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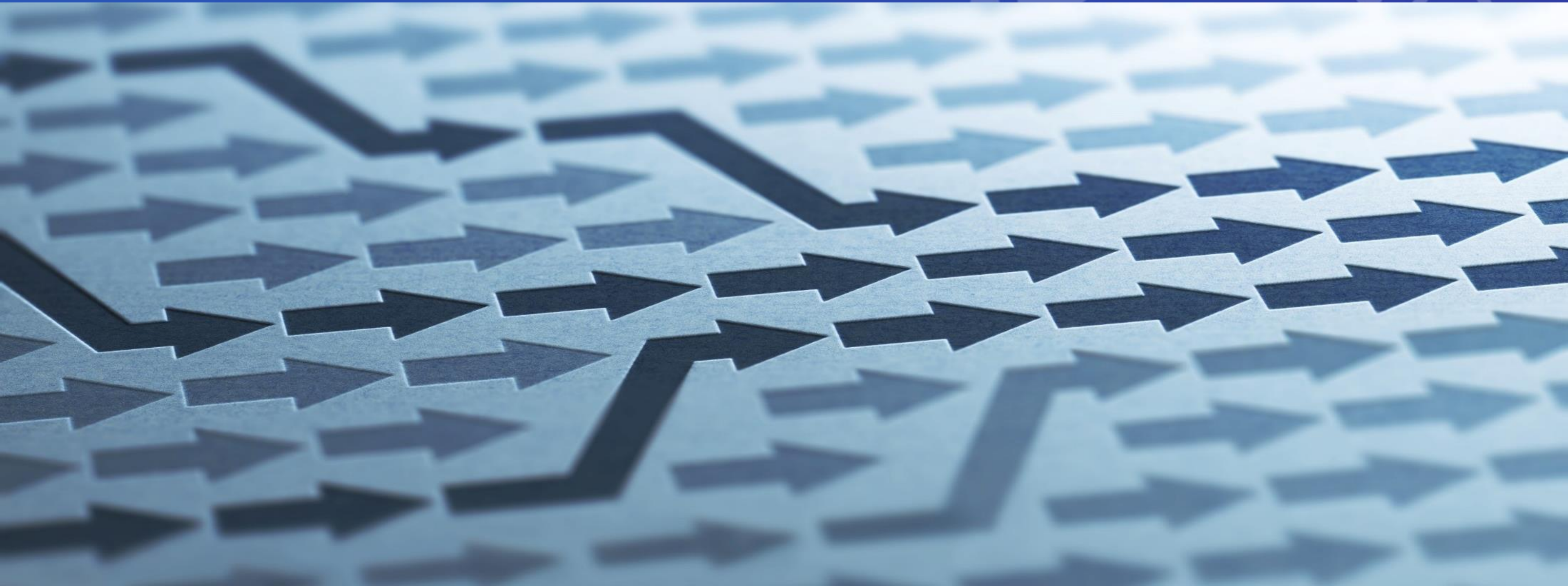
International Atomic Energy Agency
Atoms for Peace and Development

Webinar on Safety, Security and Safeguards Interfaces and Challenges for Novel Advanced Reactors

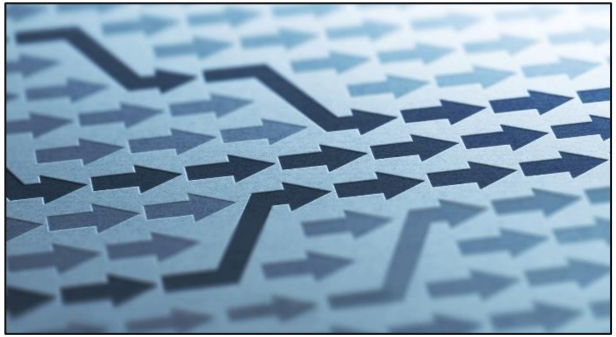


Webinar objectives

- This is the second Webinar in the series of webinars on safety of Novel Advanced Reactors
- First Webinar was dedicated to the **Design Safety** aspects of these Reactors (slides and recording are here)
- **Objective of this Webinar**: share the outcomes of recent IAEA work on 3S for NARs
  - Safety, Security and Safeguards Interfaces
  - Security and Safeguards Challenges

Webinar agenda

1. **Opening remarks** – A. Bradford (Dir-NSNI, IAEA)
2. **Overview of 3S for Novel Advanced Reactors** – S. Poghosyan (SAS, IAEA)
3. **Security challenges for Novel Advanced Reactors** - K. Horvath (MAFA, IAEA)
4. **Safeguards challenges for Novel Advanced Reactors** – J. Whitlock (CCA/IAEA)
5. **Remarks from SGCP** – G. Dyck (A/Dir-SGCP, IAEA)
6. **Panel discussion on 3S Interfaces**
7. **Closing remarks** – E. Buglova (Dir-NSNS, IAEA)



Questionnaire (Poll)

- **Questionnaire** is open in Webex (Poll tab)

- **6 questions** related to the following aspects:
  - Your area of expertise (Safety, Security, Safeguards)?
  - 3S concept in national regulations and within institutions
  - 3S interfaces and challenges (synergies, conflicts)
  - Needs in Member States/IAEA role

- **Your feedback** is important to tailor our further activities

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Overview of Safety, Security and Safeguards considerations for Novel Advanced Reactors

Shahen POGHOSYAN
Safety Assessment Section (SAS)
Division of Nuclear Installation Safety (NSNI)
Department of Nuclear Safety and Security (NS)
International Atomic Energy Agency (IAEA)

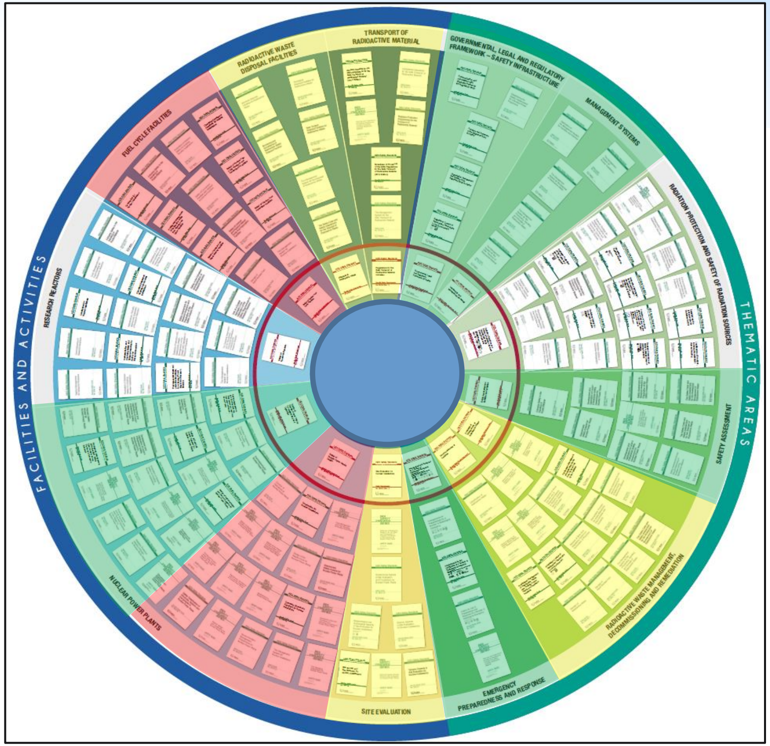
3 February 2022

Background information

Under the overarching project on **Review of applicability of IAEA Safety Standards to Novel Advanced Reactors**

- including small modular reactors (SMRs), high temperature gas cooled reactors (HTGRs), sodium fast reactors (SFRs), lead fast reactors (LFRs), molten salt reactors (MSRs), marine-based SMRs and micro-sized reactors

Dedicated part on 3S considerations



Objective

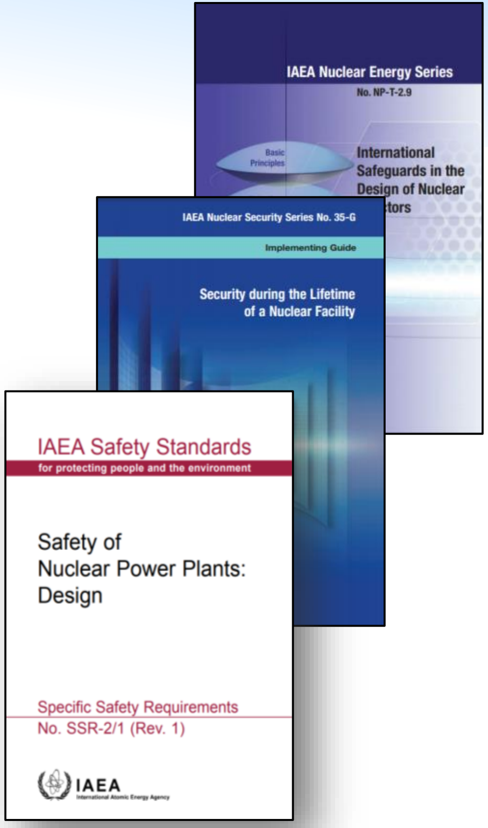
Describe the gaps, challenges and potential **interfaces** between Safety, Security and Safeguards for novel advanced reactors

- conflicts and synergies

In addition to Safety: to outline the Challenges for Security and Safeguards

- conditioned by the novelties*

Novelty – any known difference related to the: site, design, construction, commissioning, operation, safety assessment and regulation between NARs and Reference LWR

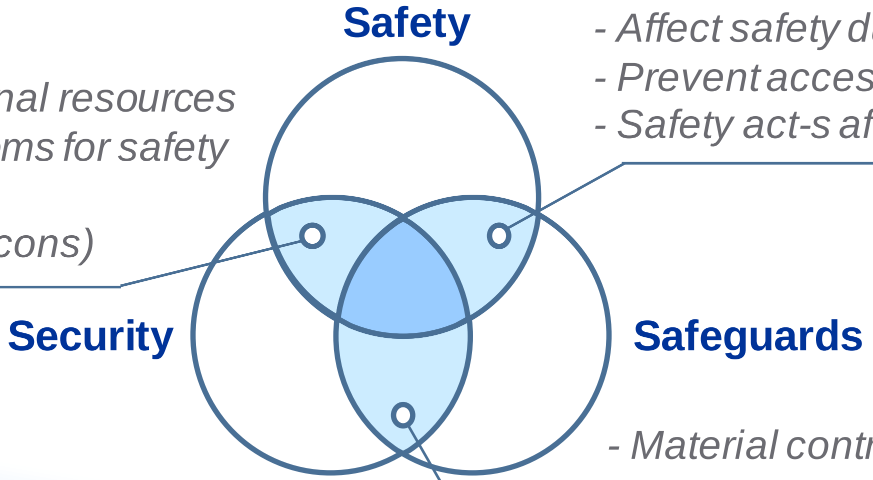


Novelties vs challenges

Transportability	New hazards, SG shipment obligations, Security treats
Locations (remote, urban)	Safety demonstration, Security arrangements (no human presence), Safeguardability - unannounced inspections
New fuel concepts	Change of safety metrics, Smaller size (diversion, storage geometry), Online refueling moving fuel verification
Long refueling periods	Material characteristics, no access to the fuel
Higher enrichment	More resources for SG
Factory sealed cores	Potential safety issues (criticality), SG during manufacturing
Highly integrated software-based systems	Complexity (multi-modularity), HFE - shared MCRs, increased potential for the cyber-attacks

