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Use of GPTS technology in geoinformation security for sustainable development of megacities

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SUMMARY

Passive radar remote sensing of the centers of destruction of natural-technical systems in a wide range of wavelengths is a scientific and technical direction, which allows to obtain qualitatively new information about the stress-strain state of objects immersed in the geological environment. Schemes and principles for the analysis of the interaction of engineering structures with the natural geological environment using airborne geophysical tomography are developed. Mapping and diagnostics of the structure of disturbing influences - risk sources that complicate the operation of real estate and reduce the time between failures. The unevenness of the impacting factors on the part of the rock masses at the locations of linear structures and high-risk structures was discovered by the included observation method. A specification has been developed for a unified air complex for remote sensing of complex structures and city monitoring in order to timely identify life-threatening incidents using manned and unmanned aircraft and working models of hardware and software implementation of the complex units. On the basis of the obtained data, maps and vertical geological sections of stress-strain activity were constructed at various scales and the tendency for the development of hazardous natural ones is calculated and technogenic processes.

Introduction. Much of the urban planning work to provide the population with harmonious conditions of interaction with the environment has resulted in nothing, mainly due to insufficient level of researches. Programs like "How do you do, the House?" or "Smart City" have proved to be ineffective. This is due to the lack of understanding of the harbingers of adverse processes in the life support system. Owners have common assets in their real estate properties. The condition of the assets depends on the effective management of the system. In order to take objective decisions, owners must be fully informed to the extent necessary to make decisions on the current state of the systems, and management organizations, in turn, should communicate reliable, complete and timely information to owners. This is not currently the case. In this regard, it is necessary to keep record case for each real estate object. Record case maintenance is provided, first of all, by diagnostics and flaw detection of property objects using the method of enabled observation of complex nature-tech systems (NTS). In the most populated areas, the natural landscape has completely given way to NTS. Protecting the population directly from adverse natural factors and from destruction by nature or misuse of technical structures of various purposes becomes quite urgent. Among the many factors that can have a significant impact on human activity, a group of factors related to processes in the Earth 's crust and the lithosphere as a whole (**Bogdanov, Yu.A. et al., 2007**). An example is the events in New Orleans in 2005. The place for the initial settlement – a fertile floodplain of the Mississippi River - had not been successfully chosen. The continuous compaction of floodplains through development has now left the city about 2 meters below water level in the Mississippi River and Gulf of Mexico. Another example relates to the process of time and space instability, which manifests itself in the alternation of prolonged periods of moderate (weak, often at all invisible without special examination) exposure and short-term periods of destructive exposure. Pipe breakage and failures in the water supply system under northern conditions occur due to the high depth of soil freezing. In Tyumen, cast iron networks experienced up to 80 accidents per day on, being the most sensitive to low temperatures at intervals of about 80 minutes. Weak fluctuations with a period of 84.4 minutes are related to fluctuations of the barycenter of the Earth-Moon system (**Bogdanov, Yu.A., 2013**). This is enough to get the breakage on the networks during the period of prolonged freezing. The use of modern achievements in the field of remote monitoring of the stress-strain state of NTS by the intensity of electromagnetic radiation (EMR) allows to start the creation of methodological and technical means of managing the safe life of the population in megacities.

Modern measurement and interpretation methods and technologies are based on the fact that electromagnetic emission characterizes the dynamic state of NTS and contains information about it (**Bogdanov, Yu.A. at., 2019**). It should be noted that EMR is present both in the geological environment and in technical facilities. The use of passive remote surveying to monitor territory using ultra-light aviation will provide additional geophysical information that will significantly increase the level of safe accommodation and reduce the risks of emergency situations.

Research methods. Search study of EMR field configurations in NTS space of states by remote mobile method GPTS (**Bogdanov, Yu.A. and Prokopenko, S.I., 2018**) using ultralight aviation. GPTS method is based on passive registration of initial electromagnetic radiation from geological objects (layers, rupture disturbances, decompression zones and tectonic stress zones in rock masses) and from construction structures, complex technical structures with DSF equipment (TOR 33.2-1873817010-001:2012) (**Prokopenko S.I., 2017**). Processing of remote sensing data in the frequency spectrum of localized oscillations of elements and units of ground and underground NTS facilities is carried out in three stages: 1) field aerogeophysical works and variation observations of EMR of the territories of megacities; 2) searching in one-dimensional information signals for the coordinates of extremes by the space and depth of the areas and units of NTS on the scale of regional character, time intervals for determining the degree of danger of transition to the stage of destruction of NTS elements; 3) detailed analysis of intensity of EMR distribution of individual areas, abnormal zones allocated in the first stage (detailed work). The structural diagram of the studies is shown in Figure 1.

