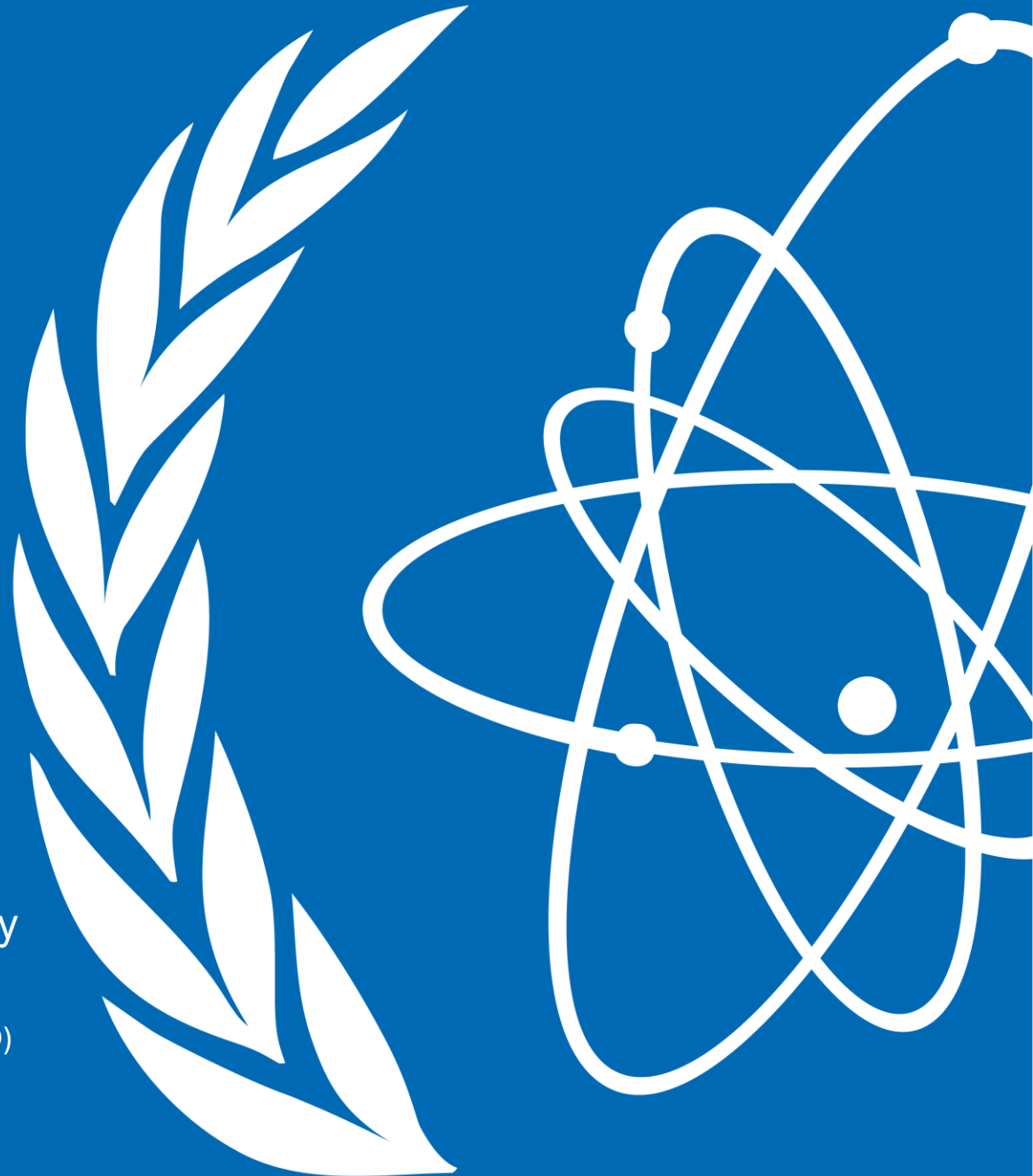


Safety Considerations for Innovative Technologies in Decommissioning

Duriem Calderin Morales, PE, CHP

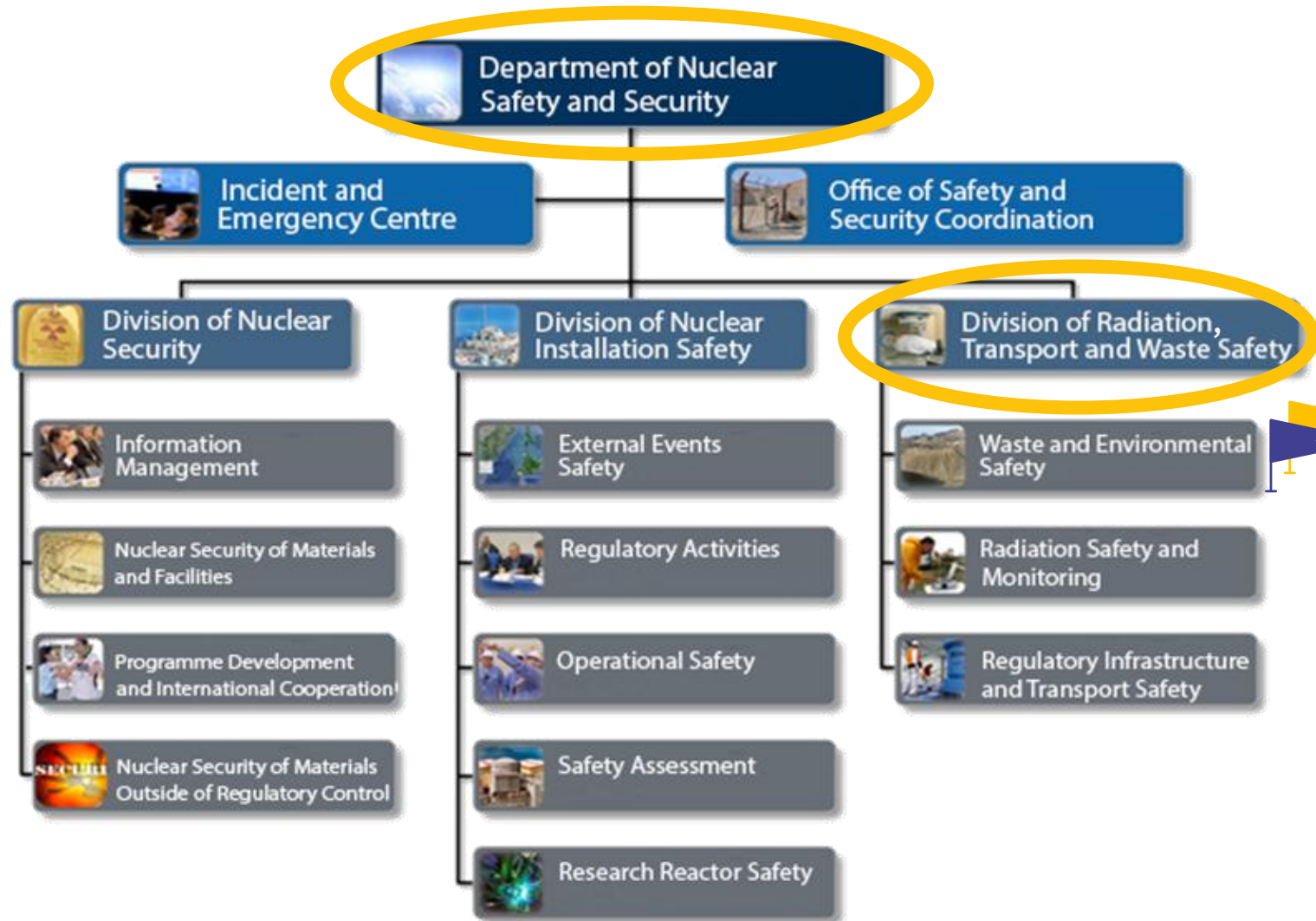
Decommissioning and Remediation Unit (DRU)
Nuclear Safety, Division of Radiation Transport and Waste Safety

Webinar: Robots and drones in nuclear decommissioning.
Digital twins and Ontology for Robot Assisted Decommissioning Operations (DORADO)
June 25th 2026



DEPARTMENT OF NUCLEAR SAFETY AND SECURITY (NSS)

- The Division establishes safety standards for radiation protection, management of radioactive waste and environmental releases, decommissioning, remediation and transport.
