Application of remotely operated equipment in nuclear decommissioning

Enhancing safety and efficiency in high-dose nuclear decommissioning operations at Ignalina Nuclear Power Plant

INTRODUCTION

Remotely Operated Machines (ROMs)

The knowledge product "Application of Remotely Operated Equipment During Decommissioning of Ignalina Nuclear Power Plant" provides practical insights into using **remotely operated machines (ROMs)** for dismantling and waste management in high-dose environments.

OBJECTIVE

The primary objective of using ROMs is to reduce **personnel dose loads** while improving **efficiency** in decommissioning tasks. The product draws from the extensive experience gained at the Ignalina NPP and focuses on the application of ROMs in dismantling pipelines, managing radioactive waste, and decontaminating concrete structures. This interactive presentation aims to share knowledge and best practices to support other nuclear decommissioning operators in adopting similar technologies.

SCOPE

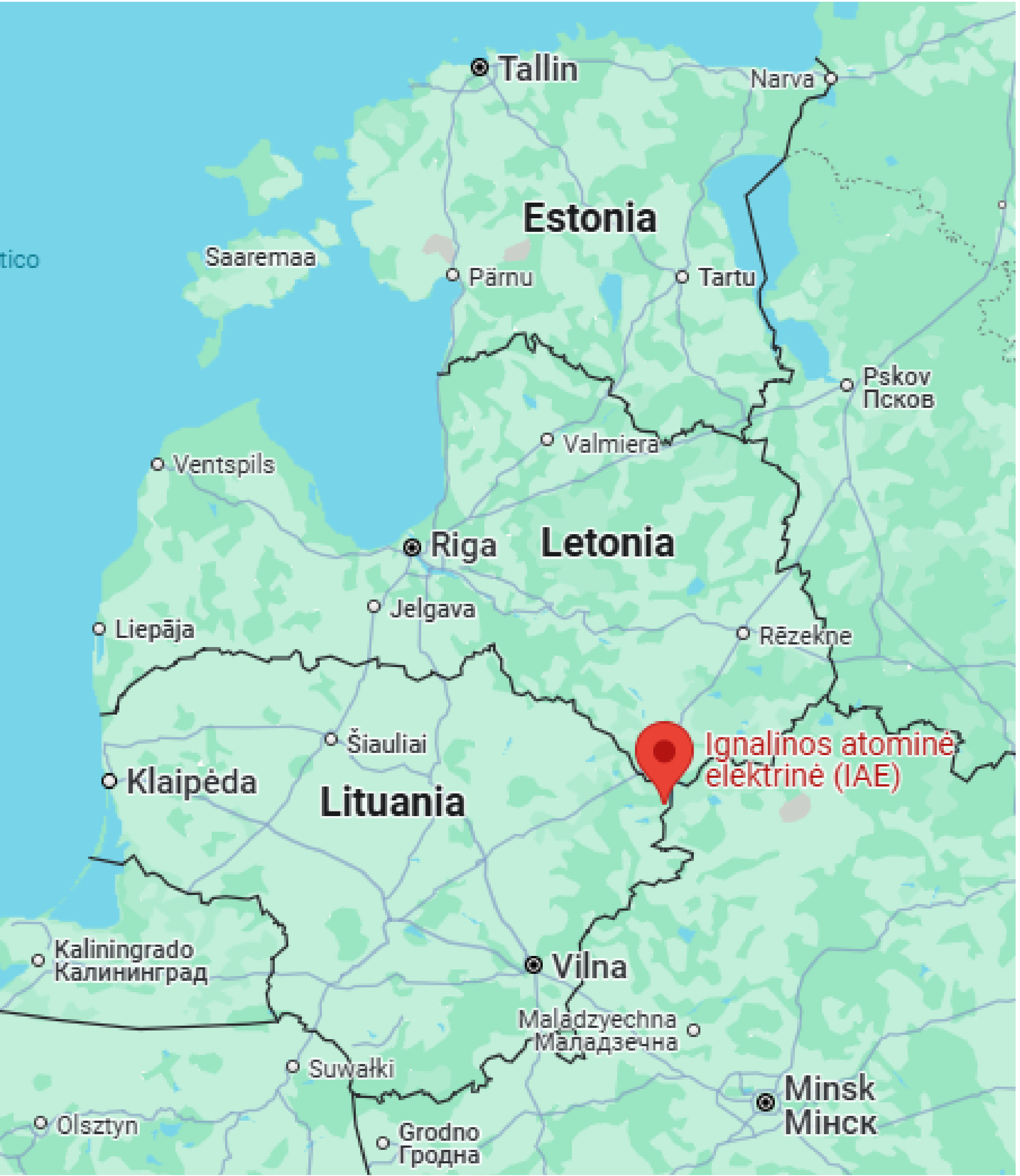
This knowledge product provides actionable insights for nuclear decommissioning operators, showcasing the use of remotely operated machines (ROMs) to reduce radiation dose loads during dismantling and waste management activities.

