NEOLANT
Engineering, IT, innovation

47A Pokrovka Street,
Moscow, Russia Federation,
105062

ask@neolant.com
www.neolant.com

Tel/Fax:
+7 (499) 999-0000

Consultancy Meeting on Application of the Modern Plant Information Models to Support and Manage Design Knowledge throughout NPP Life Cycle
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IAEA
International Atomic Energy Agency

The result of survey on the plant information management and application of the Plant Information Models (PIM) by NEOLANT for IAEA

Contents

1. Short info about organization

Group of companies NEOLANT offers complex 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 in the nuclear industry. 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 the requirements of ISO 9001:2008.

NEOLANT has the biggest international software vendors and engineering service providers for the nuclear industry among its partners: 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.

2. Current state of plant information and in particular of the design information management in the nuclear sector in your country

The structure of the Russian nuclear energy industry includes organizations performing the functions of the General Designer, Chief Engineer, Chief Process Engineer and Scientific Supervisor of NPP Start-Up and Operation. Since Rosenergoatom became the only operator of Russian nuclear power plants, it consolidates the Chief Process Engineer functions for all Russian nuclear power plants.

For many years, a certain paper-based engineering documentation workflow between the General Designer, Chief Engineer and the nuclear power plant itself has emerged.

Failures in observing the update procedures for paper-based archives and inadequate updating of archived design documents lead to the consequence that current configuration information of operating nuclear power units may differs from the data stored in archives of the organizations mentioned above.

Another bottleneck of engineering information management at nuclear power plants is the usage of multiple operation information systems based on different platforms. Each of those systems contains its own databases concerning the particular nuclear power unit configuration and equipment. Many of the mentioned operation information systems contain data about the same equipment and systems, but with different attributes, specific to a particular information system and its application.

Due to the lack of unification in the databases of the operation information system is almost impossible "seamlessly" to automate the aggregation of data from different systems and information exchange between them. When updating the configuration of the NPP units in the database of each operation information system you must manually make the appropriate changes. Manual procedures are time-consuming and error-prone.

Modern engineering information technologies enable efficient change management and nuclear power unit configuration management, based on a solution developed by NEOLANT - “NPP Units Decommissioning Database” Information System, which uses 3D engineering information models of nuclear power units (Figure 1).

Development of this solution has connected to active participation of NEOLANT in preparation of decommissioning projects for Russian nuclear power plants that will be shutdown in the near future. That was the key factor in determining the name for the solution.

The “NPP Units Decommissioning Database” Information System concept developed by NEOLANT includes

- a nuclear power unit information model in form of an engineering data management system (Figure 2) to collect and store engineering information and documents;
- Interface based on a 3D plant model (e.g. of nuclear power plant, the facility of the use of nuclear energy, any other nuclear facility) is used to search for information and display it (Figure 2).