- Supporting Member States with expertise on decommissioning, spent fuel, waste management safety and environmental remediation.
- Making sure we protect the workers, the public, and the environment while enabling nuclear science and technology.





Outline

- IAEA Safety Fundamentals
- Safety Requirements and Guides for Decommissioning of Facilities
 - Decommissioning Plan
 - Safety Assessment
 - Emerging Technologies safety considerations and approaches
- Selected Safety Report for Future considerations
- Upcoming Events
- Conclusions



SAFETY STANDARDS



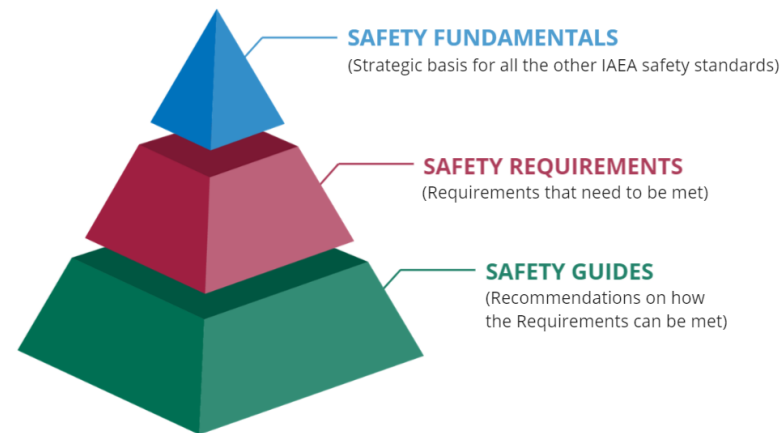
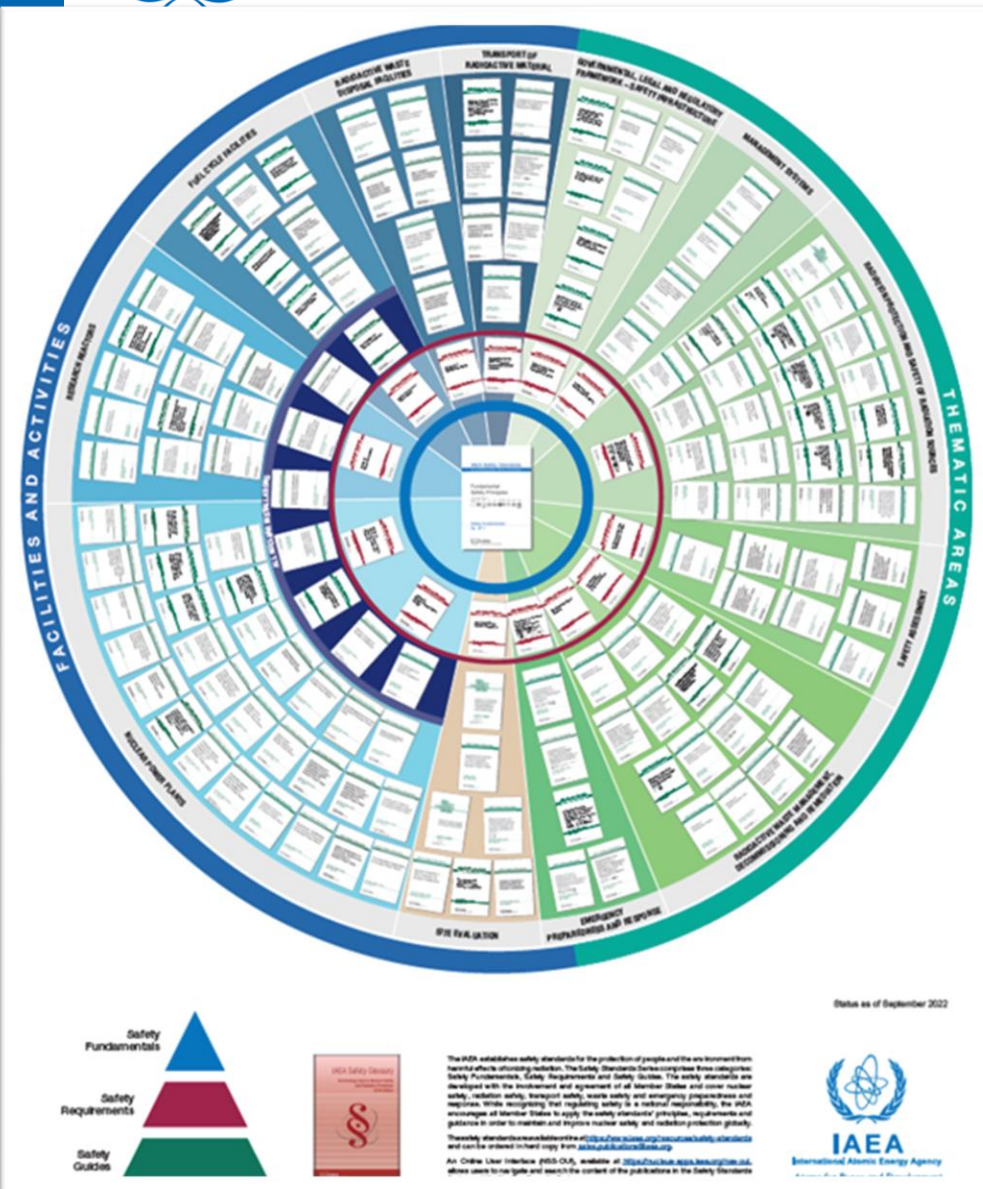
IAEA

