Earth remote sensing space programs available in Russia

Russian market, though lagging behind, tries to keep up with international trends in remote sensing and GIS-applications

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Every year can witness innovations on the Earth remote sensing market in Russia. In 2004, commercial distribution of RADARSAT-1 radar images and of 1 m resolution data of the US and Israeli commercial systems started. With the developing remote sensing market Russia becomes more and more proactive in the world information space.

Russian remote sensing market specifics:

- vast territory of the country (17 mln km^2), which makes aerial survey almost inefficient for large-scale projects, with remote sensing systems – as the only available means to resolve a number of tasks;
- increased urge of local and regional authorities and market participants to use space data to resolve practical tasks and to develop own geo-information centers;
- permanent crisis of domestic space industry resulting in only one operable Meteor-3M satellite №1 in the national space fleet with the middle resolution scanner;
- poor telecommunications system in the regions resulting in unavailability of the centralized Internet access to remote sensing data;
- strict constraints on spatial data (in resolution, geo-reference accuracy and map scales).

Different spatial data market segments develop erratically in Russia as in the rest of the world. The most dynamic are the extra-high resolution (< 1m) and high resolution (1-10 m) segments, followed by the optical and radar imagery of middle resolution (10-250 m). The

most stagnant is the low resolution market segment (>250 m) with the only advantage of higher revisit periods.

Nowadays, with the increasing specialization and globalization of remote sensing data market, no country can afford meeting the national requirements in space information by using their own satellite remote sensing systems only. Any country is represented on the world market of remote sensing data by national and foreign RS systems (including the USA, India and France, boasting the largest fleets of remote sensing satellites). Therefore, against the background of a drop in the number of domestic satellites, the appearance of data acquired from different foreign RS operators on the market looks quite logic. This, however, does not allow replenishing the market with relatively inexpensive space data.

Fig. 1. High resolution data example. First summer imaging season of EROS-A satellite in 2005, resulting in the acquisition of images of large Russian industrial facilities: the town of Arkhangelsk, acquisition date: June 22, 2005, resolution 2 m.

It is expedient to select the data supplier using the following **criteria of efficient remote sensing systems on the Russian and CIS market** as guidelines:

- reliability of supplied data (long satellite service life and high imaging equipment capacity);
- outlook for the development of the remote sensing system in subject (series-oriented operating systems);
- flexible pricing policy of the operators, combination of high quality and moderate prices;
- easy on-line interactions between the operator and the customer.

Different **methods of data access** are used nowadays in Russia and in the world:

- direct data reception to own ground station or to the station of the Russian data distributor;
- Internet access to order data from the RS operators;
- traditional option to order and receive data from a distributor or reseller (by post or other communication channels).

Data reception by the Russian ground stations is arranged in several options:

- free access to low resolution DB (direct broadcast) data. This mode is used with reference to the meteorological data delivered in APT and HRPT format from Terra and Aqua satellites (USA) using MODIS scanner, or paid access to VGT (France), SeaWiFS (USA) and MERIS (Europe) scanners data;
- acquisition of middle and high resolution data of target areas, booked in advance from an operator (the so-called “target imaging”);
- programming of space satellites to acquire high resolution images by license (the “virtual operator” scheme, provided by the US and Israeli companies; service not applicable yet in Russia).

Fig. 2. Application of EROS-A high resolution images to detect industrial forest harvesting areas in Northern Russia. Increment felling in the Severodvinsk forestry enterprise of Arkhangelsk Region, acquisition date: July 10, 2005, resolution 2 m at a scale of 1:15 000.

The scheme of using own ground station, despite the need in initial investments to purchase the station and signal decoding equipment, provides for a much quicker data access and is the most cost-efficient way to resolve regular satellite monitoring tasks.

Internet-access to remote sensing data is also managed in several options:

- purchase of middle and high resolution data from archives using Internet sites of some major commercial RS operators;
- acquisition of low resolution data in direct broadcast mode (meteo-data of AVHRR and MODIS scanners) from the Internet sites of operators;
- satellite remote programming and acquisition of high resolution images via Internet sites of operators (“virtual station”). This scheme is used only in the USA to receive data from commercial RS operators by national force authorities.

Internet-access to data schemes have not been widely used in Russia yet due to poor telecommunications infrastructure in the regions.