AUDIENCE

This knowledge product is intended to nuclear decommissioning operators, project managers, and technical teams involved in decommissioning nuclear power plants.

RELEVANCE

The product addresses challenges faced in high-dose areas, sharing lessons learned at Ignalina NPP to improve safety, performance, and technology application elsewhere.



CONTEXT

Ignalina NPP Nuclear Decommissioning Plan

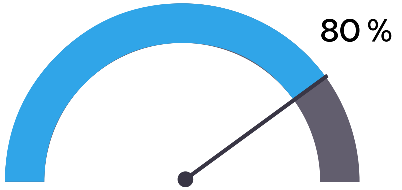
Ignalina NPP adopted the immediate dismantling strategy, closing its RBMK-1500 reactors in 2004 (Unit 1) and 2009 (Unit 2). The plan includes auxiliary facility dismantling, waste management, and infrastructure development.

Unit 1 — Commissioned 1983; Closed 2004; Dismatnling (starts) 2010

Unit 2 — Commissioned 1987; Closed 2009; Dismantling (starts) 2014

ELECTRICITY GENERATION, 2004

Nuclear (INPP U1, U2)	15.1 TWh
Gas	2.69 TWh
Oil	0.53 TWh
Hydro	0.42 TWh



INPP became the main electricity producer in Lithuania, with a share of 80 %.

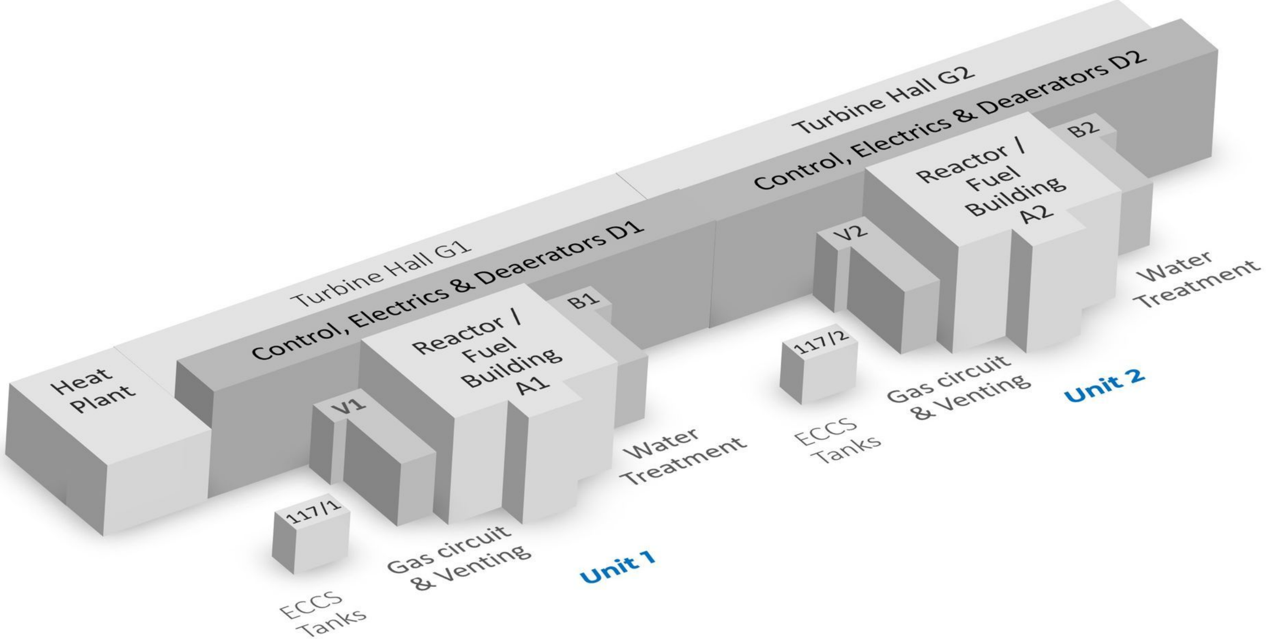
CONTEXT

Ignalina NPP Nuclear Decommissioning Plan

The Ignalina Nuclear Power Plant, once a major electricity provider in Lithuania, is undergoing **immediate dismantling** as per the strategy adopted in 2002.

