Uncertainty in Decommissioning, the Benefits of 3D Simulation - 15124

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ABSTRACT

Any industrial plant whatever the industry is will face its end of life. In the nuclear field decommissioning is inevitable for returning to green. Because of the specificity of each plant, decommissioning projects are never the same. The choice of a specific strategy for each operation during a scenario has cascade consequences on the generated waste, extension of due date, costs and risks.

Decommissioning in nuclear industry is a new domain where countries have a limited experience. When starting a decommissioning project engineers have to gather some data needed for planning and realizing the best scenario strategy. Scenario which should consider the costs, waste management, received dose and the planning. The quality of the input data has a strong influence on the risks and should be analyzed with care to reduce all doubts for the study. Nuclear plants running decommissioning programs concerns old plants with poorly documented history resulting in missing or uncertain data. The ambient dose rate is not always well-known as dose measurement or samples have not been taken or updated for many years. This kind of data may vary quite a lot when radiological events happen.

An efficient way to reduce contingencies is to go through simulations. It allows determining the best scenario strategy for each set of data while evaluating the influence of all uncertainties.

INTRODUCTION

Since the first generation of nuclear power plants reached their end of exploitation time, decommissioning became an expensive problem for which the nuclear industries have to deal with. In order to keep that energy at a low-level price, all operations along the plant lifetime have to be well managed: maintenance, upgrades for increasing its lifetime, dismantling... An inefficient control of these costs could challenge the sustainability of the civil nuclear industry.

On such project each single operation on one element interact on all other elements. It can significantly impact the results of the scenario in global. In the same way, the choice of a dismantling process has cascade consequences on the amount of waste, extensions of due dates, costs, and the risks. Therefore, it is important, straight from the conception stage, to use a global approach.

This need can be efficiently fulfilled with virtual reality technologies associated with expert models. The simulation tool *DEMplus for nuclear* has been developed this way by the French start up OREKA Solutions. OREKA Solutions supported by the CEA is specialized in nuclear decommissioning, maintenance and renovation.

DESCRIPTION: A SOFTWARE TO SIMULATE DIFFERENT SCENARIOS

The goal when using such software is to provide a simple way to simulate an operation and to examine instantaneously its impact on all results. The user successively specifies each operation of a reference scenario, interacting with an interface representing the 3D model of the facility (called the "scene"), the type of operation (cutting, moving, decontamination, radiological inspection…) and outfits. After that, the user can simulate alternative scenarios and compare them. He may change the order of the operations, increase the number of decontamination (for

example to do the next operations in contact instead of remote handling), add radiation shielding, use specific equipment or tweak the input data…

The user is able to determine the most effective scenario depending of his prior objectives by testing and simulating each action with a specific set of parameters and evaluate the consequences.

A TECHNIQUE TO IMPROVE FEEDBACK ACQUISITION AND EXPLOITATION

Dismantling nuclear installations is a recent activity where each specialist have his own methods to estimate and present results. This field is lacking of a structure for costs allocation and their range. It is complex to use feedback data and compare different yards due to the lack of codification, even within a same company. The software computes results and generates reports. To achieve this we studied how to structure and normalize these feedback data.

One of our primary objectives is to standardize a costs grid to improve the acquisition of what was learnt from experience, record and exploit it. The estimated values of the study phase and figures obtain from the realization should be cross-checked to better understand why some actions were under or over-estimated. It is necessary to increase our dismantling intelligence. As for oil and gas industry, we established structured cost codes with the goals to get them normalized by safety authorities and to standardize dismantling frameworks.

