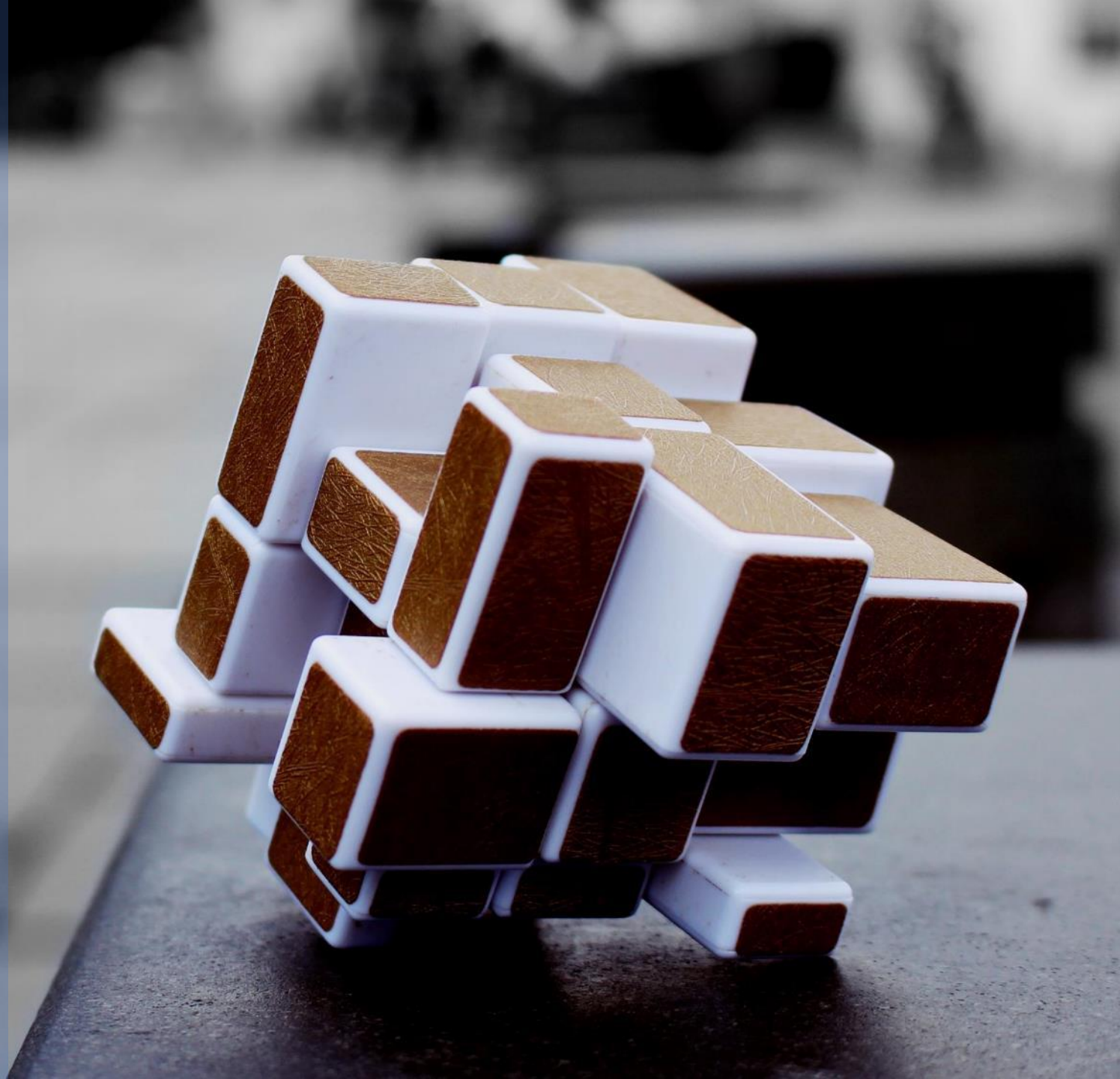
Project N°ENER/D2/2020-273

Knowledge Product KI-S-01

SERAW

5 November 2021

3D model use experience in Kozloduy NPP Units 1-4



What is the goal?

This technical visit will showcase the experience of SERAW in the use of 3D models to manage decommissioning and raw waste management activities.

Who may benefit?

Decommissioning operators that need to determine the approach and scope of their 3D work from a cost-benefit perspective.

What will you learn?

Attendees will become familiar with the tools used by SERAW and will learn from their experience in the field.