Safety Standards Review

Safety means the protection of the people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks.

Highest standards of safety to assure:

1. To control the radiation exposure of people and the release of radioactive material to the environment;
2. To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
3. To mitigate the consequences of such events if they were to occur.



International Consensus

Safety Fundamentals Principles

IAEA Safety Standards

for protecting people and the environment

Fundamental Safety Principles

Jointly sponsored by

Euratom FAO IAEA ILO IMO OECD/NEA PAHO UNEP WHO

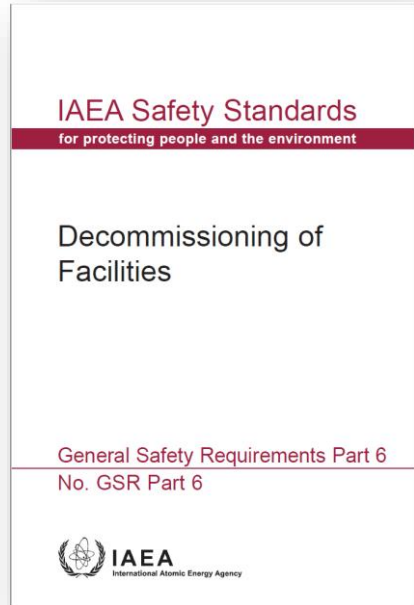


Safety Fundamentals

No. SF-1

- **Principle 1:** Responsibility for safety
- **Principle 2:** Role of government
- **Principle 3:** Leadership and management for safety
- **Principle 4:** Justification of facilities and activities
- **Principle 5:** Optimization of protection
- **Principle 6:** Limitation of risks to individuals
- **Principle 7:** Protection of present and future generations
- **Principle 8:** Prevention of accidents
- **Principle 9:** Emergency preparedness and response
- **Principle 10:** Protective actions to reduce existing or unregulated radiation risks

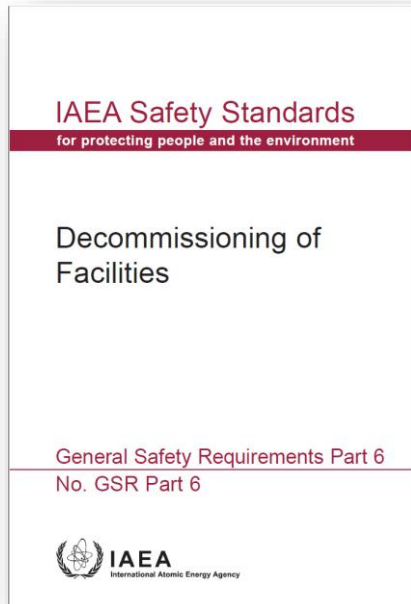
Decommissioning of Facilities Safety Requirements



1. Optimization of protection and safety in decommissioning
2. Graded approach in decommissioning
- 3. Assessment of safety for decommissioning**
4. Responsibilities of the government for decommissioning
- 5. Responsibilities of the regulatory body for decommissioning**
- 6. Responsibilities of the licensee for decommissioning**
7. Integrated management system for decommissioning
- 8. Selecting a decommissioning strategy**
9. Financing of decommissioning
- 10. Planning for decommissioning**
- 11. Final decommissioning plan**
12. Conduct of decommissioning actions
13. Emergency response arrangements for decommissioning
14. Radioactive waste management in decommissioning
- 15. Completion of decommissioning actions and termination of the authorization for decommissioning**

Decommissioning: refers to the administrative and technical actions taken to allow the removal of some or all the regulatory controls from a facility.

Decommissioning of Facilities Safety Requirements (cont)



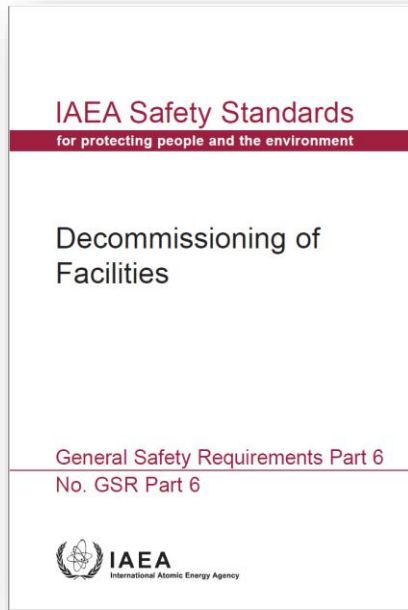
Requirement 3: Assessment of safety for decommissioning

Safety shall be assessed for all facilities for which decommissioning is planned and for all facilities undergoing decommissioning.