Fig. 1: Scenario editor. The user clicks on an object, select an operation and an operating condition to define an action. Then an avatar (the Brokk in this case) can be moved into the scene to check accessibility and dosimetry.
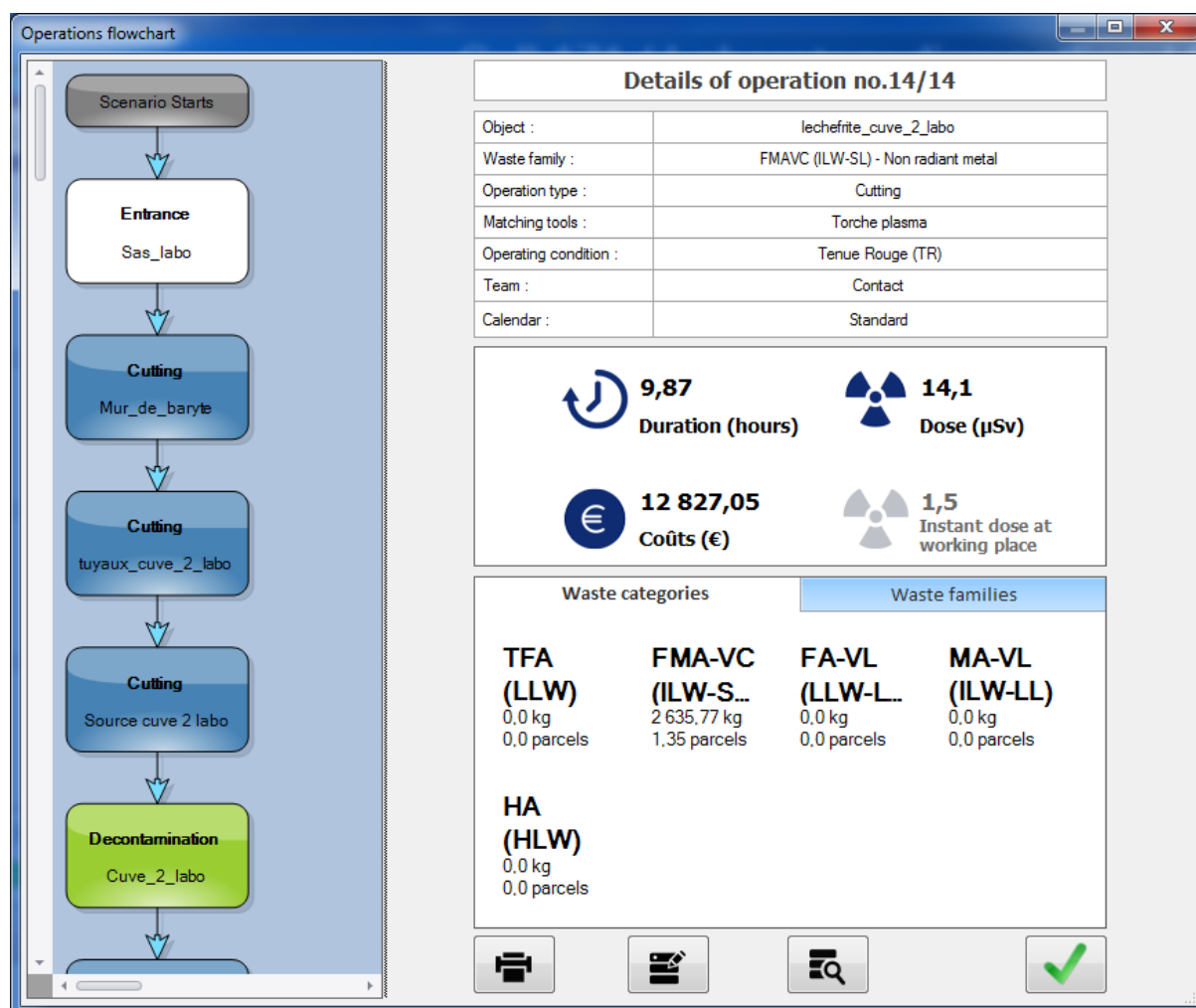
Fig. 2: Scenario editor. Results from the current scenario.

TECHNICAL BACKGROUND

The software is based on 3D interaction using the model of a scene coming from a CAD file as SolidWorks, Catia or others. The assembly is automatically split into single components so the user can enrich them with additional data as the weight or activity. The user has then an overview of the scene at anytime of the scenario. By clicking on an item, he gets its properties or can realize an operation (Fig. 1).