Finally, the **traditional option to order and receive data from a distributor or reseller (by post or other communication channels)** is the slowest, however the most widely spread one in Russia when dealing with the American commercial operators of remote sensing systems with the resolution of 1 meter.

Foreign commercial remote sensing operators, doing business in Russia

Data segment	Operating satellites (country)	Access mode
Extra-high resolution (<1 m)	IKONOS-2, QuickBird and OrbView-3 (USA)	
High resolution (1-10m)	EROS-A (Israel), IRS-P6/LISS-4 (India)	Direct reception by ground stations in Russia (ScanEx's know-how)*
	SPOT-5 (France)	Data ordering and delivery via the operator in France
Middle resolution (10-250m, multispectral images)	IRS-1C, - 1D, -P6 (India), SPOT-2, -4 (France)	Direct reception by ground stations in Russia (ScanEx know-how)*
	SPOT-2, 4, 5 (France), Landsat, EO-1 and Terra/ASTER (USA)	Data ordering and delivery via the operator in the USA and France
	Meteor-3M №1 (Russia)	Data reception via the operator of the Federal Space Agency (ScanEx and FSA know-how)
Low resolution (>250m, multispectral images)	Terra and Aqua (USA)	Direct reception to stations in Russia (direct readout mode)
	SPOT/VGT (France)	Internet technology
	ENVISAT-1/MERIS (ESA)	Data ordering and delivery via the operator in Europe
Optical stereo-images	SPOT-5 (France)	Data ordering and delivery via the operator
	IRS-P5 (India)	Direct reception by stations in Russia (under negotiation)*
SAR images of middle resolution (10-100 m)	RADARSAT-1 (Canada)	Direct reception by ground stations in Russia (ScanEx know-how)*
	ENVISAT-1, ERS-2 (ESA)	Data ordering and delivery via the operator in Europe and Canada
* Data reception by license		

Two basic and fundamentally different types of remote sensing data reception and distribution are used in the world:

- centralized scheme with RS data downlink according to pass schedule per request;
- direct broadcasting;

Centralized scheme is inherent in the remote sensing systems with the high and middle resolution imager equipment (was used in the military imagery intelligence and in the governmental RS systems of the former USSR).

Decentralized scheme of direct broadcasting is used to distribute low and middle resolution data from meteorological satellites. RS operators use widely different combinations of two basic schemes to expedite data access and to increase the clientele.

The last 15 years of the RS market development in Russia revealed that the centralized schemes of RS data distribution in former USSR using two-three satellites for data collection do not meet users' requirements in space information. Simplification of hardware and development of information technologies enabled to set up decentralized regional networks of space data reception throughout Russia (Russian Federal Service for Hydrometeorology and Environmental Monitoring, Russian Ministry of Natural Resources, Emergency Ministry). Regional remote sensing centers are the backbones of the decentralized ground networks based on the universal ground stations, which provide for data reception, acquired from different satellites, and can be upgraded to be compatible with future satellites.

Data products of world largest space system operators from the USA, India, Canada, France and other countries are represented on the Russian market, covering the entire segments of the world market of space information (see table above).

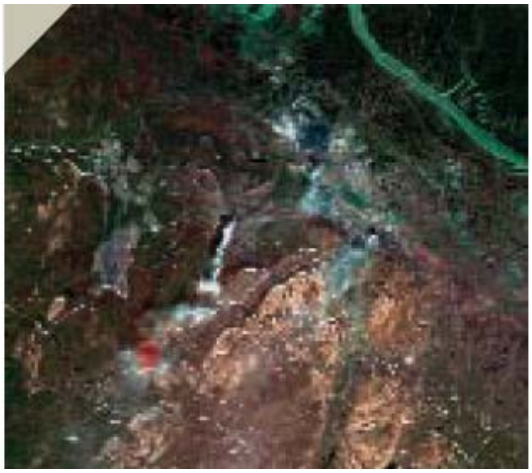

Fig. 3. A classic example of middle resolution data is the image acquired using ETM+ multispectral scanner of the American Landsat-7 satellite. The town of Norilsk and the Norilsk mining and metallurgical plant. Acquisition date: July 2, 2002, resolution 30 m.
Data archive of RDC ScanEx

Within **extra-high resolution data segment**, where the data of only three American operators are used, low-level processing products are marketed to Russian due to the existing constraints using traditional assets of ordering via distributors (by delivering data by post or Internet).

