DEFENSE MAPPING AGENCY

REPORT

ON THE

EVALUATION AND PROCUREMENT

OF

FORMER SOVIET UNION IMAGERY AND MATERIALS

A REPORT TO THE CONGRESSIONAL DEFENSE COMMITTEES

Response to Public Law 103-139, HR 3116

10 March 1994

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
SECTION I - REFERENCE 3
SECTION II - BACKGROUND 4
SECTION III - SCOPE AND OBJECTIVES 5
SECTION IV - MATERIAL AVAILABILITY 6
4.1 DESCRIPTION OF SOURCES. 6
4.1.1 VENDORS 6
4.1.2 CIS ORGANIZATIONS 7
4.1.2.1 PRIRODA 7
4.1.2.2 Inter-Regional Center for Geological Cartography (GEOKART) 9
4.1.2.3 Sokol-Almaz - Radar Corporation (SAR Corporation). 9
4.1.2.4 Other Russian Organizations 9
4.2 ACQUISITION APPROACH. 9
4.2.1 ACQUISITION ALTERNATIVES 10
4.2.2 CONCLUSIONS 11
SECTION V - PRIORITIES FOR ACQUISITION 12
5.1 ANALYSIS OF VENDOR RESPONSES. 12
5.1.1 SENSOR CHARACTERISTICS 12
5.1.2 COST DATA 14
5.1.3 METHODOLOGY FOR PROCUREMENT 15
5.2 POTENTIAL APPLICATIONS 15
5.2.1 DOD APPLICATIONS 15
5.2.2 OTHER FEDERAL AGENCIES 16
5.2.3 STATE/LOCAL GOVERNMENTS. 17
5.2.4 ACADEMIC INSTITUTIONS 17
5.2.5 PRIVATE SECTOR 18
SECTION VI - PROCESS FOR DISSEMINATION 19
6.1 DOD, CIVIL, AND PRIVATE USERS 19
6.1.1 DOD 19
6.1.2 NON-DOD GOVERNMENT 19
6.1.3 NON-GOVERNMENT 20

TABLE OF CONTENTS (Cont'd)

SECTION VII - EVALUATION PLAN **21**

7.1 PHASE II EVALUATION 21

7.2 PHASE III EVALUATION 23

7.3 TYPES OF MATERIALS NEEDED 24

SECTION VIII - CONCLUSIONS **25**

8.1 MATERIAL AVAILABILITY 25

8.2 PRIORITIES FOR ACQUISITION 25

8.3 PROCESSES FOR DISSEMINATION 26

LIST OF ACRONYMS 27

GLOSSARY OF TERMS 28

EXHIBIT 1. Russian Imagery Material Vendors 31

EXHIBIT 2. Copy of HQ DMA Message to USDAO, Moscow 32

EXHIBIT 3. Copy of USDAO, Moscow, Message to DMA 33

EXHIBIT 4. Russian Sensor System Characteristics 34

EXHIBIT 5a. Small Chip from Russian KFA-1000 Image System 39

EXHIBIT 5b. Small Chip from French SPOT Image System 40

EXHIBIT 6. Vendor Price Range, By Product, for Russian Imagery 41

EXHIBIT 7. List of Russian Material to be Ordered for the Phase II Evaluation 44

EXECUTIVE SUMMARY

BACKGROUND. Public Law 103-139, HR 3116 (Department of Defense Appropriations Act, Fiscal Year 1994) requires the Defense Mapping Agency (DMA) to evaluate and procure available imagery photographs, and materials from successor states of the former Soviet Union. It also requires a preliminary assessment of the availability, acquisition priorities, and dissemination process.

GENERAL. This report summarizes actions taken by DMA in response to this tasking. DMA solicited information from commercial and Government sources necessary to document availability of imagery and materials, and the process to purchase and disseminate to federal, state and other institutions. A plan was also established to complete acquisition of imagery and materials.

MATERIAL AVAILABILITY. Russian imagery and materials are available from a wide range of commercial sources. The imagery materials and ephemeral data vary widely in quality and accuracy. Eight vendors were identified as primary sources for Russian imagery materials. Diplomatic contacts were made through the U.S. Embassy to ascertain guidance and proper avenues of pursuit. These sources and current organization of Russian agencies are presented, along with potential acquisition parameters. Priroda, in Moscow, serves as the primary civilian organization in the Russian Federation for using and applying remote sensing data from space platforms for commercial purposes and customers. DMA is currently pursuing several options, and a final decision will be made in the ensuing phases.

PRIORITIES FOR ACQUISITION. Sensor system data provided by identified sources was analyzed using information obtained. The characteristics of eight different imaging systems were analyzed, including cost, availability, content, and operational parameters. System performance compares favorably with SPOT and Landsat. Cost and coverage comparisons are made, and imagery examples provided. Based on limited samples and inputs from other agencies, a statement of potential applications was determined. This established acquisition priorities which were used to configure a DMA procurement of materials for evaluation. Image materials' quality and metric content are the elements required in current acquisition priorities. No utility evaluations were made to support acquisition priority for or by other agencies. A list of potential applications is provided for other DoD, state/local governments, academia, and the private sector, by example.

PROCESS FOR DISSEMINATION. A number of methods for domestic dissemination of Russian materials were examined. The merits of each are delineated based on currently available data. Potential options identified separate DoD, non-DoD Government, and non-Government channels for dissemination consideration. The dissemination approach will, of necessity, be linked to the chosen acquisition approach. DoD agencies could be assigned to disseminate material which supports DoD requirements. For DoD and non-DoD agencies, distribution channels currently exist through Earth Science Information Centers (ESIC). Another approach is to rely solely on existing commercial vendors for dissemination. Both methods are currently under investigation.

CONCLUSIONS AND RECOMMENDATIONS. Preliminary conclusions were made on the availability, acquisition priority, and dissemination methods for the identified imagery materials. Conclusions were made from the perspective of information available at this time.

Limited examination of small available samples of source materials indicated wide variations in quality, cost, and delivery times. Not all vendors offer all materials, and in general, coverage information was not available. Collateral imagery materials are sometimes available, but with marginal quality. The current Russian marketplace is fluid, unreliable, and Russian vendors do not follow normal free enterprise business practices.

Once adequate Russian materials are available, a comprehensive evaluation can be conducted.

A specific configured list of materials is being acquired to more fully determine material availability and metric content, and provide a sound basis for utility assessment.

SECTION I - REFERENCE

Public Law 103-139, H.R. 3116, Department of Defense Appropriations Act, Fiscal Year 1994, 21 October 1993.

SECTION II - BACKGROUND

Public Law 103-139 requires the Defense Mapping Agency (DMA) "to evaluate and procure available imagery photographs and materials from successor states of the former Soviet Union." The Congressional Act further stipulates that the Director, DMA, "shall report to the Congressional Defense Committees the availability of such imagery materials, priorities for acquisition, and the process for dissemination of such materials to Federal agencies, state and local authorities, academic institutions, and private sector." A sum of $1,000,000 was provided to DMA for this purpose. The report to the Congressional Defense Committees is required no later than 15 March 1994.

Russian military photographic and synthetic aperture radar (SAR) programs are now available to customers in the United States, as well as the rest of the world. Material from current sensor tasking, as well as archives, is available. The Russian Federation is currently evolving into a free market environment which has not stabilized as of the date of this report and Russian classification rules may close the current window of opportunity. Resources that were previously dedicated to the former Soviet Union are now being shared between Russian government agencies and small private Russian companies. Private business practices are such that a query about availability is considered tantamount to a firm order, and payment is required at the same time products are received. These situations emphasize that the sources from which these materials may be acquired are unstable, do not follow American business practices, and are ultimately controlled by the political and military establishments. Consequently, there is a risk in relying on the availability of these materials.

SECTION III - SCOPE AND OBJECTIVES

Due to the anticipated extent of the tasking and the temporal constraints, the evaluation effort was divided into three separate phases. Phase I was identified as that portion of the evaluation and procurement effort which could be completed prior to the 15 March 1994 Congressional Report date, and Phases II and III include the continuing evaluations if needed to provide metric and full assessment of the imagery and materials.

Phase I is documented in this report. This activity included preliminary efforts necessary to address the response to the Public Law and Congressional Act which requires analysis, procurement, and evaluation of Russian photographs and materials. In addition, activities were initiated to determine the availability of such materials, priorities for acquisition, and processes for dissemination.

The Phase II effort will be designed to evaluate the metric properties of the camera systems from the data provided with the imagery. Imagery will be ordered over DMA test ranges and analyses will be performed to determine the validity of the camera calibration data and the reliability of the position and attitude information provided with the imagery. Appropriate mathematical relationships will be documented to guide users in how to interpret and use the information provided with each set of imagery. Any information that is lacking or its use not clearly understood will be documented for further discussion with the vendors or Russian source. Completion of this phase is anticipated no later than 30 June 1994.

If necessary, the Phase III effort will be designed to complete the system evaluation process and to develop an operational concept for the utilization of selected imagery. Each imagery system's characteristics will be identified to inform potential users of what to expect and not to expect from the source. Systems that appear to be applicable for Mapping, Charting and Geodesy (MC&G) operations will be investigated further to determine their full metric potential. This phase will be completed no later than 30 September 1994.

SECTION IV - MATERIAL AVAILABILITY

4.1 DESCRIPTION OF SOURCES. A number of domestic and foreign commercial sources have recently been identified to support the sale of space imagery and related materials from the former Soviet Union. These sources were identified by means of a notice placed in the Commerce Business Daily (CBD), and by telephone calls and referrals. A list of identified known Russian imagery material vendors is provided in **Exhibit 1.** In addition, meetings were held with domestic commercial vendors during the month of January.