Decommissioning includes Units 1 and 2, auxiliary facilities, and radioactive waste management infrastructure, and it is governed by the **Decommissioning Safety Requirements BSR-1.5.5-2015**. This approach ensures efficient dismantling while addressing safety, environmental, and economic considerations.

The plan, supported by **European Union funding and national contributions**, prioritizes in-house expertise and creates employment opportunities. Ignalina's lessons serve as a benchmark for similar projects across the EU.



- First RBMK decommissioning
- 2 x RBMK-2500 reactors
- Water-cooled, graphite-moderated
- Inmediate dismantling strategy
- Completion by end 2038
- Approximated cost: 3.400 M€

STRATEGY

REGULATION

FINANCING

National regulation (VATESI)

VATESI is the State Nuclear Power Safety Inspectorate

Order No. 22.3-216, November 30th, 2015, approved by the Head of State Nuclear Power Safety Inspectorate **"On the Approval of Nuclear safety requirements BSR-1.5.1-2019 "Decommissioning of Nuclear Facilities"**

Order No. 22.3-206, December 20th, 2016, approved by the Head of State Nuclear Power Safety Inspectorate **"On the Approval of Nuclear Safety Rules BST-1.5.1-2020 "The Evaluation of Compliance with Free Release Criteria of Buildings, Engineering Structures and Site of Nuclear Facilities"**

Law on Nuclear Energy of the Republic of Lithuania, 14 November 1996 No. I-1613; State Gazette, 11/12/1996.

Law on the decommissioning of Unit 1 of the State Enterprise Ignalina Nuclear Power Plant, 2 May 2000. No. VIII-1661; State Gazette, 22/06/2000.

Ignalina Nuclear Power Plant Decommissioning General Requirements (by VATESI)

Treaty of Accession to the European Union 2003. Protocol No 4 on the Ignalina Nuclear Power Plant in Lithuania

Legislation and relevant links (More.

Ignalina NPP Decommissioning Program Funding

The decommissioning funds are administered by several organisations, each having its own funds allocation mechanism and its own management rules, so that each of these funding mechanisms can be considered as a conditional source of funding.

The funds allocated to the decommissioning of the Ignalina NPP can be broken down into external support (granted by other states) and funds at the disposal of the entities of the Republic of Lithuania (internal sources).

Internal sources of funding

- Funds from the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund (ENF), administered by the Public Enterprise Lithuanian Energy Agency
- Funds from the budget of the Republic of Lithuania:
  - Funds from the specific Ignalina Programme, administered by the Ministry of Energy of the Republic of Lithuania;
  - Ministry of Interior funds for physical protection and fire safety in INPP
- Funds of the SE Ignalina NPP.

External sources of funding

- Ignalina International Decommissioning Support Fund provided by the EC and the Governments of 15 countries, administered by the European Bank for Reconstruction and Development (EBRD)
- The European Community Ignalina Programme Fund, administered by the Central Project Management Agency under the Ministry of Finance of the Republic of Lithuania
- European Union Structural Funds, administered by the Environmental Project Management Agency (EPMA).

Strategy: Inmediate Dismantling

Immediate Dismantling selected by Government for technical, social and financial reasons.

Why inmediate dismantling?

- Use of new waste facilities
- Use of existing workforce
- Use of existing services
- Lower total cost
- No future burden

Although compared to deferred dismantling...

- Higher initial cost
- No know-how from abroad
- Higher dose rates

Staffing matters

- A key factor in immediate dismantling that is being implemented using INPP's own resources.
- INPP by far the main employer in the region

ROMS AND THEIR APPLICATIONS

ROMs Examples and Features

This interactive presentation focuses on using ROMs for dismantling and decontamination tasks in high-radiation areas at Ignalina NPP. By sharing specific operational insights and challenges, this product seeks to assist operators in understanding and implementing these technologies in similar environments.

