

Full Cycle of RS Data Processing in IMC Software Suite

V. Lobzenev, I. Logvanev

Innovative Centre LLC, Moscow, Russia

Nowadays, for socio-economic, scientific and defense purposes, creation and development of space systems and technologies dedicated to remote sensing (RS) is one of the major applications of space equipment. Current Earth remote sensing space systems provide data collection on a global scale with high spatial and spectral resolution.

The provision of an open and commercial access to satellite imagery materials, along with their transfer to digital form has been the most important change in the RS market. The development of computer-based image processing has led to creation of fundamentally new analytical systems – geographic information systems (GIS). Recognition of data by binding to the geographical location provides an ability to receive new information through spatial, temporal and visual complexation.

Satellite imagery is widely used in various fields such as cartography, ecology, land-use planning, area development management, agriculture, forestry, industry, discovery of new mineral deposits, impact assessment on the aftermath of natural disasters, etc.

Currently, there are number of Russian and foreign software products for RS data processing. Usually, specialized software suites allow you to work with one type of the RS material; either picture, a map or GIS. Thus, each software solution is specialized for a certain task and the complete cycle of processing requires 2 or 3 programs which significantly increase time and cost of this process. However, the Russian market provides an innovative solution – “Image Media Center” (IMC) software suite, fully developed by the Russian company “Innovative Centre”, which allows the full cycle of RS data processing in a single geographic information space.

The main advantage of IMC software suite is the combination of fully functional geospatial environment, satellite images that can be easily worked with and the ample choice of professional graphics and vector editors.

Image Media Center software suite provides users with the following capabilities:

- Loading of monochrome and color images with different types of data, including 8, 16 and 32-bit, floating point, and complex.
- Support of six color models: Grayscale, RGB, CMYK, HLS, HSB, Lab.
- Support of the following data types: raster images, marks, text, vector images, geo-referencing points.
- Work with layers: transparency, blending mode, the display order, grouping.
- Improvement of the image quality by using filters, direct editing of image pixels, the radiometric characteristics.
- Support of GIS functionality while working with vector data.
- Geo-referencing data.
- Logging of the operations history.
- Customizable interface and availability navigation windows.
- Preparation of report documents, support of profiles.

Modern remote sensing space systems widely use multispectral data. The information content of images is enhanced by using a system of features based on the spectral characteristics of recorded optical radiation.

The combination of high spatial and spectral resolution allows the user to see the world in amazing details and solve thematic problems with a high degree of efficiency. Multispectral high resolution imaging provides better object recognition with greater accuracy and thus contributes to decision-making in public and private economy sectors.

IMC software suit uses radar and optical satellite imagery, including panchromatic, multi- and hyperspectral images, vector masks, and images without geo-referencing and geo-referenced images as data input for thematic RS data processing.

“Image Media Center” supports the most popular formats of raster and vector images: Bitmap Format (*.bmp), Erdas Imagine (*.img), Tagged Image File Format (*.tif), JPEG (*.jpeg), Targa (*.tga), AutoCAD 2007 File (*.dxf); MapInfo Interchange Format (*.mif), Shapefile (*.shp).

Own Image Media File format allows you to:

- store information in a hierarchical structure;
- store multiple layers of different types in a single file, (raster and vector images, marks, text data, etc.)
- save more than one image in a single file;
- use alpha channels of the images;
- save images in different scales;
- work with various types of data;
- work with large files (over 300 GB , such as formats *.imf, *.emg);
- quickly access to data, regardless of file size.

Receiving satellite images is associated with serious technological difficulties. Converting optical signal into digital data is influenced by a number of distorting factors which should be considered and compensated maximally. Therefore, the RS data processing requires special mathematical methods and computational algorithms.

Technology of RS data preprocessing imple-

mented within IMC software suite is fully automated and allows the user to perform the following steps:

- Formation of satellite images mosaic.
- Formation of images composite, obtained in each spectral range of surveying.
- Eliminating the offset between the channels.
- Formation of synthesized color images of individual spectral bands.
- Increasing the detail of panchromatic image by 10-12% if necessary.
- Obtaining complexed images in natural colors with the resolution of panchromatic image (Figure 1).
- Atmospheric correction.
- The brightness and tone correction, elimination of noise in the image.
- Sharpening the image using the algorithm that eliminates defocusing.