4.1.1 VENDORS. DMA issued a "sources sought" synopsis in an effort to identify domestic commercial vendors of imagery photographs and materials from successor states of the former Soviet Union. Eight responses to the CBD announcement were received, as follows:

Autometric, Inc. 5301 Shawnee Road Alexandria, VA 22312	Jofuskie, Inc. 5724 Cedar Creek Dr. Forth Worth, TX 76109
WorldMap (JEBCO/RAMP Int'l) 3120 Rogerdale, Suite 100 Houston, TX 77042	Russian and East European Partnerships 724 East Industrial Park Dr., Unit 9 Manchester, NH 03109
Novecon Technologies 1203 Sunrise Valley Drive Suite 300 Reston, VA 22091	* Computer Sciences Corp. Science Systems Div. 10000-A Aerospace Rd. Lanham, MD 20706
* DBA Systems, Inc. 1200 South Woody Burke Melbourne, Florida 32902	Wirin & Associates 555 Indian Trail Palm Beach, CA 92264

These vendors reported to offer imagery/material products from eight imagery collection systems of interest, as summarized in Table 4.1.1-1.

* The responses from DBA Systems, Inc. (DBA) and Computer Sciences Corporation were marked proprietary, and are thus being regarded as proprietary information as required by the Federal Acquisition Regulation 3.104.

Table 4.1.1-1. Russian Imagery Vendors Matrix

Russian Imagery Vendor Vs. Sensor					
Sensor System	DBA Systems, Inc.	Computer Sciences Corp.	WorldMap	Jofuskie, Inc.	Autometric, Inc.
TK-350	X	X	X	X	X
KVR-1000	X	X	X	X	X
KATE-200	X		X	X	X
KFA-1000	X		X	X	X
MK-4	X	X	X	X	
KFA-3000	X		X		
DD-5	X		X		
ALMAZ	X				X

NOTE: The general characteristics of each of these sensor systems are in Table 5.1.1-1.

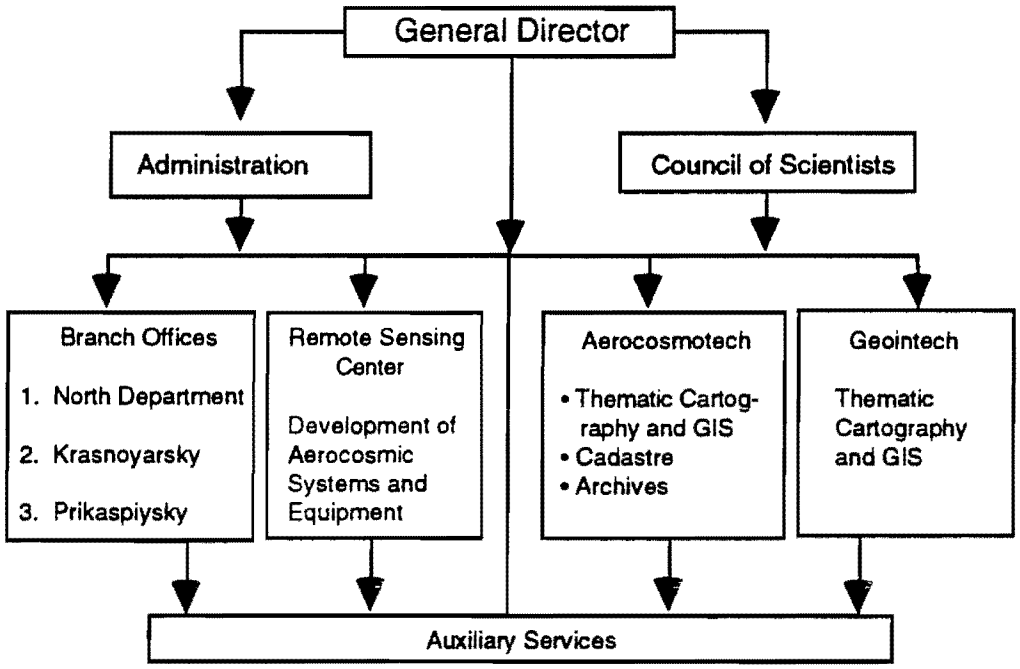
4.1.2 CIS ORGANIZATIONS.

4.1.2.1 PRIRODA. The State Centre, Priroda (meaning "Nature"), in Moscow serves as the primary civilian organization in the Russian Federation for using and applying remote sensing data from space platforms for commercial purposes and customers. Priroda's cartographic activities include the use of space imagery to make digital maps, thematic maps, and specialized maps (such as ecological and natural resource maps). Priroda's activities support both Geographic Information Systems (GIS) and traditional map-making activities.

Dynamic political and economic circumstances within the Russian Federation are creating a blend of "traditional" government-run organizations that are closely involved with many smaller groups of "private" companies whose employees work both for the parent government organization and also use its assets to pursue private commercial ventures with foreign private firms, institutes and governments. The situation in Priroda is no different. The chart below reflects the latest organizational structure. The branch offices, Aerocosmotech and Geointech, perform similar applications functions, including thematic mapping, GIS support, digital terrain modeling, and image processing. The four groups within Priroda (each under a different manager) use the same "central" budget, pool of personnel and equipment. There is only one foreign currency account, but within Priroda there are several small private companies, including GeoInform (which is located within Aerocosmotech). GeoInform is a two-year-old group which has done small domestic projects and is in the process of negotiating larger contracts with foreign firms. Under current working relationships within Priroda, the information, imagery, processing

equipment and personnel "belong" to Priroda, but execution of projects (especially modest-size, hard currency projects) is conducted by small private companies.

PRIRODA ORGANIZATION



When dealing with Priroda today, a foreign group has two distinct options: contract directly with Priroda, which then will subcontract with one or several of the small, embedded private firms, such as GeoInform; or contract with the small private firm within Priroda, and this private firm will then obtain permission to use Priroda resources to conduct the project. The choice depends on the type of project being contemplated. If the project involving Russian space imagery is clearly defined and not too large or too long, direct interaction with the private company within Priroda is considered the more expedient approach. If, however, the contemplated project is large and spans several years, and/or needs specialized support systems and hardware, then it is recommended that the foreign group approach Priroda directly.

The "Remote Sensing Center" group depicted in the Priroda organizational chart is the group responsible for hardware and GIS equipment manufacturing.

Some of the typical imagery-related services provided by small private firms embedded within Priroda include the following:

a. Creation of new and updating of old maps and photomaps covering any territory on earth

b. Creation of digital terrain matrixes (DTMs) and electronic maps

c. Thematic cartography (natural resources and environment)

d. Creation of cartographic data bases and knowledge bases for expert systems

e. Sale of space imagery, DTMs, and cartographic products

f. Creation of a new world atlas

The political, military, private enterprise, and economic situations in the Russian Federation are very fluid at this time, and concurrent efforts are now underway to obtain the most accurate "current" information about the firms, organizations and institutions responsible for the acquisition, processing, and sale of Russian high resolution space imagery.

4.1.2.2 Inter-Regional Center for Geological Cartography (GEOKART) This organization functions as a research-production and commercial enterprise in the sphere of complex geological investigation. It produces and markets high quality cartographic, technological, and other natural resource information products. The staff consists of approximately 220 scientists who perform professional and analytical services. They maintain an extensive data base of approximately 8000 mineral deposit locations and associated information. Much of the data is collected by aimed satellite surveys which image sites of interest from various optical angles. At this point, they do not sell the imagery, they acquire.

4.1.2.3 Sokol-Almaz - Radar Corporation (SAR Corporation). This is a Russian-American enterprise which has been established to complete development of the space system ALMAZ-1B. The satellite will have 3-frequency radar, with a stated resolution of 5-7 meters, which will obtain detailed images of the earth around the clock in any weather conditions. In addition, onboard optical and infrared sensors will obtain images with various resolutions (starting at 2.5 meters) in 8 frequency ranges. The ALMAZ-1B is scheduled to be launched in the 1997 timeframe into an orbit at 350-400 kilometers, with a scheduled lifespan of 3 years.

4.1.2.4 Other Russian Organizations. The following are other organizations involved in satellite imagery: Soyuzkarta; NPO Energlya; NPO Mashinostroenlys; Sovinformsputnik. During the follow-on phases, we will investigate whether materials are available directly from these organizations.

4.2 ACQUISITION APPROACH. Acquisition of the Russian materials is an untested critical concern from many aspects.

4.2.1 ACQUISITION ALTERNATIVES

DMA contacted the USDAO in Moscow, Russia, seeking information/ guidance on alternatives for procuring commercially available Russian-obtained satellite imagery and materials (**Exhibit 2**). USDAO responded that there were three acquisition contact alternatives that could be pursued (**Exhibit 3**).

Alternative 1 - Purchase through private Russian commercial enter-prises or Russian national-level non-defense government agencies with commercial contracting authority.

Alternative 2 - Purchase through a U.S. vendor to private Russian commercial enterprises or Russian national-level non-defense government agencies with commercial contracting authority.

Alternative 3 - DMA direct to Russian military mapping organization under terms of U.S./Russian Federation ministerial-level defense mapping agreement, to be negotiated.

Advantages and Disadvantages

a. **Alternative 1.** USDAO advised DMA that this alternative was the most risky. It compels DMA to deal in a "private" Russian business environment with many "legal and administrative" nuances that could potentially foster future legal/administrative problems for DMA. DMA historically does not deal with such details; however, such expertise could be developed, if required.

b. **Alternative 2.** DMA could greatly reduce or eliminate the above risk by contracting with qualified U.S. commercial vendor(s) to work as middlemen for procuring the desired Russian-obtained satellite imagery/materials. The vendor(s) would not be DMA representatives, but rather suppliers to DMA of Russian imagery/ materials. Transactions between the vendors and the above enterprises/agencies would be transparent to DMA.

c. **Alternative 3.** DMA plans to visit Moscow, Russia, in mid-April 1994 to initiate defense mapping agreement discussions with the Russian military mapping organization. Accordingly, DMA intends to discuss with the Russian military the feasibility of including the procurement of Russian-obtained satellite imagery/ materials under the terms of the defense mapping agreement.

