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Technical Meeting on Preparation of a Guidance Document on Life Cycle Management of Design Knowledge

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Computer-Based Simulators, Training and Virtual Reality Tools as a Part of Design Knowledge Management

RUSSIA

NEOLANT, Group of companies

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1. Introduction – General Info

Group of companies NEOLANT offers comprehensive engineering and IT solutions in support of plant management for nuclear and power generation industries. The solutions are based on the extensive IT expertise and industry-specific sets of knowledge the NEOLANT design team possesses.

Services we provide include:

- development of information and simulation models for industrial facilities to support the facilities lifecycle;
- development and implementation of information systems to manage engineering and plant operations data through CAD, PLM, BIM, GIS, PDM, PM integration;
- research and development and engineering design aiming at implementation of plant-scale processes, systems, equipment, capital construction projects.

The most substantial experience NEOLANT has acquired fulfilling nuclear industry projects. For more than ten years, NEOLANT solutions have been contributing to ensuring reliability and safety of nuclear facilities.
Our customers in the Russian nuclear industry include, but not are limited to, leading enterprises of ROSATOM State Corporation:

- **Rosenergoatom (ROSATOM) –** the only operator of nuclear power plants in Russian Federation, managing 10 nuclear power plants.
- **NIAEP – ASE (Atomstroyexport) –** the biggest engineering company in ROSATOM; General Designer and General Constructor of nuclear power plants in Russia and abroad.
- **ATOMPROECT –** one of the ROSATOM's leading enterprises providing nuclear facilities integrated design, conducting research and development for new generations of nuclear power technologies.
- **Mining and Chemical Combine (GKhK)** – the Russia's leading company offering spent nuclear fuel management and closure of the nuclear fuel cycle.
- **NIIAR (Scientific Research Institute of Atomic Reactors) –** the largest scientific and experimental research center for civil nuclear power in Russia;
- **MAYAK Production Association (PO MAYAK) –** the leading nuclear weapons manufacturer in Russia, contributing to the national security, producing modern nuclear weapons components.
- **NIKIEKT –** one of the biggest Russian centers for implementation of nuclear technology, working on development of efficient and safe solutions for nuclear power plants and for nuclear facilities, both civil and defense.
- etc.

NEOLANT has a design & engineering center and IT department. Our team is made up of more than 500 specialists, including research engineers, design engineers, programmers, analysts. Our experts have been and continue to be part of many international projects, including, but not are limited to, accident management at Paks Nuclear Power Plant in Hungary and construction of Taiwan Nuclear Power Plant in China.

Due to unique competences and expertise, our company has been successfully solving unconventional tasks that require development of approaches and solutions, previously not applied in Russian nuclear industry, based on up-to-date design and engineering IT tools. For instance, NEOLANT has participated in the following project of ROSATOM:

- development of a government system for radioactive material and radioactive waste management;

- development of the corporate level of the industry-wide decommissioning system for nuclear and radiation facilities;
- development of information systems to support operation and decommissioning of nuclear power units;
- simulation modeling to develop and try out dismantlement technologies for nuclear reactor structures and other technical equipment;
- etc.

NEOLANT's quality management system meets ISO 9001:2008 requirements.

NEOLANT is a partner of the largest international software vendors and engineering service providers for the nuclear industry, the vendors being: Autodesk, Bentley Systems, CIC Consulting Informatico, Dassault Systemes, ENVINET, IBM, Intergraph, Flourintec, Microsoft, Noumenon Consulting Ltd, OpenText, Oracle, SAS, SKODA JSa.s., Veeam, VMware, Wonderware.

For the purpose of knowledge management during operation and decommissioning of facilities of the use of nuclear energy, NEOLANT experts have developed the "NPP Units Decommissioning Database" Information System concept based on plant information modeling. Solutions built on this information system have been implemented at 6 Russian nuclear power plants and will be deployed at all Russian nuclear power plants to be decommissioned till 2020.

2. Issues and Challenges in Managing Design Knowledge

The knowledge management is to meet the following objectives:

- full compliance with industrial, radiation and environmental safety requirements during operation and decommissioning;
- decommissioning cost management.