The software also embarks two calculation modules developed by the French CEA using a 3D model: a collision detector to deal with access issues and a dosimetric calculator which takes into account environment geometry and all properties (materials, absorptions, reflections...). An avatar of the operator (or remote handling system) is displayed for each operation. It can move in the scene using a 3D mouse as the SpaceMouse from the company 3Dconnexion. This way we can check the accessibility to the working area and make sure the received dose will be acceptable for the operators. We can also determine the best paths for minimizing the dosimetric exposure as the scene evolves during the dismantling operations.

The software uses specific calculation models developed by nuclear specialist from what was learnt from experience. It provides results for each operation. The results offers different levels of precision depending on the level of details the user knows about the scene and the scenario. The better they will be described, the better the results will be. The calculation model computes all given parameters to deliver the following figures: costs, durations, wastes and received doses (Fig. 1 & Fig. 2).

DEMplus for nuclear is a client-server based application to allow team working and share information and data through the enterprise network. Different kind of users can be involved in constructing the scenario (operational team leaders, decommissioning specialists, robotics experts...). They can share information and experience on common supports which are the scene and the scenario flowchart of *DEMplus for nuclear.*

A STEP BY STEP METHOD

DEMplus for nuclear has been developed for nuclear people and doesn't require to be a qualified IT expert. The procedure to build a scenario follows an intuitive approach.

Scene Characterization

The first step is to load a 3D model of the installation coming from a CAD tool or a 3D scan. The software automatically splits the assembly into separate items with their recorded properties.

Then the user sets all date from the physical inventory on the different objects according to the level of precision he wants. Inventory data which should have been previously sourced during the study phase. The user places and defines the radioactive sources. He enters the activity of the sources with their spectrum and their location in the scene. Finally the entry point for the operators is defined (the operators will be represented by an avatar).

A project is fully customizable to be adapted to the local constraints. This may be achieved via specific menus:

- Waste menu (where the user defines the containers he will use during the project, their dimensions, materials and allowed activities, prices…);
- Staff and team menu (to customize the properties of the operators);
- Tool editor menu (to define the tools and equipment with their characteristics as performances and costs);
- Operating condition menu (to set the different operator's outfits and remote handling systems)...

Each menu of the software comes with default values but it is possible to customize the calculation models depending what the users would want. These customized data are saved to be reused for future projects.

Building the Scenario

Once the scene is fully prepared, the user can start building the dismantling scenario. The user with the 3D scene simulates the operations to do successively. This by selecting objects, choosing the operation to do (e.g. cutting, moving, decontamination, radiologic inspection…), choosing the appropriate tool and finally by choosing the operating conditions (operator's outfit or remote system). An avatar manipulated by the user with a 3D mouse represents the team of operators. The user checks the accessibility (using the anti-collision engine) and check the operators' received dose (Fig. 1).

By validating the operation, the scene is updated (for example if we cut an item which also act as a source. The object and the source will be removed and *DEMplus* will calculate and display the following figures: cumulated received dose, amount of waste, duration and estimated costs.

The user virtually dismantles the scene and evaluate in real time the consequences of his choices prior to validate the operation.

A flowchart of the scenario is available with all results provided for each operation.

COMPARING SCENARIOS

To build the most effective scenario it is worth to simulate multiple scenarios and compare them to extract their best assets.

With this software it is very simple to copy a reference scenario and apply modifications to it. For example the user can change the schedule of some operations. He can check the relevance of decontamination processes according to different techniques and different decontamination factors. He can adapt the size of the team and its composition or the tools to use…

In some cases because of their location in highly radioactive areas the data of the scene can only be estimated (e.g. the activity of the source and its distribution). In this case the user can develop several scenarios based on each set of data and the hypothesis made.

A comparison of the graphs and figures of the scenarios can be done to help making decisions. This is very practical to isolate relevant parameters or to estimate the result range depending on the confidence you have in the input data.