Within **high resolution data segment**, a scheme of real-time data reception to Russian ground stations from EROS-A (fig. 1, 2), IRS (PAN sensor) satellites and a traditional scheme of data advance ordering and delivering via operators are used. EROS-A program is in favorable position (best resolution among the competing satellites, which data can be booked and acquired in Russia in 2-3 days). The Taiwan ROCSAT-2 satellite data are at the back of the pack with 2 m resolution data in panchromatic mode, distributed by the French SPOT Image company. The multiply-synchronous satellite's orbit provides for daily observation of the regions located near the track, however blind zones also occur. Panchromatic data at 5.8 m of resolution from Indian IRS-1C, -1D PAN scanners are very popular in Russia. ScanEx has compiled an archive of full coverage of the Russian territory based on the Indian satellites images. Distribution of color images with 5.8 m of resolution, acquired using an upgraded LISS-4 scanner onboard the Indian IRS-P6 satellite, was launched in 2005.

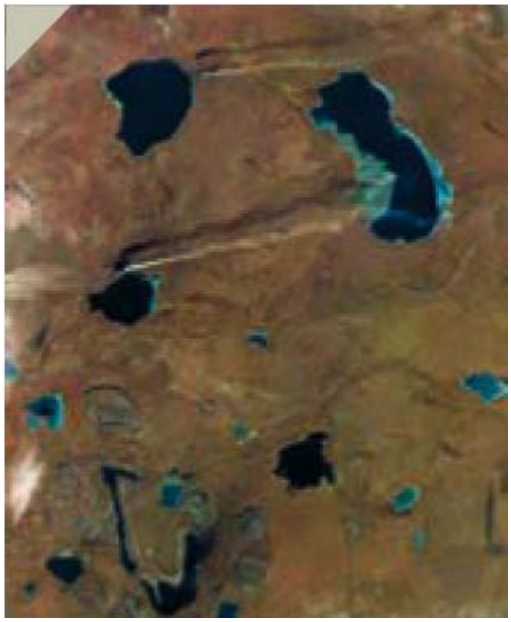

Fig. 4. Indian IRS series satellites' data are widely used in Russian and in Kazakhstan. Image of industrial facilities in the town of Ekibastuz, LISS-3 scanner, resolution: 23 m, acquisition date: November 16, 2004.
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Fig. 5. Low resolution images of MODIS 36-channel spectral radiometer of Terra/Aqua satellites are largely used in Russia to resolve tasks related to daily near real-time monitoring. The most common practical application of MODIS data is the on-line monitoring of forest and grass fires. The image illustrates the Baikal area fires in August 2005. Resolution 250 m. Red spots – areas, delineated with automatic algorithms of fire detection.

Within **middle resolution data segment** (10-250 m), images of IRS series (LISS scanners), SPOT, Landsat and Meteor-3M №1 are represented on the Russian market. Unfortunately, the American Landsat program experience a crisis – the ETM+ scanner is malfunctioning - resulting in additional correction of received images that can be used only for specific tasks. A new scanner onboard the NPOESS satellite is to be launched only in 2009. Due to Landsat-7 data sales drop (fig.3) in the world and in Russia, the demand on the images of competitive programs – IRS (fig.4) and SPOT - has increased.

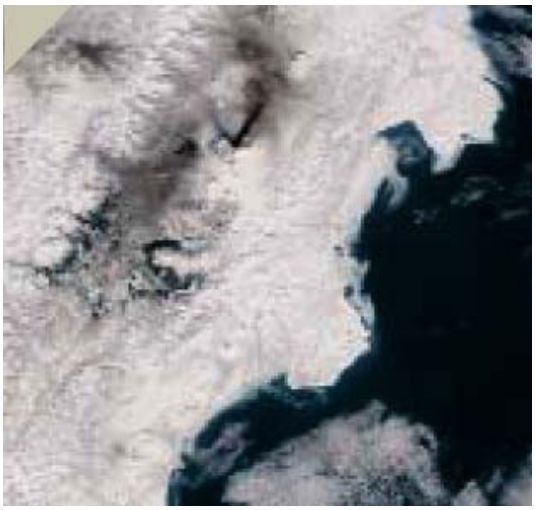

Fig. 6. Using MODIS scanner data to monitor volcanic activities in Kamchatka. March 2005 lava ash outburst of the Kluchevskaya Sopka volcano can be seen (black snow around the volcano is due to the previous ash outbursts). Ash outbursts data are used by the international information systems of air routes safety.