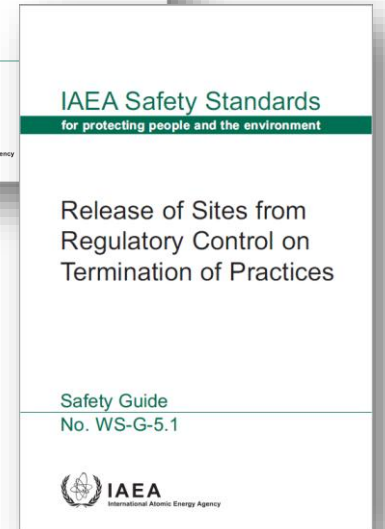
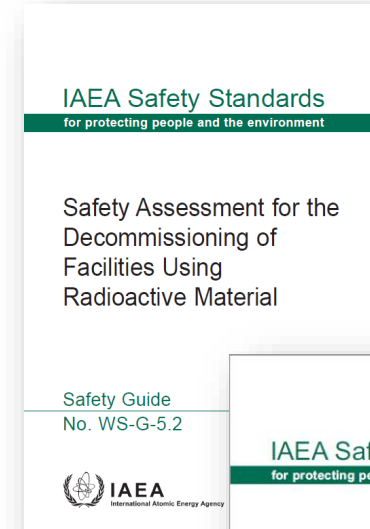
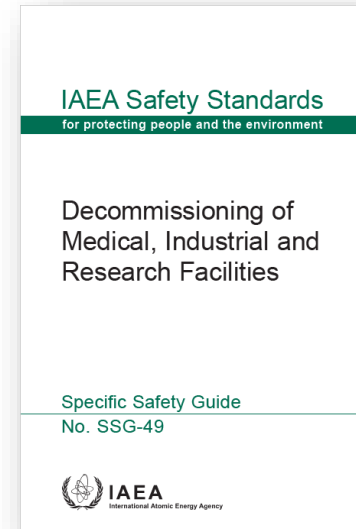
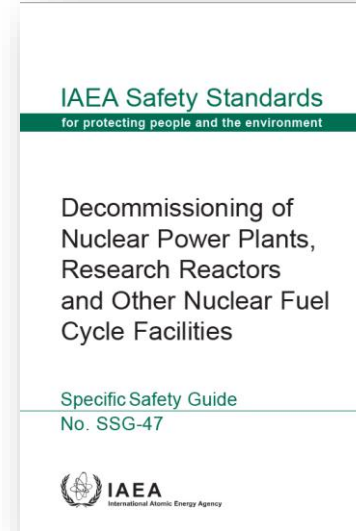
2.6. The final decommissioning plan shall be supported by a safety assessment addressing the planned decommissioning actions and incidents, including accidents that may occur or situations that may arise during decommissioning.

2.7. The supporting safety assessment shall be prepared by the licensee in accordance with Ref. [8].

Guidance on Meeting Safety Requirement 15 using Graded Approach – in Decommissioning

