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# Geo-Information System In The Intellectual Network Management Structure.

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**ABSTRACT**

This article discusses the concept of innovative transformations in the electric power industry, the role of geo-information technologies in the management system of an intelligent network, as well as the technology of maintenance and repair of electrical network equipment according to their actual condition.
**Keywords**: intellectual network, geographic information system, equipment maintenance and repair.

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## INTRODUCTION

In Russia, there is interest in the rapidly developing direction of power industry transformation around the world on the basis of a new concept, called Smart Grid [1].

In [2], based on the analysis of numerous materials, it is concluded that the intellectual network is interpreted today throughout the world as a concept of innovative transformation of the electric power industry.

This concept is based on the need to revise the existing and create a new, innovative technological basis for energy. In accordance with this, in [2] five groups of main technological areas were formed, ensuring the breakthrough nature of changes:

- measuring devices and devices - first of all, smart-meters and smart-sensors;
- advanced control systems containing distributed intelligent devices and analytical tools to support communications at the level of grid facilities operating in real time;
- improved technologies and components of the electrical network, in particular, flexible AC transmission systems FACTS, superconducting cables, elements of semiconductor and power electronics, etc .;
- integrated interfaces and decision support systems, such as SCADA system, demand management system, distributed monitoring and control system (DMCS), distributed monitoring system of generation processes (DGMS), etc .; New IT solutions for the design and planning of the elements of the power system;
- integrated communications that ensure the interconnection of the first four technological groups and guarantee the innovative level of network functioning; in this row: automated substations on the basis of modern integrated software and hardware systems for automated process control systems using IEC 61850; integrated measurement and metering systems; telecommunication systems on the basis of various communication lines - satellite, fiber-optic communication line (FOCL), HF communication over power lines (BPL); WAMS (Wide Area Measurement System) transient monitoring systems; distributed protection and emergency control systems WAPS (Wide Area Protection System).

The creation of intellectual energy in the Russian Federation is a necessity due to the growing quantitative and qualitative demand for energy services, the new status of the consumer as an active subject of organizational and economic relations, new demands made by society on the appearance of energy. At the same time, in order to implement the concept of an intelligent network in Russia, there are objective constraints: the degree of development of information technologies, power electronics, alternative sources of electricity, etc. The technological gap between the state of the Russian and foreign energy systems [1-3] will also have a decisive influence on the introduction in Russia.

According to the authors of [2], one can speak only of the point realization in the Russian electric power industry of individual components of the concept of an intelligent network, the implementation of specific pilot projects with the subsequent generalization and replication of the results. The introduction of this concept allows to solve electrical problems at a higher quality level and achieve significant results [1-4].

Geographic information systems (GIS) have long been widely used in the management of electrical networks [5]. And, of course, this technology will play an important role in managing the intelligent network. The need to use GIS to build energy systems of the new generation is now recognized by all. GIS in the power industry has long received the status of a basic infrastructure technology and is considered as the basis for building a management system and corporate IT infrastructure of energy companies. About 90% of the information used in the power industry enterprises is spatially referenced due to the geographical nature of the main assets - electrical networks and the entire associated infrastructure.

Using GIS, electrical companies can accumulate spatial information about electrical equipment. This data can be shared in basic business applications, it is possible to combine data from GIS, SCADA and other user systems and applications with other information coming from outside. Electric companies use this combined information in their activities: from visualizing the overall and operational environment to conducting inspections and repairs, analysis and planning of the electrical network.

## MATERIALS AND METHODS

In [6], Bill Meehan, ESRI director for utilities solutions (utilities, engineering communications management companies), talks about modern approaches to effectively supporting the functioning of an intelligent network based on geo-information technologies.

Another direction of technological development in line with the concept of the intellectual network is associated with the development of asset management systems. The process in such systems is based on the data of diagnostics and monitoring of equipment, which implies a transition to repair and maintenance technologies as of [2].

The traditional system of preventive maintenance, based on planned walking tours and visual inspections of overhead lines (AL), by a team of electricians identifying damage sites, can become an unacceptably long process. Given the length of AL on the territory of the Russian Federation, much of which takes place in hard-to-reach places, the practiced visual examination cannot be considered sufficient to assess the state of AL.

