*Nuclear Science and Technology Symposium - SYP2022*
*Helsinki, Finland, 1-2 November 2022*

# Robotics in Decom - Research of Robotic Installation Suitable for Clearance Measurements of Nuclear Facilities

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## ABSTRACT

*Robotics in Decom* R&D project was established in order to develop methods to measure and remove radioactive materials from the building structures during the decommissioning of nuclear facilities. The project is divided into two phases. The first phase of the project is completed while the second phase is ongoing. During the first phase, robotic installations, measurement methods and decontamination methods were researched. In addition, The features for the robot possibly to be built in the future were chosen and the robotic clearance measurement was compared to the manual labor.

The second phase of the project further develops the concept of the robot and researches the requirement set by the authorities. In addition, a pilot demo featuring the similar robotic installation than designed during the first phase is tried to be arranged in order to collect valuable data for further development.

## 1 INTRODUCTION

When nuclear facilities are decommissioned, their buildings and other structures usually undergo the measurement and decontamination process for clearance. Currently these actions are almost completely done manually. This method is time consuming and most likely won’t provide comprehensive enough characterization of radioactive materials. This is not cost-effective, and the volume of dismantled waste is larger than it probably should be.

The *Robotics in Decom* R&D project was established in order to develop methods to measure and remove radioactive materials from the building structures during the decommissioning of nuclear facilities. The project is divided into two phases, from which the first phase is completed and the second phase is ongoing.

The target of phase 1 was to analyze the needs and requirements of robotics in decommissioning, map the current robotic solutions which could be utilized in the studied installation and create the business case for said installation. The objective of the phase 2 is to further research and design the clearance robot and arrange a pilot demo of similar robotic installation.

The goal of the robotic installation is to gather more accurate radiological data and reduce the amount of manual labor, thus potentially decreasing the total cost of decommissioning works. The findings of the project will determine whether the researched robotic installation is worth investing.

## 2 RESEARCHING OF ROBOTIC INSTALLATIONS

### 2.1 Preliminary Needs From the Robotic Installation

At the beginning of the project the preliminary requirements regarding the features and equipment were given to the robotic installation. The requirements were:

- the robot should be able to operate autonomously;
- the robot should be as adaptive as possible for different kinds of rooms and measurement surfaces;
- the robot should be able to overcome some basic obstacles;
- the robot should be modular: if needed, the parts of the robot could be easily switched on site;
- the measurement equipment of the robot should be suitable for clearance measurements;
- the robot should be able to decontaminate surfaces it finds too radioactive for clearance;

These preliminary requirements were taken into consideration while researching suitable and optimal solutions.

### 2.2 Surveying technology

The project started by surveying existing methods utilized in the nuclear industry. Instead of searching for complete robotic installation suitable for project's needs, the research was divided into three categories: robotic platforms, measurement methods and decontamination methods.

The research of robotic platforms consisted of treaded and wheeled models [1] [2] as well as four-legged models [3] [4] [5] and drones [6] [7] [8] [9] [10]. During the research some robotic installations utilized in nuclear facilities were also discovered, such as the floor surveying robot MACS and the wall climbing robot MAFRO [2].

The research of contamination measurement methods consisted of direct measurement methods, as well as drilling samples and laboratory analyses [11] [12]. The research of decontamination methods varied from traditional mechanical decontamination to dry ice blasting, foaming and laser decontamination [13] [14].

### 2.3 Chosen Features

The need from the possible future robotic installation were updated at the workshop meeting held after the research of current technology was completed.

The structure of the robot was chosen to be a treaded platform with a scissors lift-like installation and a robotic arm. The treaded platform was seen as the most versatile choice when considering mobility and tolerance to basic obstacles. When equipped with scissors lift the robot can reach and measure areas unreachable for manual labor without scaffolding.

The robot would be equipped with surface contamination meter, which would be its primary measurement device. In addition, the robot is planned to have a bore drilling equipment paired with surface inspection camera. Whenever the camera detects cracks or any other inconsistencies in the surface, the bore drilling equipment would collect a sample from that spot in case of penetrated contamination. The samples would be collected to vials located in a magazine.

Despite the preliminary need, no decontamination tools are further planned for the robot. There were several reasons leading to this decision, most important ones being prolonged battery life and more compact size, as well as the assumption that robot-made decontamination wouldn't be sufficient enough.

While performing the measurements, the robot would simultaneously draw a color coded 3D map which would tell all the contaminated areas exceeding the clearance levels. The robot would also mark the locations of bore drilling samples to said 3D map. The base of this 3D map would be made with separate laser scanning and would be downloaded to the robot's memory.

### 2.4 Comparison to Manual Labor

Based on the reference [15], the estimated clearance measurement speed of the robotic installation was compared to the calculated clearance measurement speed of manual labor.

When the investigated surface is measured completely the robot is expected to be slightly faster than manual labor. On the other hand, the speed of manual labor might be instead slightly faster when lower portions of total surface area is measured.

However, it is estimated that the overall amount of preparatory work required for the robotic clearance measurements is smaller. The largest factor to this is scaffolding works that are required when rooms with high ceiling are measured manually. With the planned robotic installation the scaffoldings are obsolete due to the scissors lift.

## 3 FUTURE STEPS OF THE PROJECT

The second phase of the project commenced at the first half of 2022. The main objective of this phase is to arrange a pilot demo with a robotic installation that is as similar as possible to the robot designed during the first phase of this project. This includes compiling the demo plan for the event. The pilot demo will be conducted in cooperation with VTT in December 2022.

The goal of the demo is to compare the speed, accuracy and reliability of the robot's contamination measurements to those made manually with approved methods. The demo also includes the inspection of the robotic installation's ability to draw color coded 3D maps.

In addition to this, the second phase of the project includes other tasks as well. These are researching of the requirements set by the authorities for the clearance robot, basic planning of the robot's structure and roadmap of operational use of the robot, including, among other things, building and testing of the robot. Further progress of the second phase is expected in 2023.

## 4 CONCLUSIONS

Based on the findings of the first phase of the project, it is seen that the robotic installations have their place in the decommissioning project of nuclear facilities. It is also seen that one of the applications during the decommissioning project is the clearance measurements of buildings and other structures.

However, the technology still needs development before it can be utilized with its full potential.

The clearance measurement robot is not expected to replace the manual labor completely. However, it is expected to be a great compliment to it, once it is completed and approved by the authorities. While the robotic installation would succeed in vast areas with high ceiling, the manual labor would outperform it in smaller, cramped areas.

During the second phase of the *Robotics in Decom* R&D Project a pilot demo with a similar robotic installation will be arranged in cooperation with VTT. The further development of the robot is dependant on the finding that emerge from the demo.

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