To achieve the above objectives, we have to deal with:

- **Significant volume of information** describing the as-designed facilities of the use of nuclear energy configuration; **huge volumes of data** generated during the operation. The facilities of the use of nuclear energy engineering, design and technological documentation is a result of work of more than 20 organizations, total manpower effort for creating these documentation reach 1 million man-hours.
- The need to ensure **comprehensive, accurate and consistent knowledge transfer** throughout all lifecycle stages and between different personnel generations.
- **Phased commissioning and significant geographical distribution** of nuclear infrastructure, complexity of applied technologies.
- **High importance** of facilities of the use of nuclear energy modernization and reconstruction projects as well as lifetime extension and decommissioning projects.

3. DKM Activities for Nuclear Organization

Plant information modeling lies at the core of NEOLANT solutions for knowledge management throughout the nuclear facility lifecycle. Such a modeling supports safe and efficient facility operation through information systems, virtual simulators and training tools as well as digital documentation based on a unified substratum presented by the three-dimensional plant information model.

NEOLANT has substantial expertise in implementing systems where 3D models are used as the main user interface (figure 1). This approach enables quick and convenient access to data about radiation safety, fire safety, performance of routine maintenance activities etc.

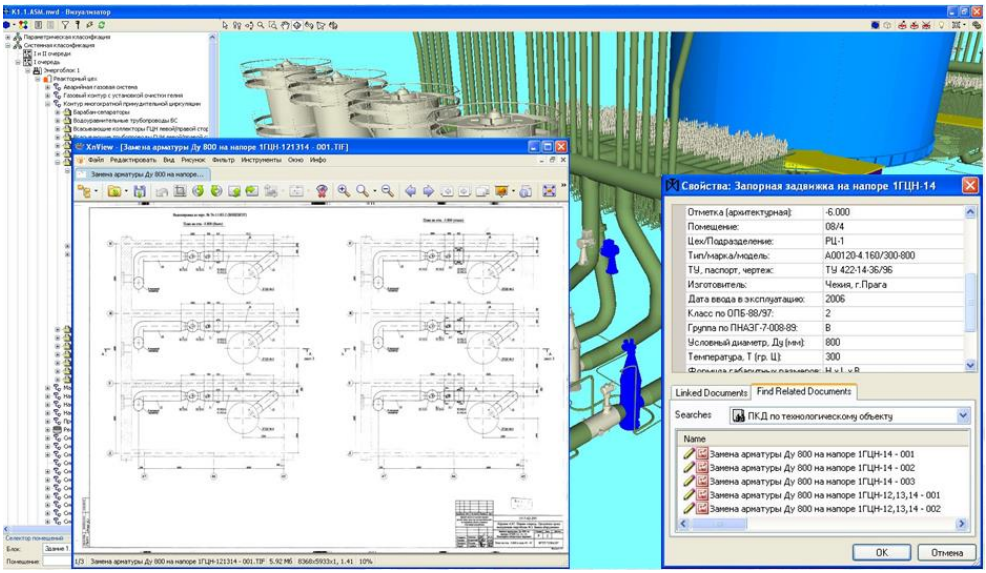

Figure 1. Access to plant data from the 3D model

Using 3D engineering information models as the source of information about architecture, construction and process-related plant configuration enables

- automated data updates based on decisions made by the General Designer regarding facilities of the use of nuclear energy modernization, reconstruction, lifetime extension and decommissioning;
- plant configuration unification in specialized applications – information systems that support operation processes.

Having an integrated source of data – the plant information model – ensures a better understanding of the current integral condition of plant equipment and accelerates decision-making.

Apart from that, 3D engineering information models give an opportunity to effectively leverage comprehensive information about facilities of the use of nuclear energy for the following purposes:

- personnel training using digital documentation and computer-based training tools;
- preliminary practice of complex preventive maintenance activities and decommissioning processes on computer-based simulators and training tools.

Training tools are efficient for teaching the personnel how to use the equipment and for practicing accident and emergency actions. Training tools and digital documentation make sure that the employees automate their skills in safe equipment and facility operation, they provide seamless integration of safety rules and job skills.