An important component of the policy of technical development of electrical networks is to increase awareness of its current state. This helps to optimize the planning of repairs and increase the efficiency of emergency and recovery operations. Using the latest innovative technologies, such as laser scanning for AL technology certification, will allow power engineers not only to carry out air monitoring of the AL condition, promptly send emergency recovery crews to power supply points, but also shift the focus from emergency rescue activities to preventive measures.

According to statistics, more than 80% of violations in distribution grids are connected with damage to AL wires. This is largely due to the aging of the power grid infrastructure. In the distribution grid complex of Russia, the share of 0.4-110 (220) kV overhead lines that have worked for more than 30 years is 57%. At the same time, the majority of emergency cases connected with wires are caused not so much by the condition of the wire itself, as by the modified geometry AL. Over the years of operation, as a result of natural phenomena or short-circuit currents, wires are drawn closer and closer to the ground, and the build-up of the cultural layer also leads to loss of AL dimensions and changes in the wire-to-ground system. AL geometry is directly related to its throughput. When designing AL, among its technical characteristics, the limiting levels of wire position relative to the ground are laid. Extension of wires leads to thermal degradation - under the same meteorological conditions, the level of the maximum allowable currents AL decreases sharply, which leads to an increase in the number of emergency cases. Therefore, it is extremely important for power engineers to quickly find out about the current state of each AL (including data on the dimensions of the wires to the ground, intersecting lines, trees and shrubs), as well as actual data on the current load and temperature of the wire [7].

## RESULTS AND DISCUSSION

To obtain reliable information about the technical condition of AL, it is necessary to carry out laser aero scanning with subsequent modeling of the behavior of AL elements and their state in various meteorological and operational conditions, as well as the creation of an appropriate 3D model of the transmission lines under study. Laser scanning is the most accurate and informative method of input (digitization) of electrical networks in the GIS [8].

The use of aerospace laser scanning allows to solve the following tasks: assessment of the technical condition of the AL; AL inspection in the right of way; troubleshooting; AL certification, determination of actual parameters, deviations from project documentation; survey of substations and other objects of the electric grid economy; engineering and survey work; pre-project examination of AL during reconstruction; topographic and geodetic works; creating topographic plans; creation of cadastral plans.

The processed three-dimensional data obtained as a result of laser imagery provides information on the position of AL elements with respect to the earth's surface, vegetation and adjacent objects (Figure 1).

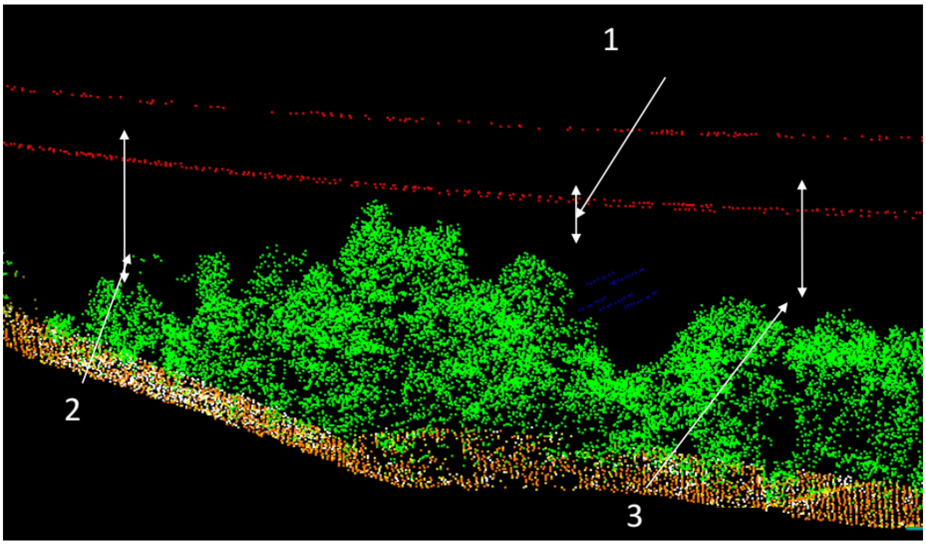


**Figure 1: Based on the results of laser scanning, we determine:**
**1 - distance to the intersected line; 2 - distance to the ground; 3 - distance to vegetation**

The created high-precision digital 3D models are used to solve the following tasks: monitoring the condition of the cuttings of lines and detecting trees dangerously growing outside the protected zone, threatening to fall on the AL elements; detection of violations of the regulatory overall characteristics AL, threatening failures and accidents; measurement of sag, distance to the ground and intersected objects (roads, rivers, other structures); bringing outdated paper documentation in accordance with the current state of AL, which allows to evaluate the technical condition of networks in the interests of planning measures to improve their reliability and throughput. An example of an insufficient distance from the wires to the ground is shown in Figure 2.