Knowledge Product KI-S-01

Title: 3D model use experience in Kozloduy NPP Units 1-4

Type: Technical Visit

Produced by: SERAW

Agenda

3D work at KNPP
Concept
45 min

Needs
- The issues that this tool addresses

Solution proposed
- Tool Requirements
- Capabilities
- Scope

Deployment
- Planning
- Implementation
- Costs

Hands-on practice
Use
2 hours

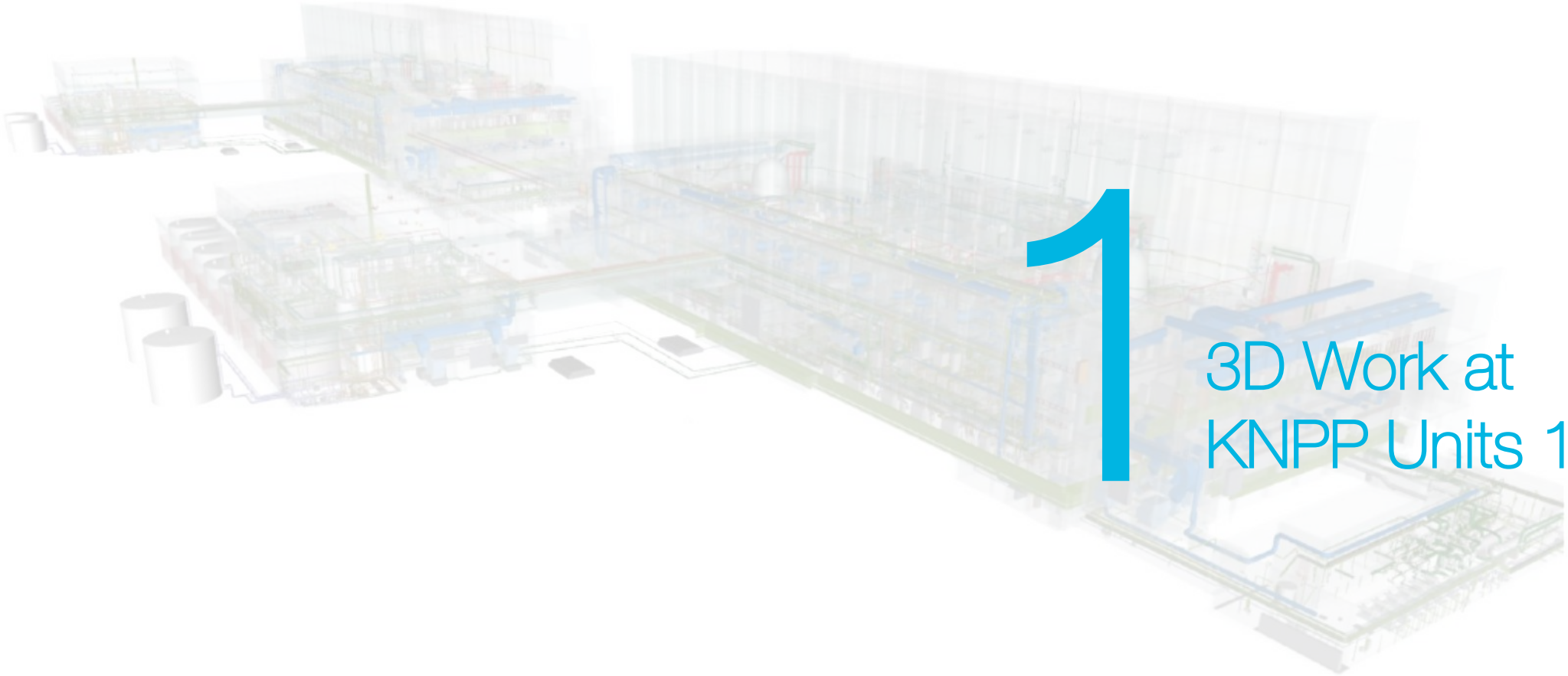
Site walkdown

Demo
- Use Case 1: Dose Management
- Use Case 2: Work Planning & Inventory

Questions & Answers

Lessons Learned
Experience
45 min

- Scope of work
- Planning
- Platform/technology selection
- Field Work
- Implementation (IT, licenses)
- Use
- Training
- Users experience
- Value



1 3D Work at KNPP Units 1-4

The Need

PIM-based detailed as-is engineering configuration for KNPP Units 1-4 Reactor Buildings and Auxiliary Buildings

Actual data

Structures, systems and components inventory and characterization

Single source of truth

Engineering and radiation data integration in “single source of truth” available for all authorized stakeholders throughout all decommissioning phases (>30 y.)

High-quality design engineering

Dismantling detailed design with enhanced quality level

Management system

PIM-based decommissioning management system implementation

Application of gained experience

PIM-based engineering design for HLW conversion facility using 3D models of Units 3-4 Reactor Building

High accuracy of design estimations

High accuracy estimations for RAW, scope of dismantling works and necessary equipment aimed to obtain the final decommissioning estimated cost

Safety

Personnel training before the field works

The Solution – Requirements

- Prompt response from PIM-based model of 2 Reactor Buildings and 2 Auxiliary Buildings (more than 2 million of elements). Fast graphics engine is needed
- PIM-integrated data-centric and document-centric information management system for working with structural data linked with design and operating documentation
- Integrated custom reports system for data reception at different layers
- Usable web-interface for distributed Consortium team work management (Bulgaria, Germany, Russia – specialists located at 8 cities)
- Multi-types hierarchical grouping of NPP components in PIM (topological and functional principle)
- Display NPP components setting in PIM through class hierarchy and attributes
- NPP component connection with its mapping onto PIM and digitalized engineering flowcharts and documentation in electronic archive

Fast graphics engine

Data-centric and document-centric approach

Custom reports system

Usable web-interface

Hierarchical grouping

Display components settings

Component connection

The Solution – Scope

The 3D model of Reactor Buildings (KNPP Units 1-4) and Auxiliary Buildings (1&2) was developed using gamma scanning of systems, structures and components at all clean and non-occupied areas. The model visualizes precise engineering configuration of each room/area, including connections with adjacent rooms where associated systems are located.

- More than 150 rooms of Unit 1 RB and AB were radiation surveyed, spectrometry characterized, investigated by surface sampling and gamma-scanned
- Laser scanning of more than 600 rooms of Units 1-4 RB and AB 1&2
- Digitalizing of more than 40 000 design documents
- Digital executive engineering model of AB 1&2 and RB 1-4 was developed. The model consists of more than 700 000 elements

600 rooms
Laser scanning

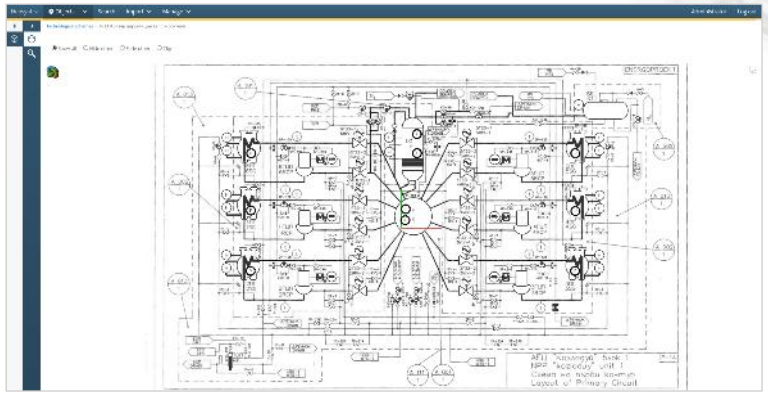
40 000 units
Digital archive

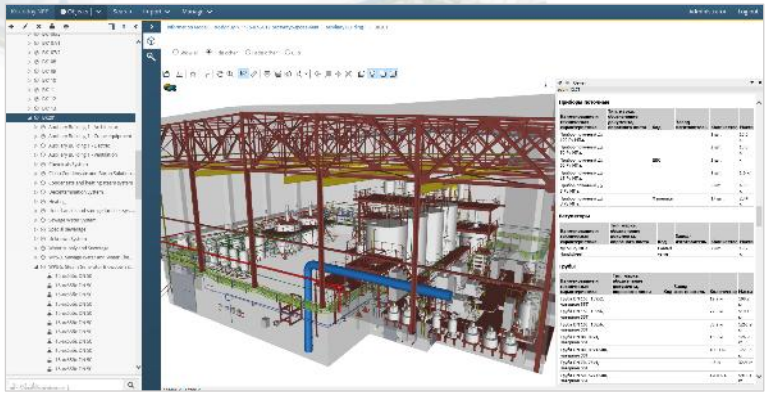
700 000 elements
Digital executive engineering model

