EARTH REMOTE SENSING: OVERALL CHALLENGES AND RUSSIAN SPECIFICS

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Satellite-based monitoring data become nowadays an important integral part of the information support to the society, required for security and stable economic development of each country. The circle of active space information users in modern state infrastructure is added by meteorological services and ministries, controlling natural resources, transportation, construction, cartography, power-engineering, as well as by force ministries and environmental agencies. In order to obtain the required remote sensing (RS) data the countries both use their own satellite systems and purchase space data from other RS operators abroad.

International RS data market

The international RS data market has been developing with the annual increase in sales by 10-14% which inspires the GIS-applications and data processing software market growth. In 2005, over 30 world countries operated own remote-sensing satellites (over 30 operating RS satellites are currently on orbit, see Table 1), but only 12 states and organizations are the operators of high-performance operational RS systems.

Table 1. Operational RS satellites (as of June 1, 2005)

States and organizations	Number of operational RS satellites
USA	8
India	7
France	3
ESA	3
China-Brazil	2*
Taiwan	2
Algeria, Argentina, Great Britain, Israel, Canada, Malaysia, Nigeria, Republic of Korea, Russia, Thailand and others.**	1 (for each state)
* No data on the international market	
** Singapore, Turkey, Egypt, Saudi Arabia, Iran and others have plans to launch their satellites	

Unlike the market of space communications and navigation services and assets, the commercial remote sensing data market has not yet reached the return-on-investment level; therefore the development of the most capital intensive – orbital – components requires governmental involvement and state budget support. Different segments of the space information market develop erratically with the leading role of the high and extra-high resolution data. International RS data market is ranged in the following descending order of sales:

- extra-high resolution (< 1 m) and high resolution (< 1-10 m) data;
- high and middle resolution stereo imagery data;
- radar imagery data;
- middle resolution (<10 -250 m) multispectral data;
- low resolution (>250 m) multispectral data;

Meteorological low resolution data, acquired by the governmental meteorological satellites, are at the bottom of this hierarchy.

Meeting national requirements in space data

In the current conditions of world economy globalization and internationalization of economic life no country can support national requirements in space information by using their own satellite remote sensing systems only. For example, the United State of America purchases 100% of synthetic aperture radar (SAR) data, 40-60% of optical stereo imagery and 6-8% of middle resolution data (Table 2) of the RS operators from India, Canada and Europe.

Table 2. Segments of RS data market in the USA,
where purchases of foreign RS operators' data dominate or are significant

RS data market segments	**Satellite (country-operator)**	**Share of foreign RS operators on the US market**
Radar images	RADARSAT-1 (Canada), ENVISAT-1 and ERS-2 (Europe)	100%
Optical stereo images	SPOT-5 (France), IRS-P5 (India)	40-60%
Optical multispectral images of middle resolution	IRS-1C/D, -P6 (India), SPOT-2/4 (France)	6-8%

To boost up the industry development and support to the national RS operators, the US implements two programs of space data purchase (Fig. 1): ClearView Program of the National Geospatial Agency (500 mln dollars for five years) and the Program of the U.S. Geological Survey (USGS, 15 mln dollars for three years). China with its own RS satellites of CBERS series spends several million of dollars annually to purchase RS data of foreign satellites (Table 3, Fig. 2). There are schemes of budget purchase of space data from foreign operators on behalf of the state agencies in India and Japan, which have their own fleets of civil and military satellites.

Table 3. Number of scenes, acquired by
the Chinese RSGS center (Miyuan, Beijing suburbs)
from foreign RS satellites and the national CBERS-1 satellite in 2002

Satellite (country-operator)	**Number of scenes**
Landsat-5 (USA)	671
Landsat-7 (USA)	644
SPOT-5 (France)	36
SPOT-4 (France)	435
SPOT-2 (France)	294
RADARSAT-1 (Canada)	182
ERS-2 (European countries)	144
CBERS-1 (China-Brazil)	1354
Total	**3760**