Attachments

At the Ignalina NPP, a range of remote-operated machines (ROMs) are employed, specifically the BROKK models 110, 170 and 200. This section presents these machines' technical specifications to exemplify the ROMs' capabilities utilized in the INPP Decommissioning Programme.

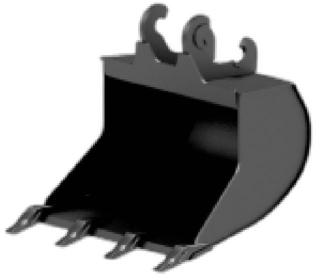
Feature	BROKK 110	BROKK 170	BROKK 200
Slewing speed	10 s/360°	10 s/360°	10 s/360°
Transport speed, max	2.5 km/h	2.1 km/h	2.1 km/h
Climbing inclination, max.	30°	30°	30°
Hydraulic system capacity	40 l	85 l	85 l
System pressure	18 MPa	18 MPa	18 MPa
Pump flow, 50 Hz	54 l/min	69 l/min	85 l/min
Power	19.5 kW	24 kW	27.5 kW
Width, min.	780 mm	780 mm	780 mm
Height, min.	1147 mm	1254 mm	1351 mm
Weight	990 kg	1600 kg	2100 kg
Horizontal reach	3700 mm	4400 mm	5100 mm
Vertical reach	4300 mm	4800 mm	5450 mm

Breaker

Concrete crusher

Metal shear

Drum cutter



Bucket

Clamshell bucket

Cutoff saw

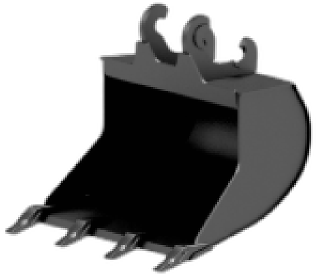
Sorting & demolition grapple

Breaker

Concrete crusher

Metal shear

Drum cutter



Bucket

Clamshell bucket

Cutoff saw

Sorting & demolition grapple

ROMS AND THEIR APPLICATIONS

Areas of Application of ROMs

ROMs at Ignalina NPP are primarily used in three critical areas: dismantling pipelines of various sizes and purposes in hard-to-reach zones, removing and safely disposing of radioactive waste from old burial sites, and dismantling massive concrete structures for decontamination.

This kind of machines have a **remote controller** and **specialised attachments**, such as hydraulic breakers for crushing concrete and steel cutters for slicing through metal components. These capabilities significantly enhance dismantling precision, reduce operator exposure to radiation, and streamline managing contaminated materials.

- **Dismantling and decontamination of concrete structures:** ROMs are effectively used for dismantling and decontaminating concrete structures. They can dismantle massive concrete blocks and perform their decontamination, significantly accelerating the dismantling process and reducing radioactive contamination.
- **Dismantling of pipelines:** ROMs are used for dismantling pipelines of different diameters and purposes. Their ability to operate in hard-to-reach places ensures safe and efficient pipeline dismantling, minimizing risks to personnel.
- **Disposal of waste:** ROMs enable the safe extraction and disposal of radioactive waste from old burial sites. Using remotely operated equipment reduces the radiation exposure to operators and the environment, providing more effective and safer disposal.

Concrete slab pretreatment

Concrete slab destruction

Metal pipe cutting

Attachment replacement

How to Change an Attachment?

ROM's are designed for versatility in demolition and cleanup tasks, relying on interchangeable attachments to adapt to specific operational requirements. The process of changing attachments involves precise handling, operator participation, and careful integration of the selected tools, ensuring seamless transitions between tasks. This capability enhances the machine's flexibility, allowing it to perform a variety of functions, such as breaking concrete, cutting steel, and clearing debris. Efficient attachment replacement is critical to maintaining operational flow, minimising downtime, and ensuring safety in high-radiation environments.

The following videos illustrate the attachment change process, from delivery to installation and application, highlighting the procedural steps and demonstrating the machine's adaptability in action.

Go back

Delivery of the attachment

This video showcases the delivery phase, where a crane with a capacity of up to 200 tons moves the new attachment to its designated installation site. Precision handling ensures the attachment is positioned correctly for integration with the ROM. This preparatory step is vital for efficient task execution, setting the stage for subsequent operations.

ROM attachment replacement

The operator begins by manually disconnecting the hydraulic system, ensuring safe detachment of the existing attachment. Using remote control, the operator then removes the attachment and installs the new one—a hydraulic breaker—designed for concrete demolition tasks. The entire procedure, which typically takes 15 to 30 minutes, depending on the operator’s proficiency, underscores the importance of skill and precision in maintaining workflow efficiency.