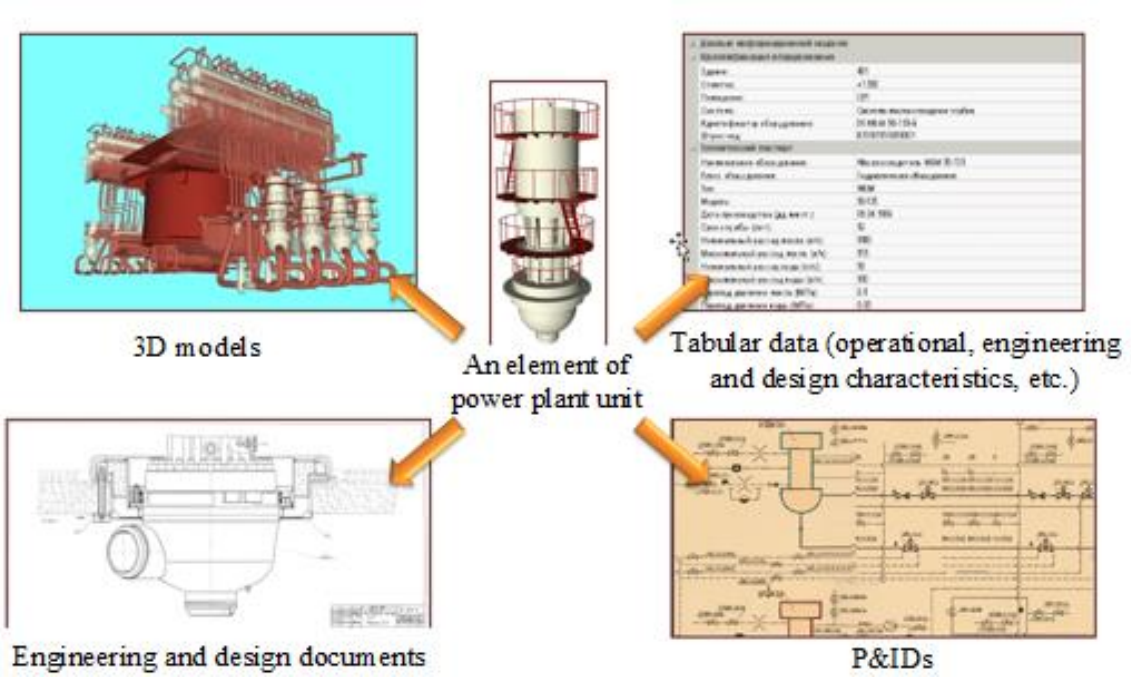

Figure 1. Engineering data management information system, based on 3D models.

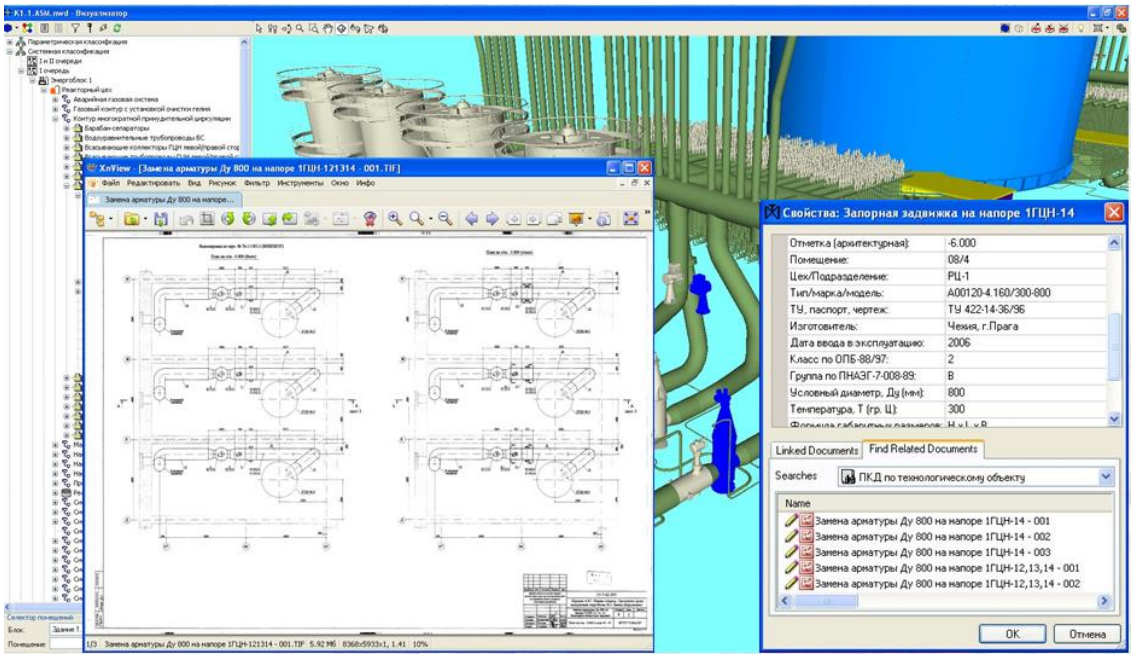

Figure 2. Interface element of the "NPP Units Decommissioning Database" Information System, enabling access to different types of information through the 3D model

The use of commercial of-the-shelf (COTS) databases for the purposes of "NPP Units Decommissioning Database" Information System opens a wide range of functions (see paragraph 4 for details).

Working program "Development and improvement of NPP decommissioning database based on 3D modeling, within the Rosenergoatom corporate information system, for the period from 2010 to 2020" [1] lays a foundation for systematic creation of 3D engineering information models for Russian nuclear power plants.

While providing informational support for decommissioning of shutdown nuclear power units, NEOLANT has not only developed information models of nuclear power units, but also made an inventory of original documents, restored lost documents, converted paper-based drawings and diagrams into digital form.

NPP's information models were developed in exact accordance with available paper-based documents. In cases when some drawings had been lost or had not been updated after reconstruction or redevelopment, laser-scanning technologies were applied in order to collect precise and detailed spatial as-built information.

NPP's information models developed by NEOLANT are being used as a basis for implementation of the "NPP Units Decommissioning Database" Information System for specific nuclear power plants - based on PLM platforms which are harmonized with the platforms currently used by the General Designers of those plants.

