Remote sensing technologies for infrastructure management: Russian experience

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Abstract

Remote sensing technologies are used to have very wide application field. Here we’d like to consider more thoroughly area of infrastructure management including following topics: monitoring of illegal construction, geoportal solutions for decision-making support, disaster satellite monitoring and finally how such technologies could be in common practise by applying at universities and other educational organizations. Especially in Russia using remote sensing technologies is very relevant and important point in account of different reasons. Firstly, surely, it is a huge territory with regions difficult of access. Also it is a specific situation when there is necessity for federal government to have a possibility for control and monitoring activities of regional and local administrations or other federal ministries. The problem is exacerbated by almost full absence of own Russian remote sensing satellite group in orbit. Thus it is a really urgent question if we speak about infrastructure management. Let us consider some case studies from Russian practice.

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1 Monitoring of illegal construction

We would like to start with project concerning monitoring of illegal construction (Novitsky and Mikhailov, 2009). In 2008 ScanEx specialists analyzed surface changes in Irkutsk for local government. The main goal of the project was detection of illegal construction within the area of interest – about 360 sq. km. Unfortunately, space imagery is unable to answer a question about the legality of the construction at the detected areas. Thus they should be used together with state cadastre papers. However, remote sensing data provides infrastructure management with high accuracy and qualify of detection of construction changes.

Illegal construction is typical for big Russian cities because the traditional methods are not able to control situation in proper time especially taking into account furious pace of contemporary building. Today Russian local government should check every land area to be sure that:

- all documents are drawn up in appropriate way and there is no unauthorized occupation of areas;
- area developing corresponds to rent agreements or other required documents;
- areas are using accordingly to their end-use with necessary actions for soil protection from erosion and other destructive processes.

Thus it is obvious that remote sensing data is useful and very important tool for monitoring of illegal construction.
In frame of this project we used EROS B (Israel) data because of high spatial resolution (0.7 m) and high speed of access to information. Last point is connected with direct reception EROS B data by ScanEx commercial network of ground receiving stations. During the project two satellite mosaics for whole Irkutsk infrastructure were received in May and September. These mosaics were a base for changes detection analysis such as appearance of new construction areas, changes of coastlines (Figure 1), park areas and etc.

![Figure 1. Changes of coastline (changes areas are set off in white frames; image “a” on the left side is acquired in May, 2008; image “b” on the right side is acquired in September, 2008).](image)

As a result of analysis such multi temporal coverage 1262 changes in construction were detected. Detailed information concerning changes is placed into Table 1.

<table>
<thead>
<tr>
<th>Nature of changes</th>
<th>Number of objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance of new buildings</td>
<td>515</td>
</tr>
<tr>
<td>New construction area</td>
<td>218</td>
</tr>
<tr>
<td>Changes of objects under construction</td>
<td>145</td>
</tr>
<tr>
<td>Changes of landscape conditions</td>
<td>37</td>
</tr>
<tr>
<td>Housebreaking</td>
<td>34</td>
</tr>
<tr>
<td>Changes of coastlines</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>311</td>
</tr>
<tr>
<td>Total</td>
<td>1262</td>
</tr>
</tbody>
</table>

The layer with changes detection results was included in local geoinformational system (GIS) and compared with other thematic layers containing data about areas with correct documents, end-use of land areas, etc. Such comparison allowed finding illegal construction objects and land areas that are not used accordingly to their end-use in the shortest time.

Also the information about changes was used not only for detection of illegal construction objects but also for city map and local GIS updating.
2 Geoportal solution for “Russian railways” infrastructure management

Next point of remote sensing application for infrastructure management which we would like to consider here is concerned with geoportal solution for “Russian railways”. In our opinion geoportal should based on satellite imagery as source of the most relevant and reliable information about territory. Thus geoportal means a geographic information technology with web-interface based on regularly updated remote sensing data (Ash, 2009). It is significant that such technology allows adding any geospatial layers (vector or raster) connected with data bases, tables and etc. in one window. Thus the geoportal is a complex geographic information technology composed of many interrelated complicated elements. Such technology covers different fields such as satellites, reception and processing of space imagery, analysis of geospatial data, web-interface for visualization and integration of different information, decision-making support, etc. (Figure 2) and could be considered as a decision support system for infrastructure management.

Figure 2. Geoportal as complex geographic information technology for decision making support.

In 2008 ScanEx together with “NIIAS” (daughter enterprise of “Russian Railways”) carried out the project aimed at the development of decision support system for geospatial information providing – “Russian Railways” geoportal.

Today “Russian railways” geoportal consists of Landsat (USA) imagery (with spatial resolution 15 m) as a base coverage for Russia and CIS countries, IRS (India) imagery (with spatial resolution 5.8 m) for Krasnodar region and very high resolution multi temporal imagery (0.5-0.6 m) from QuickBird (USA) and GeoEye-1 (USA) satellites for part of railroad from Tuapse to Adler because the first stage of project was focused on Sochi area. Satellite imagery was mixed with internal information e.g. concerning geomorphologic exogenous processes, infrastructure objects, etc. in the area of interest (Figure 3). Thanks to the possibility of viewing such geospatial data in one window today “Russian
railways” geoportal helps to solve problems of monitoring of potentially dangerous railroad parts as well as registration of infrastructure objects.