4.2.2 CONCLUSIONS. At this time, DMA is pursuing two of the above alternatives (2 and 3) during the first phase, and will make a decision during Phase II to either choose one alternative or continue with both alternatives. Alternative 1 has not been ruled out, and will be pursued in Phases II and III if it looks attractive.

SECTION V - PRIORITIES FOR ACQUISITION

Users will base the priority of acquiring the Russian imagery on a number of different factors. This section summarizes some of those factors based on the salient information which was submitted to DMA by commercial vendors of the Russian imagery materials. Initially, a summary of the sensor characteristics (image quality), comparative cost of the data, and the methodology for procurement are given. A subsection presents some of the potential users and applications for the material.

5.1 ANALYSIS OF VENDOR RESPONSES. A broad range of Russian image materials is available. Resolution of the images ranges from less than 2 meters for the DD-5 sensor, to 15-30 meters for the KATE-200. Table 5.1.1-1 gives a summary of the sensors and their characteristics. Additional details regarding each of the sensors and their characteristics are in **Exhibit 4.** Figure 5.1.1-1 illustrates the comparative image footprint for each sensor. Footprints for the SPOT and Landsat commercial systems are given for comparative purposes. Table 5.1.2-1 is provided to show cost comparison between the systems. Again, the SPOT and Landsat sensors are presented to give a known commercial baseline. Photographic comparisons of SPOT and Russian (KFA-1000) imagery materials are provided as **Exhibits 5a and 5b.**

5.1.1 SENSOR CHARACTERISTICS Russian military photographic and SAR materials are now available to customers in the United States as well as the rest of the world. Imagery and materials are available from the current tasking of on-orbit sensors, and current archives. Some even offer the option of funding and fully controlling a dedicated launch vehicle. The 5-10 meter panchromatic and 10-meter color archives were started in the early 1970's. The 2-meter digitized and film archive appears to extend back to the mid- to late-1980's. The SAR data and images started in the very late 1980's. The ALMAZ I SAR System failed in October 1992; however, follow-on launches are planned. The 1994 launch schedule is MK-4, June; KFA-1000/KATE-200, May; and KFA-3000, July.

However coverage information is not yet complete by sensor, geographic area, nor by date. Worldwide coverage from some of the sensors is believed to be available. Several Russian companies and many other U.S. private firms are selling the photographic and SAR products. As might be anticipated in this environment of rapid commercialization of formerly restricted information, not all companies offer products from all sensor systems. There is also a great deal of information concerning cameras, sensors, platforms, processing, archiving, etc. Some information provided was found to be conflicting.

Table 5.1.1-1. Russian Imagery Sensor Characteristics

Primary Commercial Sensors								
Sensor Name	KVR-1000	DD-5	KFA-3000	TK-350	KFA-1000	MK-4	KATE-200	ALMAZ
Type	Panoramic	Digital	Frame	Frame	Frame	Multi-spectral	Frame	Digital
Resolution	2-3 m	<2m	3m	5-10 m	5-6 m	6-8 m	15-30 m	>15m
Format	18x72 cm	Tape	30x30 cm	45x30 cm	30x30 cm	18x18 cm	18x18 cm	Tape
Footprint	36-44x165 km	Variable	21x21 km	265x170 km	80x80 km	170x170 km	225x225 km	Variable

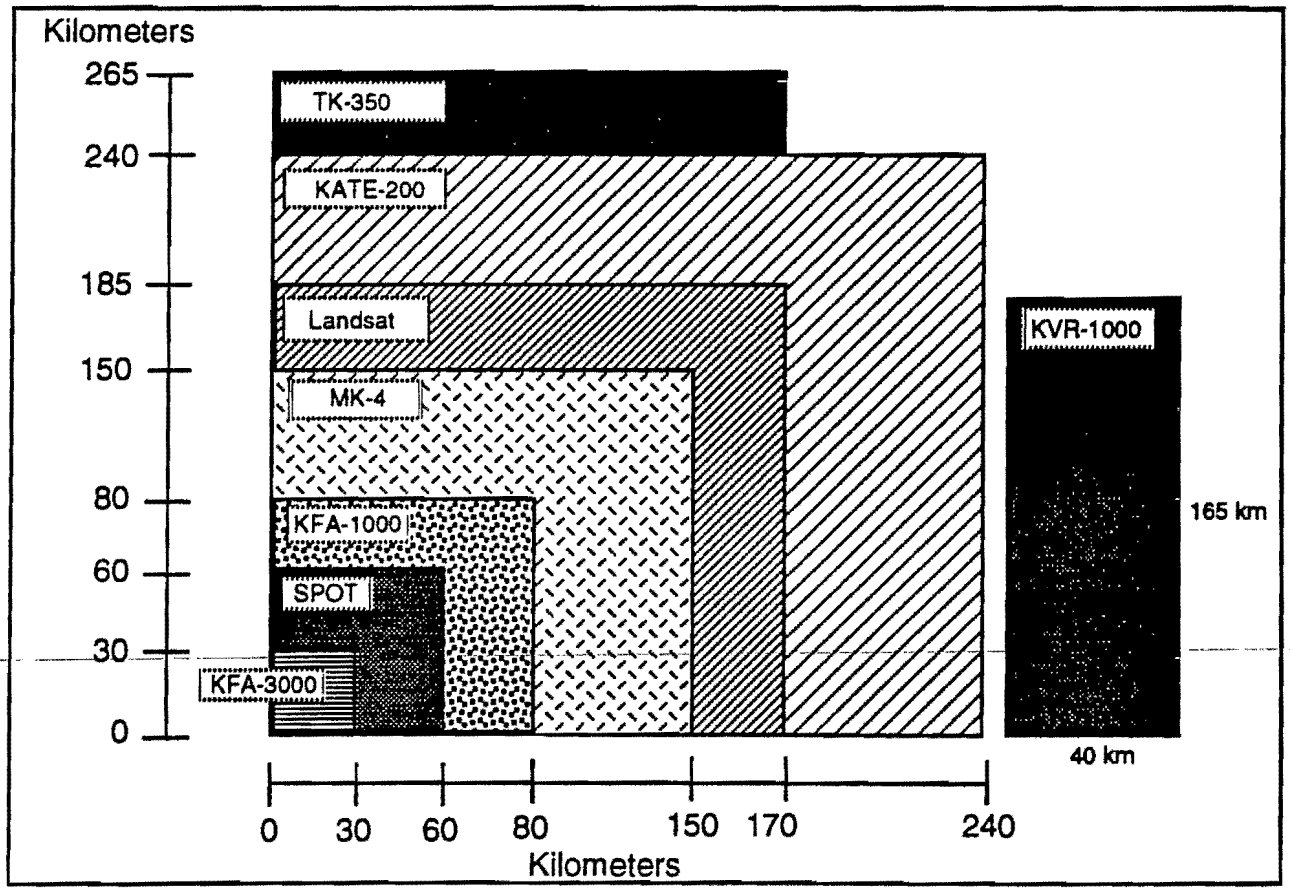


Figure 5.1.1-1. Comparison of Earth Resources Satellite Footprints

5.1.2 **COST DATA.** Approximate cost, by sensor, per square kilometer for film positives and digital form are shown in Table 5.1.2-1. SPOT and Landsat are included to show a comparison to other available commercial products.

Table 5.1.2-1. Cost Comparison by Area of Coverage

Sensor	Type	Approximate Area of Coverage in Sq Km	Resolution	Approximate Cost/Sq Km ($ U.S.)
KVR-1000	P	6,600	1-3m	.46
DD-5	Various	2,430	2m +	Variable
KFA-3000*	F	441	3m	7.26
TK-350	F	45,050	5-10m	.10
KFA-1000	F	6,400	5-6m	.24
MK-4	MS/F	28,900	6-8m	.04
KATE-200	MS/F	50,625	15-20m	.01
KATE-200*	MS/F	50,625	15-30m	.07
ALMAZ	SAR	Variable	15m	Variable
SPOT* Panchromatic	S	3,600	10m	.72
Landsat-TM*	MS/S	31,450	30m	.14

Sensor Types:

F - Instantaneous Frame Camera
P - Panoramic Camera
MS - Multispectral Sensor
S - Strip/Pushbroom Sensor
SAR - Synthetic Aperture Radar Sensor

* Digital Data

Exhibit 6 shows cost comparison data, by system, extracted from vendor responses. High and low costs are provided for each product offered.

5.1.3 **METHODOLOGY FOR PROCUREMENT.** Orders can be placed directly with each of the vendors listed in Section 4.1, as well as by other avenues noted earlier. Each has individual licensing agreements with one of several Russian agencies who provide the requested imagery and associated materials.

The following procurement options are available from:

a. Existing Archive - If current coverage is on hand, a price quote is given and imagery plus associated materials are delivered nominally within two to four weeks. Xerox quality paper "quick look" prints of the imagery are available for approximately $20.00 each.

b. Tasked Collection - If coverage is not available, a tasking request is sent and eventually coverage is taken. Imagery and materials are then provided in greater than 30 days (nominally 45 days).

c. Tasked Collection with New System Launch - An acquisition avenue also offered is to help fund launch of satellites with desired sensors and acquisition of desired coverage. Costs here are in the greater than $1,000,000 range. (Reported offerings include $12 million for one year of dedicated use of an optical sensor, to $96 million for a new ALMAZ-1B.)