In the course of their deployment, "NPP Units Decommissioning Database" Information Systems are being integrated with legacy information systems that are currently in use at particular nuclear power plants. This ensures a smooth "shock-free" transition to working with the integrated information system during the operation and decommissioning stages.

3. Issues and challenges to plant information management

Managing engineering data for an industrial facility, including integration and maintenance of all engineering and technical data, ensuring fast and convenient access to that information and its analysis, proves to be necessary in order to perform the following tasks:

1. to increase economic efficiency of the industrial facility throughout-lifecycle, including the decommissioning stage;
2. to ensure strict adherence to industrial safety requirements, radiation and nuclear safety requirements and environmental safety requirements during operation (including modernization and reconstruction projects) and decommissioning.

While performing tasks (1) and (2), one faces a range of challenges:

- **A huge amount of information describing the plant configuration.**
  For instance, at the time of a nuclear power unit start-up the amount of production and technological documentation reaches 2600 volumes, classified into 15 main sections and 70 subsections; the total labor of 20 or more organizations involved in creation of design and technological documentation reaches 1,160,000 man-hours.
  A large amount of data is also generated during the industrial facility operation phase.

The total labor of the engineering staff at a nuclear power plant spent on searching for paper-based information may reach several dozens of days per staff member per year.

- **Complexity of engineering procedures, step-by-step commissioning and significant geographical distribution of industrial infrastructure.**
  For instance, a nuclear power plant includes several sites, located at a distance from each other, each consisting of various buildings and structures. Each of such buildings or structures itself is a complex industrial facility, supporting special functions of energy generation and/or ensuring safety of technological processes at the nuclear power plant.

  As a rule, informational support of industrial plant and infrastructure operation is based on so-called "patchwork" automation.
  In such a case, specialized operational IT systems use isolated data storages dedicated to particular tasks of the central office and functions of the operating organization. The particular system usage efficiency depends heavily on the quality of the data that has been put into the system: their correctness, integrity, completeness, consistency.
  Databases of legacy information systems lack spatial representation of systems and equipment, which complicates data search and analysis.

- **High importance of industrial facilities modernization/reconstruction projects.**
  In case of nuclear power facilities, design and engineering projects at such life cycle phases as lifetime extension and decommissioning are characterized by special importance and responsibility.
  In order to be able to develop high-quality modernization/reconstruction projects, lifetime extension and decommissioning projects, the General Designer needs to know the current operational state of a particular facility.
  The best way to provide exact information quickly and conveniently is to abandon paper-bases document workflows and dispersed data storage in favor of a solution based on:
  - a single information storage and data management system, enabling input and storage of information, multidimensional information classification, object search and report generation.
  - a digital archive, enabling input, storage and search for digital copies of paper documents.
  - a visualization subsystem for original data and documents as well as analysis results.

- **The need to ensure comprehensive knowledge transfer between generations of operating staff, which is especially important for the nuclear energy industry, and between generations of staff involved in NPP decommissioning.**

A nuclear power plant has a lifetime of several decades, and nuclear power plant decommissioning may go on for half a century.

4. Technologies and approaches to plant information management

Creation of an integrated database with all technical engineering information concerning the nuclear power plant (design, construction, operation, diagnosing, maintenance, modernization) and this database throughout-lifecycle maintaining (ensuring a high level of adoption by all plant employees and permanent updating) are key factors for an efficient implementation of nuclear power unit lifecycle management. The optimal way of creating and maintaining such a database implies application of such information technologies as 3D CAD systems, digital document workflow systems, web-portals etc.

Modern CAD tools allow not only designing an industrial plant, preparing a complete set of construction documentation ("main product"), but also creating a useful "byproduct" – an engineering information model of the plant. In terms of information technologies, an engineering model created with modern CAD tools is a database with engineering information necessary for efficient plant management during regular phases of operation, maintenance and repairs. Using it as a foundation and employing de-facto standard commercial DBMS allows to create an information model that can be used as a basis for making decisions concerning engineering issues and processes as well as for managing economic aspects.

The introduction of tools similar to Intergraph SmartPlant Enterprise – solutions with analogous or comparable functionality are offered by Autodesk, Dassault Systemes, Bentley Systems and AVEVA – divided the history of CAD application into the "pre-information-modeling" era and the modern era. The "pre-information-modeling" era stretches right up to the adoption of "digital 2D drafting".

During the "pre-information-modeling" era, a design process of industrial plants ended in creation of a set of documents in form of drawings, cost estimates, explanatory notes etc. (design, construction, commissioning documentation) as "hard" copies – paper sheets of various sizes. Those documents performed at least two functions: they served as a storage place of information about the plant and, on the other hand, as a reference and guidance toolbox for construction workers, equipment installers, supervisors and inspectors of various levels.