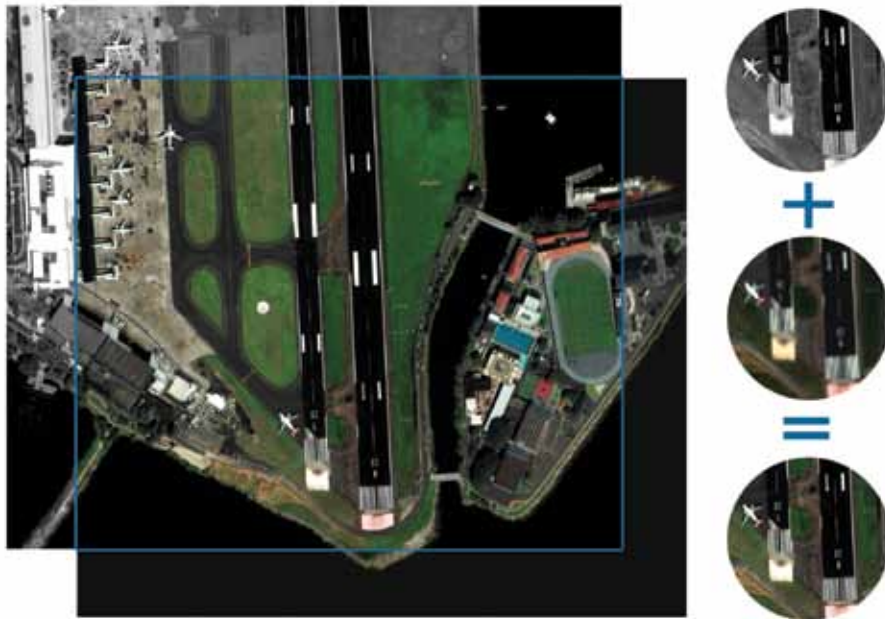


Figure 1. Complexed images in natural colors with a resolution of the panchromatic image. WorldView-2 spacecraft. Andorra territory.

IMC software suite provides an ability to create thematic maps based on satellite images using the following algorithms:

- Work with color components.
- Formation and analysis of the index images.
- Vectorization and the assignment of display styles.
- Working with vector masks addition / subtraction of vector layers.

- Formation of attribute tables and filling them with content.
- Clustering, interactive supervised classification.
- Multi-temporal monitoring.
- Texture analysis.
- Structural analysis.
- Processing and analysis of an unlimited number of spectral channels.

- Display of spectral curves in tabular and graphical forms.
- Formation of spectrogram libraries.
- Comparison of the spectral curves to each other.
- Search for spectrograms in the library with a certain confidence interval.
- Search for objects in the image on the spectrogram according to the value of the confidence interval.
- Formation of spatial spectrograms by row, column, or arbitrary profile of the image.

Automated processing algorithms implemented in the IMC software suite allow you to analyze not only spatial but also temporal changes occurring in the study area; identifying the most intensive causes and classifying their combinations.

Multispectral data processing technology is implemented based on the formation of both well-known index images (NDVI, NDWI, NDSI, etc.)

and specialized ones.

The result of thematic processing are vector layers, containing separate vector objects filled with attributive data.

In recent years, hyperspectral images are used increasingly to identify the qualitative characteristics of terrestrial objects, including hidden ones.

Hyperspectral survey is the evolution of multispectral systems. Due to innovative technologies, the number of multispectral channels increased from 3-5 to 220 (multispectral sensor onboard the spacecraft Hyperion EO-1).

High information capacity of multispectral systems is based on specific differences in the emission spectra of natural and man-made objects.

Figure 2 shows spectrograms of different terrestrial objects based on the hyperspectral image that is taken by Resource-P spacecraft, containing 130 spectral channels.