Hydraulic breaker replacement

Metal shear replacement

ROMS AND THEIR APPLICATIONS

Concrete Slab Pretreatment

A remotely controlled machine operated from a safe location performs the pretreatment of a concrete plate in a radioactive environment. The machine uses a specialised attachment to remove a thin outer layer of the surface, eliminating potentially radioactive particles quickly and without direct human involvement.

THE MACHINE

The machine is a compact remote-controlled demolition robot designed for versatility and high performance in confined spaces. It features a powerful 24 kW electric system, advanced hydraulic capabilities with variable load sensing, and a lightweight design. The unit has a 4.8 m vertical reach and a 4.4 m horizontal reach, supporting a variety of attachments such as breakers and crushers. With its ergonomic control system and low-noise operation, it is ideal for construction, nuclear decommissioning, and other demanding applications.

THE ATTACHMENT

The drum cutter is a robust attachment designed for precision demolition, trenching, and working with concrete surfaces. It offers a cutting depth of up to 30 mm and a cutting width of 480 mm, making it suitable for medium-sized applications. Weighing 160 kg, it is compatible with specific demolition robots and requires a drainage hose. The unit excels in handling soft or porous materials, efficiently performing specialized tasks such as shaping, grinding, or removing material in controlled environments.

THE PROCESS

See full process

Go back

The video showcases the ROM, equipped with a concrete slab, removing a thin superficial layer of concrete and eliminating potentially radioactive particles, thus carrying out the pretreatment process.

Concrete Slab Pretreatment

The concrete slab pretreatment process involves removing a thin superficial layer of concrete, eliminating potentially radioactive particles.

THE OPERATOR

THE PROCESS

Go back

Concrete Slab Destruction

The process of concrete slab destruction utilizes a remotely operated demolition machine equipped with a hydraulic breaker. This equipment generates significant hydraulic force to induce controlled fracturing and fragmentation of the concrete structure. The remote-control feature ensures operator safety by allowing operation from a secure distance, minimizing exposure to hazardous environments. The hydraulic breaker is designed for high-impact demolition, demonstrating precision and effectiveness in dismantling dense materials. This method is optimized for efficiency, combining safety, precision, and robust performance for heavy-duty demolition tasks.

THE MACHINE

The machine is a compact, remote-controlled demolition robot with a 24 kW electric system, 4.8 m vertical and 4.4 m horizontal reach, and advanced hydraulics. It supports versatile attachments and ergonomic, low-noise operation for demanding tasks like construction and decommissioning.

THE ATTACHMENT

The hydraulic breaker attachment is optimized for demolition tasks. It delivers 406 J/Nm of impact energy, operating at 850–1800 blows per minute. Weighing 205 kg, it is compatible with demolition machines in the mid-range category, designed to handle concrete and other tough materials effectively.

The attachment accommodates various chisels and tools for versatility in different applications. A drainage hose or additional fittings may be required based on the operational setup.

THE PROCESS

See full process

Go back

The video shows a remote-controlled demolition robot equipped with a hydraulic breaker, actively dismantling a concrete slab. The process involves the precise application of hydraulic force to fracture the slab into smaller fragments.

Concrete Slab Destruction

The video shows a remote-controlled demolition robot equipped with a hydraulic breaker, actively dismantling a concrete slab. The process involves the precise application of hydraulic force to fracture the slab into smaller fragments.

THE OPERATOR

THE PROCESS

Go back

Metal Pipe Cutting

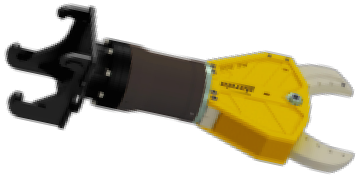
The ROM equipped with a steel cutter attachment, efficiently cuts through metal pipes and rebar during demolition work. The attachment utilizes advanced hydraulic power to generate high cutting force, allowing for precise and quick severing of various metallic materials, including pipes of different diameters. This process enhances demolition efficiency by ensuring that the machine can handle tough materials with minimal vibration and noise, contributing to a safer and more effective demolition operation, especially in confined or challenging environments.