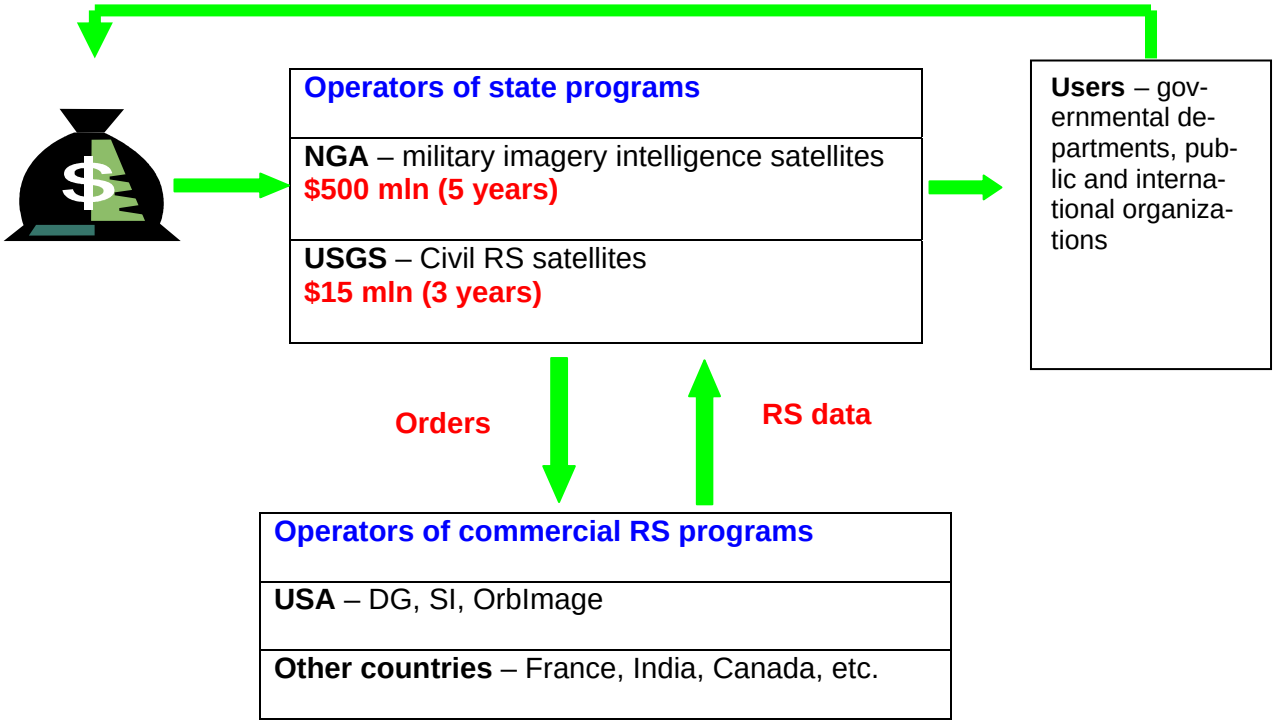

Fig. 1. State orders placement scheme for space imagery using state civil and commercial systems in the USA

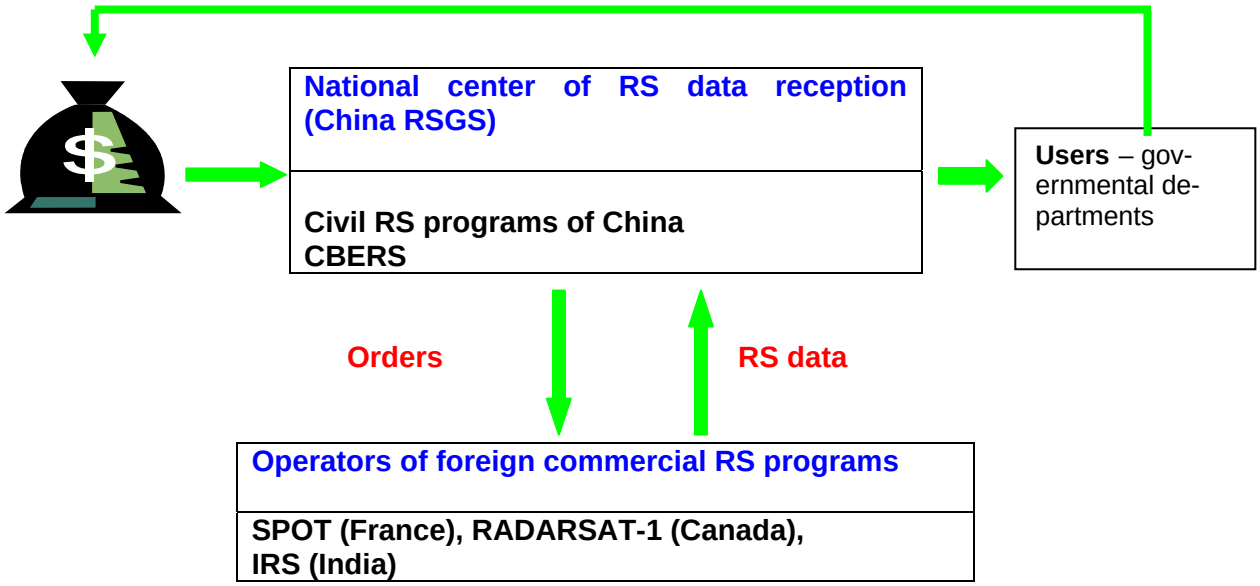

Fig. 2. State orders placement scheme for space imagery using state civil and commercial systems in China

Space monitoring in Russia

In Russia after the administrative reform of the Russian government, held in accordance with the Presidential Decree #314 from March 9, 2004, several departments share the responsibility for the remote sensing data collection and processing:

- Ministry of Defense of the Russian Federation;
- Ministry of Natural Resources of Russia;
- Ministry of the Russian Federation on Emergencies;
- Federal Space Agency;
- Federal Service for Hydrometeorology and Environmental Monitoring;

Projects to create assets of RS data collection, processing and usage are also managed within the frames of general and thematic federal target programs, under the auspices of the FSA, Ministry of Natural Resources, Emergency Ministry, Federal Agency of Government Communications & Information, Ministry of Economic Development and Trade, Ministry of Industry, Science & Technology, Ministry of Communications, Federal Agency of Geodesy & Cartography, Russian Federal Service For Hydrometeorology and Environmental Monitoring (RosHydroMet), Federal Construction Agency and others.
For the last years, due to continuous crisis of the Russian space industry, the fleet of the domestic RS satellites shrank to only one Meteor-3M-1 satellite with the MSU-E scanner of middle resolution with limited lifetime. Starting 2003, all the space meteorological monitoring data have been received by RosHydroMet from American and European meteo satellites (currently not requiring any budgetary funding, however subordinating Russia to the policy of space data distribution by foreign countries). In the conditions of absence of own RS satellites the only way out for Russia to get space data, required for stable economic development, is to purchase them from foreign operators of commercial RS systems on the state budget. However, such programs and projects are not currently funded in Russia.
Ignorance of country's needs in space data tells on the rate of economic and social development of the society as a whole. There are no up-to-date images of high and middle resolutions, covering the entire territory of Russia, available to the Russian governmental agencies. Such drastic situation brings to the lack of the updated cartographic products, high costs of the conducted construction projects, poor control of natural resources and their embezzlement, low efficiency of nature protection and insufficient environmental awareness of the society.

Poor RS data market in Russia backed up by the lack of space data state procurement has an impact on the intensity of imaging Russia's territory by foreign operators too. To date, Russia is the least covered land even by the Landsat-7 program, conducting continuous global imaging of the Earth's surface. According to the USGS data, judging by the Landsat-7 coverage for 1999-2003, Russia can be compared with the regions of Central America, African Sahara and Central Asia (imaging ratio constitutes 15-50 times, whereas for European countries, the USA, Australia, South America – from 72 to 91). Russian territory is the blank spot both in SPOT Image (France), Imagesat International (Israel) and American commercial companies' space data archives. At the present time the most comprehensive archive of high and middle resolution images of Russia has been collected only thanks to the cooperation between ScanEx R&D Center and India under the Indian IRS Program in 2002-2005.

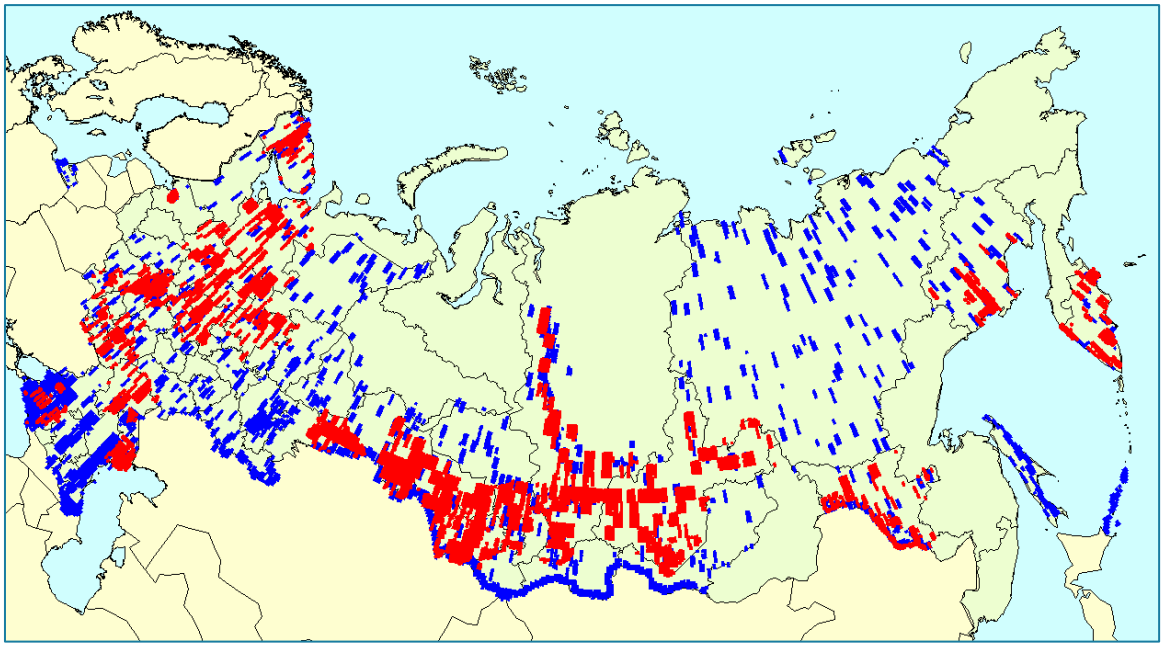

Fig. 3. QuickBird-2 (blue color) and Ikonos-2 (red color) data coverage of Russia (as of 2004)