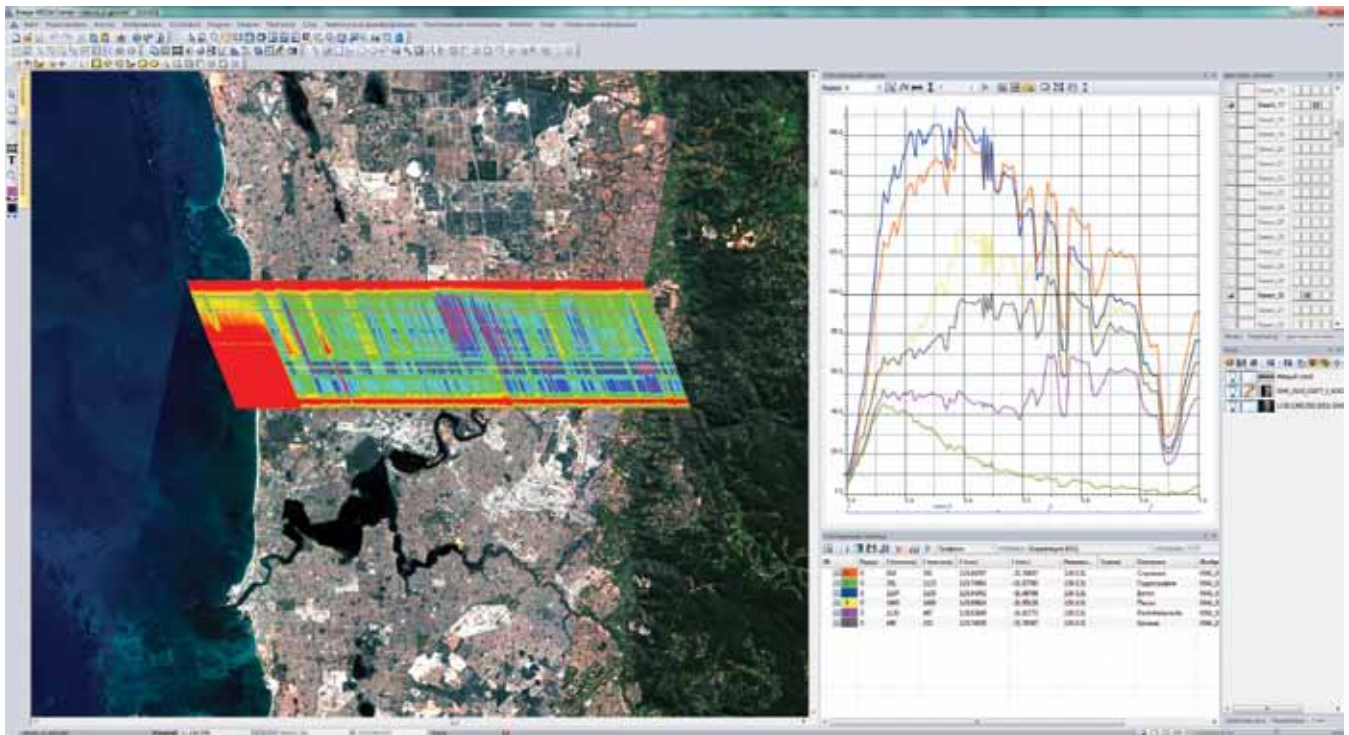


Figure 2: Hyperspectral image taken by Resource-P spacecraft, Australia territory. Formation of spectrogram database of different terrestrial objects using hyperspectral data.

GIS allows you to clearly and interactively conduct multivariate area analysis. Often, even a large amount of information cannot help to solve the problem, unless it is visualized on the map.

Based on the results of test measurements and process simulations and visualized with the help

of GIS, it is possible to predict the development of overall situation, identify performance bottlenecks and make quick decisions to rapidly respond to negative changes in various fields of interest.