If design and engineering companies apply some of the modern CAD tools, the design process results is a database that includes information about the plant geometry (3D), materials, P&IDs and control paths, power supply schematics, equipment lists, suppliers of materials and equipment.

In this case and in terms of information technologies, generation of drawings, explanatory notes, cost estimates and schedules is just a product of services running in the engineering data management system which has as its core a database, where design data is stored in a structured way – as "intelligent objects", linked by parametric constraints and filled with information.

"NPP Units Decommissioning Database" Information System developed by NEOLANT is a concept and a successfully implemented technology for information support of industrial facilities operation and decommissioning. "NPP Units Decommissioning Database" Information System is based on information models developed using 3D CAD, serving as a foundation for centralized data storage filled with information crucial to safe and efficient plant decommissioning (Figure 1).

"NPP Units Decommissioning Database" Information System is not only an informational database, but also a supporting instrument for efficient decision-making during operation and decommissioning. This information system offers the possibility of implementing a wide range of functions: from getting access to information through industrial plant 3D models to supporting design analysis and simulation modeling.

Main purpose of the "NPP Units Decommissioning Database" Information System:

- collect data and information;
- support decision-making;
- simulation modeling;
- verification and validation of decommissioning processes and technologies;
- automation of documents generation.

Basic functional components of the "NPP Units Decommissioning Database" Information System:

- *Data management subsystem*. Enables input and storage of information about a nuclear and radiation facility, multidimensional classification, object search and report generation.
- *Digital archive subsystem*. Enables input, storage and search for digital copies of paper documents.
- *Engineering models subsystem*. Enables work with 2D and 3D models which are a part of "NPP Units Decommissioning Database" Information System.
- *Visualization subsystem*. The visualization interface (Figure 2) of the "NPP Units Decommissioning Database" Information System offers various representations:
  - industrial plant structure;
  - digital documents;
  - 2D general plans, P&IDs;
  - 3D/4D models;
  - spherical panoramas;
  - 2D GIS /3D GIS;
  - schedules, timelines;
  - analytic dashboards.

Based on the "NPP Units Decommissioning Database" Information System, the following application and information subsystems can be implemented:

- calculation as to how the radiation level of structural elements may change over time;
- simulation of equipment dismantlement steps;
- management and control of radiation exposure of personnel during dismantlement activities;
- decommissioning costs calculation;
- radioactive waste management;
- decommissioning staff training.

5. Benefits and opportunities for improvement with application of the Plant Information Models and complementary technologies

An engineering data management system – **an industrial plant information model together with specialized applications** – provides support for various plant departments in making well-informed decisions concerning processes, design engineering and plant management as well as in implementing those decisions.

In comparison to automation solutions of the previous generation, which did not utilize an information model, information modeling has the following advantages:

- unity, integrity, completeness, consistency of data used as a basis for decision-making;
- increasing validity of decisions in all departments due to analytic modules that can process data from the whole information model and due to a wide range of data sections available to the personnel;
- higher speed of decision-making due to user-friendly and informative graphic interfaces of IT tools.

Information modeling applied to nuclear power units allows creating an integrated database based on 3D models, making it accessible to all nuclear power plant departments, Rosenergoatom and supported by the General Designer.

Using up-to-date engineering models as a source of information about nuclear power unit configuration for the purposes of operational information systems (information about structure and components of technical locations/project items and process lines derived from P&IDs, electrical diagrams and schematics etc.) gives an opportunity to unify nuclear power unit configurations in each of such information systems, to update information depending on decisions made by the General Designer.

Unification of the data source (information model in form of an engineering information management system) and open APIs enable the personnel of a particular nuclear power plant and the General Designer

to obtain comprehensive information about NPP components through engineering 3D models integrated with various complementary information systems, to visualize operational data in 3D models. Thus, a better and more comprehensive understanding of the current state of plant equipment can be achieved, along with acceleration of decision-making and consideration of performance characteristics while designing and planning modernization and repairs.

NEOLANT has accumulated experience with obtaining and visualizing data through engineering 3D models for such systems as automated radiation monitoring systems and fire protection control systems. This allows Rosenergoatom technical managers to get quickly and conveniently access data about the state of the nuclear power unit in terms of radiation safety, fire safety, progress of planned maintenance activities etc.

The majority of technical nuclear power unit systems are spatially distributed and located in different rooms. Using 3D models filled with engineering data gives an opportunity to present and use information about nuclear power unit topology in an efficient way for the purposes of

- staff training,
- preliminary exploration and try-out of complex preventive maintenance activities.

