Global solutions through simulation for better decommissioning

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Decommissioning is a new activity in sense that it only exists a limited experience. Moreover, each facility is different due to their own history and there is no rule about choosing a decommissioning strategy. There are three major decommissioning strategies. First, "immediate dismantling", which means the action of decommissioning begins immediately after the transfer of waste and nuclear material [1]. Second, "deferred dismantling strategy", which means that the facility is maintained into a containment zone from thirty to one hundred years before being decommissioned [1]. Finally, "entombment", means the facility is placed into a reinforced containment until the radionuclides decay and reach a level allowing the site release [1]. When a strategy is decided many factors have to be taken into account.

Into a major project such as a reactor decommissioning, there are many smaller projects. The decommissioning strategy can be different among these smaller projects. For some reasons, some entry data are not perfectly known. For example, dosimetric activity has not been updated through time or after specific events.

Indeed, because of uncertainties and/or hypothesis existing around projects and their high level of interdependency, global solutions are a good way to choose the best decommissioning strategy. Actually, each entry data has consequences on output results whether it is on costs, cumulated dose, waste or delays. These output data are interdependent and cannot be taken apart from each other. Whether the dose, delays or waste management, all have impact on costs. To obtain an optimal scenario into a special environment, it is necessary to deal with all these items together.

This global solution can be implemented thanks to simulation in dedicated software which helps to define the global strategy, to optimize the scenario, and to prevent contingencies.

As a complete scenario simulation can be done quickly and efficiently, many strategies can be tried, analyzed and compared on all output parameters in a total accordance with the ALARA/ALARP approach. Then, contingencies can be prevented by testing an infinite number of situations whatever the uncertainties are, and this enables to determine the best scenario strategy for each set of data. Simulations also allow people to test not only access issues into some environment but also

radiological access. By testing different dosimetric configurations or hot spot location, simulation allows you to test them and so reduce risks.

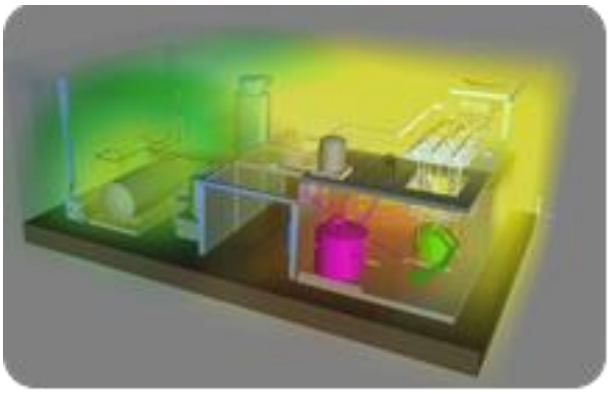

Figure 1: Example of a dose map into a simulation tool

Figure 2: Choose the best strategy by changing some entry data

For a specific environment, when many scenarios have been developed and tested, sensivity studies are really important to choose the optimal decommissioning strategy. Sensivity studies can be done with simulation tools by comparing results of scenarios directly into the software. This comparison helps to choose the optimal scenario according to which output data is considered as key determinant. Simulation offers a very good return on investment in the sense that many scenarios are quick to do, they can be copied and the user can change one input data to observe instantaneously the impacts of this change on results. Doing different simulations permit to quantify risks, reduce hazard and therefore reduce costs.

Finally, simulation tools enable to collect output data of decommissioning projects during realization, comparing them in real time to the studies assessments. This improve the feedback acquisition, very important in the decommissioning field in which we do not have a lot of experience.

Current experiences of studies using DEMplus [2] on different kind of projects (new build, maintenance, exploitation, D&D: Bugey 1 – EDF; MAR200 – CEA; quench tower – SOCODEI; R7 – AREVA; …) show several benefits either on the entry data consolidation, the scenario optimization and the risks studies. The ALARA/ALARP approach is fully developed by simulating a large set of strategies, using a cost-benefits analysis on many criteria. A unique software that deals with all types of entry data in order to compute results is clearly a powerful tool as a decision taking helper, and as a justification provider (cf. Figure 1).