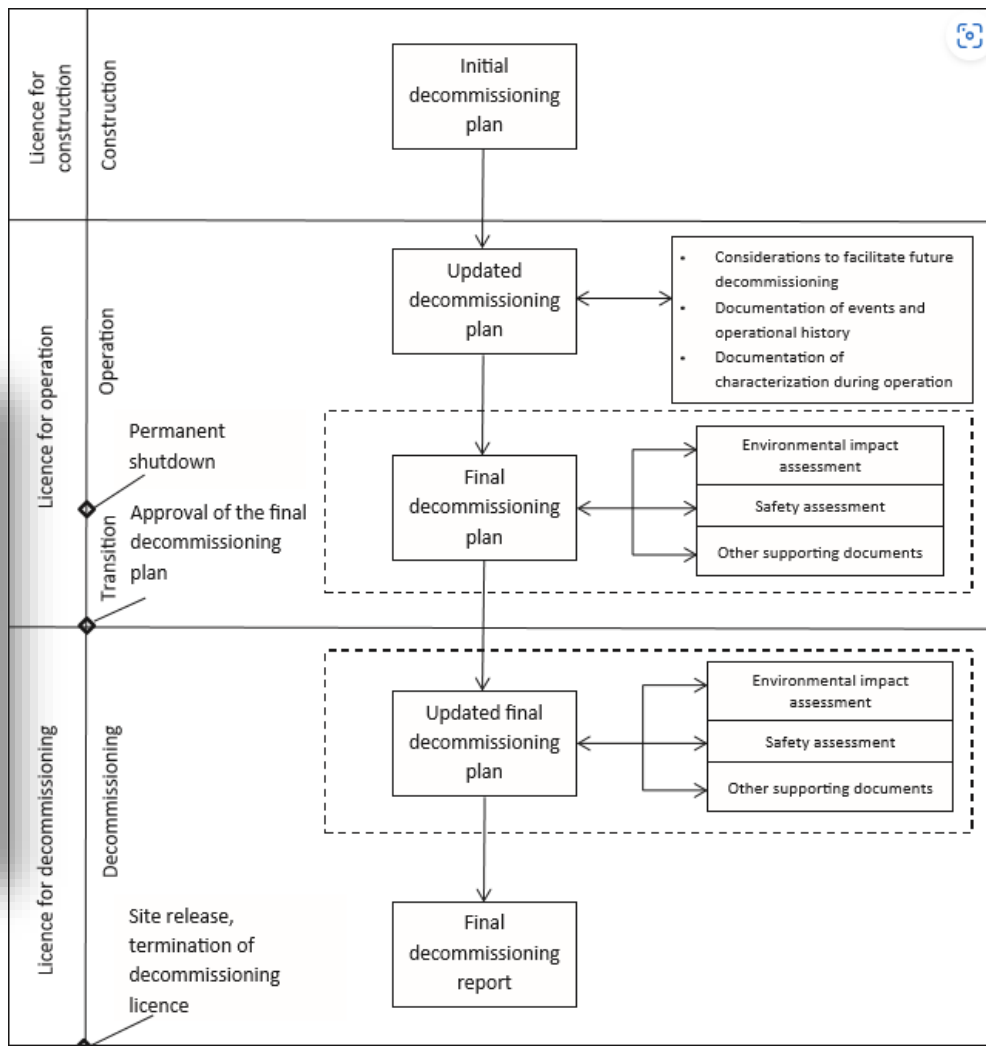


Specific Safety
Guidance for
Types of
Facilities and
Activities



Both Safety Guides are
under Revision!

Key Specific Safety Guides for Decommissioning Safety



Planning For Decommissioning During the Lifetime of the Facility

- Planning for decommissioning is required to **start at the design stage** and to continue throughout the **lifetime of a facility**
- The **decommissioning plan** should be **periodically reviewed and updated**, typically every **five years** or as prescribed by the **regulatory body**
- Relevant Features to Facilitate Decommissioning
- Considerations for Older Facilities
- Unanticipated Permanent Shutdown

Requirement 2: Graded approach in decommissioning

IAEA Safety Assessment for the Decommissioning of Facilities Using Radioactive Material (WS-G-5.2)

IAEA Safety Standards

for protecting people and the environment

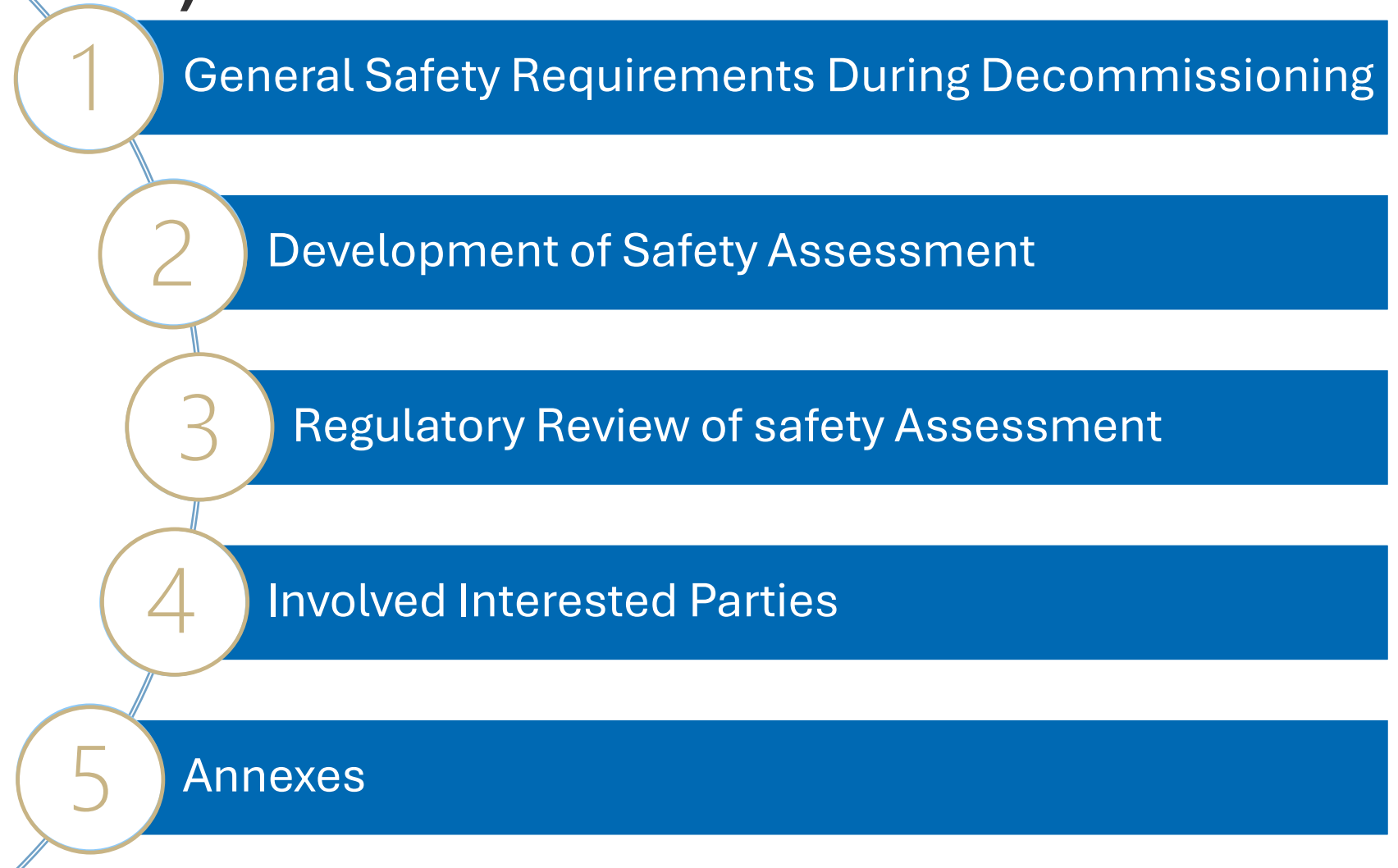
Safety Assessment for the
Decommissioning of
Facilities Using
Radioactive Material

Safety Guide

No. WS-G-5.2



Under Revision



IAEA Safety Assessment for the Decommissioning of Facilities Using Radioactive Material (WS-G-5.2)

IAEA Safety Standards

for protecting people and the environment

Safety Assessment for the
Decommissioning of
Facilities Using
Radioactive Material

Safety Guide

No. WS-G-5.2



Section 3: An overview of general considerations for safety assessments for decommissioning