150 rooms
Radiation survey

The Solution – Capabilities

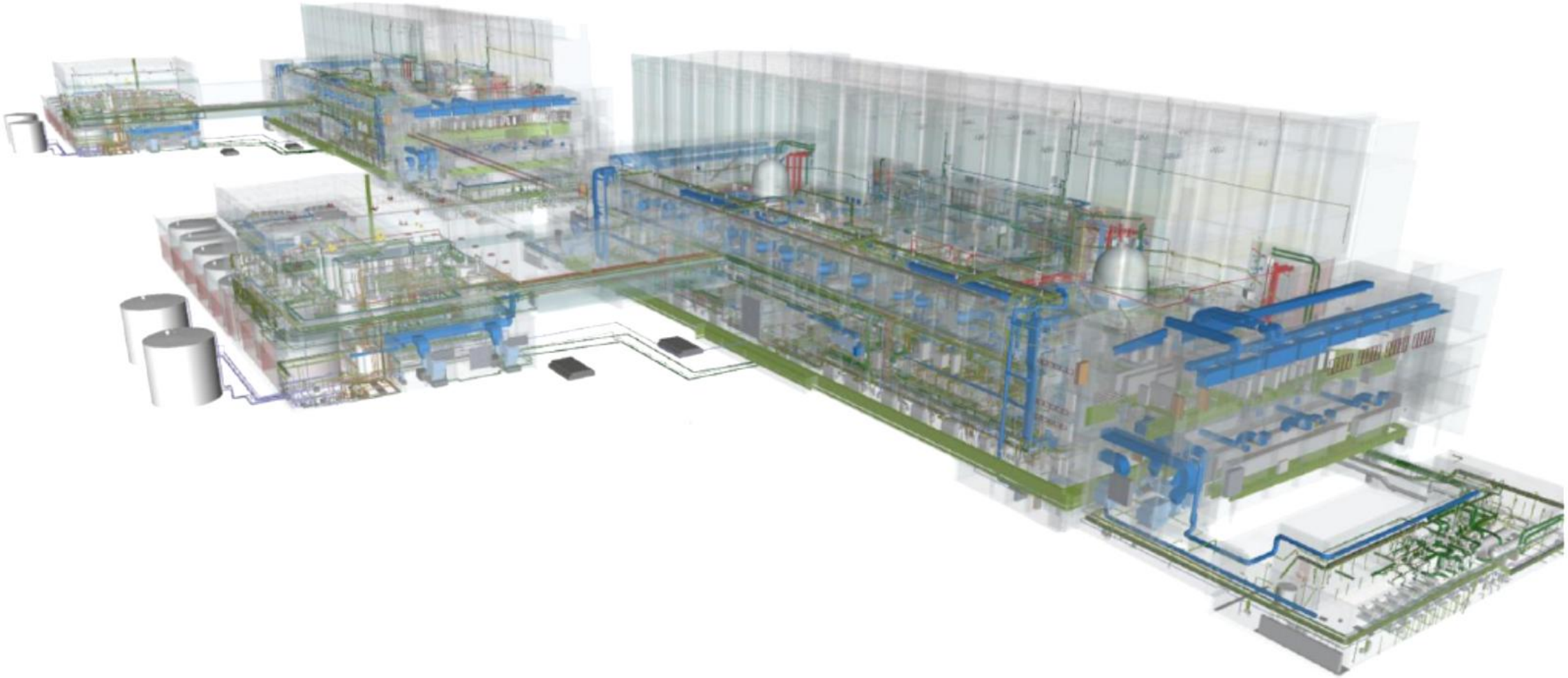
- Single web-portal for team work based on detailed 3D-model of Units 1-4 RB and AB 1&2
- Spherical photopanoramas integrated with the model
- 3D-model of Units 1-2 RB contains more than 700 000 elements
- Electronic documentation archive connected with the model contains over 40 000 design documents
- MS Windows OS/MS IE11
- Custom reports based on the model
- NEOSINTEZ as the base engineering data management platform and Digital Decommissioning platform from NEOLANT Group (Moscow, Russia)





2 Hands-on

Site walkdown



Hands-on

Use Case 1
Dose Management

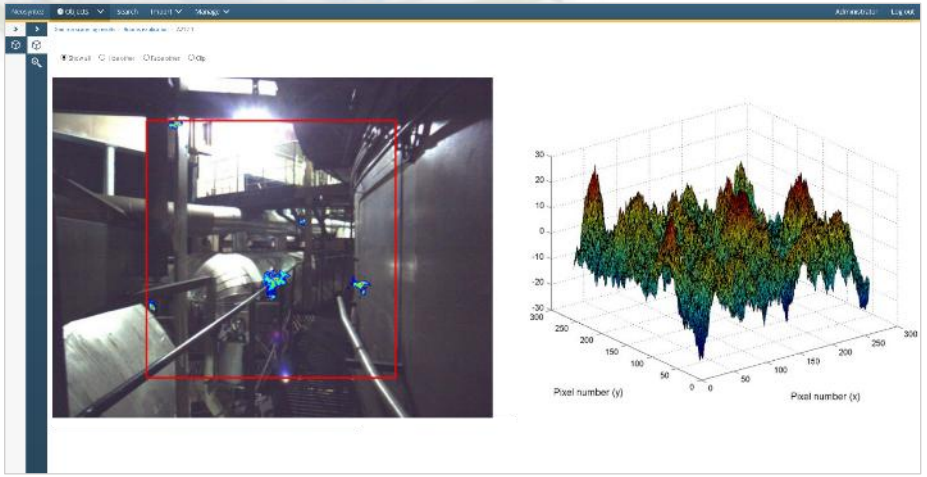
- Radiation survey results are integrated into digital model and used for subsequent dismantling design engineering. Digital model contains:
  - Dosimetry results
  - Spectrometry results
  - Gamma-scanning information

Value:

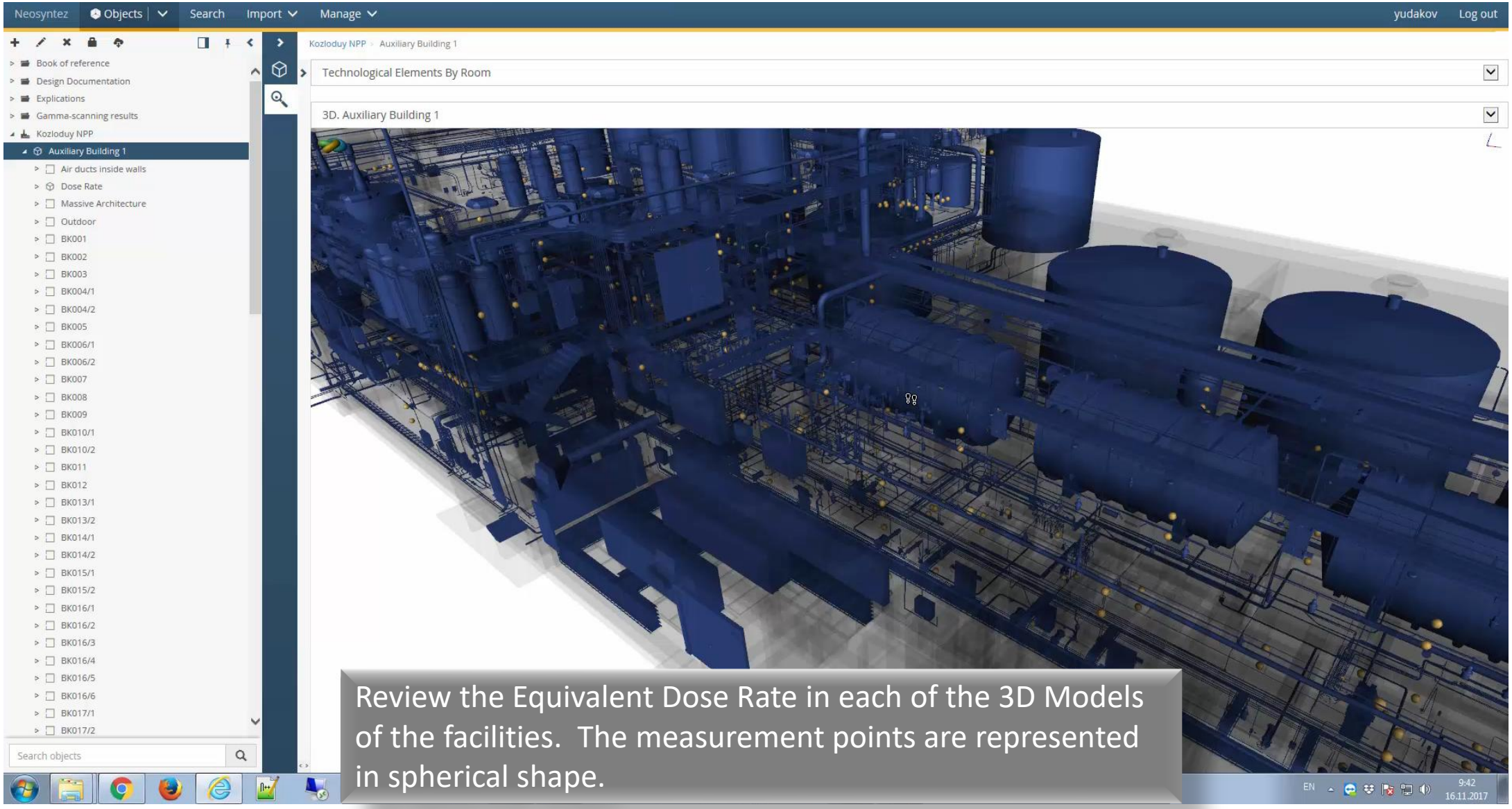
- Dose rates accounting while programming dismantling works
- Accurate RAW estimation
- Tracking the radiation situation as the works progress
- 3D visualization of radiation survey results to meet regulator's requests

By selecting a given point, the 3D model operator will get on the screen all the necessary data, such as:

- Ambient Dose Rate values – Ambient Dose Equivalent Rate,
- beta particles flux and their accuracy as at date of the survey,
- measurement point – Unit, room, elevation, and others.



Use Case 1 Dose Management



Review the Equivalent Dose Rate in each of the 3D Models of the facilities. The measurement points are represented in spherical shape.

Hands-on

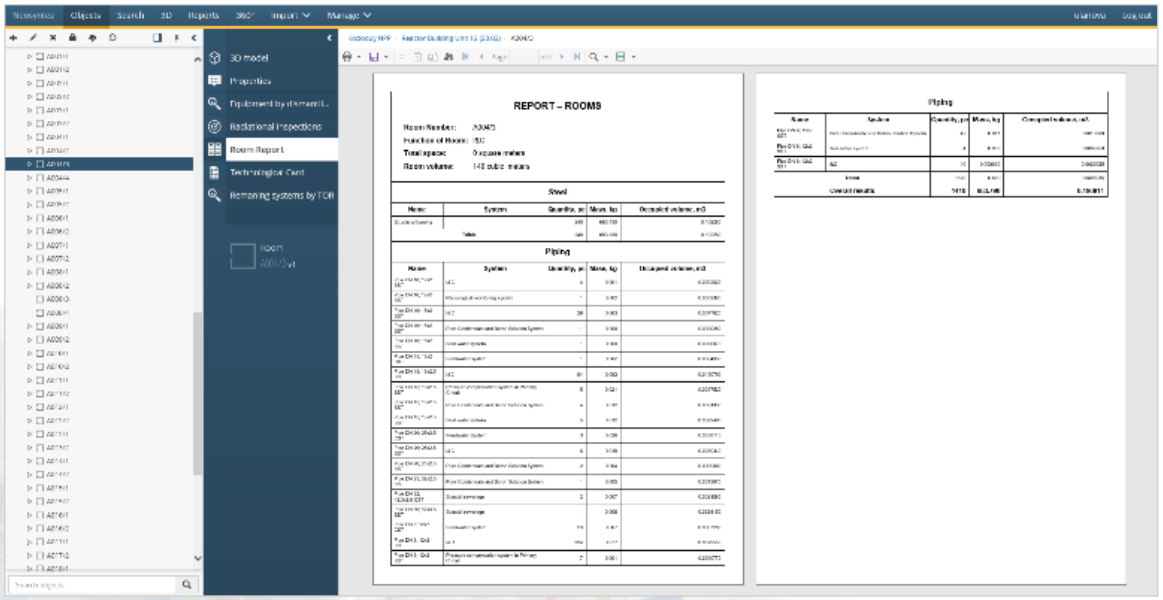
Use Case 2
Work Planning and Inventory

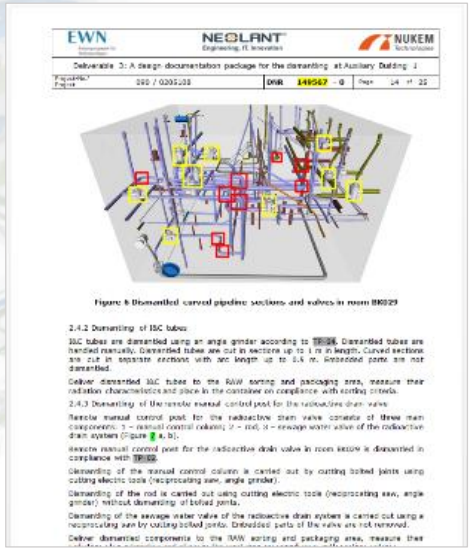
- Engineering data (mass, dimensions, materials of equipment, systems, structures, pipelines) and actual as-is engineering configuration (3D, drawings, attributes) integration into digital model, including:
  - Thermal and electric equipment of reactor buildings
  - Piping and cable runways
  - Metal structures (service and maintain areas)