For the past couple of years three leading American RS operators providing extra-high resolution images (Space Imaging, DigitalGlobe and OrbView) has been actively acquiring space data of the Russian territory (Fig. 3). However, according to experts' assessments, the share of orders from Russian companies and organizations makes up only 5% of the total volume. The absence of governmental policy in Russia in sphere of RS data purchase from foreign operators shapes the ground infrastructure of data reception and processing. Acting under the auspices of the Federal Space Agency network of large-scale THA ground stations (deployed in Moscow and Khanty-Mansiysk) was not designed to receive data for multiple satellites. Distributed networks, created on the basis of UniScan ground stations (16 sites in Russia and abroad), are universal and can receive data from 10 operating world RS satellites and can be programmed to receive data from future domestic and foreign Earth observation satellites.

With no national satellites and no funding for the purchase of foreign RS data, a lot of important issues are resolved by governmental authorities using low resolution data, freely distributed according to the US policy, or using one-time data purchase from commercial operators. According to calculations, the most cost-efficient option to buy space data is to purchase licenses for direct data reception. Fig. 4 illustrates that it is more profitable to use UniScan ground station for direct data reception than to purchase data from the world archives of international RS operators in case of territory coverage from 0.5 mln km^2 (for example, Arkhangelsk Region acreage is around 0.6 mln km^2, Republic of Sakha (Yakutia) – about 3 mln km^2, entire Russian territory – around 17 mln km^2).

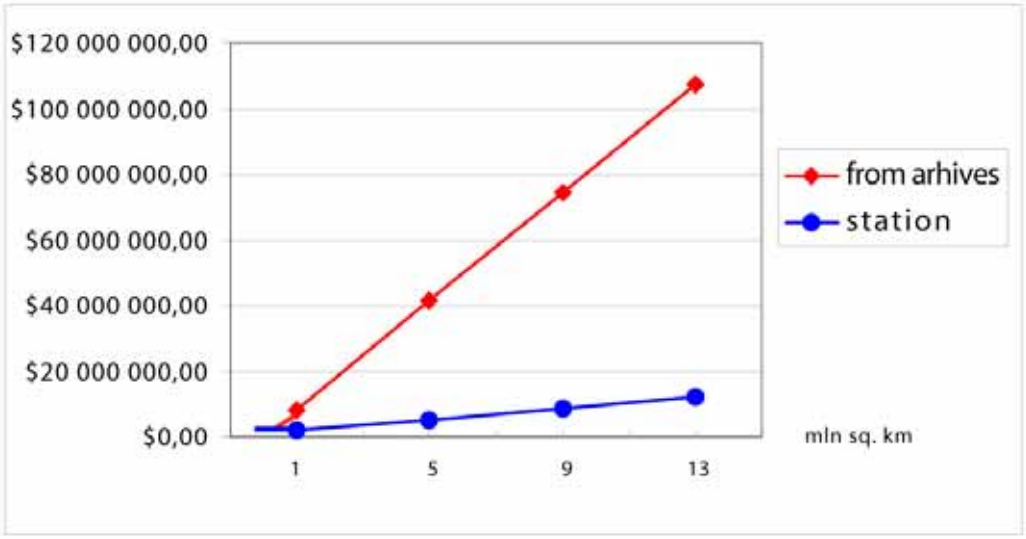

Fig. 4. Total costs of IRS-P6, RADARSAT-1, and SPOT-2/4 images. Purchase from the international data archives vs. data reception by the UniScan ground station.

Nowadays, with the advance of the economy globalization processes, no country (the USA included) can fill the requirements of governmental authorities in space information using own RS systems and has to resort to buying data from foreign RS operators at the expense of state budget.

Buying RS data from abroad when there are no own satellites enables Russian users both to resolve tasks of the federal level and to use state-of-the-art technology of remote sensing data processing for geo-information purposes (mosaics, fusion, 2D- and 3D- modeling, DEMs, InSAR, change detection, etc.)

In Russia, with almost no domestic RS satellites, the only way to obtain space data, required for the stable economic development, is to purchase them from foreign operators of commercial RS systems on the state budget. The most cost-efficient option for data purchase is to buy license for direct data reception. The infrastructure in support of direct licensed data reception to Russian ground stations has already been created and is currently operational (for example, the network of ground stations of the Ministry of Natural Resources), however it is not developing if not funded by the government.