- Graded Approach
- Hazards during Decommissioning
- Defence in depth
- Safety Functions
- Optimization
- Long term Safety
- Engineering Analysis
- Uncertainties
- Material Management & Systems
- Emerging Technologies and Novel Facilities

Under Revision

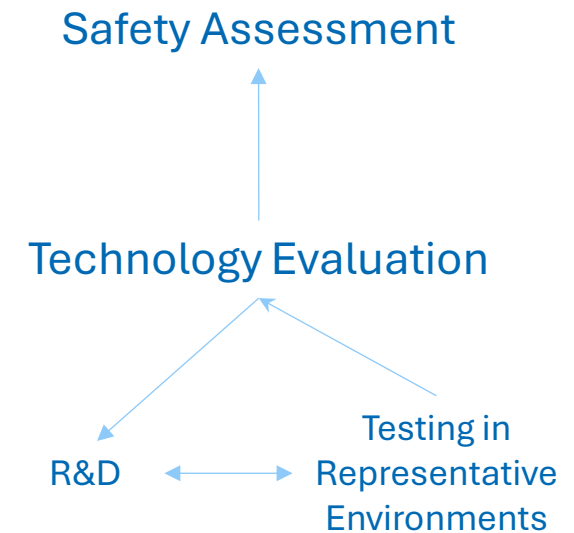
Safety Considerations for Emerging Technologies (*draft*)

- If the safety assessment for decommissioning considers the use of **computer codes** or **calculational methods** for **safety** (dose consequence calculations, digital twins, inspections of SSCs, waste segregation, surveys or other novel technologies), then **this code or program** should undergo **verification** and **validation** process in alignment with **national requirements** and international standards
- If **novel technologies** (e.g. robotic systems, unmanned aerial vehicles, laser cutting systems, other tools), introduce **novel failures modes** not traditionally accounted in **decommissioning safety assessments**, their associated **risks**, **hazards**, and **uncertainties** should be **evaluated**.
- The safety assessment should evaluate **specific design features** of these **technologies relevant to safety** (e.g. total **ionizing dose tolerance**, **temperature**, humidity, etc.), such that no additional **incidents** or **hazards** remain **unaccounted** for.
- If new hazards are identified, then **safety measures** should be **implemented** to mitigate them.

Generic Example

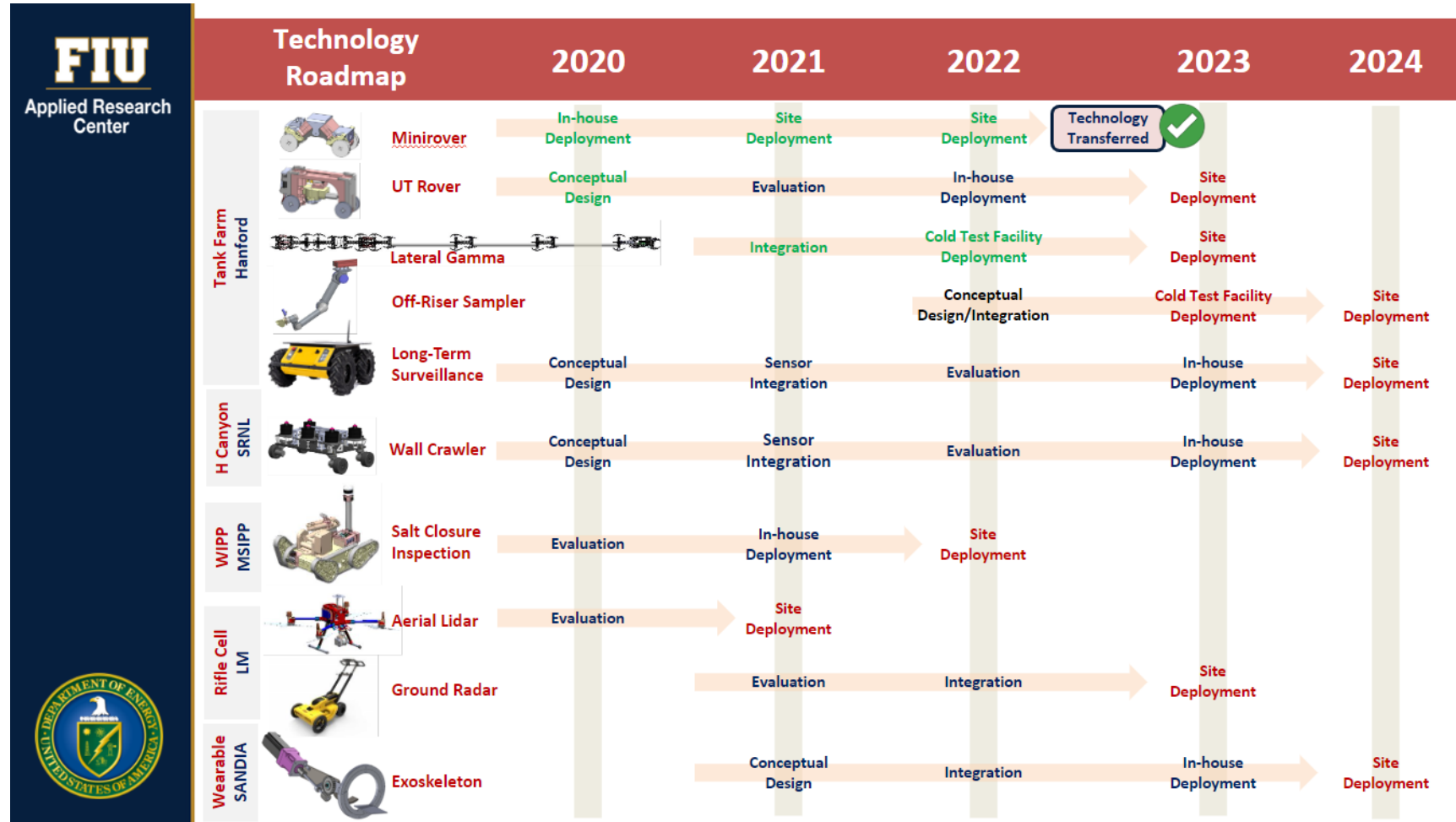


Propose to use emerging technologies to optimize safety and protection



Technology Maturation Before Deployment

Florida International University , Miami, FL, USA



Special thanks to Leonel Lagos from Florida International University for providing Robotics content and all their work to advance decommissioning technologies

European Cutting-edge Laser Technology for Decommissioning

[Home](#)[Nuclear Reactors Dismantling](#) ▾[About LD-SAFE consortium](#)[Collaborators](#)[Project Deliverables](#)A photograph of three large, cylindrical nuclear reactor cooling towers against a blue sky with some clouds. The towers are made of metal and have a ribbed texture. The central tower is emitting a plume of white steam or smoke.

