography, apparently to handle the manned and unmanned photographic earth resources data. [redacted]

The 1-kilometer resolution of the MSU-M is adequate for most meteorological purposes. The 250- to 300-meter resolution of the MSU-S—although adequate for some types of earth resources studies—is not as good as would be desired for many such investigations. It also does not compare favorably with the 80-meter pixel size of the current US Landsat MSS or the 30- to 40-meter resolution envisioned for the next Landsat MSS. The Soviets probably would not rely entirely on photographic data to fulfill their requirements for higher resolutions, because these data are not available on a timely basis. Some users, such as those in agriculture, require both high resolution and timely data, and these requirements probably could be better met by an improved multispectral scanner system. [redacted]

In the early to middle 1970s, the Soviets showed a great deal of interest in purchasing US multispectral scanning equipment. The acquisition of these better scanners, however, would necessitate improved data processing capabilities; acquisition of such capabilities has long been a problem with the Soviets. At the time that they attempted to purchase US scanners, they also tried to obtain US data processing hardware and software and display systems. [redacted]

A third area of weakness in the Soviet program is that of recording capability. This was demonstrated in 1976, when an eight-band scanner was flown aboard an aircraft to collect agricultural data. Since only four channels could be recorded at one time, the plane had to make two passes over the area in order to obtain data from all eight channels. Little is known about what steps the Soviets are taking to alleviate this recording problem. [redacted]

Soviet attempts to purchase US multispectral scanners and associated data processing systems have diminished since the middle 1970s. The Soviets probably have concluded that it would be too expensive and too troublesome to rely entirely on foreign purchases for such equipment and have decided to develop their own. [redacted] the Soviets are developing a new multispectral scanner that is to have better resolution than the MSU-S [redacted]

Little is known about steps the Soviets have taken recently to develop or acquire associated data processing equipment. In any case, they would be unlikely to have appropriate equipment for a near-real-time system by 1983; a more reasonable date for such a system to come on line probably would be the late 1980s. Despite the fact that the Soviets are developing bigger and better computer systems, the problem of processing earth resources satellite data probably will be with them for some time to come. [redacted]

In recent years the Soviets have tended to allow other socialist countries in the Intercosmos satellite program to develop increasingly complex instrumentation. In addition to the MKF camera, the East Germans also have developed a Fourier spectrometer, which the Soviets have flown on several of the recent Meteor spacecraft. One of the East European countries—probably East Germany or Czechoslovakia—very possibly could be assigned the task of designing a new multispectral scanner and possibly data processing equipment, as well. [redacted] Intercosmos is designing a remote-sensing scanner of some sort that is scheduled to be launched in 1981. Whether or not this instrument is a multispectral scanner remains to be seen. [redacted]

Ocean Remote Sensing Program

The Soviets maintain a very large oceanographic research program and for many years have displayed interest in using remote sensing systems in space as an additional tool for ocean observations. Considering the vast area covered by oceans and the difficulty in taking observations over any significant percentage of that area, this interest is natural. Soviet oceanographers have worked with data from the Meteor satellite program, as well as with visual and instrumental observations from manned spacecraft, but not until 1979 did the Soviets launch any satellites dedicated to oceanographic observations. [redacted]

The Meteor satellites have provided visible imagery, as well as infrared and microwave radiometer measurements. These data have had limited utility for oceanographic research in areas such as sea surface temperature measurements, sea state studies, and observations of ice cover and pollution. The use of multispectral scanners in the Meteor spacecraft probably resulted in oceanographic data of somewhat greater utility, but these data are better suited for meteorological and earth resources evaluations rather than for oceanographic studies. [redacted]

The manned space program has played a somewhat larger role in the field of oceanography, and instruments used for observations of the earth's land surfaces (such as the MKF multispectral camera) also have provided important oceanographic data. A discussion of results from Salyut 6 by K. N. Fedorov, Director of the Section of Space and Experimental Oceanology at the Institute of Oceanology of the Academy of

Sciences, stresses observations of internal waves and eddies and currents, as well as oil slicks, as being important products of the Salyut flight. Articles by personnel from the All-Union Scientific Research Institute of Marine Fishing and Oceanography naturally have pointed out Salyut 6 observations of interest to the fishing industry, such as regions of high biological productivity. Synchronous observations were taken by Salyut 6, [redacted] vessels, and aircraft reportedly over areas of the [redacted] Sea, and routine communications were maintained between the cosmonauts and scientists. [redacted]