Within **low resolution data segment**, the images of MODIS 36-channel scanners from the American Terra/Aqua satellites are used widely throughout in Russia (fig. 5, 6). Thanks to a democratic data distribution policy (direct broadcast), MODIS data have been used for real-time detection of fires, large-scale emergency situations (flooding, freshet), ice and snow cover monitoring, land cover, climate and environmental monitoring, etc. Presently, 101 officially registered ground receiving stations are installed worldwide, which indicates the existence of the largest distributed network (after meteorological one) of remote sensing data reception stations. Notably, 21 of them are located in the USA, 21 more in Europe, 9 in China, 8 in Japan and finally 22 in Russia (all of them produced by ScanEx R&D Center, with 8 more stations installed aboard). This fact illustrates that in the low resolution data segment Russia is by no means “at the outskirts of the world”. In 2006, an American NPP satellite is to be launched to replace Terra, which is a transitional model to future NPOESS series meteorological satellites that will continue Earth observation program of direct low resolution data broadcasting.

Fig. 7. Middle resolution radar data of RADARSAT-1 satellite are successfully used in Russia in ice reconnaissance, forestry and hydrology. The Terek river delta image was acquired on May 25, 2005 from RADARSAT-1 per the request of the Water Resources Federal Agency of the Russian Ministry of Natural Resources to access the damage of the flooding and to work out an emergency response plan with respect to the catastrophic breakthrough of the protection embankment in the Terek river estuary. Flooded areas are shown in color (image processed by State Oceanographic Institute specialist)

For optical stereo imaging several types of data are used around the world**:

- stereo-pairs of high and extra-high resolution from IKONOS-2, QuickBird-2, OrbView-3 and EROS-A, acquired in along-track direction (single pass) after satellite pitch maneuver;
- stereo-pairs of high and middle resolution, acquired using two-camera (or two-three matrix) optical systems of IRS-P5 Cartosat-1, Terra (ASTER scanner) and SPOT-5 (HRS scanner) satellites;
- stereo-pairs of middle resolution, acquired on different passes with oblique viewing of IRS-1C, -1D, -P6 and SPOT-2,4 optical systems.

Stereo-pairs of the first type are the most expensive ones with a small coverage area; stereo-pairs of the second type are most widely used due to a moderate price and a bigger coverage. Stereo-pairs of the third type are the most affordable ones due to low quality (because the images are multi-temporal). It is expected that by the end of 2005 the Indian ANTRIX company will come up with a price list for the new IRS-P5 satellite data with 2.5 m of resolution, which will make it possible to start receiving and distributing its data in Russia.

Radar images are quite a specific segment on the Russian remote sensing market. A direct reception of radar data at 8-100 m resolution (fig. 7) from the Canadian commercial RADARSAT-1 satellite to the ScanEx ground stations was launched in Russian (starting in late 2004) and Kazakhstan (2005). Under joint research project of the Federal Space Agency and ESA, the European ERS-2 satellite SAR data reception will be started at the Khanty-Mansi remote sensing center. Data from another European research satellite – ENVISAT-1 – can also be ordered from the European operators. According to the experience of the RADARSAT-1 data usage, radar images are irreplaceable in resolving tasks of Northern Sea Route ice reconnaissance, provision of data to off-shore oil production industry, control of illegal fishing, forest cuttings and emergency situations (oil spills, floodings and freshets), etc. In 2006, new SAR satellites are to be launched – RADARSAT-2 (Canada) and TerraSAR-1 (Germany), which data will also be largely used in Russia.

Russian market, though lagging behind, tries to keep up with international trends in remote sensing and GIS-applications. The nearest future will witness a significant increase in number of remote sensing programs and operators. Starting in 2006 China is planning to launch a program of commercial distribution of data, acquired using the future CBERS-2B satellite. Unfortunately, spatial data and GIS-applications market has been dragging due to inadequate trends in development of the own fleet of satellites.

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** Wide-field stereo imaging mode with overlapping scenes ("Kometa" satellite) is also used in Russia.