Computer-based simulators help analyze fine details of plant processes by visualizing them, simulate technogenic environmental impacts and find best ways to eliminate them.

Multimedia and interactive components of training tools enable the personnel to learn and train in close-to-field conditions. These systems contain virtual models of equipment, technical processes and work situations that enable multiple “rehearsals” without using real equipment, consuming real resources, risking violation of industrial safety rules and creating real technogenic threats. Using virtual models in their training and refresher training, employees acquire the necessary knowledge and skills in a shorter time.

Simulations for Safe Fine-Tuning of Technical Operations

Computer-based simulation of complex technical processes is a modern tool for ensuring industrial safety. Here are some examples, implemented by NEOLANT at companies belonging to the government-owned ROSATOM corporation:

- verifying a technology for unmanned dismantling radioactive graphite stack in nuclear reactors,
- designing a groundwater diversion system reconstruction for industrial nuclear reactor disposal;
- planning workflows for industrial uranium-graphite reactor disposal: dismantling metal structures and filling free spaces with barrier material.

For instance, verification of the initially suggested graphite stack dismantlement technology on the simulator (figure 2), created by NEOLANT experts, uncovered a number of problems and showed that it would be impossible to perform all required activities as planned. NEOLANT experts suggested several changes to the initial technology, the technical process was corrected and simulated on the virtual model, implementation of those corrections ensured practicability of dismantlement tasks.

Figure 2. Simulation: dismantling radioactive graphite stack of a nuclear reactor

A simulator serves not only as a technology verification instrument, but also as a training tool. Simulators allow polishing day-to-day work activities in a virtual environment as well as simulating various accident situations and teaching operators how to act under such circumstances.

Emergency Modeling

The tasks performed by the simulation can vary significantly: from analyzing particular technologies to simulating actions of regional disaster response teams in case of technogenic emergency.

An example of simulating large-scale processes is the system for analyzing radioactive contamination spread around a nuclear power plant in case of a reactor failure. NOSTRADAMUS software developed by the Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE) is used for

modeling the radioactive contamination spread; a visualization tool developed by NEOLANT is used to visualize:

- Radioactive contamination spread dynamics in the bottom air layer (figure 3).
- Consolidated diagrams and tables with all readings of radiation control sensors, with highlighted location of sensors that registered threshold exceeding.
- Mobile radiation detection data.
- Government notification procedure with real-time visualization indicating the time when emergency notifications reached particular government agencies.
- Zones and routes of evacuation simulated in virtual reality. The model is overlaid with data about functions and resources of different accident response departments, radiation control data and final radiation doses, results of the analysis whether protective measures are necessary, specific contents of such measures.

The analysis of this information provides a general understanding of the situation and empowers management decisions.