Cosmos 1076, launched on 12 February 1979, was the first known Soviet satellite dedicated to oceanographic observations. According to press reports, the main tasks of Cosmos 1076 are to chart optimum and safe shipping routes, to search for areas of good fishing prospects, and to collect meteorological information. Instrumentation for the satellites reportedly was developed by the Marine Hydrophysics Institute of the Ukrainian Academy of Sciences, the Institute of Radio Engineering and Electronics, and the Institute of Oceanology—the last two institutes are in the USSR Academy of Sciences. The announcement was made that Cosmos 1076 was to work closely with surface ships that would provide ground truth for the satellite observations. [redacted]

[redacted]

A second satellite related to oceanic investigations, Intercosmos 20, was launched on 1 November 1979. Like that of Cosmos 1076, the mission of Intercosmos 20 reportedly includes observation of regions of high biological productivity, as well as zones of ocean pollution. The payload for this satellite was developed by scientists from the USSR, East Germany, Romania, Czechoslovakia, and Hungary. Instrumentation aboard reportedly includes a multichannel spectrophotometer for measuring the magnitude of the emitted radiation from the ocean surface in various wavelengths—probably in the visible—a double polarization radiometer for measuring emitted radiation in the microwave, and a magnetometer that probably is for attitude determination. A large part of the Intercosmos 20 mission is to receive scientific information from ocean buoys and some remote land stations and to retransmit it to central receiving stations in the participating countries. Intercosmos 20 may be the Okean satellite on which the Intercosmos organization was reported to be working for launching late in 1978. [redacted]

Cosmos 1151, sent up on 23 January 1980, is the most recent oceanographic research satellite launched by the Soviets. This satellite appears to be generally similar to Cosmos 1076, but the Soviets have announced that it carries a radar to collect information about the magnitude of waves, in addition to the instruments that were aboard Cosmos 1076. Although the type of radar aboard Cosmos 1151 has not been specified, it most likely is a scatterometer, a special purpose instrument designed to provide information about the roughness of the underlying surface. [redacted]

[redacted]

[redacted]

International Issues—Data Sharing

International interest in earth resources data is widespread and growing. To date, the US Landsat is the only active satellite providing such data routinely, but as the Soviet program develops, the Soviets could become competitors with the United States in supplying data. The United States has the advantage of getting an earlier start: ground stations in Brazil, Italy, Canada, Japan, and Sweden already are receiving data from Landsats, and several other countries are planning to install these stations in the near future. On the other hand, several of the developing nations are uneasy with the US policy of making Landsat data available to anyone who wishes to purchase it. [redacted]

The Soviets traditionally have imposed strict controls on satellite photography and generally have been reluctant even to share such information relating to observation of earth resources. This policy began to change, however, after the development of the MKF-6 multispectral camera; the Soviets apparently have been sharing these data with other socialist countries. In 1977, the Soviets broadened their data sharing policy considerably when they announced to the United Nations that they were prepared to carry out remote sensing of territory belonging to other countries and to provide those countries with the resulting data. [redacted] that two conditions would be imposed before any country could obtain such data. First, the requester would have to pay an unspecified charge, and, second, the requester would have to agree to allow Soviet personnel to assist in mapping the data. [redacted]

Since then, the Soviets have reached an agreement with the CEMA states regarding the distribution and use of satellite data for earth resources studies. This convention—which probably is intended to be a model for dealing with other states—stipulates that the consent of a sensed state does not need to be obtained before sensing activity takes place. A second requirement is that data with a resolution better than 50 meters shall not be released to a third party without the consent of the sensed state. [redacted]

We expect that Soviet bilateral offers to other countries will increase in frequency as more satellite data are accumulated. The major source in the near term for these data probably will be MKF cameras aboard manned spacecraft, such as Salyut. Data from the unmanned photographic satellites also may be offered, but exchange of these data is less likely than an exchange of data from the manned spacecraft. MKF data from manned satellites are apt to be much more plentiful, and the Soviets probably would like the added propaganda value of an international exchange to boost their manned space program. Multispectral data from the Meteor satellites could be offered, but these data probably would not be very desirable because they are so inferior to Landsat data. [redacted]

Its good resolution will make the Soviets' multispectral photographic data attractive to other countries. Other selling points that the Soviets could use are the massive size of their mapping establishment and their competence to assist developing countries in using the data, as well as their willingness to keep the data from other states. We do not believe, however, that the MKF data will challenge seriously Landsat data. The Soviets may become more competitive when they are able to provide improved MSS data; however, by that time, their competition probably will include other countries—such as France [redacted] in addition to the United States. [redacted]