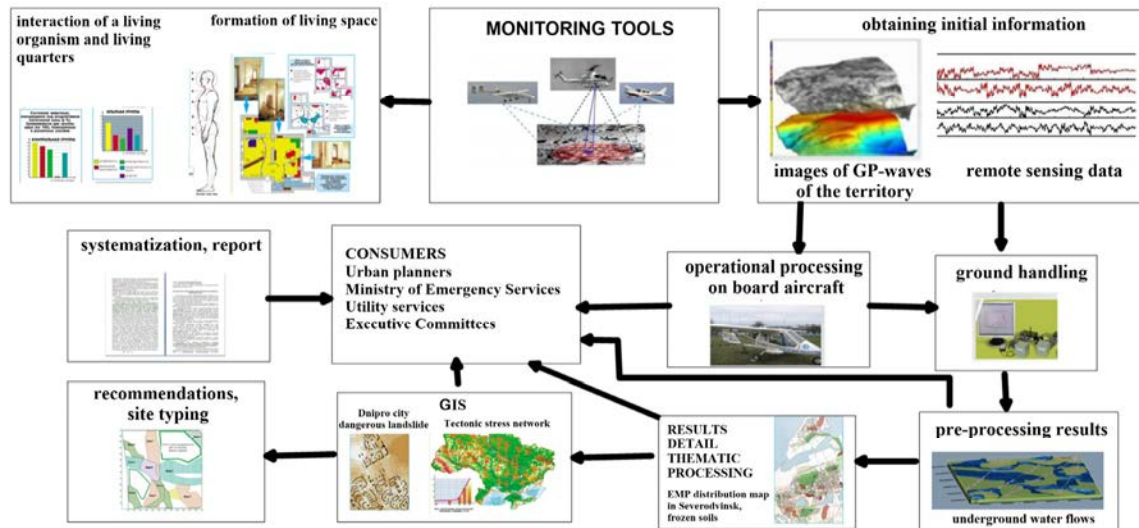


Figure 1 Structural remote monitoring scheme of objects of urban infrastructure by GPTS method and formation of information products in its process

Source and geological data. The object of research in the work is meant the objects of a kind of arbitrary nature, which are found in a stressed-deformed state, while interacting with each other. These are megacities, complex technical structures (bridges, dams), linear networks (water and gas pipelines), power transmission lines and much more. Information on possible unfavourable zones is carried by studies of the surface shape and the geological structure of the territories. In particular, rivers, ravines and other peculiarities of the landscape are timed to fault zones. Geological data expand the vision of the regional structure, its geological history. The timing of the zones of accumulation of modern tensions to the already formed zones of brokerage of the Earth's crust makes it possible to assess the modern state of the examined territory and to make a certain forecast for ensuring the sustainable development of the territory. The networks (hierarchies) of structural geological disturbances and their similarity at a considerable distance from each other indicate the presence of some global (planetary-wide) mass-forming factors, so that the forecast for an individual territory necessarily takes into account factors of planetary scale, including the Earth's own fluctuations.

Results of researches. In order to find and detect sources of environmental risk in 1995-2018, a number of works were carried out using DSF equipment. Search and detection of individual risk sources (earthquakes, landslides, mudflows, flooding) in the territories of cities Kyiv, Dnipro, Kharkiv, Severodvinsk. Mapping of buried fault-fracture zones of karstic cavities, search of aquifers, study of internal structure of detected construction objects (concrete floor slabs) immersed in geological environment. Figure 2 shows EMR maps in regional and detailed scale.

In 2018, a study was carried out on the sites of water leakage out of the fire extinguishing system consisting of a water reservoir and a system of underground pipelines at Beijing Polytechnic Institute. The work used the geophysical method GPTS. Measured frequency range from 0.5 kHz to 50 kHz by -3 dB level, sensitivity not higher than 1 $\mu\text{A}/\text{m}$ and background noise not higher than -10 dBmA. Geophysical survey of 1:500 scale was carried out by DSF instrument within the site. The directions of the survey profiles are south-north and west-east, the length of each line is 50 m, the interval is 0.6 m. As a result of the works, a geophysical abnormal zone was identified, which determines the selected area of aquifers.

Zone contours have isometric outlines (zone length in the West-East direction of 48 m and width in the South-North direction is 30 m). In Figure 3, anomalies found in 2018 are indicated by a dotted line. The results obtained (Figure 1) during the detailed analysis confirmed the data of

aerogeophysical surveys and allowed to identify aquifers, which were not taken into account when laying aquifers. On the A-A1 profile aquifers are located at depths of 2.8-3.2m, 7.3 -8.2m and 10.85m.