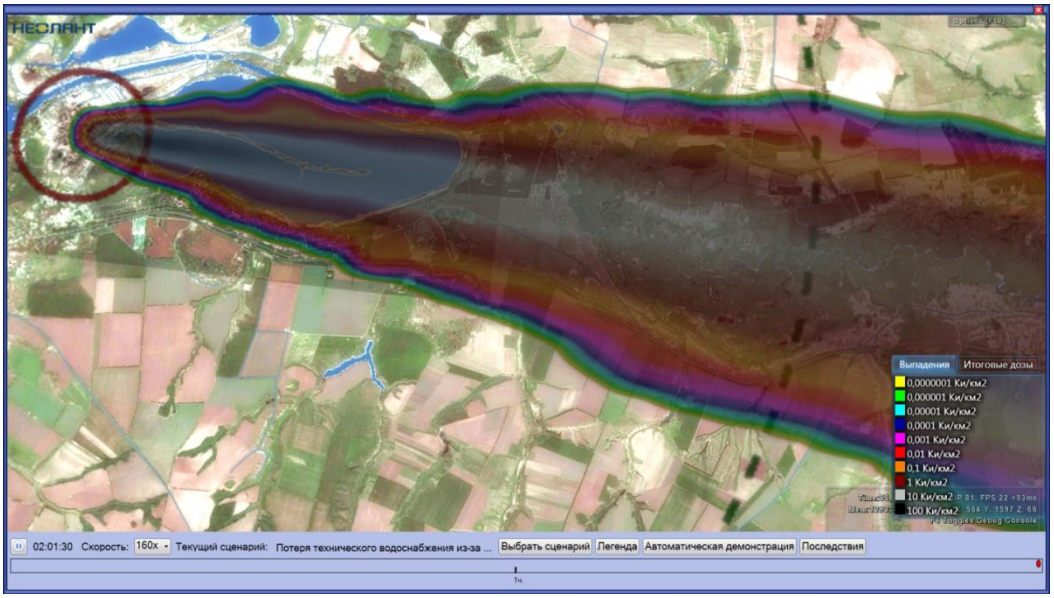

Figure 3. Visualization: Radioactive contamination spread simulation around a nuclear power plant

This simulator helps to analyze radioactive contamination spread in case of a nuclear power plant disaster, supports decision-making and can be used as a training tool: it enables evacuation personnel to practice emergency response actions. For that purpose, one can select specific accident parameters, the system "pictures" the scenario and trainees create an evacuation plan with measures aimed at minimizing radiation exposure of the local population. The training tool evaluates the correctness and timeliness of user's actions.

The visualization tool developed by NEOLANT is a universal instrument for viewing results of accident situations modeling. It is not only used in evacuation training tools, but also finds successful application in the accident scenario simulator for nuclear power plant equipment.

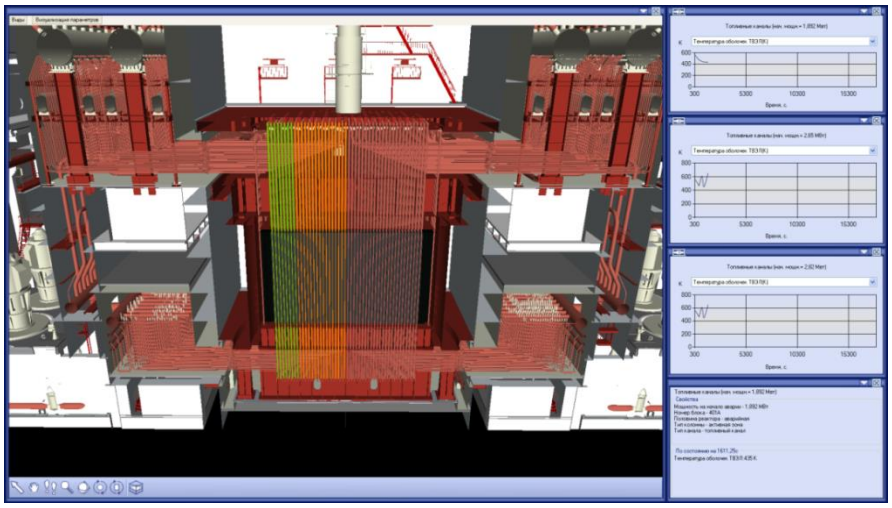

Figure 4. Simulated scenario: failure of a downflow pipe in a nuclear power unit

Virtual Reality – a "Safety Bootcamp"

Efficiency and safety of nuclear facilities operation directly depends on the degree to which the personnel understand the spatial layout of the facility. Presenting that information in a simple and visual way, based on high-precision detailed 3D models, helps accelerate the learning processes.