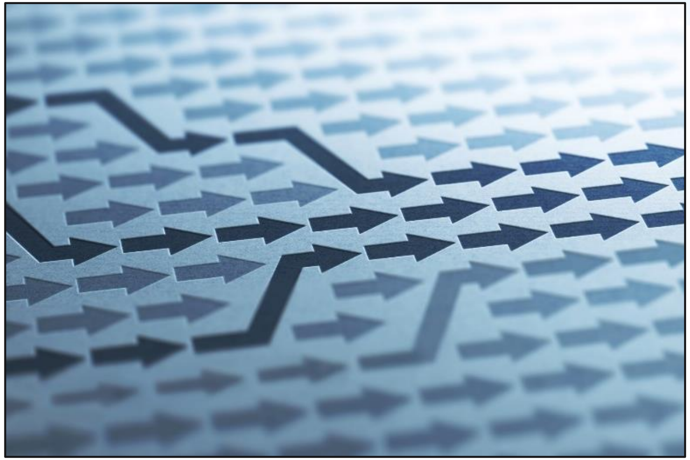
Interfaces

	Threat	Consequences
Safety	System failure, human error, or natural disaster	Radioactive releases from authorized activities
Security	Sabotage, external attack, or insider malicious act	Intentional misuse of radioactive materials
Safeguards	Diversion or misuse	Acquisition of nuclear weapons



Potential synergies

- Optimal design solutions
- NM Accountancy and Control
- Access control systems
- Legal and regulatory framework
- Fuel manufacturing
- …



Key messages

- **Novelties** in advanced reactors (e.g. SMRs) bring many benefits, but also provide specific challenges

- **Gap** in relation to holistic approach to Safety, Security and Safeguards (lack of guidance, examples, practice, experience)

- **Unique opportunity** to address holistic approach to 3S in the early design stage of novel advanced reactors

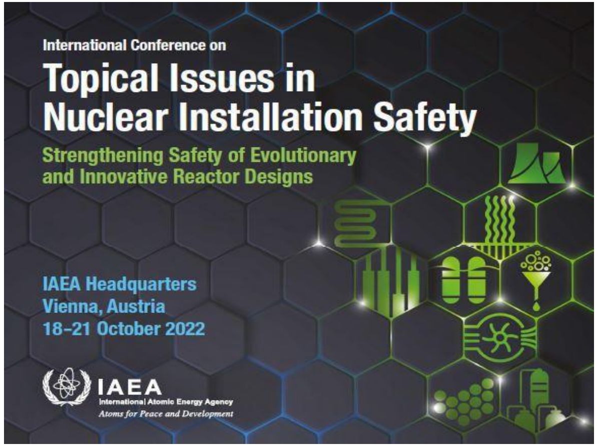
Upcoming events on 3S

Technical Meeting on Safety-Security-Safeguards by design for SMR

- Vienna + virtual, 1-3 June 2022
- Nomination request sent - deadline 23 March

International Conference on Topical Issues in Nuclear Installation Safety: Strengthening Safety of Evolutionary and Innovative Reactor Designs

- Vienna + virtual, 18-21 Oct 2022
- Conference web-page
- Abstract submission link
- Abstract deadline is 14 Feb 2022



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Panel discussion on Safety, Security and Safeguards Interfaces

Panelists

Donald KOVACIC

Principal Investigator, ORNL, USA

Duncan BARLEY

Lead for civil Nuclear Security regulation for new technologies (SMR), ONR, UK

Guido RENDA

Project Officer, Directorate G - Nuclear Safety and Security, ECJRC

Paula KARHU

Principal Advisor in Nuclear Security, STUK, Finland

Discussion topics

1. **Main prerequisites** for a holistic approach to 3S

2. **Potential benefits** from 3S approach (in practice)

3. **What needs to be done** in the international perspective

Discussion topic #1

What do you see as main prerequisites for a holistic approach to 3S?

- regulatory perspective
- attractiveness of 3S approach for the industry
- role of the designers
- …

Discussion topic #2

In practice, how these three disciplines could benefit from harmonization and integral approach?

- Potential synergies
- Mitigation of the conflicts in the interfaces
- Cost effectiveness?
- …

Discussion topic #3

What needs to be done in the international perspective to move towards a holistic approach to 3S?

- Intensification of international co-operation?
- Detailed guidance?
- National regulatory frameworks?
- Specific examples?
- …

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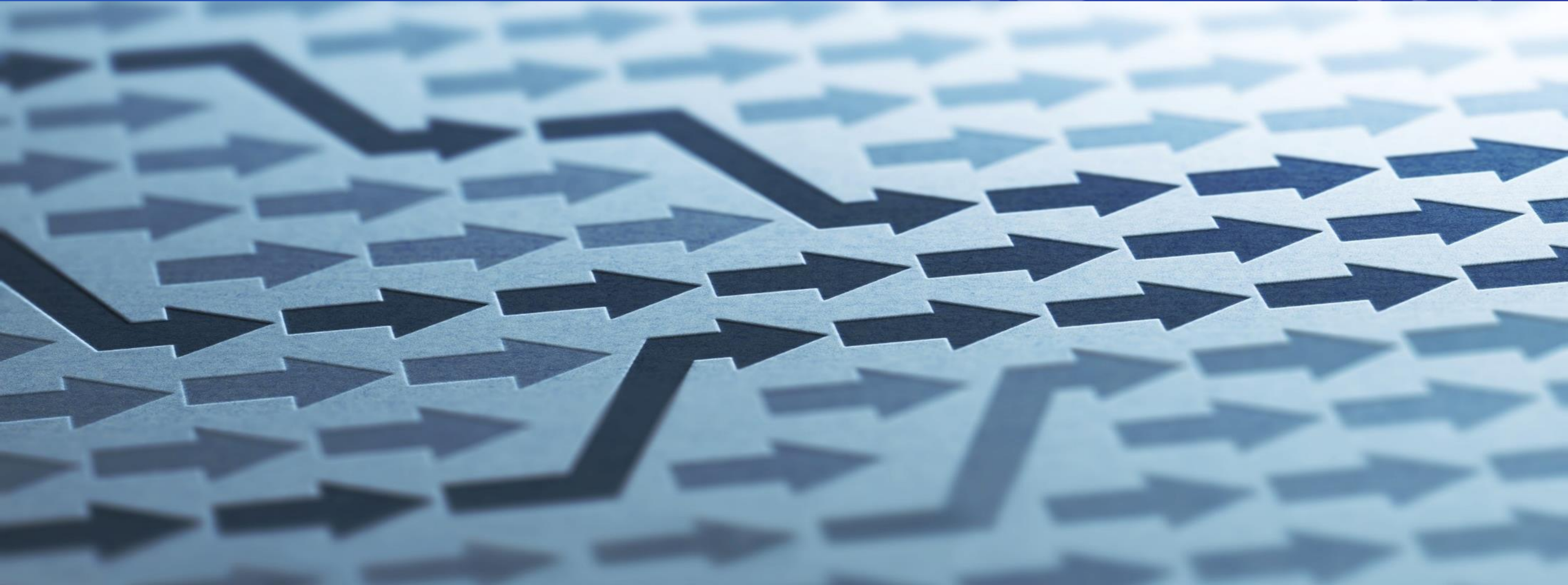

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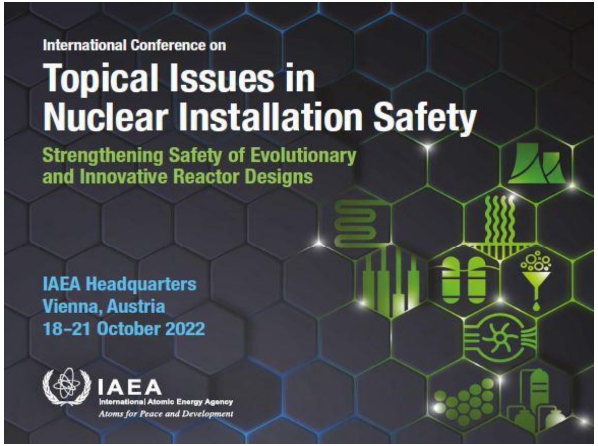


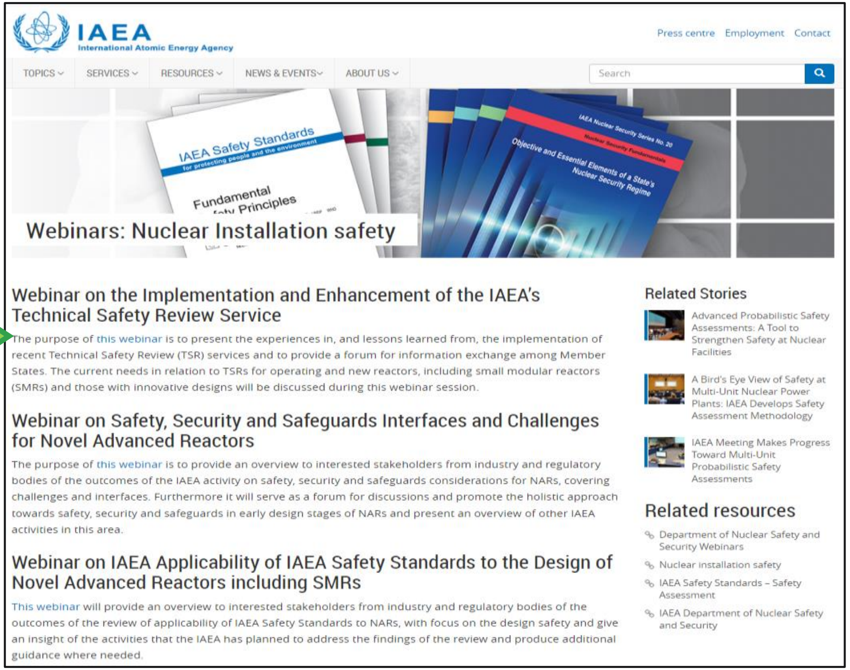
Webinar series continuation

Webinar on the Implementation and Enhancement of the IAEA’s Technical Safety Review Service: **Register** here

Date/time: 15 March 2022 - 14:00 CET

Objectives

- Lessons learned from recent Technical Safety Reviews
- Current MSs needs for operating and new reactors, including SMRs and innovative designs
- Technical guidelines for the conceptual design review



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Thank you!