Dry weather during the hot periods of the year in several regions of Russia often leads to forest

and peat fires. Fire suppression effectiveness, especially when there is limited access and high fire danger, is determined by the rapidity of fire detection at an early stage and the course of actions taken for its termination. Detection of thermal anomalies during image processing contributes to the rapid assessment of the situation and early termination of potential ignition sources.

The results of fires and cinders monitoring based on data collected by Landsat-8 spacecraft are

represented on the Figure 3. Basic image displayed in the color components of visible spectral range (Fig. 3-a) is not informative. It is required to use multispectral channels, which record radiation in red and infrared range of the spectrum, for fire visualization. As a result of former thematic processing, vector map, on which red represents open fires, and orange – cinders (Figure 3-c) is formed.

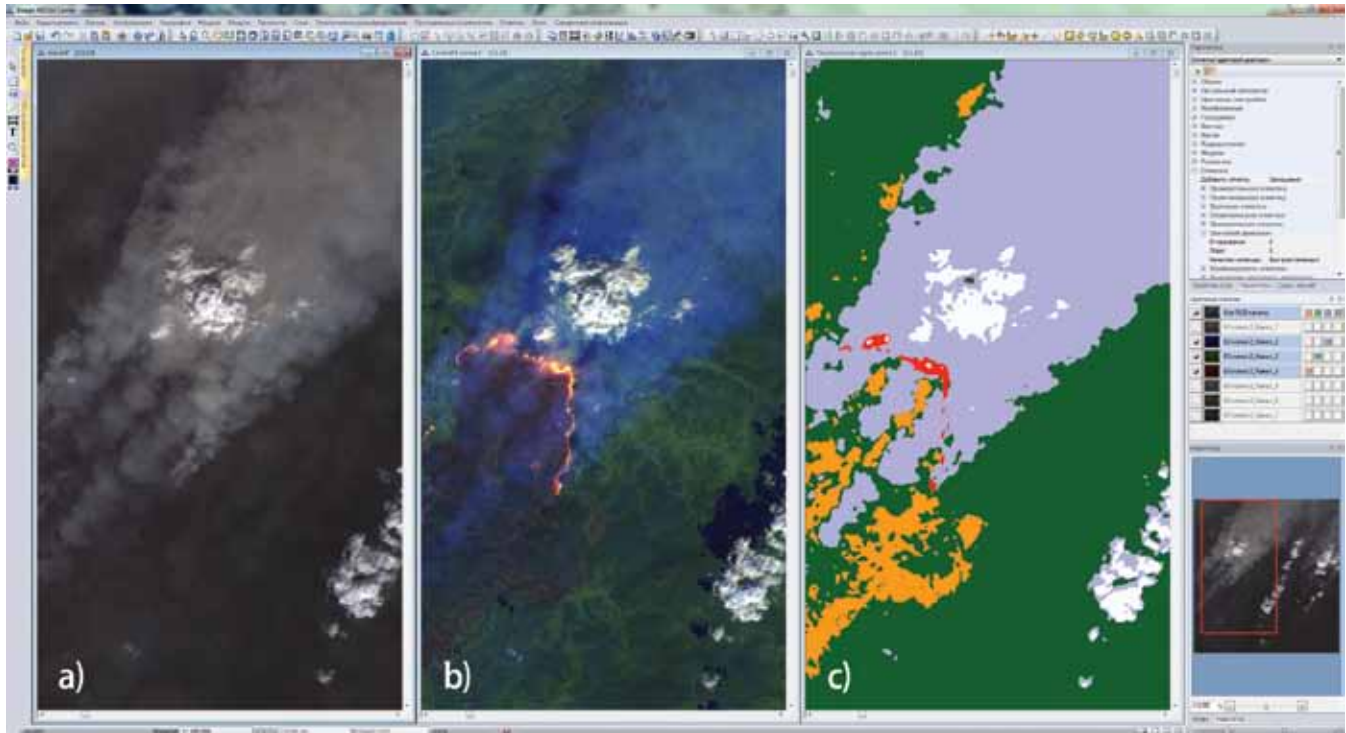


Figure 3: Detection of fires and cinders based on multispectral data collected by Landsat-8 spacecraft, Evenk autonomous territory. a) multispectral image in natural colors; b) the visualization of fire, the combination of multispectral bands 7-6-3; c) the vector map, the result of classification (red – open fire, orange – cinder, blue – smoke plumes, green – vegetation, white – clouds).