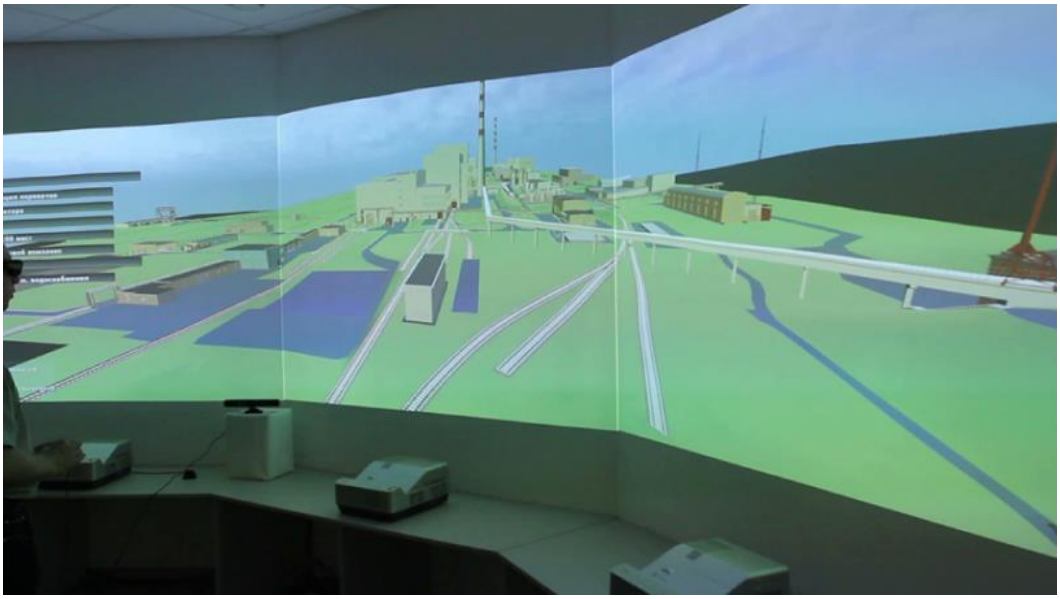

Figure 5. Virtual representation of an industrial facility

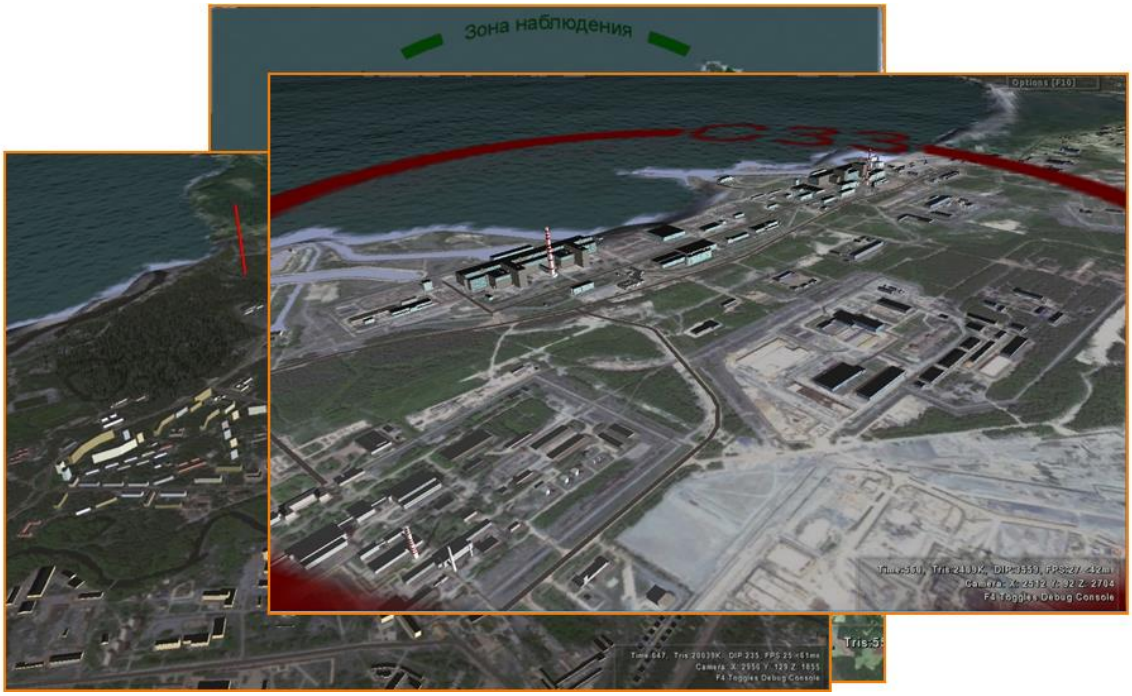

Figure 6. Realistic model of nuclear power plant observation area

4. Supporting Documents

While developing plant information models and knowledge management systems, NEOLANT follows the ISO/IEC standard 15288:2002 – "Systems engineering - System life cycle processes".