THE MACHINE

The machine is a compact, remote-controlled demolition robot with a 24 kW electric system, 4.8 m vertical and 4.4 m horizontal reach, and advanced hydraulics. It supports versatile attachments and ergonomic, low-noise operation for demanding tasks like construction and decommissioning.

THE ATTACHMENT

The metal shear attachment is designed for efficient cutting of steel and metal materials in demolition and recycling applications. It features a 175 mm jaw opening and delivers a cutting force of 524 kN (66 tons). This shear offers high cutting capacity for a variety of metals, contributing to precise and powerful metal processing tasks in challenging environments. It is ideal for work where both compact size and high cutting efficiency are required.



THE PROCESS

See + diameters
Go back

The video showcases the ROM equipped with a steel cutter attachment, demonstrating its ability to efficiently cut through metal pipes of varying diameters and rebar during demolition. The machine’s powerful hydraulic system enables precise and effective cutting.

ROMS AND THEIR APPLICATIONS

Process and the ROMs setup applied summary

	CONCRETE SLAB PRETREATMENT		CONCRETE SLAB DESTRUCTION		METAL PIPE CUTTING	
Attachment model	Drum cutter		Hydraulic breaker		Metal shear	
						
Attachment features	**Feature**	**Value**	**Feature**	**Value**	**Feature**	**Value**
	Cutting depth	0 - 30 mm	Hitting power	406 J/Nm	Jaw opening	175 mm
	Cutting width	480 mm	Blows/min	850 - 1800	Cutting force	524 kN/66 t
	Weight	160 kg	Weight	205 kg	Weight	380 kg

Global process

A. PRETREATMENT - DECONTAMINATION

B. BREAKING - DEMOLITION

C. CUTTING

D. COLLECTION AND DISPOSAL

BENEFIT ASSESSMENT

Benefits Associated to ROMs in Nuclear Decommissioning

The deployment of ROMs at Ignalina NPP has significantly enhanced safety by eliminating direct operator exposure in hazardous areas, ensuring zero dose loads during tasks like pipeline cutting. Their efficiency in confined and high-dose environments accelerates dismantling timelines while maintaining precision. The adaptability of ROMs, with interchangeable attachments for diverse tasks, offers high potential applicability to similar decommissioning projects across the EU. Although innovative, their use provides immediate value by optimizing existing processes and improving radiation protection measures.

- **Safety:** The use of ROMs eliminates direct exposure, achieving zero dose loads during operations. Zero dose loads during operations (e.g., pipe cutting).
- **Performance:** The use of ROMs has proven to deliver high accuracy and efficiency, especially in confined spaces and high-radiation zones.
- **Applicability:** The experience gained at Ignalina NPP in the use of ROMs demonstrates significant potential for adoption across EU decommissioning projects, offering high transferability to similar initiatives.

Despite the benefits, deploying ROMs at Ignalina NPP presented challenges, including lengthy operator training, frequent hydraulic failures, and reliance on spare parts, which caused occasional delays. However, Ignalina effectively overcame these obstacles through comprehensive training, proactive maintenance, and efficient spare parts management. These solutions provide valuable insights for other nuclear decommissioning operators, helping to ensure a smoother and more efficient transition to ROM-based operations while maximizing safety and performance.

- **Operation and maintenance:** The use of ROMs enhances existing decommissioning processes, though challenges persist in equipment training and maintenance, requiring ongoing attention to ensure optimal performance.
- **Training:** The training required for effective ROM operation is time-intensive, often taking up to two months, which can delay project timelines.
- **Hydraulic failures:** ROMs are prone to hydraulic system failures, which necessitate regular maintenance and can lead to unexpected downtime.
- **Reliance on spare parts:** The need for specialized spare parts creates dependency, with long delivery times contributing to operational delays and increased downtime.

Preparation for ROMs Deployment

Proper deployment of ROMs requires detailed planning and preparation. The present section shows a quick guidelines for ROMs deployment as per the experience gained in Ignalina NPP, establishing several steps to maximise the benefits of using ROMs in nuclear decommissioning.

Technical preparation

- Conduct a detailed audit of the work areas where the ROMs will be used to ensure compliance with dimensional, floor loading and accessibility requirements for equipment transport.
- Evaluate and, if necessary, strengthen the load-bearing capacity of floors and slabs in the work areas to support the additional loads from the ROMs.

Workspace organisation

- Clear and prepare work areas by removing excess equipment and providing adequate space for ROM manoeuvring.
- Ensure that aisles and doors are wide enough to move the ROMs to their deployment locations.