IMC software suite allows the user to not only effectively solve tasks, but also provides ample opportunities for the investigation and forecasting of natural disasters. For example, it can be used to identify dangerous areas on the pipeline.

Often, late diagnostics of the territory where pipeline is located results in pipeline damage, which leads to serious consequences. IMC software suite provides the ability to identify the range areas, which require greater attention, using RS data. Image classification is based on highly detailed multispectral data obtained by WorldView-2 spacecraft. During thematic processing, contact between “Pipeline” vector object and vector objects of the map (wetlands, bare soil and water

bodies) is performed, which results in the creation of new vector layer displaying possible dangerous fields. On the Fig. 4-b, they are displayed in red.

Figure 5 shows a thematic map, which is based on multispectral data obtained by MODIS Terra spacecraft.

Information on ice consolidation ratio on the area of interest is required for safe navigation in the northern seas. Ice sea travelling routes usually lie through the zones of lesser ice consolidation ratio and thickness, polynyas, cracks, bypass ice gatherings, large ice fields and their debris, barriers, ridges and stains of hummocky ice. IMC software suite provides the ability to create ice maps using optical and radar RS data.

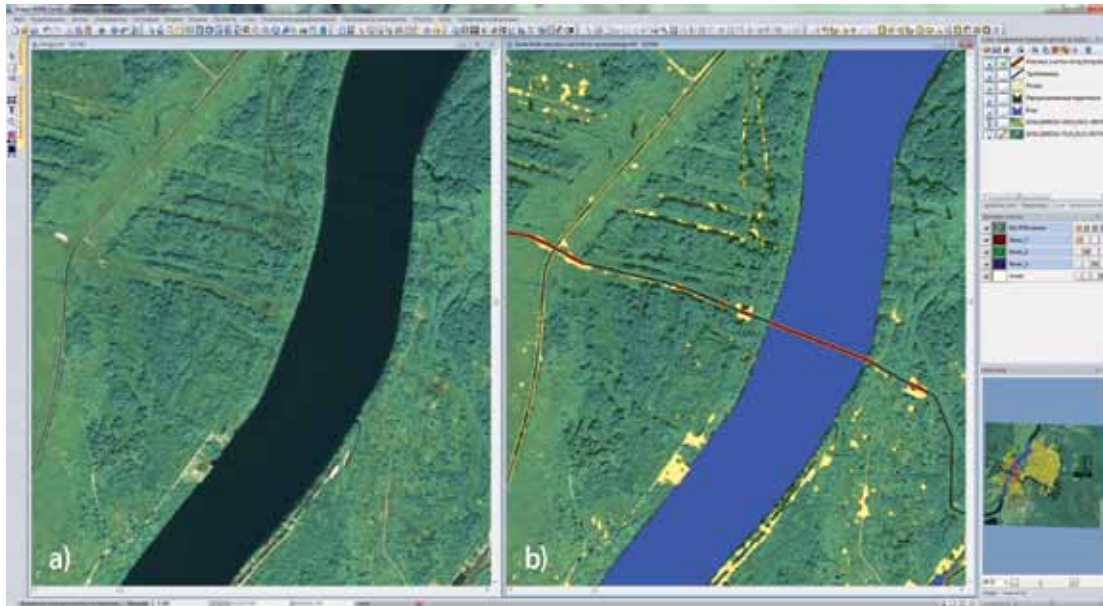


Figure 4: Identification of dangerous areas on the pipeline, based on WorldView-2 cpascraft data. Kirishsky district, Leningrad region. a) Highly detailed multispectral image in natural colors; b) vector map (linear black object – pipeline, red line – the dangerous areas on the pipeline, blue – water bodies, yellow – soil).