Value:

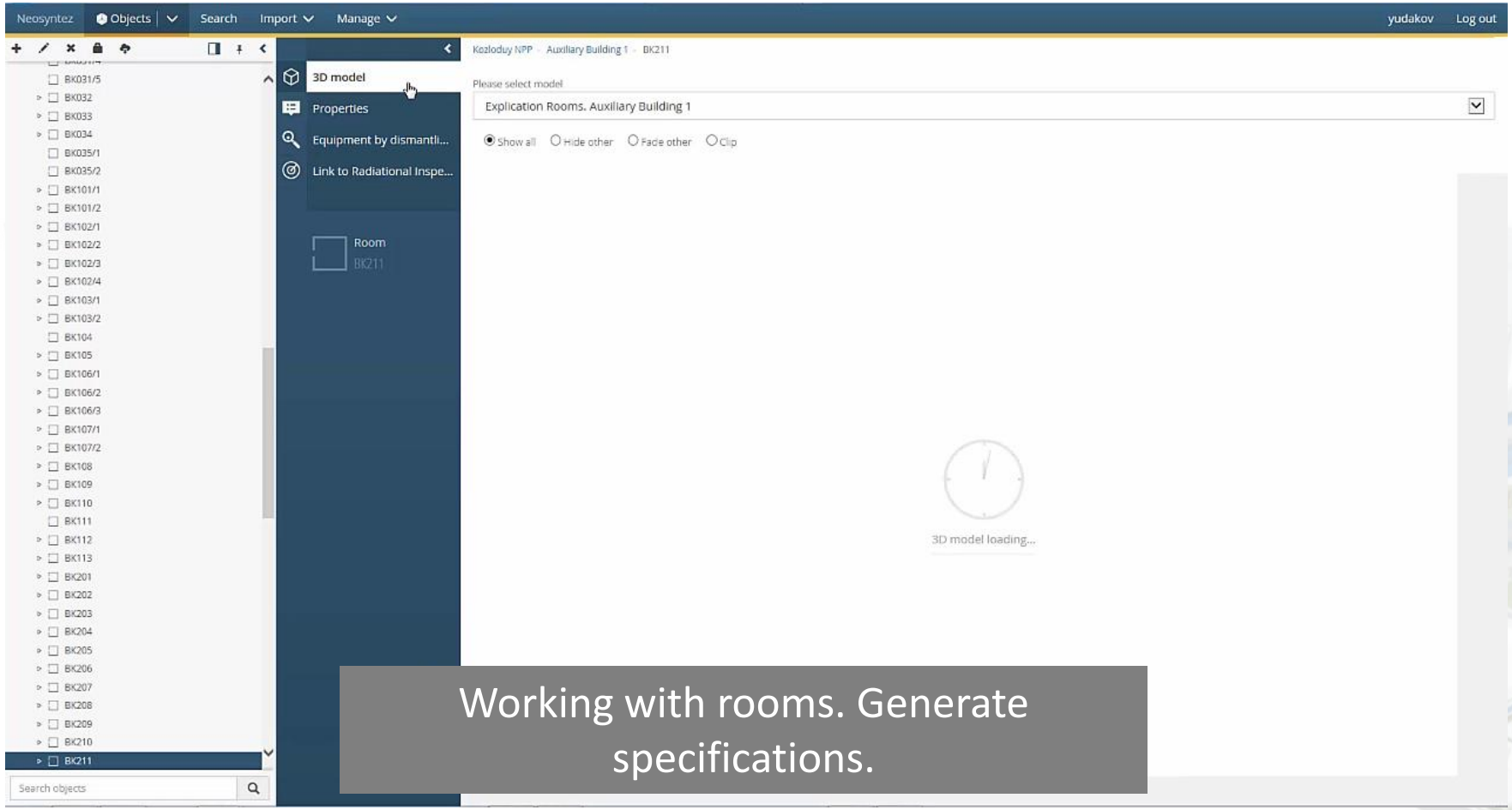
- Accurate estimation of RAW generated from dismantling
- Accurate equipment set and quantity estimation

For the purposes of planning and dismantling needs, the 3D model ensures easy and rapid access to process diagrams which have preliminarily been uploaded to the database. By means of integrated powerful search and report generation tools, a detailed technical information can be retrieved for each single detail, SSC, or system, located in one or more rooms, by the use of huge array of filters.





Use Case 2 Work Planning and Inventory



Working with rooms. Generate specifications.

- Specifications menu is an additional option we are familiar with, but which is not included in our 3D model portal. NEOLANT could develop and import this option into the portal based on the Client's needs.

3 Lessons Learned

Lessons Learned – Scope

1. Laser scanning provides executive level for digital model. And digital executive model, in turn, provides high quality, applicability and extensive study for dismantling design documentation
2. The most drawings don't reflect actual NPP configuration, but along with operating documentation provide necessary attributive data for plant components to be added to digital model and used for estimations
3. Thus, the combination of laser scanning and design/operating documentation analysis provides the optimal way for digital model development
4. For auxiliary rooms, free from complex equipment and radiation contamination, using spherical photography (as more cheap technology comparing to laser scanning) is acceptable. Existing drawings could be used for digital model development, which then is corrected by photopanoramas' results

- All the described information above is needed for the decommissioning process stages in our Controlled Area

TIP 1

Laser scanning is used at all areas (like occupied, semi-occupied and non-occupied premises) with complex equipment