5.2 POTENTIAL APPLICATIONS. Over the past years, organizations from the national level down to city governments have become aware of the usefulness of image maps (orthophotos). These image scenes, which are precisely referenced to known ground coordinate systems, are a cost-effective solution for deriving spatial information. Imagery used for these image maps ranges from remotely sensed data (Landsat, SPOT) to aerial photography flown with standard mapping cameras. Most of these organizations are, at this point, not aware of the quality, availability, or potential usefulness of the Russian image scenes.

DMA, in assembling information for this report, conducted a very brief survey of potential interest within the U.S. Geological Survey (USGS), Forest Service, and Bureau of Land Management (BLM), and found there was interest in those agencies. The National Oceanic and Atmospheric Administration (NOAA) also has an interest in Russian data. The following sections discuss some general applications for the identified organizations known to have an interest in spatial information.

5.2.1 DOD APPLICATIONS. DMA creates accurate, current maps over most of the world. This is often accomplished using imagery in combination with available map information. In addition, there is a need for worldwide orthophotography (Control Image Data Base) to support mission planning and related functions. Other DoD agencies and the Commands and Services also have requirements for imagery. In some cases, these requirements can be met or significantly augmented by the Russian materials.

5.2.2 **OTHER FEDERAL AGENCIES.** Government agencies which are currently supporting the Federal Geographic Data Committee include: Department of Agriculture, Department of Commerce, Department of Energy, Department of Housing and Urban Development, Department of Interior, Department of State, Department of Transportation, Environmental Protection Agency, Federal Emergency Management Agency, Library of Congress, National Aeronautical and Space Administration, National Archives and Records Administration, and the Tennessee Valley Authority. Each of these agencies has an interest in using spatial information to accomplish its mission. No attempt has been made in this report to relate specific requirements and/or utility to specific agencies; however, the following paragraphs briefly describe the general uses. It should be noted that the Russian imagery provides current, as well as historic imagery, thus providing a tool for change analysis.

Topographic Mapping. Much of the information collected and used by these agencies is most easily accessible if it is keyed to a map reference system. These maps, now often digital Geographic Information Systems (GIS), can be created from the Russian imagery as an alternate source. For example, cloud-free image data over Alaska would be very valuable.

Seismic Maps. Fault systems, fault zones, and features associated with fault zones can be mapped with high resolution space imagery. Such detailed maps could support detailed seismic risk analysis (that is, delineating areas on the basis of their relative susceptibility to damage from such natural hazards as earthquakes and landslides).

Agriculture and Land Administration. Detailed land use maps and color image maps can be produced from high resolution multispectral space imagery. Although the Russian imagery has limited spectral extent, it may be useful as a stopgap if Landsat fails, and SPOT imagery becomes limited. These maps can be used to support the evaluation of land use, perform detailed vegetation analysis, support wetlands mapping and monitoring, assist in urban planning, support coastal zone mapping and monitoring of beach erosion processes, and support shallow water monitoring. Some important uses of high resolution space imagery in this category would also include: monitoring of rangeland for assessment of stress and drought conditions; environmental assessment of pipeline corridors; and an identification, delineation and measure of major crops and a qualitative assessment of crop condition as affected by weather, disease, and insects.

Water Resources. The hydrological cycle involves the processes of precipitation, evaporation, evapotranspiration, ice and snow formation and melting, and runoff. High resolution space imagery could support a quantification of this cycle in a number of critical areas, including flood plain mapping, flood forecasting and water resource planning. Some specific questions that would be addressed using detailed imagery data include: What are the distributions, capacities and properties of major freshwater reservoirs? What are the transfer mechanisms between these reservoirs? What are the effects of irrigation on regional water use and groundwater

recharge? How has the course of a river or stream changed in a decade or so due to both natural and anthropogenic influences?

Forest. High resolution space imagery supports a more detailed assessment of forest inventories and reserves, a delineation of forest types (e.g., type and density of trees, crown-closing), and an accurate and timely detection of changes in important forest resources due to natural (defoliation and desertification) and anthropogenic (rain forest destruction) causes.

Abandoned Mine Site Locations. Mining activities have, over the years, been very uncontrolled. There is no extensive data base of the locations or types of mining activities that have occurred. These often have a potentially significant impact on the surrounding environment. High resolution space imagery can support a regional environmental assessment of mining activities, permits detailed monitoring of surface mining and mine reclamation activities, and assist in the detection and location of abandoned mine sites. High resolution multispectral imagery also has the potential for supporting a better understanding of surface mineralogy, thereby supporting (at least qualitatively) surficial prospecting from space.

National Transportation System. An activity is underway, by the Department of Transportation, to create a national GIS-T System to monitor the highway system. A potentially cost-effective way to collect some of the required demographic and mapping information is by means of an image map base.

Summary. Many other potential applications could be added to this list. The Russian imagery is one potential, and largely unexploited, source of information to satisfy these needs. The following summarizes the current applications to satisfy the assumed needs of other organizations. Due to the limited temporal constraint of this study, no direct contact has been made.

5.2.3 STATE/LOCAL GOVERNMENTS. Many state agencies have procured, are in the process of procuring, or will in the near term procure some form of image maps. The specifications for these procurements vary from those that can be satisfied by the SPOT/Landsat-type sensors, to requirements for sub-meter accuracies. Broad area requirements (those requiring general change detection) such as growth management, urban planning, transportation planning, etc., can be satisfied by medium resolution imagery. Several states are working with USGS, which will cost share if the image data base is created to the USGS one-meter-pixel specification.

Local governments (county and city) typically require high resolution data bases which do not appear to be satisfied by the Russian imagery. However, it is possible that multisensor data may be combined to meet some needs.

5.2.4 ACADEMIC INSTITUTIONS. Academic institutions are involved in studies which cross the entire spectrum of source requirements. Their requirements are typically small quantities with non-metric emphasis. These institutions are very

instrumental in developing interest in new materials such as the Russian imagery. Graduates ultimately drive new technology development.

5.2.5 PRIVATE SECTOR. Private sector requirements are in the oil industry, agriculture, and mining. These requirements would capitalize on the full spectrum of the Russian sensors, including radar as well as optical sensors. The private sector is, of course, supporting the public sector in attaining their goals. Considerable resources are being used to populate GIS data bases at the local level. Recent trends are toward imagery as a cost-effective means of acquiring this data.

SECTION VI - PROCESS FOR DISSEMINATION

DMA has identified various approaches for the dissemination of Russian imagery. Each of these options and its advantages are discussed in the following paragraphs.

In some cases, the image dissemination approach will, of necessity, be linked to acquisition when both are funded directly by the end user. When imagery photographs and materials are purchased through commercial vendors, copyright restrictions may limit the user to a non-exclusive non-transferable license to use the imagery photographs and materials for internal purposes. This could limit the right to sell, supply or disclose the scenes to a third party. In alternate approaches, the imagery may be acquired through a commercial vendor by a Government agency for a specified user group, in which case dissemination could be less restrictive.

Similar third party dissemination restrictions have not been identified at this time when acquiring photographs and materials directly from the Russian agencies licensed to sell in a free market environment. DoD purchases made in this fashion could be available for archive at the USGS EROS Data Center at Sioux Falls, South Dakota, and used as a distribution channel (see discussion in Paragraph 6.1.2).

6.1 DOD, CIVIL, AND PRIVATE USERS. Different dissemination channels would be available based on users in the following groups: (1) DoD; (2) non-DoD Government; (3) non-Government.

6.1.1 DOD. Dissemination to DoD organizations would be in accordance with the purchasing arrangement made with a commercial vendor or with the Russian agency. Alternative arrangements could be established to purchase through a centralized Government agency similar to the way DoD acquires imagery products from the SPOT and Landsat Systems. Specific agreements regarding the numbers of copies and authorized users would be established.

6.1.2 NON-DOD GOVERNMENT. All Russian imagery photographs can be placed in the archive at the USGS EROS Data Center (EDC) at Sioux Falls, South Dakota, by any purchaser. All users would have access to this distribution channel within the restrictions of a licensing agreement for redistribution. This distribution channel exists through the Earth Science Information Centers (ESIC). ESIC currently maintains a data base of all the aerial photographic coverage of the United States and its territories. These offices, spread throughout the United States, are administered directly by the USGS or by individual states in cooperation with USGS. The ESIC office interfaces with the public, assisting customers in locating aerial photographs, satellite images, maps, and other cartographic materials. Orders are taken, either directly over the counter, or by standard forms which can be submitted by FAX or mail. An on-line help facility is provided to assist customers with placing or tracking orders. The actual imagery is housed in the EDC. This center houses the National Satellite Land Remote Sensing Data Archive (NSLRSDA), which stores all multispectral sensor (MSS) data purchased by the U.S. Government over the last 10 years. The Russian imagery would

complement this data resource. This facility has a capability to reproduce film, as well as digital information. If users desire, they can also order imagery directly from the EROS Data Center.

6.1.3 NON-GOVERNMENT. An alternative approach is to simply use the existing commercial vendors. Using this approach, each user would be solely responsible for dealing with the commercial suppliers for acquisition and dissemination. Commercial vendors have been trying to develop a marketplace for the resale of the Russian Federation imagery. Several commercial vendors have responded to DMA's solicitation in the CBD. These vendors offer, according to their submittals, imagery from the sensor types indicated in Table 4.1.1-1. Costs for the purchase and dissemination of imagery and for the various products range according to the values indicated in Table 5.1.2-2. In general, vendors claim they can acquire the imagery materials within 14 days. These claims are unvalidated as of this date. Commercial firms using basic U.S. private enterprise principles in dealing with the Russian agencies, can possibly satisfy the unique needs of each U.S. image/data consumer to an extent that would be more difficult for any U.S. Government agency.

SECTION VII - EVALUATION PLAN

Two additional phases of evaluation are proposed for Russian imagery sources. Phase II provides for review and validation of the interior and exterior orientation data that is available for each sensor system, while Phase III provides for the development of an operations concept for procuring the data and its utilization within DMA for the DoD.

