Innovative Hot Lab Concept for Nuclear Industry

Maria Isabel Machado and Fanny Fouin

Assystem Engineering & Infrastructures, Paris, France
Corresponding author:Maria Isabel Machado <mimachado@assystem.com>

Despite the vast use of Hot Labs on the nuclear industry, their current designs and operations do not meet entirely today's needs and requirements of the operations nor tomorrow's. For example, the tools changes/replacements are a factor for delays on the operations that are not completely taken into account today at the design stage. This is due to the difficult access to the interior of the cell. It has to be further emphasized that the maintenance is almost inexistent inside the cells. This complicates the end-life of the Hot Cell with a consequent increase of complexity in the decommissioning operations.

According the aforementioned issues, we propose in this paper to investigate into Hot Cells design and concept in order to integrate new operability modes and functions. The overall idea is to bring modularity, flexibility and adaptability to the Hot Lab nuclear industry.

Figure 11 reports the different phases of the hot cells that will have to be considered during the System engineering approach that will be driven by digital continuity and an efficient information management system that will be discussed later.

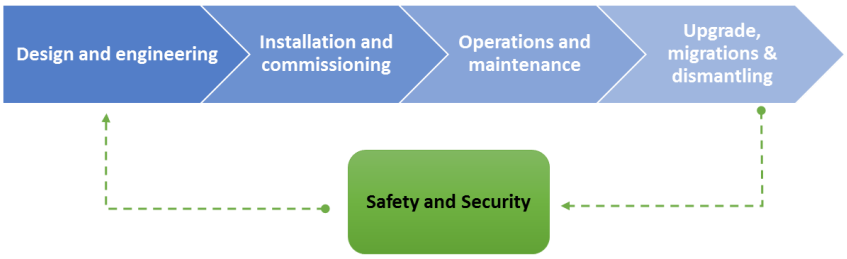

Figure 11: System engineering approach adopted

We initially proposed to focus on the development and implementation of four main aspects: implement the Industry 4.0 concept to the nuclear industry, explore the concept of in service maintenance and predictive maintenance, optimise the decommissioning & dismantling process by taking into account the entire life-cycle process and implement the use of modular and flexible solutions.

This paper proposes to concentrate on a concept of Hot Cell for maintenance operations. This is a case study developed taking several assumptions and could be adapted to any particular project thanks to the global approach taken.

Innovative Hot Lab

The innovations present on the project developed can be divided into three main categories: Modularity, Flexibility and Industry 4.0. The combination of these leads to the complex concept building detailed in Figure 12.