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Security Challenges for Novel Advanced Reactors (NARs)

Presented by

Kristof Horvath

MAFA-NSNS/IAEA

Nuclear Security

Potential Nuclear Security Threats

- **Nuclear explosive device**
  - Theft of nuclear weapon
  - Theft of material to make a nuclear explosive device

- **Radiological dispersal device (RDD) or Radiological exposure device (RED)**
  - Theft of radioactive material/source
  - Use of radioactive material out of regulatory control

- **Contamination of food, water or air**
  - Theft of radioactive material/source
  - Use of radioactive material out of regulatory control
- **Sabotage**
  - of a facility or transport to cause dispersal of radioactivity

Nuclear Security

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Prevention

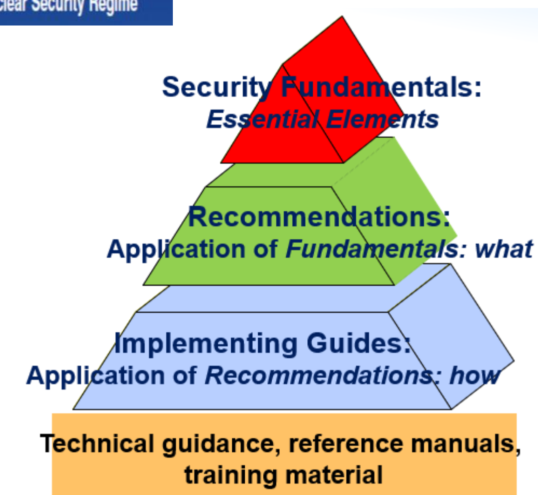
Detection

Response

Nuclear security focuses on the prevention of, detection of, and response to, criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities. The most important part of nuclear security is physical protection of the nuclear material or nuclear facility.

Physical Protection Objectives

- To protect against *unauthorized removal.*
  - Protecting against theft and other unlawful taking of *nuclear material*.
- To locate and recover missing *nuclear material.*
  - Ensuring the implementation of rapid and comprehensive measures to locate and, where appropriate, recover missing or stolen *nuclear material.*
- To protect against *sabotage.*
  - Protecting *nuclear material* and *nuclear facilities* against *sabotage.*
- To mitigate or minimize effects of *sabotage.*
  - Mitigating or minimizing the radiological consequences of *sabotage*.



Physical Protection System (PPS)

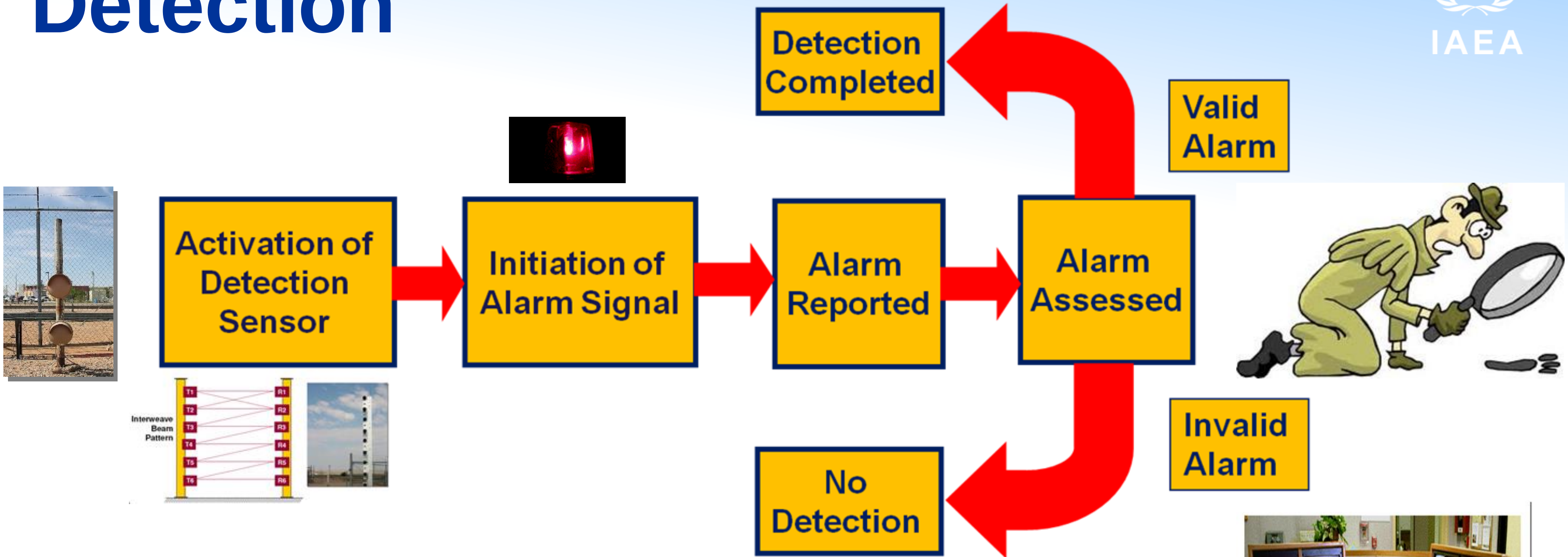
- **The main objectives of PPS are achieved through a comprehensive and integrated strategy by using a combination of**
  - **Deterrence,**
  - **Detection,**
  - **Delay, and**
  - **Response.**

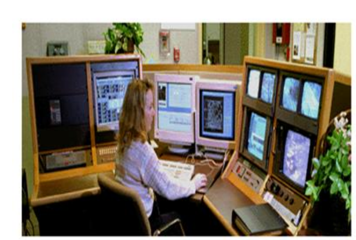
Deterrence

- **Deterrence is achieved**
  - **if potential adversaries regard a facility as an unattractive target and decide not to attack it because they estimate the probability of success to be too low**
- **To promote deterrence, the operator may use observable protection measures, like**
  - **Visible presence of armed guards patrolling the facility,**
  - **Warning signs,**
  - **Controlled access points,**
  - **Barriers and fences,**
  - **Bright lighting at night, and**
  - **Vehicle barriers, etc.**

- **Implementation of policy for determining the trustworthiness of all people working on a nuclear facility will also serve as strong deterrence against the possible insider adversary.**

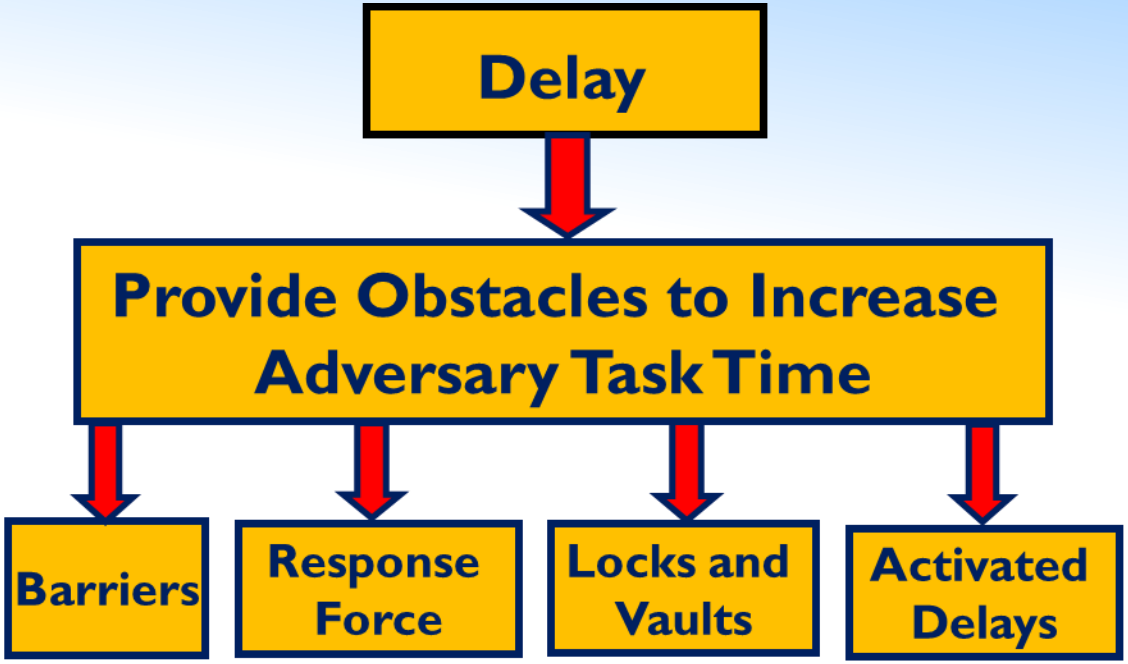
Detection





- **The detection function depends on**
  - **The capabilities of the systems for sensors,**
  - **Alarm signal activation,**
  - **Alarm reporting and assessment, and**
  - **The performance of the staff of the central alarm station**
- **Technology can increase the efficiency of all stages of the detection process.**

Delay



- Delay is the function of the physical protection system that seeks to slow an adversary's progress towards a target, thereby providing more time for effective response.
- Each type of delay takes time for the adversary to penetrate or defeat.

Response

Response is the function of the physical protection system that seeks to interrupt and neutralize an adversary before the completion of a malicious act.

Response involves the capability of facility operators, law enforcement, to respond to malicious acts related to nuclear security or threats in an effective and coordinated manner.

The response force consists of persons on-site or off-site who are armed and appropriately equipped and trained to interrupt and neutralize an adversary attempting unauthorized removal or an act of sabotage.