Conclusions of the Phase I investigation are provided in Section VIII.

7.1 PHASE II EVALUATION. Many characteristics of an image beyond its visual quality are important to the photogrammetrist. Many users are concerned only with the visual aspects of an image, not its metric properties. For these users, maps are produced with a visual display of roads, cities, and related features and their general relationships, but when produced, there is little concern for metric accuracy. One cannot accurately determine the geographic coordinates of features displayed on this type of map.

DMA and other mapping agencies are interested in providing maps, charts and images that have standard metric properties. To accomplish this objective, the imagery that the mapping organization utilizes must have supporting calibration data to support the interior and exterior orientation of each image. The evaluation of the data supplied to support interior and exterior orientation represents the second level of evaluation of the Russian imagery source. The following information will be derived and evaluated from the Russian materials obtained from the vendors:

a. **Interior Data.** The interior orientation of a camera is defined as the establishment of its optical axis and focal plane to allow for appropriate lens distortion curves and film shrinkage or stretching corrections. Table 7.1-1 details the data necessary to satisfy the interior orientation requirement.

Table 7.1-1. Interior Orientation Requirements	
Parameter	**Requirement**
1. Camera Focal Length	Exact length must be calibrated.
2. Fiducial Marks	Four to eight marks exposed in focal plane to define film shrinkage characteristics.
3. Principal Point Offset	The x,y offset of the camera optical axis as it relates to the fiducial center of the focal plane must be calibrated.
4. Lens Distortion	A calibrated correction defining radial and asymmetric curves from the optical axis must be defined.
5. Image Motion Compensation	The motion of the optical axis and/or satellite motion at the time of exposure must be defined.
6. Image Reconstruction	Due to the large formats of the imagery acquired by some of these sensors, it may be necessary to exploit the imagery using equipment which is designed for smaller formats. Thus, the smaller formats must be reconstructed to the original geometry. a. Hardcopy Reconstruction b. Softcopy Reconstruction
7. Coordinates of Reseau Marks	Reseau reference system internal to the camera must be defined.

b. **Exterior Data.** Exterior orientation is defined as the re-establishment of camera position and attitude during the moment of exposure. Table 7.1-2 lists the information required to determine exterior orientation.

Table 7.1-2. Exterior Orientation Requirements	
Parameter	**Requirement**
1. Exposure Station	The position of the camera exposure station in some reference coordinate system to be used in aerotriangulation.
2. Attitude of Focal Plane and Optical Axis	Need values referenced to a reference coordinate system to be used in aerotriangulation.
3. Definition of Reference Coordinate Frame	Coordinate frame to which parameters are referenced must be defined.
4. Definition of Camera Angles	A definition of the axis and order of rotation of camera angles must be defined.
5. Velocity Vectors, Attitude Rates, and Exposure Time	The velocity associated with the camera position, the rates of angular change, and the exposure station time.

The primary emphasis in the Phase II analysis will be to understand the parameters of interior and exterior data provided for each system and to provide some level of validation of the actual data. The intent is to use test ranges with well-established photo-identifiable surveyed positions to validate the data.

7.2 PHASE III EVALUATION. The final phase of the assessment will be to develop a potential operational scenario and use category for each kind of sensor data. All sensors may not satisfy the needs of the mapping community, but may satisfy the needs of the environmentalists, academic studies, forestry studies, geologists, historians, etc. The final phase will document the results of Phase II and describe the known available information on each sensor and its potential applications.

The results of each phase will be documented and the methods for converting the information received from the vendors into useful calibrated camera data and an aerotriangulation model will be prepared. In addition, it will evaluate the systems that have the greatest potential in the mapping community and provide the potential accuracy of triangulated data. DMA will also develop an operational concept for using the imaging systems for mapping. This phase will also detail the modifications required for DMA production equipment to accommodate the different sources.

7.3 TYPES OF MATERIALS NEEDED. A selection of imagery was made to reflect a sample set from each sensor. This provides representative materials from each of the eight known systems currently available. Coverage over controlled test ranges is desired. Materials may be obtained from each of the identified U.S. sources to determine service, availability and timeliness.

SECTION VIII - CONCLUSIONS

Over the relatively short duration of this preliminary assessment, DMA's near-term findings are summarized below by primary study objective.

8.1 MATERIAL AVAILABILITY. Russian imagery and materials are available from many domestic and foreign sources. No single source appears to have an exclusive licensing agreement with any Confederation of Independent States (CIS) organization. Also, no statement of data rights is normally supplied with orders. The following lists the preliminary study conclusions.

a. Not all vendors offer all sensor material. (Eight basic primary sensors were identified in the study, some with multispectral capability.)

b. Not all vendors had coverage information for all sensors.

c. Stereo coverage is sometimes available.

d. Data integrity is suspect and varies widely. No common standards for image quality or metric quality exist.

e. Collateral materials are sometimes available. Ephemeris data relative to collections can sometimes be obtained; however, based on a limited sample set, we believe its integrity is not reliable.

f. Based upon preliminary experiences by U.S. firms, and examination of selected materials, substantial improvements can be obtained by additional processing or modeling of the data.

g. Russian business practices and lack of understanding of the free enterprise system create problems in acquiring satisfactory materials.

h. Russian film sizes are 12x12 and 12x18 inches as opposed to the U.S. standard of 9x9 inches. This difference will require some retooling by the agency doing film processing.

8.2 PRIORITIES FOR ACQUISITION. Acquisition priorities for test imagery to support the evaluation plan were based on the following:

a. Examination of data quality obtained from small available samples of data from eight sensors.

b. Attempts to verify ability of vendors to produce imagery and support materials, attendant cost, and delivery times.

Based upon the above factors, a list of Russian imagery and materials to be ordered by DMA was constructed (**Exhibit 7**). This list provides a representative sample of both analog and digital imagery to verify preliminary conclusions made above, and permit DMA to conduct evaluation plan Phases II and III. This imagery order covers two test areas to satisfy requirements for both metric control and topographic relief. Analog and digital imagery media will permit assessment of fidelity inherent in each, and make the assessments practical for users with equipment having hardcopy and softcopy inputs.

8.3 PROCESSES FOR DISSEMINATION. Several processes for dissemination are possible. Commercial vendors' copyright restrictions may limit the right to sell, supply or disclose to a third party. Existing channels for dissemination of materials to state and local authorities, academic institutions, and the private sector are available through the Earth Science Information Centers which are spread throughout the United States.

LIST OF ACRONYMS

BLM	Bureau of Land Management
CBD	Commerce Business Daily
cm	centimeter
CIO	Central Imagery Office
CIS	Commonwealth of Independent States
DMA	Defense Mapping Agency
DoD	Department of Defense
DTM	Digital Terrain Matrice
EDC	EROS Data Center
EROS	Earth Resources Observation System
ESIC	Earth Science Information Center
GIS	Geographic Information System
km	kilometers
m	meter
MC&G	Mapping, Charting and Geodesy
MSS	Multispectral Sensor
nm	nanometers
NOAA	National Oceanic and Atmospheric Administration
RITF	Russian Imagery Task Force
SAIC	Science Applications International Corporation
SAR	Synthetic Aperture Radar
SETA	System Engineering and Technical Assistance
SPOT	System Pour l'Observation de la Terra
TBD	To Be Determined
USDAO	U.S. Defense Attache Office
USGS	U.S. Geological Survey

GLOSSARY OF TERMS

control point - An object or mark on the ground of known position and elevation that is identified on an image and used for controlling the image to the ground position.

ephemeris - Correlation of time and position of satellite.

exterior orientation - The determining of the position of the camera station and the attitude of the taking camera at the instant of exposure.

fiducial point - Point used as a basis of reference.

interior orientation - The determining of the interior perspective of the photograph as it was at the instant of exposure. Elements are calibrated focal length, location of the calibrated focal point, and the calibrated lens distortion.

multispectral - Remote sensing in two or more bands of the electromagnetic spectrum, such as visible and infrared.

orthophotograph - A photographic copy, prepared from a perspective photograph, in which the displacements of images due to tilt and relief have been removed.

orthorectification - The process of removing image displacements caused by acquisition geometry and terrain relief.

orthorectified image map - An image map in which distortions caused by tilt and relief have been removed.

panchromatic - Sensitive to light of all colors.

phase history - Raw synthetic apeture data consisting of in-phase and quadrature (I&Q) data samples.

rectification - The process of projecting a tilted or oblique image onto a horizontal reference plane.

spectrozonal - Sets of adjacent wavelengths in the electromagnetic spectrum. Often refers to film type specifically detecting these bands.

stereo pair - Two photographs with sufficient overlap of detail to make possible stereoscopic examination of an object or area common to both.

synthetic aperture radar (SAR) - An imaging radar system in which a synthetically long apparent or effective aperture is constructed by integrating multiple returns from the same ground cell, taking advantage of the doppler effect to produce a phase history film or digital record that may be optically or digitally processed to produce an image.

triangulation - The process for the extension of horizontal and/or vertical control whereby the measurements of angles and/or distances on overlapping images are related into a spatial solution using the perspective principles of the images. This process is also referred to as phototriangulation, aerial or photogrammetric triangulation.