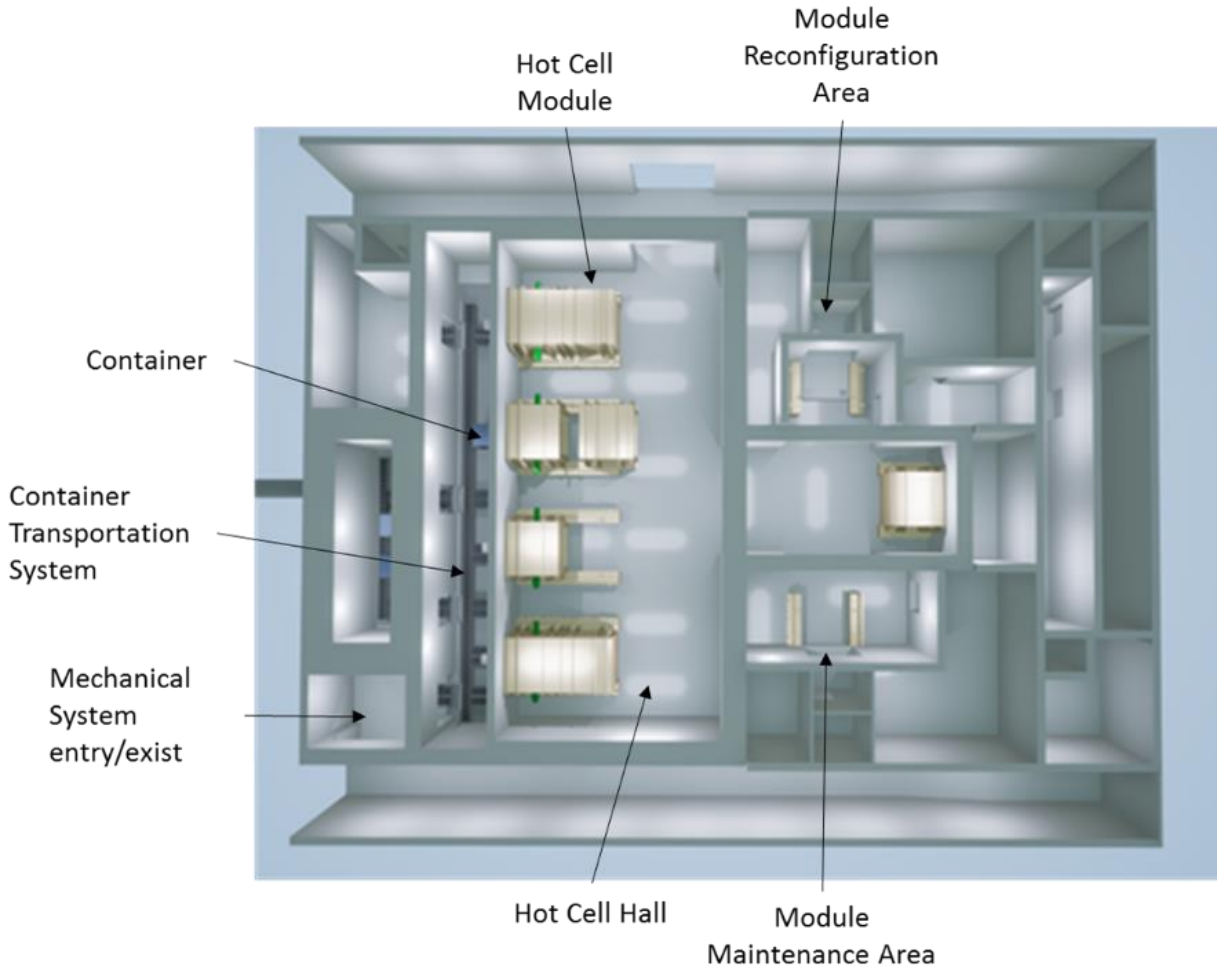

Figure 12: Complex Building Layout

Modularity. The modularity of this concept is achieved by the plug & play characteristic of 9 similar modules present in the Hot Cell Hall. The modules are the operational chambers where the maintenance of the mechanical systems arriving from the reactor will be performed. A Hot Cell assembly can be composed by plugging different type of modules together (see Figure 3).

It is expected that these modules would move to a dedicated area such as maintenance or reconfiguration in the Hot Cell Complex to allow the extension of their operational lifetime.

The modules are mobile and moving to various area and points in the building a standardise docking and alignment interface has been designed.

The modularity has been achieved through the definition of a standard template and simplified interfaces between each sub-systems. This is reflected by the manipulator arms attachment plate to the Hot Cell Module wall. The Container Transportation System (CTS) is also designed to be composed by several modules of rollers that will cover the entire corridor.

Flexibility. The flexibility is mainly achieved by the possibility of fast reconfiguration and re-arrangement of the Hot Cell Modules (HCM). The possibility to easily exchange/replace/modify equipment inside the Hot Cell Module (see Figure 13) according to the operational needs brings a great flexibility to our overall complex.

In the case of maintenance or need for repairs the HCM can also be moved to the maintenance area through the specific innovative transportation mean. Maintenance operations would be achieved to retrieve the Hot Cell Module to a functional state. The reconfiguration and maintenance area are physically separated in order to allow the parallel activities on the Hot Cell Modules.

It has to be noted that while a module is in maintenance or reconfiguration, operations can still be happening in the Hot Cell Hall. This improves the operational efficiency of such a building and reduce downtime of operations.

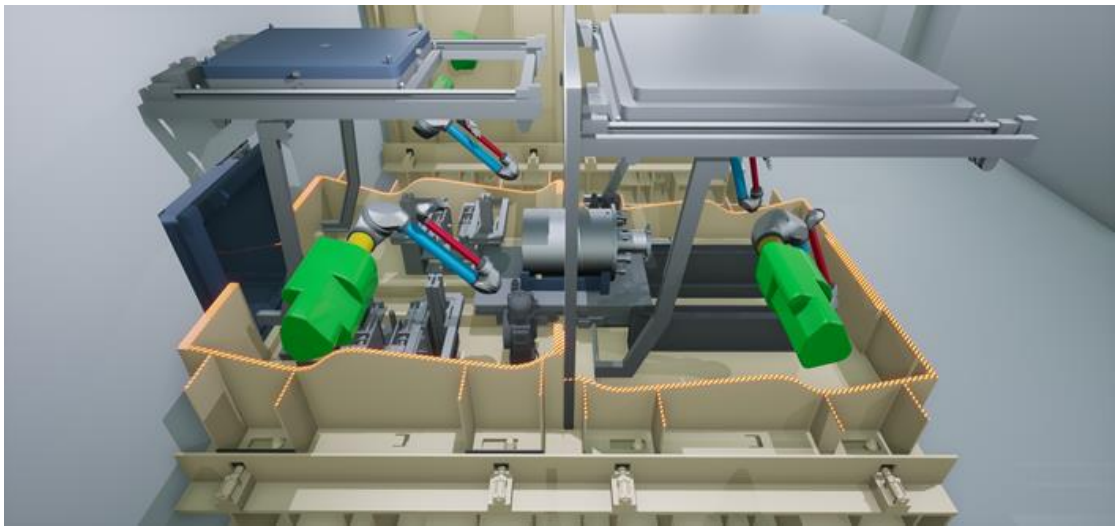

Figure 13: Overview of Hot Cell Modules plugged togeher and their equipment

Industry 4.0. Remotely controlled operations or fully automated operations have been introduced to the operations process. Indeed remote operated manipulators arms, trolleys and cranes have been implemented into the concept design to integrate the functionalities desired.

This intends to improve the activities quality of the operators and the type of work that they might be subjected to. This way it is attempted to automatized the controls and include the newest technologies in the nuclear field.

The activities and supervision of operations will be performed from a control room with remote/virtual access to all the machinery inside the complex. The control room will be also prepared to accommodate the technology upgrades that might occur during the life cycle of the facility. This will lead to use the HCM as laboratory for evaluating new technologies. It has be noticed that this will be made possible with the functionality of flexibility and modularity where some modules are used to evaluate new technologies and others modules are used for nominal operations.

Conclusions & Further Work

In this paper, we proposed a new concept of hot lab that will be enabled by digital continuity and a model based system engineering approach. The architecture proposed is using the most advanced technologies in industry 4.0 to demonstrate the flexibility and modularity requirements. More developments are on-going that will be described in the extended version of the paper and during the conference.

This Hot Lab concept brings the current Hot Lab to the next level as the design has been adapted to meet the current operational needs, implement novel ideas and take into account its entire lifecycle. Developing modular and flexible system is part of the future of the Nuclear Industry and Assystem E&I demonstrated that the Hot Lab had great potential. During this work Assystem has identified topics that would require further development to one day make this concept possible. Therefore collaboration schemes have been set up with research centres, start-ups, and universities.

Through this project Assystem also demonstrated that the use of digital tools is key in the development of a successful project.