After laser scanning, it is necessary to process the obtained data, form the reporting tables, create a mathematical model of the line. At the same time, a thermal imaging examination is performed during laser scanning, where the most critical areas with defects are identified. Further, the analysis of the existing state and the determination of the real capacity of the air line: the construction of a three-dimensional model, calculations and thermal rating. Thus, all the risks that may affect the work of AL are identified.

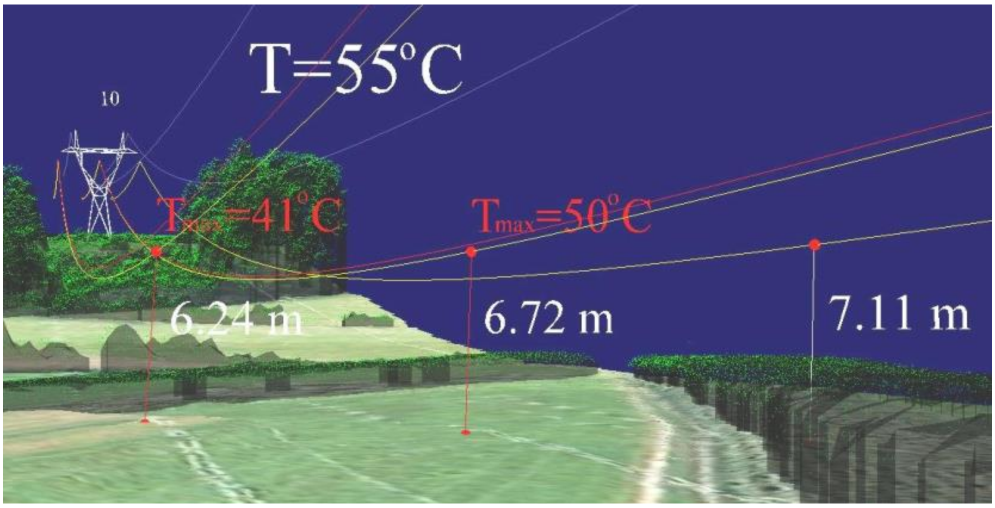


**Figure 2: 3D model of power line**

The identification of critical AL sites long before possible accidents makes it possible to assess the technical condition of networks and plan measures to improve their reliability and throughput capacity of AL. Recommendations for the elimination of identified discrepancies for AL 110 and 220 kV are given in Table 1.

The system of temperature monitoring AL is built on the basis of laser scanning data and direct measurements of real-time information on the actual AL bandwidth (Figure 3).

**Table 1: Distances from the AL lower wires to the ground**

| Span № | Non-compliance | | Regulatory value | Remedial measures |
|---|---|---|---|---|
| | For wire temperature + 40 C | | | |
| | Middle (left) phase | Lower (right) phase | | |
| Distances from the lower wires AL to the surface of the earth | | | | |
| 2-3 | – | 6,74 | The smallest permissible distance for populated areas is 8 m; The shortest allowable distance for uninhabited areas is 7 m. | 1. Reducing the lengths of supporting insulator garlands; 2. Replacing vertical garlands with L-shaped ones; 3. Constriction of wires; 4. Replacing pillar. |
| 3-4 | – | 7,60 | | |
| 4-5 | 6,84 | 7,25 | | |
| 10-11 | 7,78 | 7,42 | | |
| 16-17 | 7,72 | 7,75 | | |
| 17-18 | – | 6,68 | | |
| 18-19 | – | 6,60 | | |