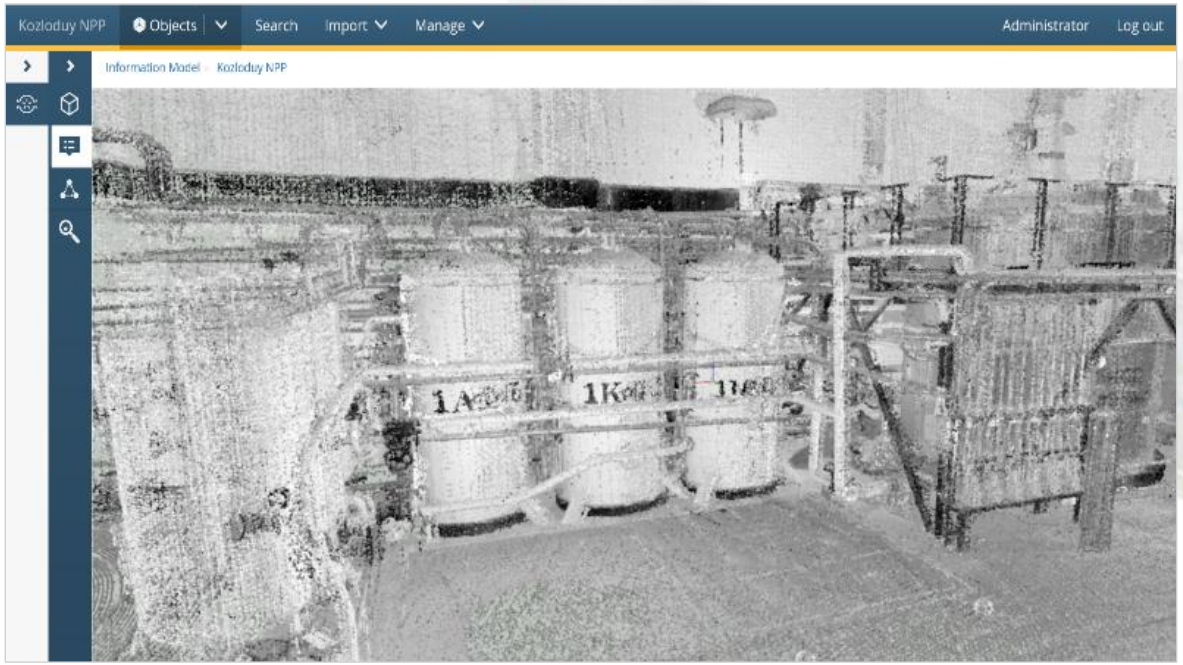
TIP 2

It is recommended to use laser scanner added with spherical photocamera in order to synchronize laser scanning images and photopanoramas

TIP 3

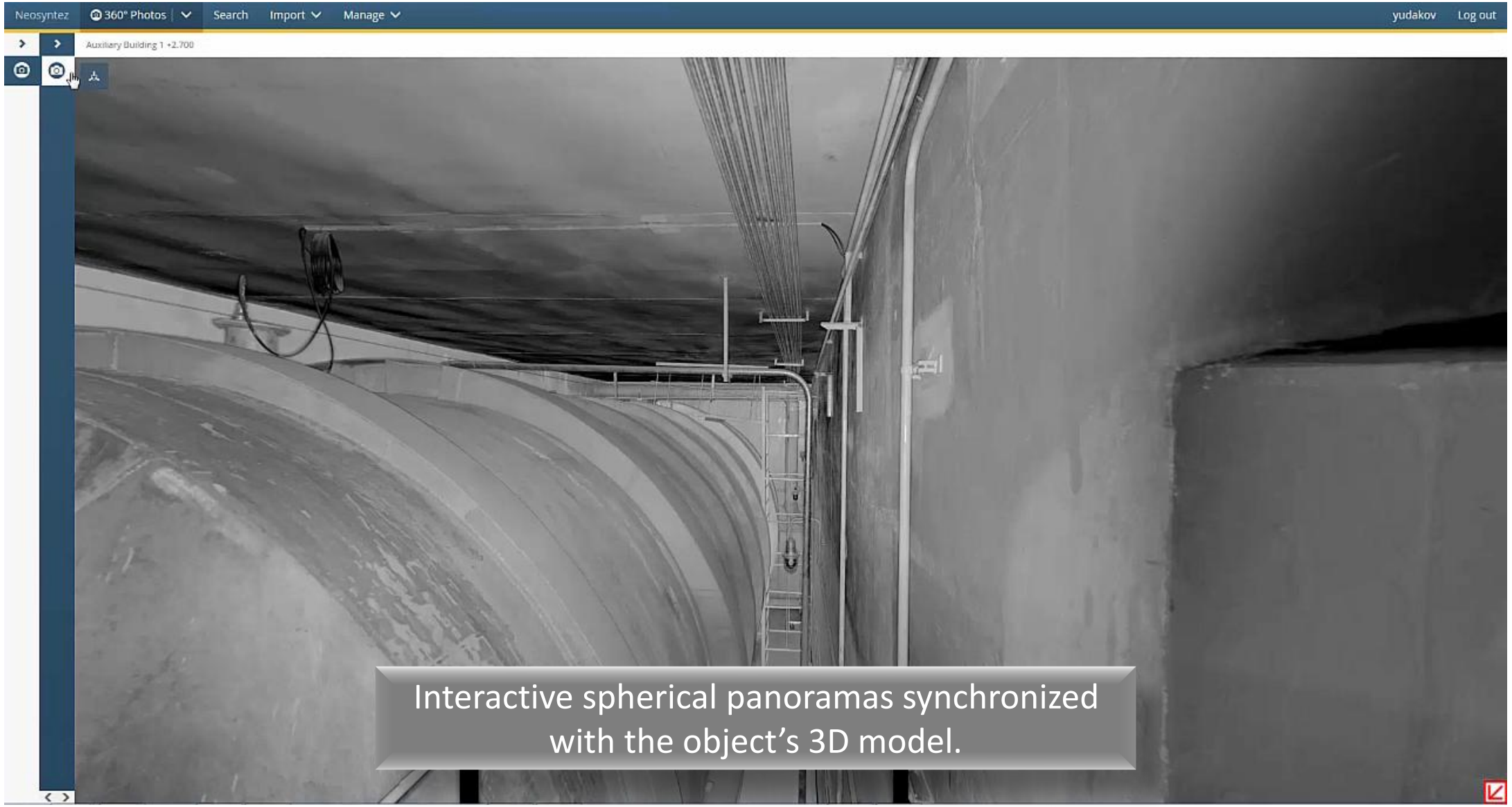
Up to 90% of documents don't reflect the actual NPP engineering configuration. Laser scanning is the way to develop digital model at executive ("as-is") level

Lessons Learned – Scope



- 360˚ plan preview of premises in Reactor Buildings by elevations - real image (after laser scan) vs 3D model
- This preview is needed for comparison of the 3D model visualization with real 360˚ view of the rooms and equipment
- In case of doubt for discrepancy in the data or spatial layout of the object in question, the user is provided the ability to compare the 360˚ view of the CA with the 3D object visualization (example: Slide 18)

Lessons Learned – Scope



Interactive spherical panoramas synchronized with the object's 3D model.