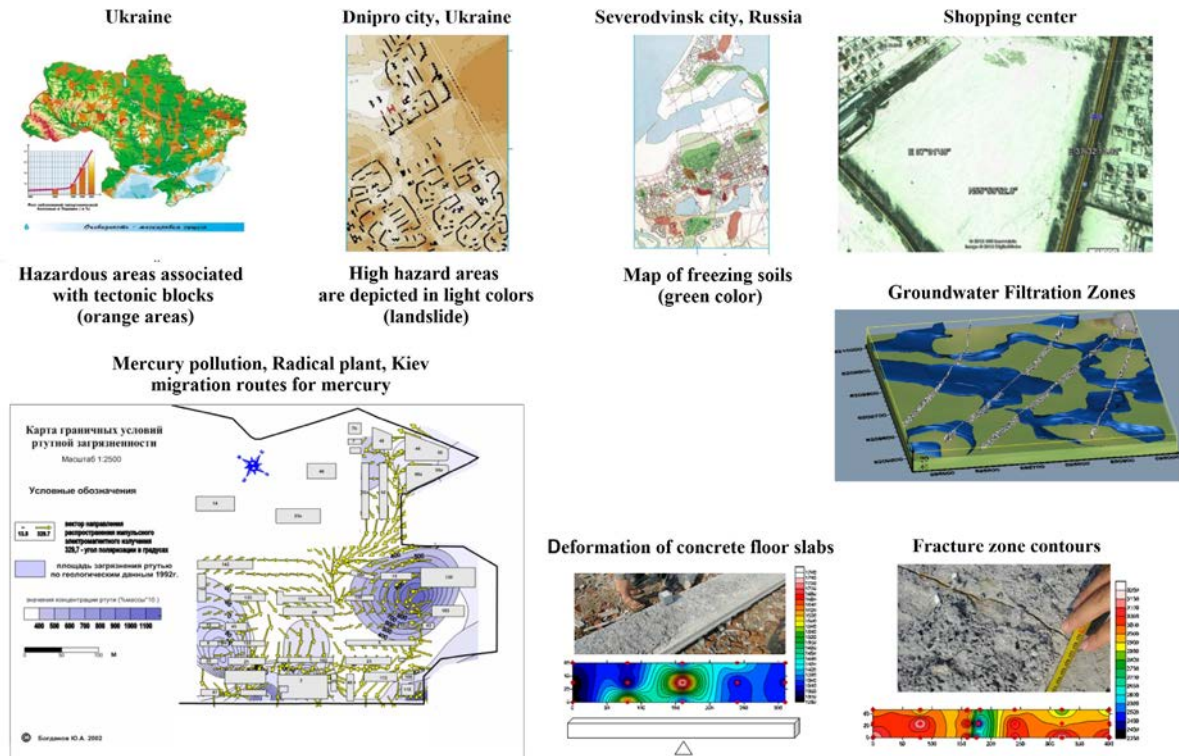


Figure 2 Hazardous natural and man-made processes detected by GPTS (by electromagnetic radiation intensity distribution analysis)