Nuclear Security Challenges for NARs

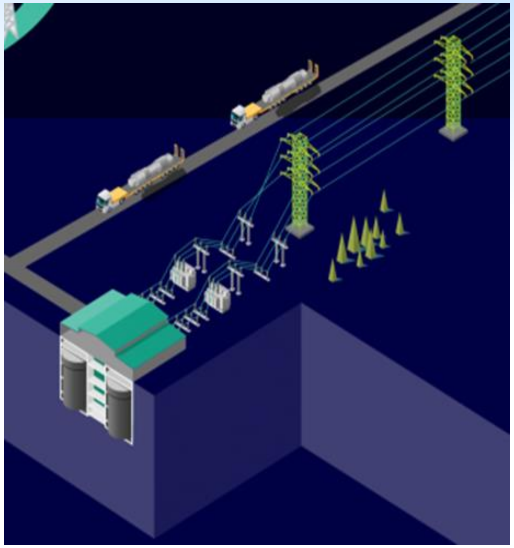
Sharing of Design Basis Threat

- **The State/regulator is responsible for obtaining, collating, analyzing and disseminating threat information to relevant organizations for making necessary arrangements for security.**
- **The State will likely define a baseline threat assessment for developing a Design Basis Threat (DBT)**
- **DBT can be used for security planning/designing purposes and must be periodically reviewed/updated to deal with evolving new threats.**
- **DBT information is a classified document which can not be shared with vendors for security by design purposes.**

- **If required, then only on the <u>need-to-know basis</u>.**
- **The complete security vetting of the NAR vendors must be done.**

Underground Construction of ANRs

- **Most of the ANRs will be constructed underground**
- **The designs that are underground might be protected against:**
  - **Aircraft impacts**
  - **External hazards like tornados**
  - **Seismic effects.**
- **These may also have less dispersion off-site in case of sabotage.**
- **However, these may perhaps be less protected against flooding that might be considered an indirect attack against safety systems.**

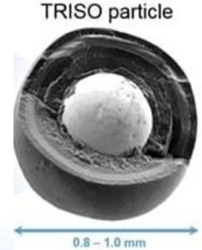


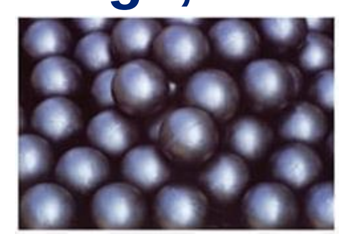
Nuclear Fuel Security Concerns for NARs

Choice of nuclear fuel design in NARs will affect the security aspects (theft and sabotage) related to nuclear fuel. It will depend upon several factors, like

- **Level of enrichment that will affect the categorization of the nuclear material,**
- **Amount of nuclear material or other radiological material that would affect any off-site release calculation after a sabotage event,**
- **The ability of the fuel for a release to spread – can it be aerosolized?,**
- **Its attractiveness for theft in terms of practicalities (amounts, form, dilution, solids/liquids, frozen),**
- **Radioactive nature of nuclear waste and its storage, and**
- **The frequency of refueling.**

TRISO particle





Spherical fuel pebbles

NAR Site Selection and Colocation with other Facilities.

- **Site selection for the deployment of NAR affects the implementation of security measures for NAR.**
- **Design process needs to take into account, addressing and utilizing surrounding environmental parameters when devising security plans, programs, policies, relevant buildings, or systems,**
- **Implementation of physical protection systems at a particular location is affected by**
  - **Geography, location, topography and environment**
  - **Types of surrounding buildings or industries**
  - **Nature of procedures and people involved.**
- **Colocation of NARs with existing nuclear facilities may have different types of challenges for NAR deployment.**

Cyber Security Considerations for NARs

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- **Cybersecurity is vital for all NARs to protect all of their operations, both from security and safety point of view due to**
  - Extensive use of digital technologies, which creates new attack possibilities:
  - Remote monitoring and support centers
  - Innovative and optimized concepts of operation and maintenance, such as autonomous operation
  - Operation of multiple units from the same control room
  - Use of digital technologies new to the nuclear industry, such as smart sensors
  - Complex digital supply chain

Transport Security Concerns of NARs

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- These NARs could be fabricated, fueled in a factory, sealed and transported to sites for power generation
- The requirement to transport fresh or spent fuel will depend on whether
  - The reactors will be transported fueled, or
  - The fuel will be transported to the reactors separately.

- The arrangements of transport security will depend upon the type of fuel, enrichment level and the quantity of fuel.
- Transport security arrangements for remotely deployed NARs will be a main challenge.

Transport Security of Marine-Based Nuclear Power Plants

- **Marine-based NPP security concerns may differ from those for land-based NPPs, such as**
  - **Means of water transports,**
  - **Underwater attack and sinking considerations, and**
  - **Unauthorized access from sea.**
- **Unauthorized access of the Marine-Based NPP may be feasible due to**
  - **The slow speed,**
  - **Poor manoeuvrability, and**
  - **Being low in the water.**

- **Underwater attacks would need to be considered in the threat assessment.**
- **During the transport to the deployment site, the necessary security arrangements must be planned ahead and well coordinated.**

Security Concerns for Remote Siting

- **In some applications of NARs, these are expected to be located at remote locations, including offshore in some cases.**
  - **It will be difficult for any offsite response force to access the site in a timely manner.**
  - **Increased vulnerability during the transport of nuclear material for NARs to the remote location.**
  - **There may be cyber security concerns in relation to remote monitoring of reactor operations**
  - **There is an additional need to ensure that a remote NAR cannot be shut down by an adversary or be vulnerable to cyberattacks.**




Defence-in-Depth for Security of NARs

- Defence-in-depth (DiD) strategy should be adopted in all protection systems of NARs
- The compact designs of NARs mean reducing the number of possible targets available for an adversary.
- The reduction in the number of layers due to compact design should not compromise the security
- Furthermore, multiple layers and strong barriers should be implemented, especially for independent systems, and no single point of failure should be allowed.

Potential Radiological Consequences

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- The main challenge is to develop a regulatory approach that will consider radiological consequences and health impacts.
- The use of graded approach facilitates the application of proportionate physical protection measures based on the potential consequences in case of
  - The unauthorized removal of nuclear material (determined using a nuclear material categorization table) and
  - The sabotage (determined using an approach of grading radiological consequences).
- NARs have lower fissile inventories inside the core compared to a regular NPP.
- The amount of the spent fuel will also depend upon how frequently the NAR is fueled or it has the core for its lifetime.

Security-Safety Interfaces

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All security-safety interfaces should be managed in a manner to complement each other.

- **Security interfaces with safety describe those safety measures, which support security, for example**
  - **Robust safety design,**
  - **Radiation detectors, including radiation portals at gates,**
  - **Tracking of shipments during transport, and**
  - **Safety measures, which may challenge security (e.g. safety first principle, rapid evacuation, transparency).**

Security-Safeguard Challenges

- The main objective of nuclear safeguards is
  - To detect the diversion of significant quantities of nuclear material by the State from peaceful nuclear activities to the military uses and
  - To detect undeclared nuclear material and activities in a State.
- SSAC (State System Accounting and Control)
  - States are required under the Nuclear Non-Proliferation Treaty safeguards agreements to establish and maintain a SSAC for safeguards at state level.
- NMAC (Nuclear Material Accounting and Control)
  - Establishment of NMAC at facility level helps to maintain and report accurate, timely, complete and reliable information on the locations, quantities and characteristics of nuclear material present at the facility

NSNS's activities related to NARs

- Development of a TECDOC on Security of NARs, including CMs and a TM (to be published in 2023)
- Establishment of CRPs to share security related information among vendors, designers, regulators and operators
- Joint activities with NSNI and SG related to interface with safety and safeguards
  - Development of TECDOC of Application of Safety Standards to Novel Advanced Reactors (in progress)
  - Development of TECDOC on Security, Safety and Safeguards by Design (in progress)
- Technical Meeting on Instrumentation and Control and Computer Security for NAR/MRs (February 2022) organized in coordination with the NSNI and NE

Conclusions

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- IAEA is coordinating with Member States to provide them all possible guidance related to secure deployment of NARs
- Efforts are in progress for reviewing and synthetization of the existing NAR related security documents to identify how the specific features of NARs may affect the implementation of nuclear security recommendations
- Different CRPs are in progress to share information on the design, implementation and evaluation of security systems of various small modular reactors (NARs),
- Development of new technical documents related to security of NARs is in progress
- NSNS is jointly working with other departments of IAEA (NSNI, NE) for the secure deployment of NARs at global level

IAEA | Safeguards

Safeguards challenges for Novel Advanced Reactors

Webinar on Safety, Security, and Safeguards Interfaces and Challenges for Novel Advanced Reactors – 3 February 2022

Jeremy Whitlock
Section Head, Concepts and Approaches
Department of Safeguards, IAEA
J.Whitlock@iaea.org

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Agenda

- Background: IAEA safeguards
- Safeguards considerations for Novel Advanced Reactors (focus on Small Modular Reactors)
- Safeguards by design

2

IAEA Safeguards

Role of IAEA safeguards

To verify that States are honouring their international legal obligations to use nuclear material and technology only for peaceful purposes

3

IAEA Safeguards

Comprehensive Safeguards Agreements

- Safeguards apply to all nuclear material in all peaceful activities in a State (INFCIRC/153 (Corr.))
- Concluded by the IAEA with Non-Nuclear-Weapons States (NNWS) party to the NPT
- Small Modular Reactors (SMRs) and related nuclear fuel cycle facilities built in States under a CSA – even prototypes – must be safeguarded, regardless of the size, technology, inherent proliferation resistance, or State of origin

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Safeguards vs. proliferation resistance

Proliferation resistance:

"…that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material, or misuse of technology by the Host State seeking to acquire nuclear weapons or other nuclear explosive devices."