Laser Dismantling Environmental and Safety Assessment

“The decommissioning of a power reactor can take up to several decades after it ceases its operation. As a result, the EU supports innovations that improve existing technologies for dismantling, risk characterisation and assessment, on-site waste management and environmental remediation.”

Upcoming Event in Safety for Decommissioning

Technical Meeting (TM) on Member States' Practical Experience in Safety Assessments for the Decommissioning of Facilities.

Objectives

- Share the updates proposed as part of the revision of the IAEA Safety Guide WS-G-5.2 Safety Assessment for the Decommissioning of Facilities Using Radioactive Materials.
- Support the development, implementation, revision and regulatory review process of safety assessments for decommissioning of facilities.
- Promote consistent and effective application of safety assessment principles for decommissioning of facilities to ensure safe conduct of decommissioning actions and achieving the decommissioning end state.
- Capture Member States' good practices during safety assessment for decommissioning of facilities with consideration of graded approach for all type of facilities (ranging from medical, industrial and research facilities, nuclear fuel cycle facilities, research reactors to nuclear power plants). Also, the safety considerations for using **novel facilities and technologies** for **decommissioning**.

Dates: October 5th-9th 2026 Vienna, AT

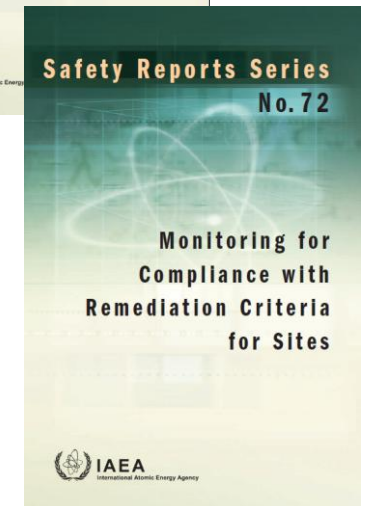
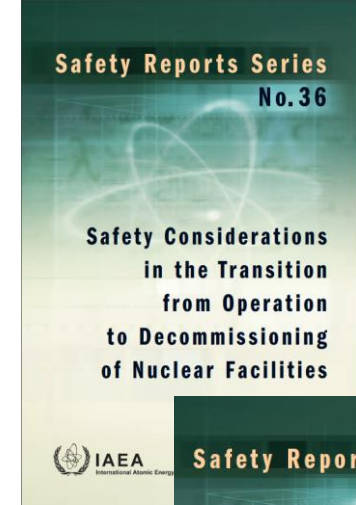
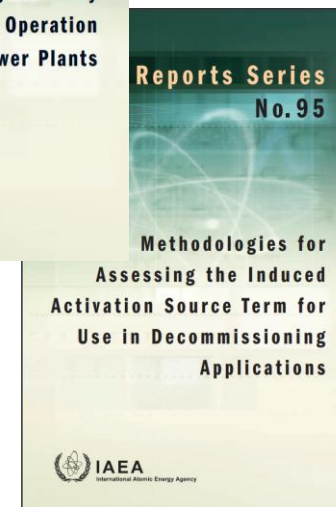
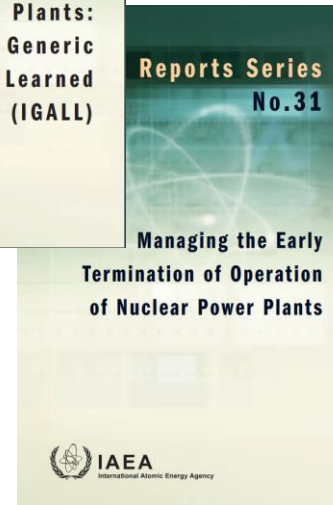
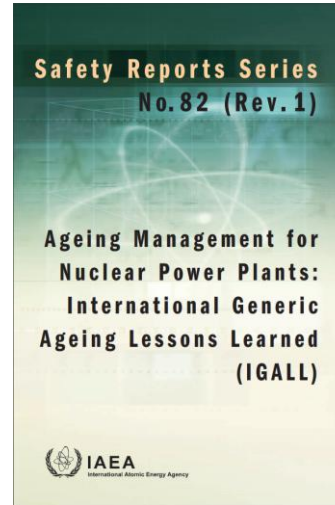
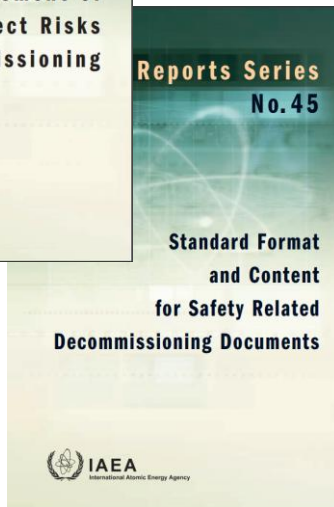
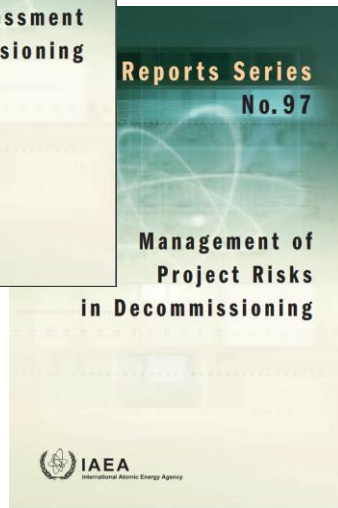
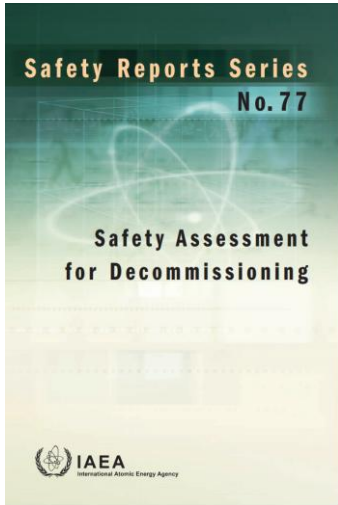
Scientific Secretary: Yulia Gorlova