Equipment setup

- Select appropriate ROM models, depending on the specific tasks and working conditions.
- Set up and test attachments, including hydraulic shears and circular saws, to ensure functionality and safety.

Operator training

- Train operators to operate the ROM, including theoretical knowledge and practical skills.
- Develop and conduct safety drills, particularly concerning remote control and operation in radiation-hazardous environments.

Maintenance

- Inspect CCTV and remote control systems, particularly their radiation resistance and reliability.
- Carry out ROM pre-maintenance, including checking hydraulic systems, electrical circuits and mechanical connections.

Experience gained by Ignalina NPP on ROMs

Several lessons emerged from using ROMs at Ignalina NPP. Limited camera coverage on the machines hinders workflow monitoring, necessitating additional cameras for improved visibility. Operator training is time-intensive, taking up to two months, with skills requiring refreshment after extended breaks. Skilled personnel are indispensable but challenging to replace. Hydraulic system failures and lengthy spare parts delivery times cause frequent delays, while deploying ROMs often requires specialized structures and robust communication systems. These challenges underline the importance of streamlining training, ensuring spare part availability, and improving equipment reliability.

To address identified challenges, it is recommended that ROMs be equipped with additional cameras for enhanced operator visibility and improved navigation system comfort. Shortening training durations using advanced simulations and retaining skilled operators through refresher programs are essential. Maintaining an on-site stock of critical spare parts can mitigate downtime, and pre-emptive maintenance routines for hydraulic systems should be implemented. Lastly, robust communication networks and tailored workplace setups are necessary to maximize ROM efficiency.

OPERATION

MONITORING

TECHNICAL

PERSONNEL

Personnel

- **Long and complex training**
  The ROMs repair and maintenance process involves a number of complexities, including the following procedures: removing the ROMs from the site, decontaminating it if necessary, repairing it and then returning it to the site. All of these steps take a significant amount of time and human resources.

- **Skills forgotten after a break**
  Skills acquired during training can be partially lost after extended vacations and illness. This leads to the need for additional training and can reduce performance when employees return.

- **Personnel indispensibility**
  Trained professionals become extremely valuable, and their absence (e.g., due to illness or leave) causes serious problems, such as difficulty finding a replacement.

- **Limited personnel suitability**
  Working on ROM equipment requires certain skills and psycho-physical qualities that young people better master. Not all categories of workers can successfully perform these tasks.

Operation

- **Workplace organisation**
  Due to the scale and specificity of the equipment, careful workplace organization is required. This includes placing the necessary equipment, ensuring safety and creating a comfortable environment for operators.

- **Communication needs**
  Robust and reliable communications, such as Wi-Fi or wired networks, are required for efficient operation, requiring additional equipment and maintenance.

Monitoring

- **Lack of cameras on the ROMs themselves**
  Not enough cameras are installed on the ROMs themselves, which makes it difficult for the operators to monitor the process. The limited number of cameras makes controlling and monitoring the workflow less efficient and, therefore, requires the installation of additional cameras in the work area.

- **Uncomfortable camera navigation**
  Existing cameras do not provide a complete view and require considerable effort to navigate effectively. It is difficult for operators to get complete and accurate information about the current status and position of equipment. It takes a long time to get used to navigating through the cameras.

Technical

- **Repair and maintenance difficulties**
  The ROMs repair and maintenance process involves a number of complexities, including the following procedures: removing the ROMs from the site, decontaminating it if necessary, repairing it and then returning it to the site. All of these steps take a significant amount of time and human resources.

- **Long spare parts delivery time**
  Long waiting times for spare parts lead to significant loss of time and downtime. Lack of spares exacerbates the problem.

- **Frequent hydraulic failures**
  Equipment hydraulic systems are prone to frequent failures and ruptures, requiring regular maintenance and repairs and increasing equipment downtime.

- **Need for special structures**
  Special structures and transportation are required to transport the ROM to the dismantling site, which adds complexity and increases lead time.

Conclusion

Implementing ROMs at Ignalina NPP highlights their transformative role in enhancing safety and efficiency in high-dose decommissioning environments. While challenges like training duration and equipment maintenance exist, the benefits in radiation protection and dismantling precision make these technologies invaluable.

This knowledge product aims to enable other operators to effectively adopt and adapt ROM technologies in their decommissioning efforts by sharing lessons learned and providing actionable recommendations.