- Generation IV International Forum Working Group on Proliferation Resistance and Physical Protection (GIF PRPPWG)

IAEA safeguards provide independent verification ("safeguardability" is one aspect of proliferation resistance)

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Safeguards challenges for SMRs

- **New fuels and fuel cycles:** Th/U-233, MOX, transuranic (TRU) fuels, higher enrichment, pyroprocessing, other new processes
- **New reactor designs:** molten salt, fast reactors, pebble bed, other new technologies
- **Longer operation cycles:** continuity of knowledge between refuelling, high excess reactivity of core (target accommodation)
- **New supply arrangements:** factory sealed cores, transportable power plants, transnational arrangements

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Safeguards challenges for SMRs

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- **Spent fuel management:** storage configurations, waste forms
- **Diverse operational roles:** district heating, desalination, hydrogen + electricity
- **Remote, distributed locations:** access issues, accessibility of nuclear material for verification, cost-benefit issues

IAEA independent verification capabilities must be ready

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Important needs for safeguarding SMR

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- **Unattended monitoring systems** (UMS) and **remote data transmission** (RDT)
- **Digital connectivity:** e.g., coverage in remote areas (reliable, high bandwidth, secure)
- **Safeguards seals** on factory-sealed, transportable cores
- **Design verification**, particularly under transnational supply arrangements

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Important needs for safeguarding SMR

- **New safeguards approaches**, including (potentially) customized Agency or joint-use instrumentation (e.g., thermal power monitor for microreactors, process monitoring)
- **State factors:** e.g., managing effective/efficient safeguards for a fleet of small, remote facilities
- **Training** for safeguards authorities in emerging nuclear energy States

All of these need time for development:
"Safeguards by Design" is critical

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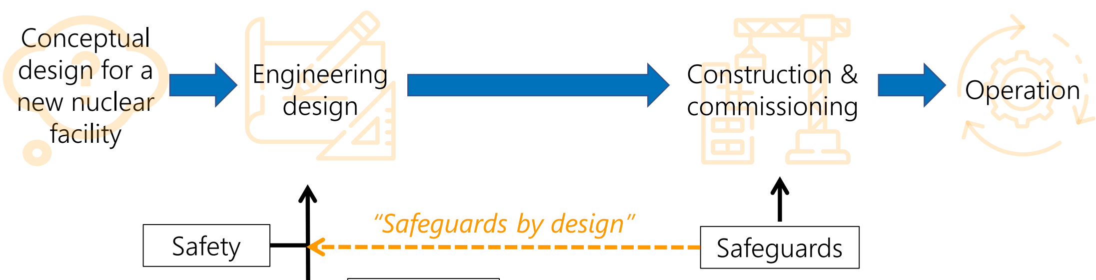
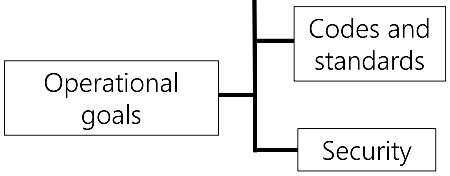
What is safeguards by design? (SBD)





- Safeguards often implemented after design completed
- This works if designs do not evolve significantly
- AND, this works if designers fully understand the requirements of international safeguards
- **Otherwise, safeguards by design is needed**

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What is safeguards by design? (SBD)

- The **integration of safeguards considerations into the design process** (new or modified facility, at any stage of the nuclear fuel cycle), from initial planning through design, construction, operation, waste management and decommissioning
- **Awareness** by all stakeholders (State, designer, operator, regulator, other IAEA Departments) of IAEA safeguards obligations, and opportunities for **early discussion with the IAEA Department of Safeguards**
- A **voluntary process** that neither replaces a State's obligations for early provision of design information under its safeguards agreement, nor introduces new safeguards requirements

Benefits of safeguards by design (SBD)

- Reduce **operator burden** by optimizing inspections
- Reduce need for **retrofitting**
- Facilitate **joint-use equipment**
- **Increase flexibility** for future safeguards equipment installation
- Enhance possibility to use facility design/operator **process info**
- **Reduce risk** to scope, schedule, budget, and licensing
- **Potential synergies** with safety and security design choices (3S)

SBD benefits all parties involved, not just the IAEA

IAEA Safeguards

Challenges in implementing SBD

- IAEA lacks a **direct channel for initiating communication** with specific designers, particularly at the earliest stages of design when greatest SBD potential exists
- Designers/vendor companies lack a **uniform understanding** of international safeguards requirements – e.g., due to being:
  - new to the nuclear industry,
  - from a State where safeguards requirements aren't as widely known, or
  - relatively small and limited in engineering scope
- Safeguards **not seen as a design driver** – of relevance closer to operation
- **Inconsistent licensing practice** in addressing safeguards requirements
- **Proprietary / commercial concerns** affecting the early sharing of detailed design information

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IAEA Safeguards

IAEA "SBD for SMRs" activities

- **SMR Member State Support Program tasks**
  - Canada, China, Finland, France, Russia, Republic of Korea, United States (extendable to other States)
  - Technologies include floating reactor, integral PWR, molten-salt reactor (MSR), pebble-bed reactor, microreactor (district heating)
  - Goal is to work with IAEA Member States to:
    - raise awareness of safeguards with technology designers
    - evaluate design aspects that could impact safeguards
    - investigate potential safeguards implementation strategies, or even design modifications

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Safeguards

IAEA "SBD for SMRs" activities

- **Internal IAEA collaborations**
  - Agency-wide SMR Platform (co-ordination and efficiency for Agency interaction with Member States on SMR issues)
  - SBD Working Group and other collaborations with IAEA Departments of Nuclear Energy and Nuclear Safety and Security (3S)
- **External engagements:**
  - Raising awareness with stakeholders (e.g. SMR Regulators Forum)

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Safeguards

How can stakeholders help?

- **Regulators**
  - **Raise awareness** of safeguards requirements, and the potential benefits of SBD to all licensees
  - Make safeguards considerations a **requirement of pre-licensing review**
  - **Encourage three-way discussion** with State authority responsible for safeguards (SRA), designer, IAEA
- **NGOs, R&D community**
  - **Raise awareness** of safeguards requirements and SBD through industry seminars and other events (invite safeguards experts/IAEA)

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Safeguards

How can stakeholders help?

- SMR developers
  - Increase awareness of safeguards requirements and potential impact of State's safeguards obligations on operation of a new facility
  - Incorporate safeguards considerations along with safety, security, economics, and other factors
  - Engage in early SBD discussions with SRA, IAEA, or other experts

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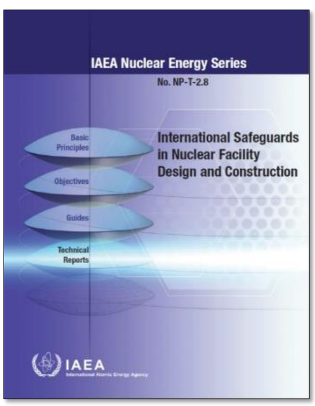
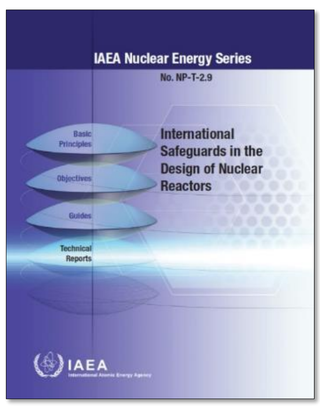
Safeguards

Safeguards by design (SBD) guidance





www.iaea.org/topics/assistance-for-states/safeguards-by-design-guidance

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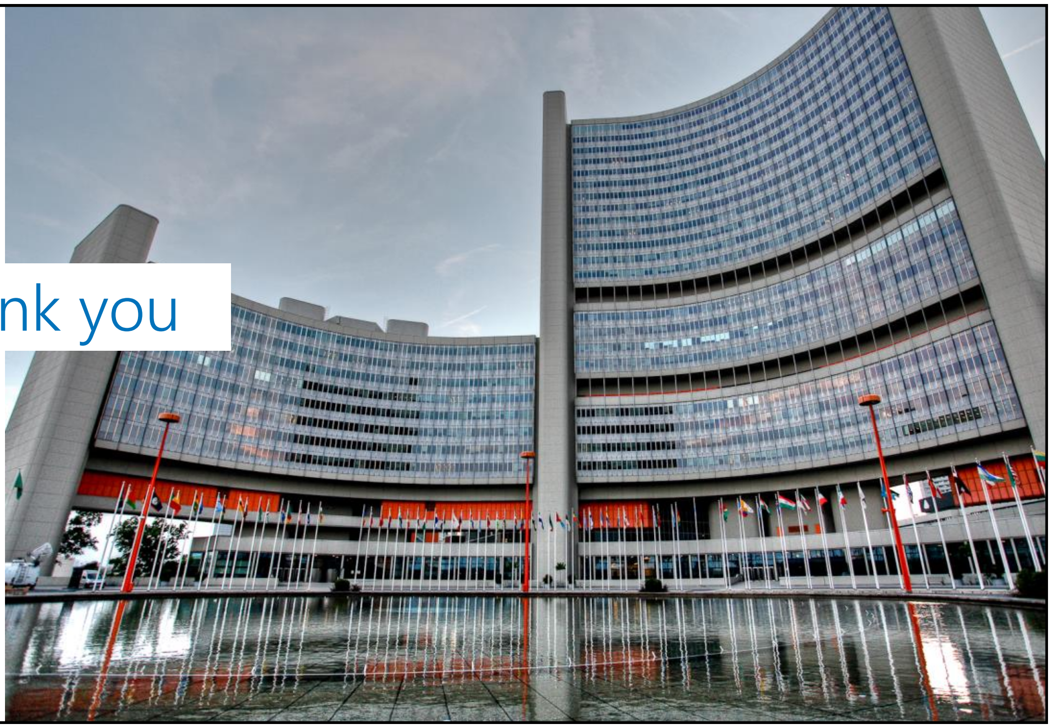
Thank you



Oak Ridge National Laboratory

3S as a Foundation for Deployment of Advanced Nuclear Reactors

IAEA Webinar on Safety, Security and Safeguards Interfaces and Challenges for Novel Advanced Reactors

3 February 2022

Donald Kovacic

Oak Ridge National Laboratory

ORNL is managed by UT-Battelle, LLC
for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Outline

Discussion of 3 basic topics:

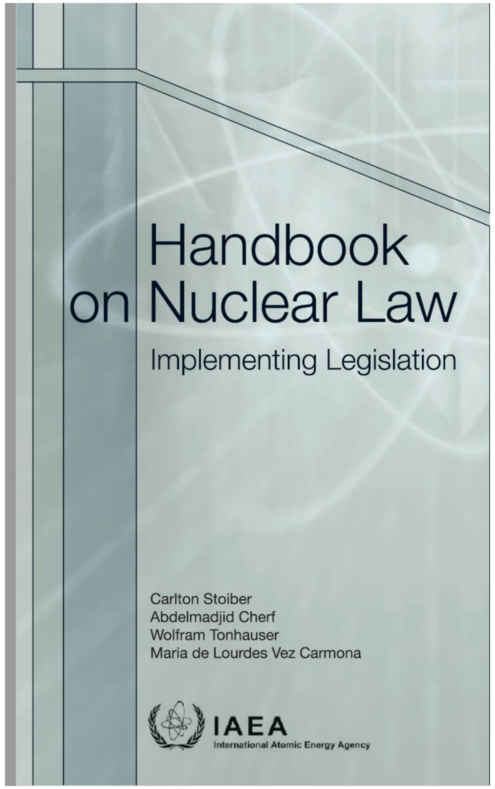
- The lifecycle of 3S – design, build, operate
- The importance of 3S during the design of advanced reactors
- Current challenges & opportunities to incorporating 3S in reactor design

The Lifecycle of 3S – Initial Focus on Infrastructure

- 3S concept was advocated in 2008 at the Hokkaido Toyako summit Japan
  - G8 countries pledged to raise awareness of 3S and to assist countries in setting up **nuclear energy infrastructures** that are essential for a successful nuclear energy program.
- The motivation **support strong national programs** in safety, security, and safeguards during the nuclear renaissance (pre-Fukushima).
- Safety, security and safeguards are three of the nineteen issues identified in the IAEA's "**Milestones in the Development of a National Infrastructure for Nuclear Power**, NG-G-3.1, for embarking countries.