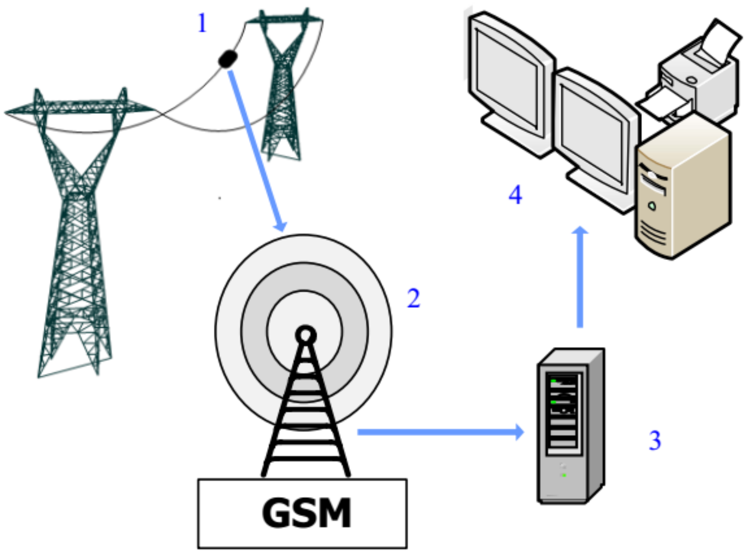


**Figure 3: AL temperature monitoring structure:**
**1 - measurement of wire parameters; 2 - sending measurement results to the server; 3 - processing of measurement results; 4 - issuing values to the dispatcher.**

Temperature sensors are installed on the power line. The sensors are attached directly to the wire, inside each of them there is a current transformer, a wireless data transmission device, a temperature meter and a microprocessor. Power electronics is provided by the current flowing through the wires. The numerical values of the measured parameters are transmitted via cellular communication channels to the receiving device for collecting, storing and processing data installed at the control center. The device is equipped with a receiver of signals of the global positioning system, so that the measurement data is annotated with exact time indicators.

The introduction of a new system using temperature monitoring will allow real-time monitoring of the status of each AL, including its real throughput (Figure 4).

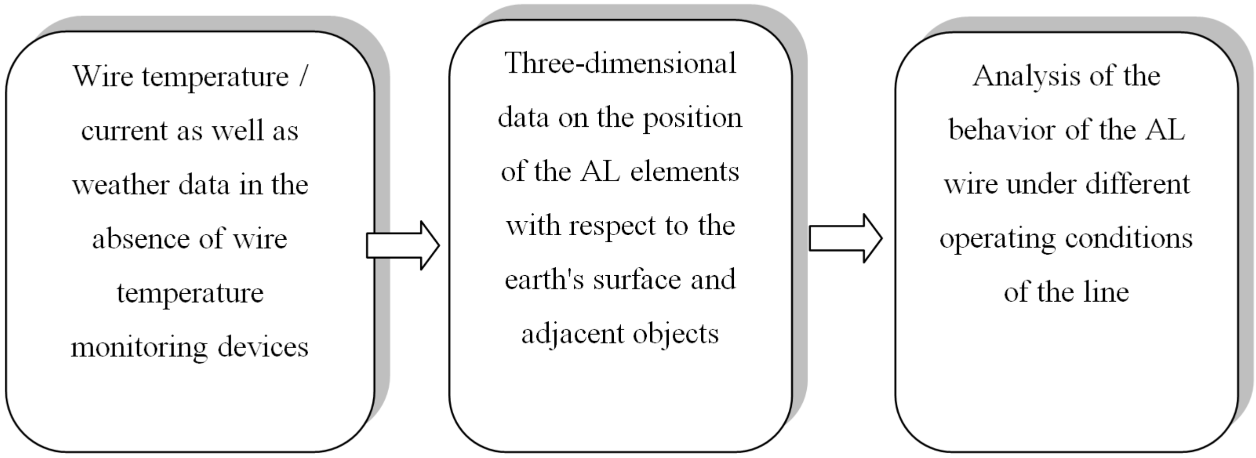


**Figure 4: Network Bandwidth Analysis**

Studies show that it is possible to pass significantly more current through wires (increasing the transmission capacity of AL up to 1.5 times or more), while not exceeding the allowable temperature of the wire. You can use this "additional" bandwidth, for example, in emergency and post-emergency modes, to meet the growing demands of electricity consumers without the cost of building new infrastructure facilities.

Systems built on the basis of laser scanning data allow reducing technical risks in the activities of energy companies, reducing the number of AL outages due to malfunctions and emergency situations.

## CONCLUSION

The intellectual network is understood as the concept of innovative transformation of the electric power industry. Currently in the Russian Federation there is a point realization of individual components of this concept. GIS can and should serve as the basis for building an intelligent network management system. The use of laser scanning allows developing an asset management system, i.e. switch to the technology of maintenance and repair of electrical network equipment according to their actual condition.

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