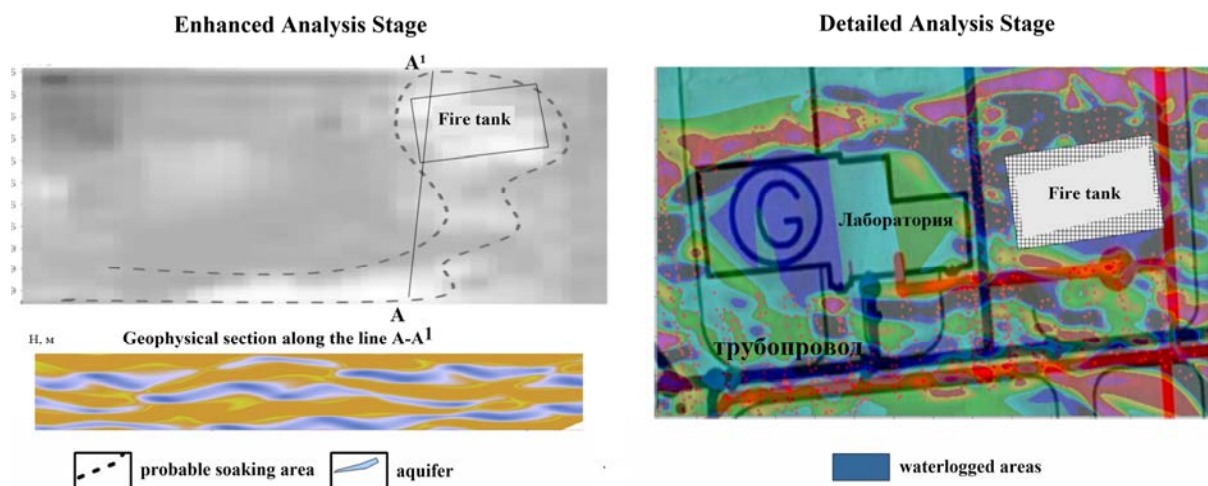
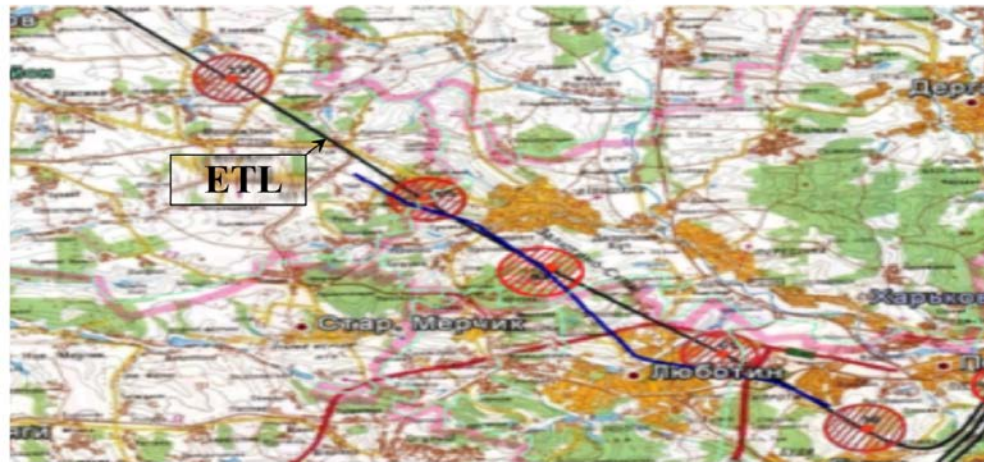


Figure 3 Results of interpretation of data from aerogeophysical and ground surveys at different stages of operations

The fact of obtaining qualitatively new information about the electric state of fault zones in the pre-storm and storm stage of clouds appeared to be rather interesting. In the lightning stage, the location and moments of lightning of different scales are determined by the outcrops of the problem zones (geological faults) to the surface. It has been found that breaks and, accordingly, disconnection of high-voltage electric transmission lines (ETL) occur precisely at the points where active faults reach the surface, as illustrated by Figure 4. Analysis of interaction of the system "ETL-cloud-fault" was carried out on the section of site profile "Lubotin-Bogodukhov" (Kharkiv region). The time between the beginning of radio noise intensity increase and the first lightning makes 10 - 15 min.

Local map thunderstorm and thunderous areas along the electric transmission lines (ETL) (red dashed lines)



Geophysical section along the electric transmission lines (ETL)

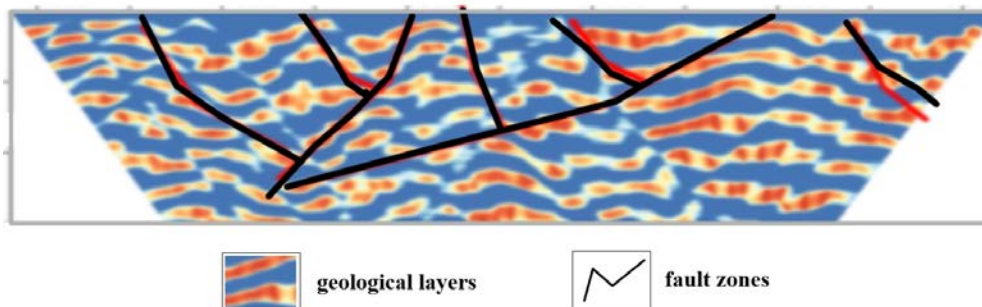


Figure 4 Passive locations of thunderstorm and storm danger sources by DSF equipment in various stages of their development: from pre-storm to dissipation

Conclusions. The developed schemes and principles of analysis of interaction between engineering structures and natural and man-made environment form the basis for solving modern urban planning problems of improving the quality of life, new technologies of urban habitat management. The GPTS method revolutionizes the scope of economic activity in the field of geophysics, geoinformatics and emergency forecasting.

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