RESULTS

A specific part of the software is dedicated to the analysis of the results and for reporting (Fig. 2). The software displays the results of a specific scenario using charts and tables. It also displays charts and figures resulting from the comparison of two different scenarios.

All data starting from input data to result data are fully exportable to Microsoft Office (Excel, Word and MS Project). People may generate automatically a complete report in Word format including the user parameters and hypothesis, the complete inventories, the results of global and unitary operations, waste containers, flow charts, diagrams... All tables (inventories, results…) can be exported to Excel. The planning can be exported to MS Project.
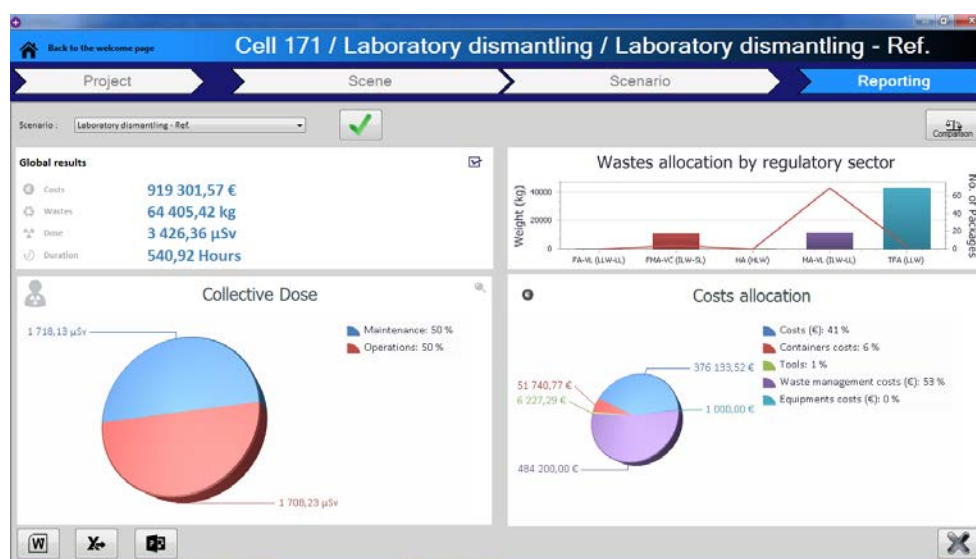

Fig. 2: All results from a scenario are displayed in a reporting window. Data can be exported to MS Office documents. Another display is dedicated to compare two scenarios (not shown on this picture).

REALIZATION AND LEARNING FROM EXPERIENCE

During realization phases the software remains helpful. As mentioned before, input data may vary from the study and the realization as some values may evolve differently during the dismantling operations compared to the initial estimations. With *DEMplus for nuclear* the user can easily update the parameters and re-evaluate the results. If needed, he can also adapt the initial scenario to optimize it considering these new data.

Furthermore, the user can quickly adapt his scenario and analyze the impacts on the results when something wrong happens during the realization which would compromise the initial scenario.

Due to the expensiveness of shutdowns and dangerousness of nuclear operations reactivity is necessary.

The learning from experience is capitalized with *DEMplus* by comparing the predictions with the values from the real situation. The calculation models and methods can be adjusted using these differences to improve the performances of the system.

CONCLUSION

DEMplus for nuclear is a handy software based on a 3D model to build efficient scenario for dismantling, maintenance, or renovation projects in nuclear areas. The global approach computing in a single model: costs, durations, wastes and received doses is contributive to consolidate the results balance sheet of the project.

It is useful all along a nuclear plant lifetime: from conception (for eco-design where dismantling plans need to be provided), during exploitation (maintenance and renovation) to the decommissioning of the plant. In addition the learning from experience is capitalized for future projects.

This software is also a learning tool to get trained on developing optimum decommissioning strategies.

Moreover the knowledge and approach used in *DEMplus for nuclear* which was initially designed for nuclear industries is transferable to other fields as oil and gas, transportation and industry.