The Lifecycle of 3S – Well Established in Laws, Regulations, and Operations

- IAEA Handbook on **Nuclear Law Vol II** – Provides guidance on how to address 3S in national legislation (published 2010)
- National **nuclear regulations**
  - * Many embarking countries have adopted 3S regulatory bodies
- **Nuclear Operations** – Operators must meet all requirements for 3S as efficiently as possible (example - Integrated Management Systems)
  - ** 2015 Survey on 3S: **92% believe that the 3S concept is applicable to their own organization**
  - 2012 IAEA TM on Safety, Security and Safeguards: Interfaces and Synergies in Development of a Nuclear Power Programme - Strong support for 3S from **nuclear power plant operators**
- However, 3S has not been fully embraced by designers



* IAEA-TECDOC-1948, Experiences of Member States in Building a Regulatory Framework for the Oversight of New Nuclear Power Plants: Country Case Studies, Vienna, 2021
** Global Survey of the Concepts and Understanding of the Interfaces Between Nuclear Safety, Security, and Safeguards 56th Annual INMM Meeting Indian Wells, CA, July 15, 2015

Need for 3S during the design of advanced reactors

- Benefits of considering all design elements as early in the design as possible results in the **most robust product** (Basic Design Principle)
- The framework of nuclear safety, security, and peaceful use are pre-conditions for **public acceptance** of nuclear and **successful deployment** of advanced reactors.
- Interfaces, synergies, and challenges have been extensively studied and are **manageable**
- Extending the 3S lifecycle to include reactor design **benefits all stakeholders** – global safety/security/nonproliferation regimes, States, regulators, designers, investors, the public/ end users, and the environment
- **Translate 3S success** from the operational realm to the design space using the institutional knowledge already developed.

Challenges & Opportunities for 3S during the design phase

- **Legal drivers**/ mandates are significantly different for each of the 3Ss
  - Safety experience is shared internationally
  - Security information may not be shared
  - Safeguards Agreements are between each individual State and the IAEA
- **Messaging is not clear** on the relationship between the 3Ss for designers
- **Multiple stakeholders** must be educated - designers, regulators, licensees, investors, architect engineers, government ministries, etc.

- National regulations could address 3S in the **licensing** process
- Future owner/ operators/ licensees could include 3S as part of **bid invitations** for new reactors to create economic drivers
- Provide designers a clear path on how 3S can be implemented and describe the **incentives** – such as attractiveness of design to future owner/ operators and improved compliance and reduced regulatory burden.

Thank you for your attention!

Don Kovacic

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Office for Nuclear Regulation

Safety, Security and Safeguards considerations for Novel Advanced Reactors

ONR early consideration of interfaces

February 2022

Task

Advanced Modular Reactors and evolving thinking that there are benefits in a 3Ss holistic approach.

What are the interfaces and why is it important to examine and work them?

My example, taken from experience, is Generic Design Assessment.

The Office for Nuclear Regulation (ONR)

- I am a Security Regulator
- Focus is the conceptual/design stage
- Technology neutral
- New GDA guidance supports a 'holistic' approach
- Legal and Regulatory guidance enables that approach
- First step - Security Assessment Principles/Safety Assessment Principles
- Safeguards in the future

Nuclear safety

Nuclear site health and safety (conventional health and safety)

Nuclear security

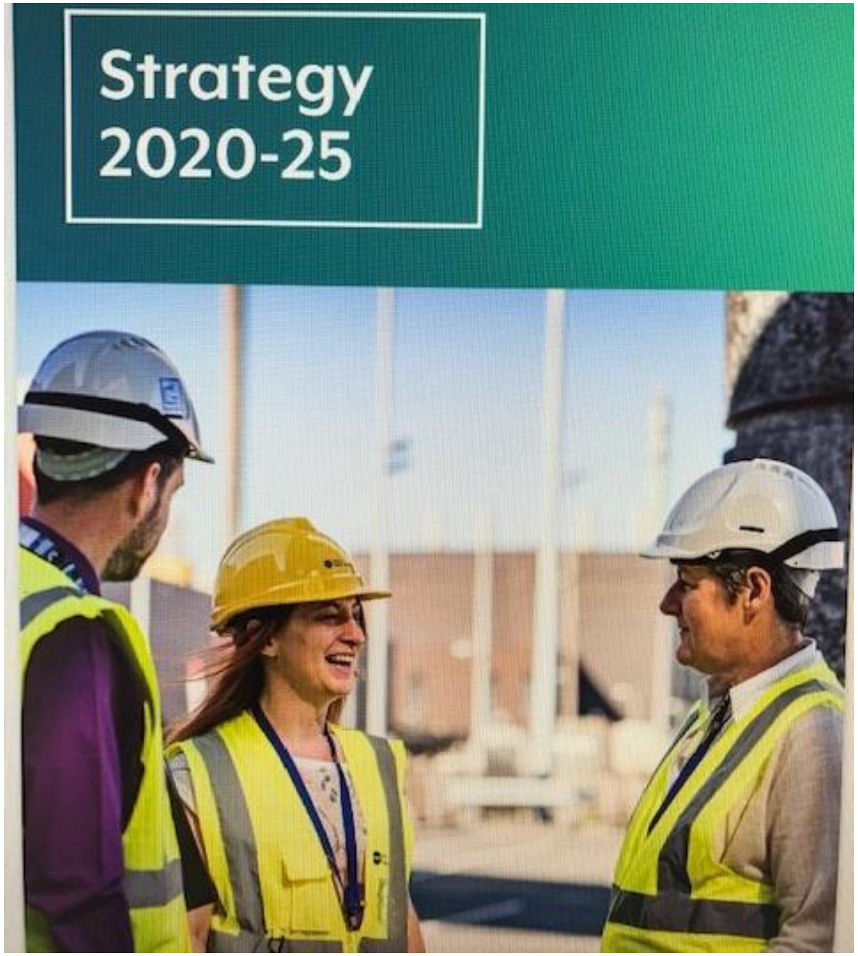
Nuclear safeguards

Transport of radioactive materials

High Level Direction

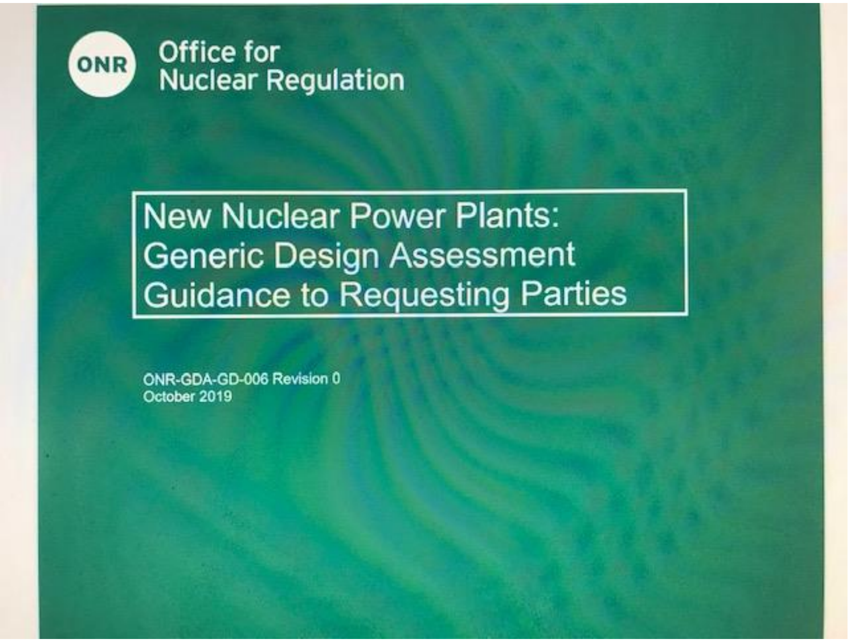
‘This includes leading the strategic thinking for improved regulatory consistency and proportionality, and working in a more joined-up way across all of our purposes and with others, to improve regulatory co-ordination and outcomes’.

Sets conditions for 3Ss.



Generic Design Assessment

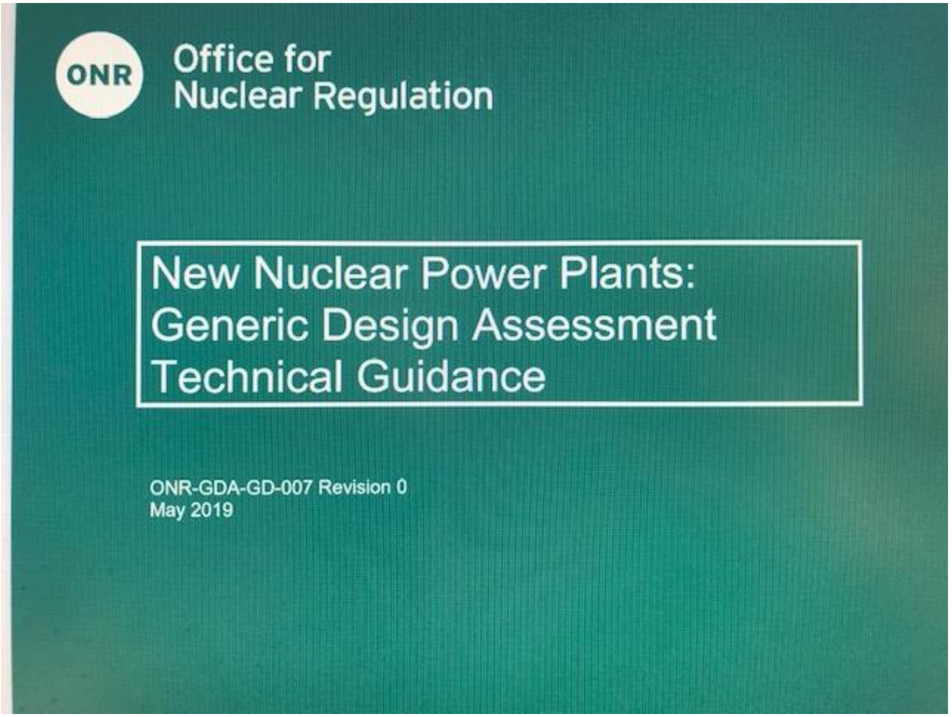
This document provides guidance on the Office for Nuclear Regulation's (ONR) Generic Design Assessment (GDA) process for the **safety and security assessment** of new Nuclear Power Plants (NPP). This process will be applied where ONR is asked to assess a proposed design in advance, or in parallel to an application for a nuclear site licence.