Lessons Learned – Planning

1. The scanning procedures of Kozloduy NPP Units 1-4 and AB 1&2 compartments took 1.5 months. During the process, over 600 rooms were laser scanned.
2. Due to lack of as-built documentation, the scanning points were placed “in field” for each certain area. The number of scanning points was from 1 to 4 for each room depending on its size and configuration. Two laser scanners were working at the same time at Occupied, Semi-occupied and Non-occupied premises.
3. The selection of “in field” scanning points for each given area is determined based on decisions taken at expert working meetings between specialists from SERAW and the 3D model project Contractor.

TIP 1

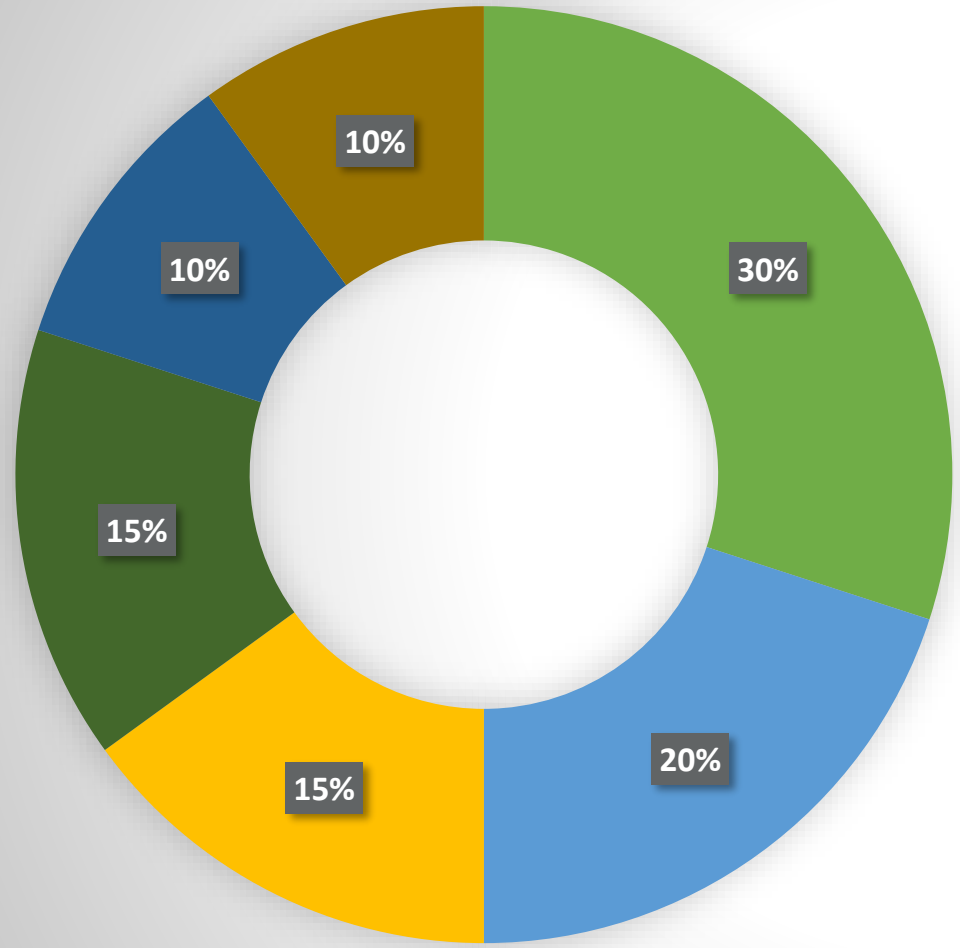
The overall scanning time depends on scanner feasibility. The best option is 500-1000 thousands point per second. Such scanner can scan the area of 30-40 square meters for several minutes

TIP 2

While working at contaminated areas, the scanner should be covered by protective film

Lessons Learned – Usage

CHART SHOWING DAILY USAGE OF THE 3D MODEL BY THE OPERATORS OF SERAW



- 3D model engineering configuration - searching and references for equipment by rooms at CA (controlled area) needed for preparation of documents for the decommissioning
- 360' preview - comparison between the real 360' photos of premises and equipment and 3D model. Searching for equipment and labels which are missing or not entered in the model
- Preview by dismantling status - all the dismantled equipment is updated daily by the operators of SERAW. Different colors are used to show different stages of the dismantling process in the model
- Reports and demands - Reports are used for generating of lists with equipment for dismantling and parameters such as length, weight, thickness and other
- Dose rates - needed for reference of the dose rates of rooms and equipment for dismantling, as well as calculating the dose load of the personnel
- Design documentation and explications - this section contains technical information and schemes for all technologies and archicectures in CA

The chart is dynamic and varies according to the activities and needs

Lessons Learned – Field Work

TIP 1

In case of outsourced contractor for laser scanning, it is important to take into account the time for access clearance and permanent customer's support

TIP 2

The target LOD should be defined at pre-tender stage and used for quality control during the subsequent works

1. Laser scanning software should upload points clouds data in a format supported by the 3D modelling software
2. The level of detail (LOD) should be defined before commencement of the works. The total cost of scanning is directly dependent on LOD. To find the optimal variant, several test scanning at different LODs are necessary. These works could be procured through pre-tender for potential contractors. At the same time, the statistics for LOD/dismantling waste estimations could be obtained
3. Logical number is team of 2 persons for each scanner. If less, the total time will increase
4. The optimal progress reporting period is every two weeks. A contractor should provide information about actual scanning and model development progress. The customer should delegate the person to compare laser scanning and spherical photography results with the model developing

Lessons Learned – Implementation

IT

1. While PIM tender preparation one need to consider the licenses must be purchased individually
2. It is recommended to purchase digital modelling software, which was already implemented at the same projects
3. It is advisable to choose PIM software with viable user licenses for using by different customer's specialists
4. As far as decommissioning is a long-time process, the PIM is better to be hosted on customer's servers
5. It is efficient to integrate PIM with existing customers information systems for access and visualization of corresponded data (single access point). This aspect should be reflected in Terms of Reference. As a result, data stitching from different information systems would be much easier for customer's specialists
6. 3D model's servers are working in secure local network and only SERAW users with protected accounts can access them