EXHIBITS

EXHIBIT 1. Russian Imagery Material Vendors

Mr. Grant S. Lichtman
JEBCO Information Services Ltd.
3120 Rogerdale, Suite 100
Houston, TX 77042

JEBCO Information Services Ltd.
P.O. Box 42120
Houston, TX 77242

Central Trading Systems
Satellite Imagery Division
611 Ryan Plaza Drive, Suite 700
Arlington, TX 76011

Wirin & Associates
555 Indian Trail
Palm Springs, CA 92264

Mr. Nate Boyer
Earth Observation Satellite Company
4300 Forbes Boulevard
Lanham, MD 20706

Space Commerce International Corp.
P.O. Box 8222
Ranch Santa Fe, CA 92067

Mr. Steve Miller
SPOT Image Corporation
1896 Preston White Drive
Reston, VA 22091

Autometric, Inc.
5301 Shawnee Road
Alexandria, VA 22554

Mr. Eric Byers
RAMP International
4221 Forbes Boulevard
Suite 250
Lanham, MD 20706-4343

Mr. Joe Webb
DBA System, Inc.
10560 Arrowhead Drive
Fairfax, VA 22030

Mr. Jim Kushner
DBA Systems, Inc.
1200 S. Woody Burke Road
P.O. Drawer 550 (32902-0550)
Melbourne, FL 32901

Dr. Velon Minshew
Jofuskie, Inc.
5724 Cedar Creek Drive
Forth Worth, TX 76100

Mr. William W. Wirin
Space Commerce Corporation
6900 Texas Commerce Tower
Houston, TX 77002

Mr. Douglas Grize
Satellite Mapping Corporation
8229 Boone Blvd.
Suite 800
Vienna, VA 22182

Ms. Michelle N. Moore
Space Commerce Corporation
5718 Westheimer, Suite 1515
Houston, TX 77057

Mr. Stephen Pedone
E-Systems, Garland Division
P.O. Box 660023
Dallas, TX 75266-0023

EXHIBIT 2. Copy of HQ DMA Message to USDAO, Moscow

FM HQ DMA FAIRFAX VA//IO//
TO USDAO MOSCOW UR//
INFO SECDEF WASHINGTON DC//RUE//
SECSTATE WASHINGTON DC
SECDEF WASHINGTON DC//OSD:C3I-INT//
JOINT STAFF WASHINGTON DC//JS/EURDIV//
HQ USAF WASHINGTON DC//IN//
CENTRAL IMAGERY OFFICE WASHINGTON DC//P3D//
GEOLOGICAL SURVEY DEPT OF INTERIOR WASHINGTON DC
UNCLAS
QQQQ
SUBJECT: HQ DMA ACCESS TO RUSSIAN IMAGERY
1. HEADQUARTERS DEFENSE MAPPING AGENCY (DMA) MUST RESPOND TO RECENT US LEGISLATION (PL 103-138, H.R. 3116) TASKING IT TO EVALUATE AND PROCURE COMMERCIALLY AVAILABLE RUSSIAN SATELLITE IMAGERY AND MATERIALS. SUBSEQUENTLY, DMA MUST REPORT TO CONGRESS BY 15 MAR 94 ITS JUDGMENTS ON IMAGERY/MATERIAL AVAILABILITY, ACQUISITION PRIORITIES, AND MODES FOR DISSEMINATION TO FEDERAL/ STATE/LOCAL AGENCIES, ACADEMIC INSTITUTIONS, AND THE PRIVATE SECTOR.
2. TO ASSIST DMA IN ADDRESSING THESE TASKS, REQUEST YOUR GUIDANCE. WOULD FORMAL DMA MAPPING AGREEMENTS WITH THE NATIONAL DEFENSE INSTITUTIONS BE PREFERABLE TO DIRECT DMA CONSULTATIONS/ NEGOTIATIONS WITH NON-DEFENSE GOVERNMENTAL ORGANIZATIONS (E.G. STATE CENTER PRIRODA)? FOR EITHER OPTION, WE WOULD NEED TO ASCERTAIN FROM OUR RUSSIAN COUNTERPART SPECIFICS ON AREA COVERAGE, RESOLUTION, DATES, RELEASIBILITY AND COST. WE WOULD ALSO NEED TO DISCERN SENSOR TYPES, PERFORMANCE, AND ASSOCIATED SENSOR/FILM TECHNICAL FEATURES. BECAUSE OF THE EXTREMELY SHORT SUSPENSE FOR REPORTING TO CONGRESS, WOULD APPRECIATE YOUR EXPEDITIOUS REPLY.
3. WE ARE ALSO PURSUING A THIRD OPTION FOR ACCESSING RUSSIAN IMAGERY. A DMA MARKET SURVEY IS NOW UNDERWAY IDENTIFYING QUALIFIED US COMMERCIAL VENDORS AUTHORIZED TO MARKET COMMERCIALLY AVAILABLE RUSSIAN SATELLITE IMAGERY/MATERIALS. THE SURVEY CONCLUDES 15 JAN 94.
4. CLEARLY, DRIVING FACTORS IN WHICH OF THE THREE OPTIONS WE SELECT WILL BE COST AND WORK VOLUME/COMPLEXITY. EVEN MORE IMPORTANT WILL BE TO ENSURE OUR "FOOT STAYS IN THE DOOR" ON THIS SPLENDID OPPORTUNITY. DOD INSTITUTIONAL ACCESS IS DMA'S OVERREACHING GOAL.
5. POINT OF CONTACT IS LT COL BOB HARMON, USAF, DMA(IOL), (703) 285-9414 OR FAX (703) 285-9374.
ZCZC

MARCUS J. BOYLE, COL, USAF, ADD/I, 59417

BOB HARMON, LT COL, USAF, 59414
IO 003
NUMBER OF PAGES: 1

EXHIBIT 3. Copy of USDAO, Moscow, Message to DMA

UNCLAS MOSCOW RS 002272

ZCZCODMA0428
RTTUZYUW RUEHMYA2272 026160B-UUUU--RULKOKA.
ZNR UUUUU
R 261608Z JAN 94
FM USDAO MOSCOW RS//
TO HQ DMA FAIRFAX VA//IO//
INFO DEPT OF INTERIOR WASHINGTON DC
JOINT STAFF WASHINGTON DC//J-6/EURDIV//
SECDEF WASHINGTON DC//OSD,C3I-INT//
CENTRAL IMAGERY OFFICE WASHINGTON DC//P3D//
HQ USAF WASHINGTON DC//IN//
SECSTATE WASHDC
DIA WASHDC//CH-2//
UNCLAS MOSCOW RS 002272

U-0086-94

SUBJECT: HQ DMA ACCESS TO RUSSIAN IMAGERY

REF: HQ DMA FAIRFAX VA MSG DTG 121528Z JAN 94

1. REF MSG REQUESTS USDAO MOSCOW GUIDANCE REGARDING OPTIONS FOR APPROACHING RUSSIAN AGENCIES WITH THE GOAL OF EVALUATING AND PROCURING COMMERCIALLY AVAILABLE RUSSIAN SATELLITE IMAGERY AND MATERIALS.

2. UNDERSTANDING THAT USDAO HAS NO SPECIFIC KNOWLEDGE RELATED TO COMMERCIAL SATELLITE IMAGERY, THIS RESPONSE WAS FORMED AFTER CONSULTING THE FOREIGN COMMERCIAL OFFICE HERE IN THE U.S. EMBASSY. IF DMA WERE TO DIRECTLY APPROACH A RUSSIAN COMMERCIAL CONCERN YOU WOULD BE SUBJECT TO THE EVER CHANGING AND OFTEN DIFFICULT TO FATHOM RUSSIAN COMMERCIAL BUSINESS MARKET. APPROACHING THE MARKET THROUGH A U.S. COMPANY, AS INTERMEDIARY, WHO IS FAMILIAR WITH BUSINESS DEALINGS IN RUSSIA WILL SIMPLIFY THIS PROBLEM BUT MAY PROVE MORE COSTLY. INCORPORATING YOU REQUIREMENTS INTO AN AGREEMENT WITH THE RUSSIAN MILITARY WOULD APPEAR TO BE THE EASIEST APPROACH BUT MAY NOT BE THE MOST ECONOMICAL OR GIVE YOU THE BEST TECHNICAL CAPABILITY AVAILABLE. THE BEST APPROACH IS PROBABLY SOME COMBINATION OF THE ABOVE OPTIONS.

3. REGARDS FROM MOSCOW.
BT
#2272

UNCLAS MOSCOW RS 002272

EXHIBIT 4. Russian Sensor System Characteristics

This table summarizes systems for which data is known to be available, and some of the attributes of each. The tables are arranged in order of highest to lowest resolution.

Unfortunately, neither U.S. vendors nor Russian suppliers have complete catalogs or listings of information available. Current Russian business practices and operations limit information until payment is actually received. This severely limits the users' ability to review quality and/or assess utility of a product prior to purchase.

It should be noted that this information has been taken from sales brochures submitted by image vendors and has not been verified.

3 Meters or Less Film Images:

KVR-1000 Archive Photographs

Sensor Type:	Panoramic
Resolution:	2-3 Meters
Approximate Coverage:	36-44x165 Kilometers
Longitudinal Overlap:	Unknown
Average Altitude:	220 Kilometers
Scale:	1:220,000
Spectral Value:	Panchromatic
Focal Length:	1,000 Millimeters
Format:	180x720 Millimeters

Vendors state that images are accompanied by photographic camera system data to allow accurate registration and rectification to maps, and corrections for lens distortion.

DD-5 Digital Imagery

Sensor Type:	Various
Resolution:	≤2 Meters
Approximate Coverage:	27x90 Kilometers
Longitudinal Overlap:	Unknown
Average Altitude:	220 Kilometers
Scale:	Various
Spectral Value:	Panchromatic
Focal Length:	2,200 Millimeters
Format:	300x1000 Millimeters

KFA-3000

Sensor Type:	Frame
Resolution:	3 Meters
Approximate Coverage:	21x21 Kilometers
Longitudinal Overlap:	Unknown

Average Altitude:	220 Kilometers
Scale:	1:70,000
Spectral Value:	Panchromatic
Focal Length:	3,000 Millimeters
Format:	300x300 Millimeters

5-10 Meter Film Images:

TK-350 Topographic Camera

Sensor Type:	Frame
Resolution:	5-10 Meters
Approximate Coverage:	265x170 Kilometers
Longitudinal Overlap:	60% - 80%
Average Altitude:	220 Kilometers
Scale:	1:660,000
Spectral Value:	0.5 - 0.7
Focal Length:	350 Millimeters
Format:	300x450 Millimeters

Photographic Products: black and white film, negatives, positives, and prints. Enlargements of 15X possible. Images accompanied by complete photogrammetric camera and satellite ephemeral system data for registrations, rectifications, and distortion corrections.