Figure 3. Interface of “Russian Railways” geoportal with mixed space imagery with vector layers concerning geomorphologic exogenous processes (1 – Dagomys area, 2 – Hosta area).

Now it is discussed new ways of project development such as studies of other railroad parts, creation high accuracy digital elevation models (DEM) for infrastructure objects, using new technologies of satellite interferometry, visualization of transport moving by GPS or GLONASS tracks in geoportal window, etc. We should say that the last point has been already successfully tested. Today there is no problem to download GPS or GLONASS tracks into geoportal in the near-real-time mode (Figure 4).

Figure 4. Transport monitoring via GPS or GLONASS tracks in geoportal window in the near-real-time mode.
3 Disaster monitoring

Speaking about remote sensing for infrastructure management we should mention about disaster monitoring. In 2008 ScanEx Center specialists carried out a program of satellite radar monitoring for the Russian Emergency Control Ministry (EMERCOM), aimed at ship navigation assessment and detection of oil spills on the surface of the five Russian seas (Kucheiko et al., 2009).

During this period two ScanEx ground receiving stations in Moscow and Magadan were capturing the radar data from RADARSAT-1 (Canada) and ENVISAT-1 (ESA) satellites. Processed satellite data was supplied to the end-users throughout Russian Regions in near real-time mode via geoportal “Kosmosnimki – Seas of Russia” (in Russian language “kosmosnimki” means “space imagery”). The main customers of data describing offshore zone situation are the National Center for Crisis Management of the EMERCOM and regional Russian EMERCOM centers. Within the two-week satellite monitoring period 37 images have been acquired, processed and analyzed.

We would not to speak about detection of oil spills on the sea surface by using radar space images in details, let us consider ship navigation assessment. The shipping situation, defined based on satellite imagery under the Sea Monitoring Project, and the one, delivered through the ships location control system of the Russian Ministry of Transportation (so called ESIMO), were compared at the EMERCOM. There are main results of the shipping situation comparative analysis:

- satellite-based radar images contain a more comprehensive and unbiased information about the number and location of ships than the control system, where only ships flying the Russian flag are displayed;
- a complete and independent shipping situation control system requires a joint application of the satellite radar imagery results (being in the stand-alone mode it does not allow to correctly identify ships) and the additional information taken from the systems of automatic ships identification, ships navigation control systems, etc.; such a complex system will enable to detect injured, damaged, illegal and poaching vessels, where radio-systems of automatic identification are not operational for different reasons;
- combination of independent radar monitoring and automatic ships identification systems will enable to perform operational search for and rescue of damaged vessels.

Also remote sensing technologies successfully solved problems of oil spills monitoring and ship navigation as well as monitoring of floods, fires and other disasters within highway corridors. This point is very important for infrastructure management because of such disasters can lead to smoke formation and visibility limitation or road destructions and etc.

4 Remote sensing technologies at Universities

It is very important that all successful experience in remote sensing applications for infrastructure management described above could be apply in common practice. That is why we would like to conclude by outlining that remote sensing technologies have been already accessible for Universities all over the world. Creation Remote Sensing Centers at Universities is a new opportunity to integrate theoretical knowledge and practical skills that allows having specialists well-known with latest technologies in the shortest time. Such Center is based on personal ground stations to receive, store and process Earth observation images from space as well as special software for preliminary processing and in-depth thematic analysis of satellite imagery.

In 2009 ScanEx together with satellites Operators made special offers for Universities which consists of personal ground receiving station (UniScan™) and licenses for space imagery real-time acquisition including in high resolution (up to 1.8 m).

The offer to the international education community means the possibility to get the universal small-aperture ground station UniScan™ with licenses to receive 100 scenes of EROS A, 600 minutes
of IRS-1D and the unlimited access to SPOT 4 images within the first year of station operations, all included. Initial inclusion of the license into the functionality of the UniScan™ station (as per the agreement with Operators of the respective RS programs) will enable to significantly decrease the total cost of the ground station and of space images for the universities and to make telemetry license prices affordable. In such way universities may efficiently use modern space technologies in education, research and development processes, applying up-to-date satellite data, received to own ground stations with the footprint of up to 2500 kilometers in radius

Currently, educational Centers of Remote Sensing Data based on UniScan™ ground stations have already been established and functioning in universities in Russia, Kazakhstan and Spain: Lomonosov Moscow State University, Bauman Moscow State Technical University, Tyumen, Astrakhan, Belgorod State Universities, Southern and Siberian Federal Universities, Samara State Aerospace University after Korolev, Ufa State Aviation and Technical University, Kazakh National Technical University after Satpaev, Kazakhstan-British Technical University, Spanish University in Valencia and others.

References