

Monitoring of oil and gas pipelines by integrated GIS

Alexander KIRSANOV
Institute of Remote Sensing in Geology (VNIKAM), Russian Federation
Sur@vniikam.spb.su

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ABSTRACT

A network of pipelines used to transport oil and gas from areas of crude oil production to oil consumers has recently broadened in Russia. To provide environmental monitoring of pipeline construction and maintenance areas and to ensure a quick and effective response to emergency it is necessary to develop an information system that would enable us to make managerial decisions promptly. These systems include Integrated Geographical Information Systems (IGIS), based on geological-landscape and topographic maps and Data, obtained through Remote Sensing (RSD).

High-resolution images, obtained from satellites, are used to compile large-scale environmental maps that serve as a base for monitoring. Comparison thereof with maps, compiled in the process of monitoring, would permit us to trace spatial and temporal landscape variations in a pipeline-impacted area and to compile sketch maps of prediction of development of negative processes. These studies make good use of digital models of the country, allowing us to make modern software, used in IGIS, and to develop three-dimensional models of the area under control.

Works, made in some areas of the North-West of Russia, showed a great potential of using IGIS in environmental monitoring along pipeline routes.

1 INTRODUCTION

An intensive development of the oil and gas complex is characterized by development and putting of large fields into operation and, correspondingly, construction of new oil and gas pipelines and auxiliary infrastructure. This poses an important problem of environmental protection in pipeline construction and maintenance. Disturbance or pollution of one of the environmental components commonly leads to change in others because of their interaction. These disturbances include felling trees, peat land drainage, change of landforms, etc. Today an urgent problem is accident prevention or elimination in the areas of long-operating pipelines with economic and environmental damages being as low as possible. Accidental spills cause heavy pollution of environmental components, especially surface water; this may result in irreversible changes in the entire landscape.

Supply of nature-oriented studies and environmental monitoring with information calls for geological-landscape information, obtained from topical maps and RSD, that must be stored in digital form, suitable for processing and analysis when taking managerial decisions. Therefore to solve this problem it is necessary to use IGIS that permit us to operate with large volumes of information, especially multispectral RSD of high spatial resolution.

2 TECHNIQUES

1. At the first stage, currently available information is used to study the geological-landscape conditions in the area throughout the oil or gas pipeline route. For this purpose, analysis of the data on the geological structure (rocks and Quaternary deposits), relief, hydrogeological regime, soil and plant cover, lake and river system,

bogs, exogenic geological processes is performed. In addition, technological (industrial, agricultural and other) objects are revealed and the areas of their environmental impact are delineated.

2. With consideration for analysis of the geological-landscape conditions, data, required to form a data bank, are selected from the above-mentioned information. One of main sources of topical information is RSD.
3. High-resolution multispectral images, obtained from satellites, are used to compile environmental maps that show natural and technological objects, areas of development of exogenic geological processes. Topographic maps are used to compile digital relief models on which Landsat images are superposed; this permits us to build three-dimensional models of the state of the country for a particular period of time. RSD are used to compile sensibility maps to determine the response of environmental components (plants, soils, rivers, lakes, bogs, etc.) to possible disturbances and pollution, caused by pipeline construction and maintenance. Wildlife habitats, breeding areas, caves, recreation areas, water-resources areas, agricultural objects and settlements are also mapped here. In addition, a sketch map, showing possible ways of oil migration and areas of its accumulation in the case of spill, is also compiled.
4. The maps compiled are also entered in the data bank and they are used, along with other geological-landscape data, to adopt the best pipeline route.
To carry out environmental monitoring in the area of an active pipeline, RSD are used to compile environmental maps at regular intervals; comparison thereof with currently available maps permits us to trace spatial and temporal environmental changes and compile a map of their dynamics.

3 RESULTS

The techniques, developed at VNIKAM with the use of GIS and based on software ERDAS IMAGINE 8.3, were used to do works on supply with information of design studies, aimed at choosing an oil pipeline route in one of the areas of Leningrad Region. The area is situated in a taiga, characterized by rolling topography and numerous lakes, rivers and bogs; there are many recreation zones, arable areas and farms, settlements and arterial roads in the area.

A digital bank of geological-landscape data and high-resolution (5 m) images, KFA-1 000, obtained from Russian satellite "Resurs-F", was formed to carry out the studies.

KFA-1 000 and results of field works were used to compile digital environmental maps and sensibility maps, scale 1 : 50 000, covering the area throughout the inferred pipeline route.

Along with other information, required to choose a route, the maps enables us to map out the most suitable route from both economic and ecological viewpoints.

In future, the data, kept at a bank, can be used as a base for environmental monitoring of the operating (active) oil pipeline.

4 CONCLUSIONS

GIS-based computer technologies of carrying out environmental monitoring in the areas of oil and gas pipelines permit targeted control of environment and spatial and temporal changes of its components. The information, kept at the bank, is of major importance: it is necessary to work out plans of nature-oriented measures and to predict the scales of possible pollution and ways of oil spreading, dictated by landforms and a lake and river system.

Under these conditions, high-resolution RSD is growing in importance because they permit us to obtain objective and operational information in emergency, for example, in the case of accidental spill, when managerial decisions, aimed at accident elimination and minimization of economic and ecological damage, must be taken.