4-7 Meter Film Images:

KFA-1000 Photographs

The KFA-1000 photography involves two cameras, each of which is aimed 8° right or left of the ground track so that each photography in actuality is a very slight oblique with an 8° tilt.

The color film is spectrozonal, with two individual emulsion layers. The color of the final photographic product depends on the number of filters employed during processing. Two filters produce a pinkish tone and three filters produce a more natural earth tone. The 3-filter products have approximately 50 percent less resolution than the 2-filter products.

Sensor Type:	Frame
Resolution:	5-6 Meters
Approximate Coverage:	80x80 Kilometers
Longitudinal Overlap:	60%
Width of Survey Band by 2 Cameras:	120 Kilometers +
Average Altitude:	270 Kilometers
Scale:	1:220,000 - 1:280,000

Spectral Zones of the Layers:	560 - 670 Nanometers 670 - 810 Nanometers Spectrozonal 2-Layer Panchromatic
Focal Length:	1,000 Millimeters
Format:	300x300 Millimeters

KFA photography is available in panchromatic and color products, as film positives or negatives, and as photographic prints. Each film has five fiducial points. A typical image is provided in **Exhibit 5a.** This can be compared to the SPOT image of similar coverage presented in **Exhibit 5b.**

All photographic reproduction is done only from master original film negatives brought down from the satellites. Only first generation derivative products are marketed. Each image is accompanied by complete photogrammetric and camera system data, allowing accurate rectification to maps and the removal of any lens distortion.

6-Meter Film Images:

MK-4 Photographs

The MK-4 is a true multispectral camera with data recorded on three separate black and white film bases which may be combined to produce a synthesized false color image. The resolution of the MK-4 is approximately 6 meters, and the vendors state that the product is excellent for cartographic and demographic surveys. The film contains 25 fiducial points, enabling high metric accuracy in enlargements. Each image is accompanied by complete photogrammetric and camera system data, which permits accurate rectification to maps and the removal of any lens distortion.

Sensor Type:	Multispectral Frame
Resolution:	6 Meters
Coverage:	170x170 Kilometers
Longitudinal Overlap:	60%
Average Altitude:	250 Kilometers
Scale:	1:650,000 - 1:1,500,000
Possible Spectral Zones of the Layers (nm):	400 - 700 460 - 505 515 - 565 580 - 800 635 - 690 810 - 900
Types of Film Used:	Black and White Spectrozonal
Focal Length:	300 Millimeters

Format:	180x180 Millimeters

These are available as film negatives or positives, and prints. All products are available in either black and white or color. Enlargements as great as 17X are possible without loss of resolution.

15 - 30 Meter Photographs

KATE-200 Photographs

The KATE-200's resolution is variable, between 15 and 30 meters, comparable or slightly better than Landsat-TM.

Sensor Type:	Frame
Resolution:	15 - 30 Meters
Coverage:	225x225 Kilometers
Longitudinal Overlap:	60%, 40%, 20%
Average Altitude:	270 Kilometers
Scale:	1:1,350,000
Spectral Zones (nm):	500 - 600
	600 - 700
	700 - 850
Focal Length:	200 Millimeters
Format:	180x180 Millimeters

These photographic products can be obtained as film negatives or positives and prints. They can also be obtained in digital form from some of the vendors. All products are available in either black and white or color synthesis. Enlargements as great as 17X are available. Each image is accompanied by complete photogrammetric and camera system data, allowing accurate rectification to maps and the removal of any lens distortion which may be present.

15-Meter Synthetic Aperture Radar (ALMAZ I Sensor)

Archival images and full phase history data are available for the life of the satellite -- 1991 to late 1992. The hardcopy (or data tape of that hardcopy) SAR images have a resolution of approximately 15 meters. Using an advanced processing algorithm and the original ALMAZ I full phase history data, the resolution has been improved to approximately 10 meters. The currently known characteristics of the SAR are:

Sensor Type	SAR
Ground Resolution:	15 Meters
Coverage of Image:	56x56 Kilometers
Average Altitude:	200 Kilometers

Products and data include: black and white hardcopy positives, film positives or negatives, data of hard or film images, and phase history data from the original sensor collection.

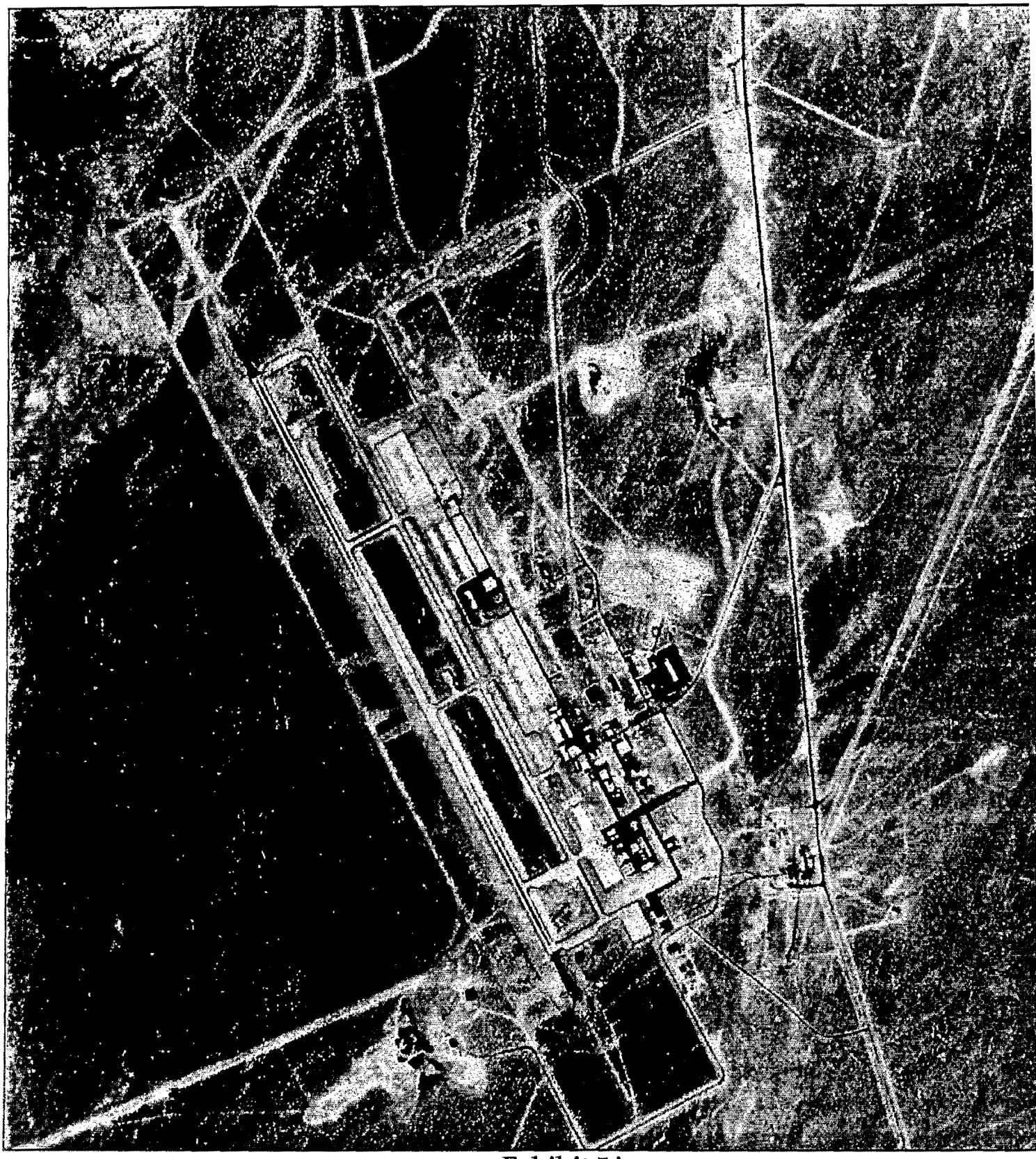


Exhibit 5A

Small Chip from Russian KFA-1000 Image System

Digitized in 256-bit gray scale at approximately 5-meter ground resolution. Printed on 600 DPI