Interfaces

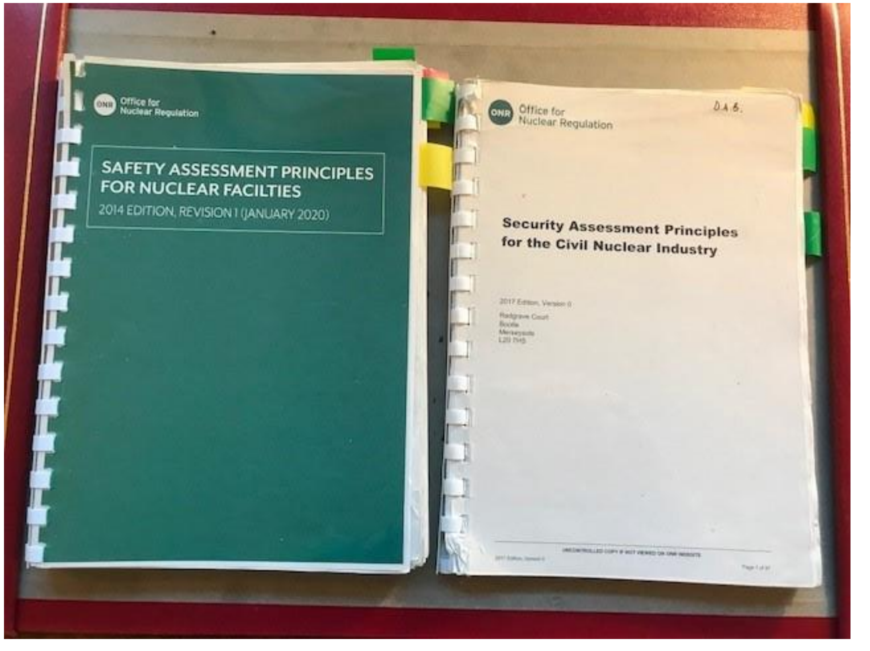
The guidance:

- Requires both a Safety and Security Case (CAE).
- And now Safeguards.
- Sets the conditions for cross-cutting considerations.



Alignment of Guidance

- High level coherence
- ‘Outcome’ based
- Based on ‘Principles’
- Security/Safety risk based
- Different ways of assessing risk
- Different concept of ‘outcomes’ sought
- Sufficient to work the interfaces

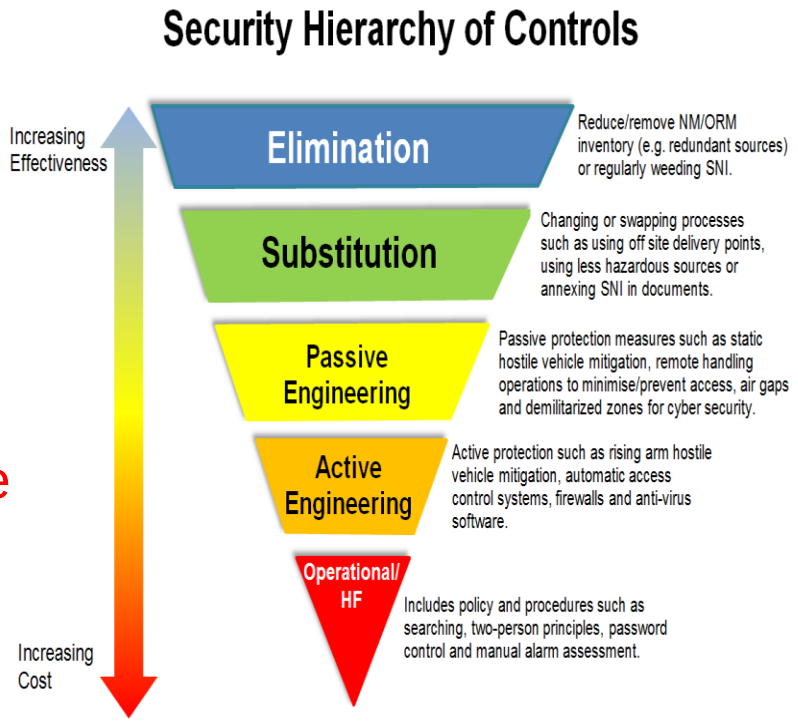


Benefit of ‘Outcome’ Based Approach

- Allows innovation in 3Ss (ends-ways-means) in the design phase.
- Safety ‘means’ meets a Security ‘end’/outcome.
- Enables a more ‘holistic’ attitude as developers are free to make such claims.
- Allows claims from Safety features that have Security benefit.
- But requires expertise.
- Regulators need an **‘enabling’ approach** and this requires resourcing.

Key Security Case/Plan Principles

- **Secure by Design**: design-out and design-in
- The design as a whole
- Reduce targets
- Indirect targets
- Increase complexity
- DBT effectiveness
- Increase robustness - SSCs
- Safety systems prevent or mitigate
- Reduce off site dose
- Not a Vital Area?



Interfaces

- Collective or holistic view of ‘risk’.
- Security draws from the safety case.
- Safety and Security ‘by Design’ – requires integrated working.
- Vital Area Identification and Categorisation and Cyber Security Risk Assessment requires safety involvement.
- Potential claims that novel safety measures add security value.
- The Cyber Security and Control and Instrumentation nexus.
- Modification of the design for safety and security benefit and its process requires joint working.

Why is it important?

- Risk management good practice – holistic approach.
- Cyber Security will require greater collaboration.
- Regulation ‘direction of travel’.
- Expect claims that safety measures/features have security benefit.
- Maybe driven by commercial imperative.
- Vendors may offer a complete plant ready to operate for assessment with the 3Ss considered and already built into the concept.
- But there will be areas that do not readily offer integration. The threat can change quickly, risk appetites and reputational .

European Commission

Interactions between Nuclear Safety, Security and Safeguards

A Systems Thinking Perspective

G. RENDA

EC Joint Research Centre

Directorate G – Nuclear Safety and Security

Webinar on Safety, Security and Safeguards Interfaces and Challenges for Novel Advanced Reactors, IAEA, 3 February 2022

Joint Research Centre

Summary

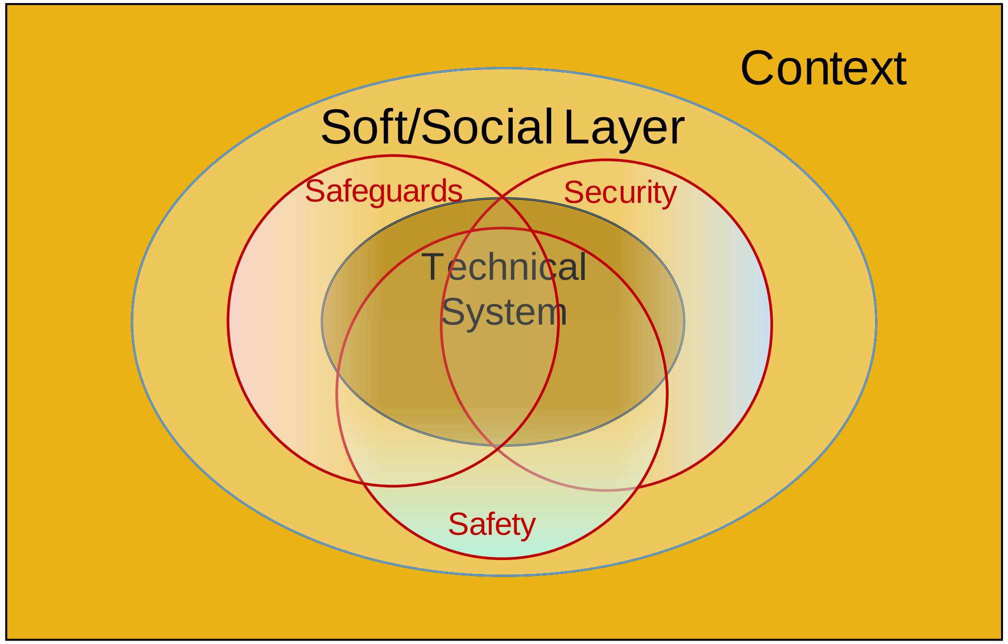
- Setting the Framework for a reflection
- Interactions between Safety, Security and Safeguards
- Possible examples of Safety-Safeguards interactions
- Possible examples of Security-Safeguards interactions
- Addressing 3S: some open questions

An important note of method and merit (a.k.a. Disclaimer)

The views expressed are purely those of the presenter and may not in any circumstances be regarded as stating an official position of the European Commission

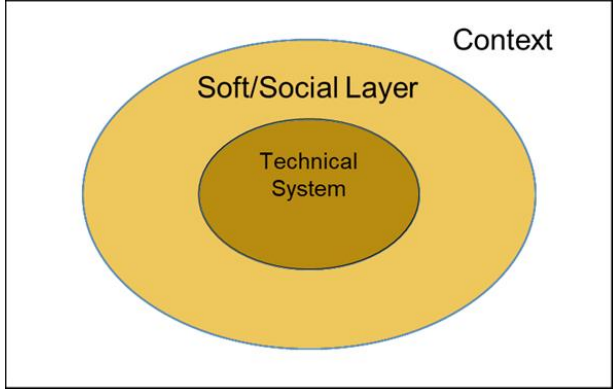
Setting a framework for reflection

- Every technical system is operated by a soft/social layer within a given context
- Each of the 3 regimes (Safety, Security and Safeguards) emerges from the complex interaction between these *layers*
- The overall 3S behaviour emerges from the complex interaction between the three *regimes*



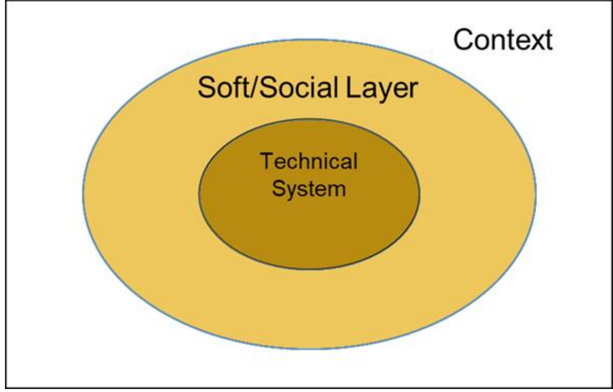
Framework adapted from:
BLOCKLEY, David I.; GODFREY, Patrick. ***Doing it differently: Systems for rethinking construction***. Thomas Telford, 2000.