TIP 1

Make sure that your IT - infrastructure and PIM software requirements fit together

TIP 2

Include the necessity of providing PIM in final and source (originally developed) formats in tender requirements

TIP 3

Be sure to purchase fixed licenses for PIM operation

Lessons Learned – Implementation

QA

1. Customer should provide Project Manager (CPM) for PIM development and quality management
2. In current practice the engagement of CPM at the high works period is 60-80% of one's labour time
3. The collation of model, points clouds and photopanoramas should be conducted twice a week at least. Uploading attributive data should be controlled in parallel
4. A contractor should agree with customer the class-attributive model which is a base for digital model and is a form for data filling
5. The drawings could be not actual and during PIM development they have to be compared with the laser scanning results, but also they serve as source of attributive data for the model together with operating documentation
6. In case of identified discrepancy between the original drawings and the generated 3D model of a given room, the SERAW specialists would comment these differences with the developers, so that they can be accurately introduced. This is done in-situ by means of additional physical survey of the rooms using the developer's equipment and specialists

TIP 1

It is necessary to perform a systematic control of the comparison of the model, point clouds and spherical photopanoramas

TIP 2

Before starting the work, it is necessary to agree on a class-attributive model

Lessons Learned – Use

TRAINING

- The Consortium's member, (NEOLANT), provided several training sessions during the project implementation

USER EXPERIENCE

- It is important that a guarantee for maintenance and technical support be included in the contract scope
- Currently, a team of 8 in-house specialists operates PIM software at SERAW
- There are no complaints against the operation and quality of the model due to fast errors fixing and model corrections by Contractor
- It is important to have a feature which makes possible pointing dismantled components and highlight it with a specific colour in order to avoid additional laser scanning
- The training and exams were conducted at SERAW premises on Kozloduy NPP Units 1 to 4 site by the developer's specialists. The Employer's employees who have successfully passed the exams, were issued the respective certificates.

BENEFITS

"The tool could save hundreds of hours in face-to-face meetings and walkdowns"

"The tool is great at providing instant information about plant assets"

"Maintaining the tool up to date is challenging and it requires a dedicated team on site to ensure it provides its full potential"

Lessons Learned – Value

Engineering risks mitigation during decommissioning

Economical decommissioning risks mitigation

Radiation risks mitigation

Social risks mitigation

Labour cost reduction for SERAW

RAW management risks mitigation

Lessons Learned – Value

Engineering risks mitigation during decommissioning

Economical decommissioning risks mitigation

Radiation risks mitigation

Social risks mitigation

Labour cost reduction for SERAW

RAW management risks mitigation

Using PIM allows engineering risks mitigation for decommissioning due to:

- *Single source of true NPP engineering data*
- *Multi-layers and multi-projections data analysis*
- *Detailed study of design engineering solutions*
- *Verification of approved design engineering solutions*

Lessons Learned – Value

- Engineering risks mitigation during decommissioning
- **Economical decommissioning risks mitigation**
- Radiation risks mitigation
- Social risks mitigation
- Labour cost reduction for SERAW
- RAW management risks mitigation

Using PIM allows economical risks mitigation for decommissioning due to:

- *Time reduction for information search and processing*
- *Efficient planning and optimal decision making*
- *Accurate RAW estimation*
- *Additional cost risks mitigation (for example, additional surveys)*

Lessons Learned – Value

- Engineering risks mitigation during decommissioning
- Economical decommissioning risks mitigation
- **Radiation risks mitigation**
- Social risks mitigation
- Labour cost reduction for SERAW
- RAW management risks mitigation

Using PIM allows radiation risks mitigation for decommissioning due to:

- *High efficiency of planning*
- *High accuracy of dose estimations*
- *Human factor reduction*
- *Labour-time reduction in contaminated areas*

Lessons Learned – Value

- Engineering risks mitigation during decommissioning
- Economical decommissioning risks mitigation
- Radiation risks mitigation
- **Social risks mitigation**
- Labour cost reduction for SERAW
- RAW management risks mitigation

Using PIM allows social risks mitigation for decommissioning due to:

- *Prominence of data layout at different cross-sections*
- *Time reduction for information search and analysis for reporting and explanatory materials*

Lessons Learned – Value

Engineering risks mitigation during decommissioning

Economical decommissioning risks mitigation

Radiation risks mitigation

Social risks mitigation

Labour cost reduction for SERAW

RAW management risks mitigation

Using PIM allows labor cost reduction due to:

- *Single source of complex and actual information about NPP*
- *Information analysis at different layouts and projections*
- *Time reduction for information search and analysis for reporting and explanatory materials*
- *Accurate labour and dose estimations*

Lessons Learned – Value

- Engineering risks mitigation during decommissioning
- Economical decommissioning risks mitigation
- Radiation risks mitigation
- Social risks mitigation
- Labour cost reduction for SERAW
- **RAW management risks mitigation**

Using PIM allows RAW management risks mitigation due to:

- *Accurate RAW estimation*
- *Additional cost reduction due to incorrect RAW estimation*

Lessons Learned – Recommendations

- *Laser scanning and spherical photography should be conducted for all process compartments and contaminated areas. Spherical photography alone could be performed for clean rooms.*
- *Choose the solution from provider which can demonstrate the fast imaging of complex 3D models developed for industrial facilities such as NPP. Fast 3D model navigation is a key point of PIM usability. Another important point is possibility to display the separate parts of digital object (areas/rooms, systems, structures, components).*
- *Level of detail should be defined before the modelling. You can make a special meeting to ask suppliers develop 3D model of several rooms with different LOD and make its optioneering to find out the necessary minimum from critical engineering estimations points of view.*
- *Make sure the supplier provides fixed licenses and long-term technical support*
- *Use high-performance laser scanners (0.5–1 million points per second) to reduce labour time in contaminated areas and total time of "filed part" of digital modelling*
- *Make sure the software allows 3D model integration with dismantling schedule charts in order to track the works progress on the model*
- *Make sure the software allows synchronized 3D model integration with spherical panoramas in order to conduct visual control of decommissioning status*
- *In our opinion, teams should be formed that could exchange a 'real-time' experience with other nuclear power plants that have already integrated such a product, as well as with such that are about to do so – by 'real time' we mean physical meetings in situ, at the particular nuclear power plant in order to be able to track how a model is used on a practical level.*
- *The best and most efficient approach would be to have all the model operators established as a department, carefully selected by specialists who have previously worked at the nuclear power plant, while the reactors were still in operation, by complementing them with specialists who have specific IT skills.*

Thank you for your attention!