However, such as all simulation tools, quantitative adjustments may be done by the user (due to used computation models that are based on feedback means); but simulation clearly helps in order to define orientations and to select on which data/option one have to focus on.

DEMplus is based on a 3D model on which extra-data are added, like physical or radiological properties (so called 3D smart model or BIM technologies). The user interacts with the 3D model in order to define different operations. The 3D model evolves along the scenario (just as other inserted data), and results are computed by combining user laws (how long for a pipe cutting for example), and operation properties (suits, tools…).

	Scenario strategy				Dosimetry			Tools		Waste streams		Suits	
Scenario	From the top (contact)	From the bottom (contact)	From the bottom (remote controled)	From the bottom (contact + remote controled)	Background noise	Background noise + 3 hot spots	Background noise + 4 hot spots	Classical tools	Dedicated tools	Strategy 1	Strategy 2	"Green" EDF suit	MURU BLU suit
Scenario 1	✓				✓				✓	✓		✓	
Scenario 2		✓			✓				✓	✓		✓	
Scenario 3	✓					✓		✓		✓		✓	
Scenario 4	✓					✓			✓	✓		✓	
Scenario 5		✓				✓		✓		✓		✓	
Scenario 6		✓				✓			✓	✓		✓	
Scenario 7			✓			✓		✓		✓		✓	
Scenario 8	✓						✓	✓		✓		✓	
Scenario 9	✓						✓		✓	✓		✓	
Scenario 10		✓					✓	✓		✓		✓	
Scenario 11		✓					✓		✓	✓		✓	
Scenario 12	✓						✓	✓			✓	✓	
Scenario 13	✓						✓		✓		✓	✓	
Scenario 14		✓					✓	✓			✓	✓	
Scenario 15		✓					✓		✓		✓	✓	
Scenario 16	✓						✓		✓	✓		✓	
Scenario 17				✓			✓		✓		✓	✓	
Scenario 18	✓						✓	✓			✓		✓

Figure 3: In this study, 90 combinations have been simulated in order to argue on the ALARA/ALARP approach.

One of the characteristics of nuclear studies is that from the first draw of the preliminary design to the realization, entry data are evolving many times (missing data, hypothesis, sampling...). Indeed, the feature of simulations to update these data all along the project is fundamental. Of course, the result's quality depends on the quality of entry data. But as sensitivity studies can be done easily, the user can compute the result of one scenario for different values of a hypothesis in order to balance the risk on the scenario due to the error margin of this hypothesis. Moreover, even if the simulation's results may have quantitative errors on values, the qualitative analysis is still relevant.

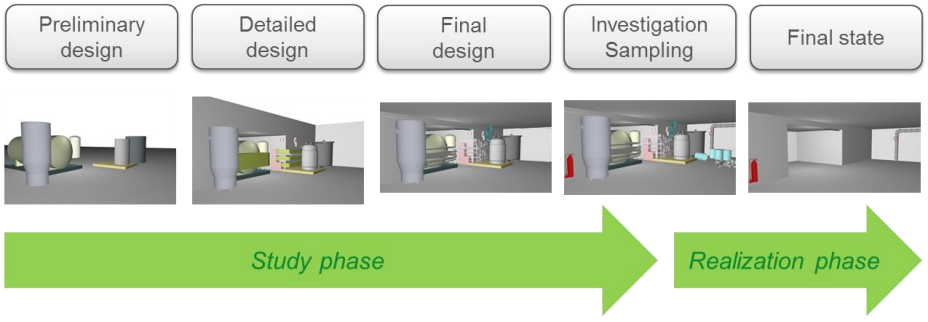

Figure 4: The quality of the CAD model or the inserted data may evolve during the study.

References

[1] OCDE 2006, NEA n°6038, "Selecting strategies for the decommissioning of nuclear facilities"

[2] http://www.orekasolutions.com/demplusfornuclear/demplusfornuclear_en.html