3S and systems design



- Safety, Safeguards and Security provisions shape how the nuclear system is designed and operated
  - The complex interaction between the system's design and the safety, security and safeguards provisions strongly influence the interfaces between the 3 regimes
- Safety usually dominates the scene, followed by Security and leaving Safeguards as a distant third in designers' priorities
  - Safety and security provisions and practices have the potential to impact significantly on the effectiveness and efficiency of Safeguards activities and viceversa

Examples of Safety – Safeguards Interactions (1/2)



Accessibility to areas containing nuclear material under Safeguards

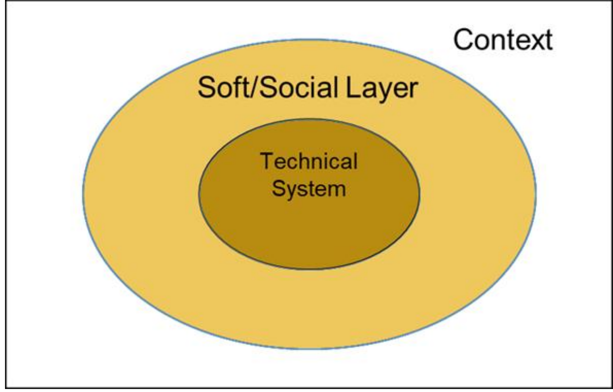
- Potential to affect safety during SG inspections (see also para. 87 of INFCIRC/153 – need to minimize burden on operator)
- Potential access restrictions due to safety considerations (e.g. high radiation level)

Interaction with Containment & Surveillance Systems

- Access to locations for safety-related inspections and maintenance could interfere with application of Containment
- Safety related activities might interfere with optical Surveillance

European Commission

Examples of Safety – Safeguards Interactions (2/2)



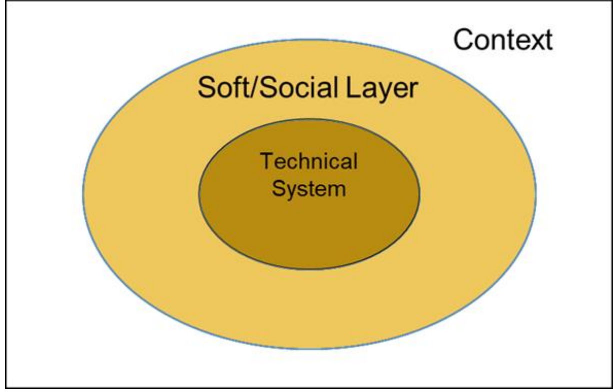
Non harmonized regulatory provisions between the two regimes

- Requirement to report transported items radiological activities for H&S reasons but not the actual mass of Special Fissionable Material can lead to wrong recording and reporting for safeguards purposes

Safety friendly design solutions might impact on Safeguards

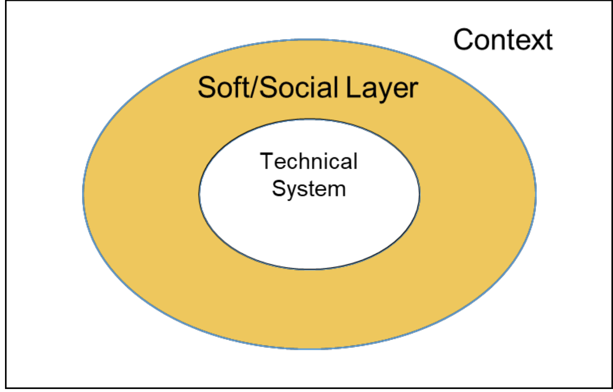
- Fuel type and composition minimizing safety and operational concerns might impact on needed safeguards resources (timeliness, type of measurements needed)

Examples of Security – Safeguards Interactions



Remote accessibility to sensitive data	• Remote C&S data transmission might open unexpected security vulnerabilities
Shared equipment and data might increase effectiveness and efficiency	• An effective and efficient Nuclear Material Accountancy and Control (NMAC) system is beneficial for both regimes • Advanced C&S safeguards systems might provide additional situational awareness to security forces and viceversa • Shared need for reliable, high-bandwidth connectivity in remote areas for remote monitoring

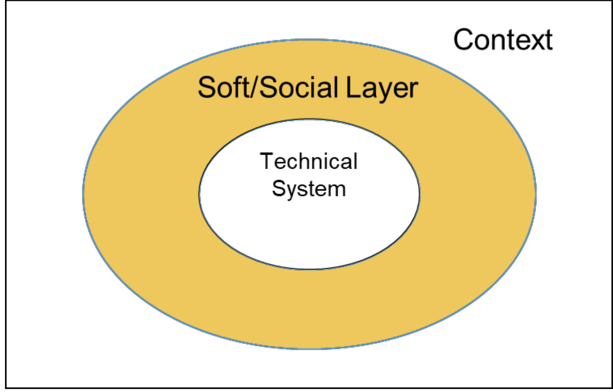
Players and Stakeholders in the Social Layer: different Hats in different Regimes



	Safety	Security	International Safeguards
Implemented by	Operator	Operator	National/Regional Authority IAEA
Postulated adversary	None	Sub-national group	State
Verified by	State	State	IAEA

- How to ensure cooperation and synergies (exchange of data, shared signals and equipment, etc) between regimes where the same actors have different and potentially contrasting roles?
- Can other domains with similar issues teach us something?

Addressing 3S: Risk Informed Approaches?



Risk Analysis successfully and routinely applied to Safety

- Design Basis Accidents, PRA/PSA
- Risk is formally well defined, techniques are well developed, results directly implemented in design

Somehow investigated and considered in Security

- Design Basis Threats
- Consequences analysis / success probability

Investigated in Safeguards

- No successful effort to define risk in a formally sound way
- No clear “Design Basis Threat/Scenario”
- Challenges in quantifying events and sequences of events
- Partially implicitly implemented (e.g. for AP Analysis)

- Is it possible to define coherent “Design Basis Scenarios” for Safety, Security and Safeguards?
- Would this help designers and authorities to work synergically on the three aspects?

European Commission

Acknowledgements

This reflection was originally proposed In the context of IAEA Consultancy Meetings on the Review of Applicability of Safety Standards to novel Advanced Reactors, within the sessions on Safeguards/Security considerations for novel advanced reactors and benefited from the discussions during these events.

Related Systems Thinking Background References

Blockley, D. I., & Godfrey, P. (2000). *Doing it differently: Systems for rethinking construction*. Thomas Telford.

Renda, G. (2008). *Resisting Nuclear Proliferation Through Design: A Systems Approach to Nuclear Proliferation Resistance Assessment.* Doctoral dissertation, University of Bristol.

Renda, G., & Cojazzi, G.G.M. (2018). *Open Source Information Analysis in Support to Non-Proliferation - A Systems Thinking Approach.* EUR 29515 EN, Publication Office of the European Union, Luxembourg.

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Thank you

CONSIDERATIONS ON 3S FOR NOVEL ADVANCED REACTORS

Paula Karhu/STUK/Nuclear Security, Finland

IAEA Webinar on Safety, Security and Safeguards Interfaces and Challenges for Novel Advanced Reactors,
3 February 2022

3S interface management

- 3S **decision point**—any decision—where security, safety and safeguards issues should be taken into consideration

  = **interface**

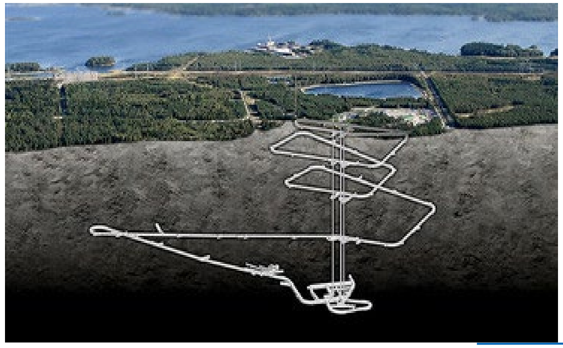
- Decision point systematically flagged and handled according to processes and procedures → taking advantage of synergies and resolving possible conflicts

  = **interface management**

>> risk-informed, balanced decision making

>> joint fundamental objective: to protect people and the environment from harmful effects of ionizing radiation

New types of owners/users – same level of 3S



Photos: TVO and Posiva

VS:

Some of those interesting questions

- Information security
  - Availabililty, integrity, confidentiality
- Interdependence
  - Digital, programmable systems and general increased connectivity
  - Potential remote monitoring/maintenance/operations for NAR
- New types of fuel, inventories, cores, fuel elements, transports

  → Pontential consequences → 3S requirements → 3S by design
- Synergistic application of monitoring and detection systems?
- Response
  - Delay, mitigation, minimization, coordination
  - Urban, remote, marine, mobile NAR

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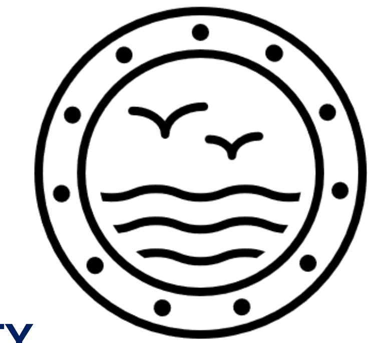

WINDOW OF OPPORTUNITY FOR 3S BY DESIGN?

Thank you!

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