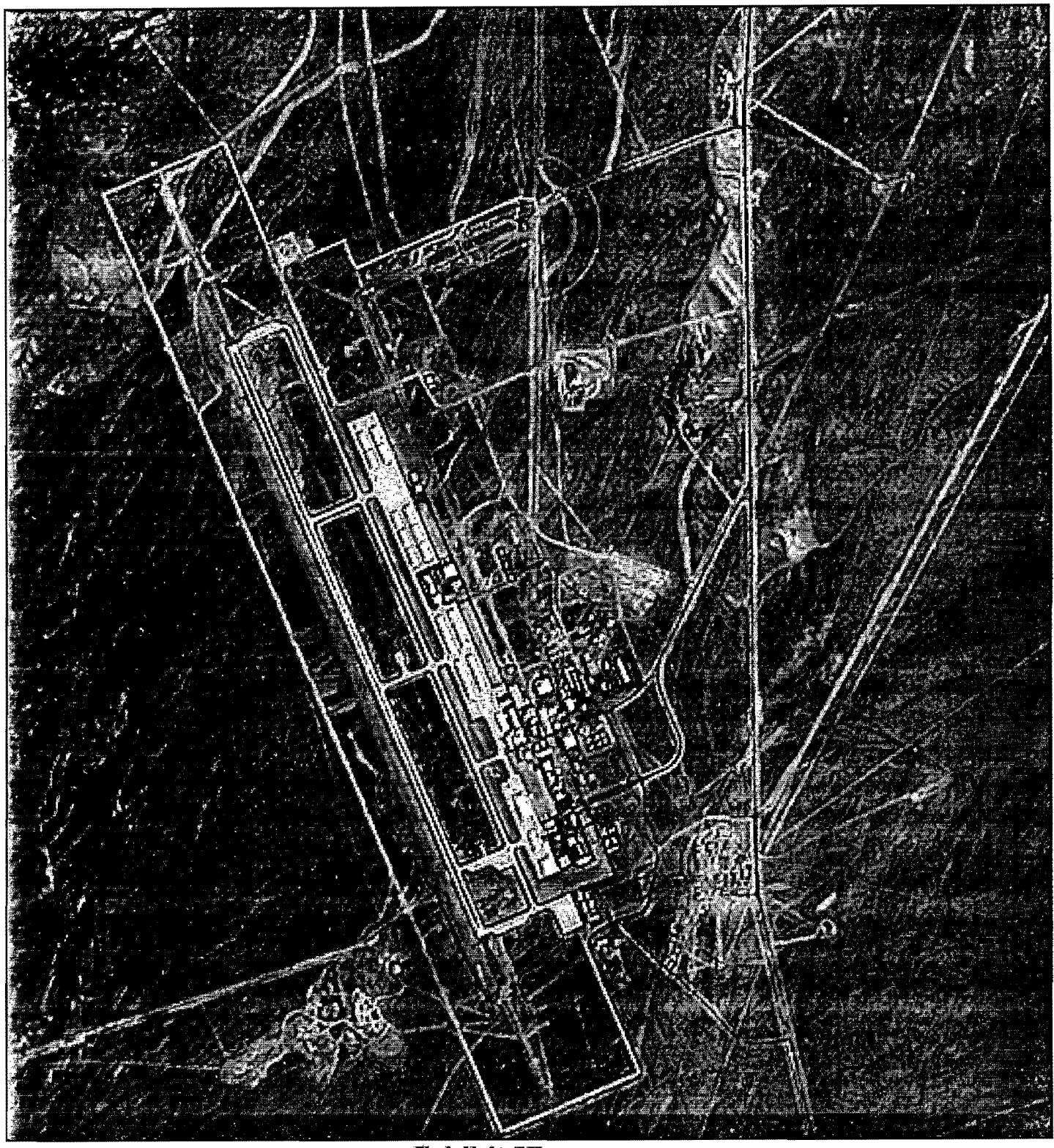


Exhibit 5B

Small Chip from French SPOT Image System

Original panchromatic image collected at 10-meter ground resolution. Printed on 600 DPI printer.

Exhibit 6. Vendor Price Range, By Product, for Russian Imagery ($ U.S.)

System	Product	High	Low
KVR-1000	Film Positive	3600	3000
	Film Negative	3840	3200
	Paper Print	1400	1200
	Digital up to 16 square kilometers	1400	1400
	Digital 17-160 square kilometers	2180	2180
	Digital 161-1000 square kilometers	3350	3350
	Digital 1001-1600 square kilometers	5200	5000
DD-5	Digitized	5000	5000
KFA-3000	Film Positive B/W 1 Band	TBD	TBD
	Film Negative B/W 1 Band	TBD	TBD
	Negative with Positive B/W 1 Band	TBD	TBD
	Digital Tape	3200	3200
TK-350	Film Positive	5400	4500
	Film Negative	5640	4700
	Paper Print	1200	1000
	Film Positive Stereo Pair (80% OL)	6480	5400
	Film Negative Stereo Pair (80% OL)	6960	5800
	Paper Print Stereo Pair (80% OL)	1440	1200
	(Also available @ 60%, 40% & 20% OL)		
	Digital (1/4 Scene)	5000	5000
KFA-1000	Film Positive	2175	1560
	Film Negative	1650	1650
	Negative with Positive	2400	1700
	Paper Print	550	550
	2-X Paper Print	820	820
	(4-5)-X Paper Print	1400	1400
	Digitized	2400	2400
MK-4	Film Positive B/W 1 Band	1400	1050
	Film Negative B/W 1 Band	1110	1110
	Negative with Positive B/W 1 Band	1650	1190
	Digitized 1 Band	2400	2400
	Paper Print B/W 1 Band	210	210
	2-X Paper Print B/W 1 Band	300	300
	(4-5)-X Paper Print 1 Band	440	440
	25-X Paper Print 1 Band	TBD	TBD

System	Product	High	Low
MK-4 (Cont'd)	Film Positive B/W 3 Bands	3225	2520
	Film Negative B/W 3 Bands	2660	2660
	Negative with Positive B/W 3 Bands	3880	2860
	Digitized 3 Bands	TBD	TBD
	Paper Print B/W 3 Band	420	420
	2-X Paper Print B/W 3 Bands	600	600
	(4-5)-X Paper Print B/W 3 Bands	880	880
	25-X Paper Print 3 Bands	TBD	TBD
	Film Positive Color Spectrazonal	1950	1950
	Film Negative Color Spectrazonal	2070	2070
	Negative with Positive Color Spectrazonal	2250	2250
	Paper Print Color Spectrazonal	700	700
	2-X Paper Print Color Spectrazonal	1020	1020
	(4-5)-X Paper Print Color Spectrazonal	1600	1600
	25-X Paper Print Color Spectrazonal	TBD	TBD
	Film Positive Color Synthesis	3220	3220
	Film Negative Color Synthesis	3470	3470
	Negative with Positive Color Synthesis	3800	3800
	Paper Print Color Synthesis	750	750
	2-X Paper Print Color Synthesis	1070	1070
	(4-5)-X Paper Print Color Synthesis	1600	1600
	25-X Paper Print Color Synthesis	TBD	TBD
KATE-200	Film Positive B/W 1 Band	325	230
	Film Negative B/W 1 Band	250	250
	Nege with Pos B/W 1 Band	395	280
	Digitized (1 Band)	1920	1920
	Paper Print B/W 1 Band	140	140
	2-X Paper Print B/W 1 Band	220	220
	Film Positive B/W 3 Bands	550	550
	Film Negative B/W 3 Bands	580	580
	Negative with Positive B/W 3 Bands	865	630
	Digitized (3 Bands)	1200	1200
	Paper Print B/W 3 Bands	210	210
	2-X Paper Print B/W 3 Band	310	310
	(4-5)-X Paper Print B/W 3 Bands	470	470
	Film Positive Color Spectrazonal	625	450
	Film Negative Color Spectrazonal	480	480
	Negative with Positive Color Spectrazonal	685	510
	Paper Print Color Spectrazonal	200	200

System	Product	High	Low
KATE-200 (Cont'd)	2-X Paper Print Color Spectrazonal	280	280
	(4-5)-X Paper Print Color Spectrazonal	420	420
	Film Positive Color Synthesis	950	690
	Film Negative Color Synthesis	750	750
	Negative with Positive Color Synthesis	1075	790
	Paper Print Color Synthesis	235	235
	2-X Paper Print Color Synthesis	300	300
	(4-5)-X Paper Pr Color Synthesis	450	450
ALMAZ	Film Positive/Negative	1000	1000
	Full Phase History	2000	2000

EXHIBIT 7. List of Russian Material to be Ordered for the Phase II Evaluation

Sensor Identification	Test Range to be Covered	Type of Coverage	Spectral Bands of Coverage
DD-5	Nellis	Single Photo	1 Band
DD-5	SWGCN	Single Photo	1 Band
KATE-200	Nellis	Stereo Triplet	1 Band
KATE-200	SWGCN	Stereo Triplet	1 Band
KATE-200	SWGCN	Ctr Photo	3 Bands
KATE-200	SWGCN	Stereo Triplet	1 Band
KATE-200	Nellis	Stereo Triplet	1 Band
KATE-200	Nellis	Ctr Photo	3 Bands
KATE-200	Nellis	Ctr Photo	Color Spectrozonal
KATE-200	Nellis	Ctr Photo	Color Synthesis
KFA-1000	Nellis	Stereo Triplet	1 Band
KFA-1000	Nellis	Ctr Photo	Color Spectrozonal
KFA-1000	SWGCN	Stereo Triplet	1 Band
KFA-1000	Nellis	Stereo Triplet	1 Band
KFA-1000	SWGCN	Stereo Triplet	1 Band
KFA-3000	Nellis	Single Photo	1 Band
KFA-3000	Nellis	Single Photo	1 Band
KFA-3000	SWGCN	Single Photo	1 Band
KFA-3000	SWGCN	Single Photo	1 Band
KVR-1000	Nellis	Single Photo	1 Band
KVR-1000	Nellis	Single Photo	1 Band
KVR-1000	SWGCN	Single Photo	1 Band
KVR-1000	SWGCN	Single Photo	1 Band
MK-4	SWGCN	Stereo Triplet	1 Band
MK-4	SWGCN	Ctr Photo	3 Bands
MK-4	Nellis	Stereo Triplet	1 Band
MK-4	Nellis	Ctr Photo	3 Bands
MK-4	Nellis	Stereo Triplet	1 Band
MK-4	Nellis	Ctr Photo	3 Bands
MK-4	Nellis	Ctr Photo	Color Spectrozonal
MK-4	Nellis	Ctr Photo	Color Synthesis
MK-4	SWGCN	Stereo Triplet	1 Band
MK-4	SWGCN	Ctr Photo	3 Bands
TK-350	Nellis	Stereo Triplet	1 Band
TK-350	SWGCN	Stereo Triplet	1 Band