6. Available standards and guides in the area as well as those under preparation and planning

While developing information models, NEOLANT follows international standards:

- ISO 15926 "Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities" is the most up-to-date standard for comprehensive integration of engineering data using semantic technologies.
- ISO/IEC 15288:2002 – “Systems engineering - System life cycle processes”.

Practical implementation experience of the “NPP Units Decommissioning Database” Information System by NEOLANT was used in some regulations of the Russian nuclear industry:

- “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” RD EO 0582-2005, Rosenergoatom, 2005.
- “Working program "Development and improvement of NPP decommissioning database based on 3D modeling, within the Rosenergoatom corporate information system, for the period from 2010 to 2020”, Rosenergoatom, 2010.
- “Concept for implementation of 3D-model-based information support of nuclear power unit decommissioning (“NPP Units Decommissioning Database” Information System) in the framework of the Rosenergoatom corporate information system”, Rosenergoatom, 2010.

7. Major achievements and lessons learnt

During development of decommissioning information systems for Smolensk NPP, Bilibino NPP, Kola NPP and Novovoronezh NPP an individual “NPP Units Decommissioning Database” Information System was created for each nuclear power unit with SmartPlant Enterprise.

In order to provide information support for nuclear power unit decommissioning at Leningrad NPP and Kursk NPP, for each power unit an “NPP Units Decommissioning Database” Information System was developed, based on the PLM platform by Bentley Systems.

At each of NPPs the “NPP Units Decommissioning Database” Information System is customized in terms of data model extension.

The following activities were performed for each nuclear power plant:

- developing and coordinating the requirements specification and engineering design;
- developing 2D model for the monitoring zone;
- creating 3D information models for industrial site and nuclear power units;
- digitizing and input of P&IDs for each nuclear power unit;
- scanning and input of engineering and design documentation concerning the industrial site and nuclear power units;
- taking inventory and collecting/issuing equipment certificates for primary equipment of nuclear power units;
- purchase, supply, adjustment, installation and adaptation of equipment that was necessary for the “NPP Units Decommissioning Database” Information System deployment;
- deployment of information system, commissioning, technical support during operation and further development according to current needs.

All systems that have been created are characterized by abundance of information. The volume of work done can be judged by the fact that many dozens of thousands of drawings, diagrams and text documents were used during the project. For instance, the “NPP Units Decommissioning Database” Information System of Kola NPP has developed based on 20931 scanned drawings from the original design documents. It presents a single information model that includes 14532 elements.

Currently, the “NPP Units Decommissioning Database” Information System of the above-mentioned nuclear power plants supports a range of important basic functions:

- collecting and storing all necessary design, engineering and other technical documents right up to the end of the decommissioning project;
- data integration and data exchange with other information system of the nuclear power plant;

- providing information for development of documents that are required for nuclear power unit decommissioning, including technical condition reports;
- collecting and integrating information about the state of radioactive waste and spent nuclear fuel;
- visualizing components and structure of nuclear power units and site facilities.

8. Conclusions and recommendations

Information modeling principles ensure transfer of engineering data and other related information throughout-lifecycle support of industrial plants, while preserving know-how from design phase and operations.

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

For a practical owner, an information model may become a prototype of the next plant construction. Therefore, an information model is a valuable intangible asset that should be taken in consideration during industrial plant appraisal.

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

The International Atomic Energy Agency is suggested to recommend the successful information system implementation know-how of NEOLANT, based on “NPP Units Decommissioning Database” Information System, to nuclear power plants outside of Russia for the purpose of supporting their operation and decommissioning.

9. References and supporting documents

1. “Working program "Development and improvement of NPP decommissioning database based on 3D modeling, within the Rosenergoatom corporate information system, for the period from 2010 to 2020”, Rosenergoatom, 2010.

10. Authors and contact information

Job title	Full name	E-mail
Director General	Vitaliy Kononov	kononov@neolant.ru
Head of Information Technologies for Power Generating Industry Department, First Deputy	Vladislav Tikhonovsky	tikhonovsky@neolant.ru
Head of Design and Development Center	Alexandr Kanishev	kanishev@neolant.ru
Deputy Director of Information Technologies for Power Generating Industry Department	Nikolay Salnikov	salnikov@neolant.ru
Head of Facilities' Digital Models Department	Alexandr Shkarin	shkarin@neolant.ru
Head of Integrated and CAD Technologies Department CJSC "NEOLANT"	Dmitry Dorobin	dorobin@neolant.ru

NEOLANT Engineering, IT, innovation

Tel.: +7 (499) 999 0000 *117
E-mail: ask@neolant.com
Web: www.neolant.com
NeolantGroupEN