Email: Y.Gorlova@iaea.org

Chairperson: Patrice Francois, ANR, France

Selection of Additional Relevant Safety Reports

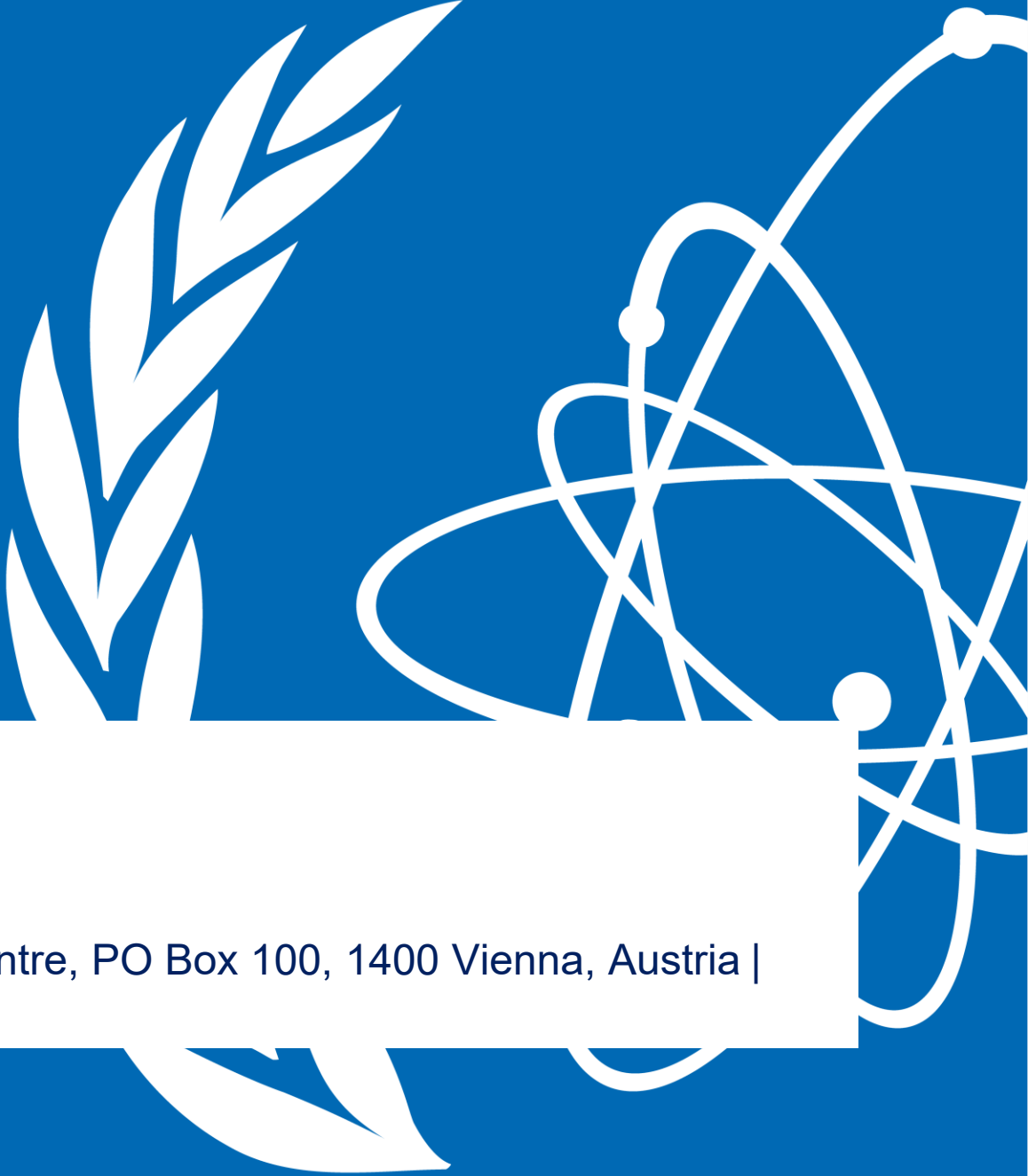
Provides Experience from Member States on Meeting the Safety Standards using relevant methodologies and technologies





Conclusions

- **Emerging technologies** has the potential to optimize safety and protection but their inherent **risks and hazards should be evaluated**.
- Use systemic approaches for evaluate **new hazards and failure modes**, consider additional safety measures needed to mitigate potential consequences and incidents.
- Apply the **graded approach**: qualification, testing in representative environments and controls should match radiological and industrial risk.
- Integrate technology choices into the **decommissioning plan, safety assessment, emergency arrangements and waste/material management**.
- **Key message**: innovation improves safety when it is mature, justified, controlled and continuously reassessed.



Thank you!

Duriem Calderin Morales

Decommission and Remediation Unit (DRU)

Nuclear Safety and Radioactive Waste (NSRW)

Department of Nuclear Safety and Security

International Atomic Energy Agency | Vienna International Centre, PO Box 100, 1400 Vienna, Austria |

Email: D.Calderin-Morales@iaea.org | T: +(43) 1260022372



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THANK YOU