Practical implementation of the "NPP Units Decommissioning Database" Information System by NEOLANT is used in several guidelines:

- "Safety rules for nuclear power unit decommissioning" (NP-012-99), Rostekhnadzor (Federal Service for Ecological, Technological and Nuclear Supervision), 1999.
- "Typical database structure for nuclear power unit decommissioning purposes. General requirements" RD EO 0582-2005, Rosenergoatom, 2005.
- "Working program for development and improvement of a decommissioning database and information system for nuclear power units, based on 3D modeling, within the Rosenergoatom corporate information system, for the period from 2010 to 2020".
- "Concept for implementation of 3D-model-based information support of nuclear power unit decommissioning processes ("NPP Units Decommissioning Database" Information System) in the framework of the Rosenergoatom corporate information system".

5. Major Accomplishments and Lessons Learned

Based on the "Working program for development and improvement of a decommissioning database and information system for nuclear power units, based on 3D modeling, within the Rosenergoatom corporate information system, for the period from 2010 to 2020", systematic development of 3D engineering information models for nuclear power units at Kola, Leningrad, Novovoronezh, Bilibino, Smolensk and Kursk nuclear power plants is ongoing.

The created information models became the basis for a number of training tools and simulators.

Here are some simulation and digital documentation projects implemented by NEOLANT:

1) Training tool for practicing nut runner operation skills at VVER-1000 reactor connectors. The training simulator provides capabilities of controlling trainee's actions and analyzing mistakes.

2) Computer training system that trains personnel in cutting off the first steam generator circuit (PGW-1000M) during repair and maintenance activities.

3) Work method statement for dismantling equipment, pipelines and fittings in the turbine island of the first power unit at Beloyarsk nuclear power plant. The work method statement provides detailed and animated description of the following technologies:

- dismantlement of equipment, pipelines and pipeline fittings;
- fragmentation of bulky equipment;
- waste management within the turbine island.

4) A set of tools to verify design decisions, calculations and detailed plans of cavity-free concreting for the "L-sector" of AW-1 industrial uranium-graphite reactor, using concreting simulation under consideration of density and flowability of concrete under normal gravity and humidity conditions.

5) Verification of design decisions and detailed construction planning for a passive groundwater diversion system around industrial uranium-graphite reactors AW-1 and AW-2, simulating the process of filling the tunnels with crushed rock.

6) Development and verification of robot-aided structure dismantlement in the "R-sector" of the industrial uranium-graphite reactor AW-1.

7) Development of a detailed simulator for filling in-reactor spaces with clay-containing compounds (decommissioning project for the industrial uranium-graphite reactor AW-1).

8) Development of a decommissioning simulator for AMB-100 reactor. The developed software suite is capable of simulating graphite stack dismantlement processes with BROKK robots and is used to train robot operators.

9) Development of a visualization system for radiation contamination spread, to be used in the technical crisis response center at the Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE).

6. Conclusions and Recommendations

Plant information modeling principles ensure knowledge transfer throughout all lifecycle phases of facilities of the use of nuclear energy, while preserving know-how from design phase and operations.

An engineering information model of a nuclear facility is the core for creating an integrated informational foundation for making process-related, engineering and management decisions during nuclear plant operation and decommissioning. Data consolidation in a unified information storage increases efficiency and ensures transparency and safety of plant operation.

Plant information modeling enables creation of IT systems to support safe and efficient operation of facilities of the use of nuclear energy, development of virtual training tools, simulators and digital documentation that are based on an integrated foundation – a three-dimensional information model of the asset.

NEOLANT has accumulated experience of successful implementation of information modeling for the purpose of facilities of the use of nuclear energy design, based on engineering information models within IT systems that support operation and decommissioning of nuclear and radiation facilities.

In that context, we suggest that the International Atomic Energy Agency recommend the NEOLANT's know-how for international use for successful implementation of Plant Information Model systems, computer-based simulators, virtual training tools and digital documentation systems based on integrated 3D information models of nuclear facilities.

7. Contact Information

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