Using IMC software suit as GIS base provides the following opportunities:

- pre-processing of images;
- eliminating defects which emerge during surveying or image digitizing;
- simultaneously working with raster and vector images, overlaying and combining images of different formats, dates and projections;
- creating vector maps using different sets of

vector styles;

- performing spatial and attributive queries, solving various analytical problems;
- thematic GIS structuring, setting the content of thematic layers and attributive information about objects;
- developing geographic databases using industrial DBMS;

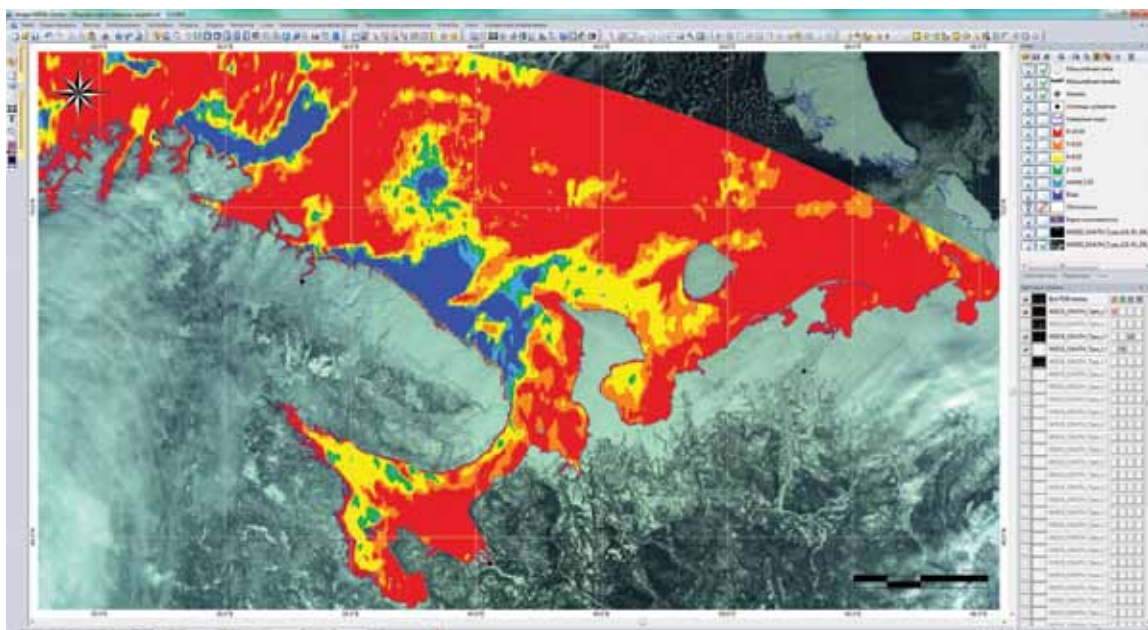


Figure 5: Vector map of ice consolidation ratio, based on optical multispectral data obtained by MODIS Terra spacecraft. Northern seas. (Blue – clean water areas, green, blue – the primary types of ice with consolidation ratio up to 3 points, yellow, orange, red – types of ice with consolidation ratio from 4 to 10 points, according to the international ice maps nomenclature).

- visualizing any spatial object on a digital map, while retaining the ability to work with its attributive (tabular) information;
- performing spatial analysis (analyzing the spatial distribution of objects and their influence on each other, acquiring the exact coordinates of objects);
- visualizing any graphical information and controlling its displaying (selective displaying of thematic layers, the latest special characters/marks/signs, styles, and colors);
- performing measurements and statistical analyzes;
- simulating various processes and phenomena,

displaying acquired results on the map.

Unlike most of other existing GIS, the functionality of Image Media Center software suit allows the user to not only pre-treat basic spatial data, which size can reach several hundred Gb, but also create thematic maps with unlimited number of vector and raster layers, as well as output reports based on the results of data processing. Thus, the user receives a unique GIS, which provides an ability to perform the entire cycle of image to map RS data processing in a single geographic information space, which drastically reduces both time and cost of the process.