IAEA | Safeguards

Safeguards Aspects of Advanced Reactors

TM on Compatibility Between Coolants and Materials for Fusion and Advanced Fission Reactors

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Jeremy Whitlock

Senior Technical Advisor (SBD), SG Concepts and Planning
Department of Safeguards, IAEA
J.Whitlock@iaea.org

Role of IAEA safeguards

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Credible assurance that countries are honouring their international obligations (under the NPT) not to divert nuclear material from peaceful use to a nuclear weapon.

- In safeguards planning scenarios, **the State** is the prime 'actor'.
- **Nuclear facilities** support the State in meeting its international obligations.

Challenge of safeguarding advanced reactors

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- All new nuclear facilities in a Non-Nuclear Weapon State (NNWS) under the NPT **will need to be safeguarded when deployed**
  - ➢ regardless of the size, innovation, accessibility, owner/operator, or supplier of technology
- Many vendors are from Nuclear Weapons States (NWS)
  - ➢ lack of 'international safeguards culture' within domestic nuclear design community
- Advanced reactors may require advanced safeguards (which requires R&D)
  - ➢ new core/fuel designs, plant layouts, SF management, fuel cycle facilities
- Enhanced security and 'inherent' proliferation resistance **do not** necessarily mean simpler safeguards
  - ➢ 'safeguardability' is an important but often overlooked external component of PR (and customer requirement)

How can plant design improve safeguards?

Verification of Nuclear Material Accountancy

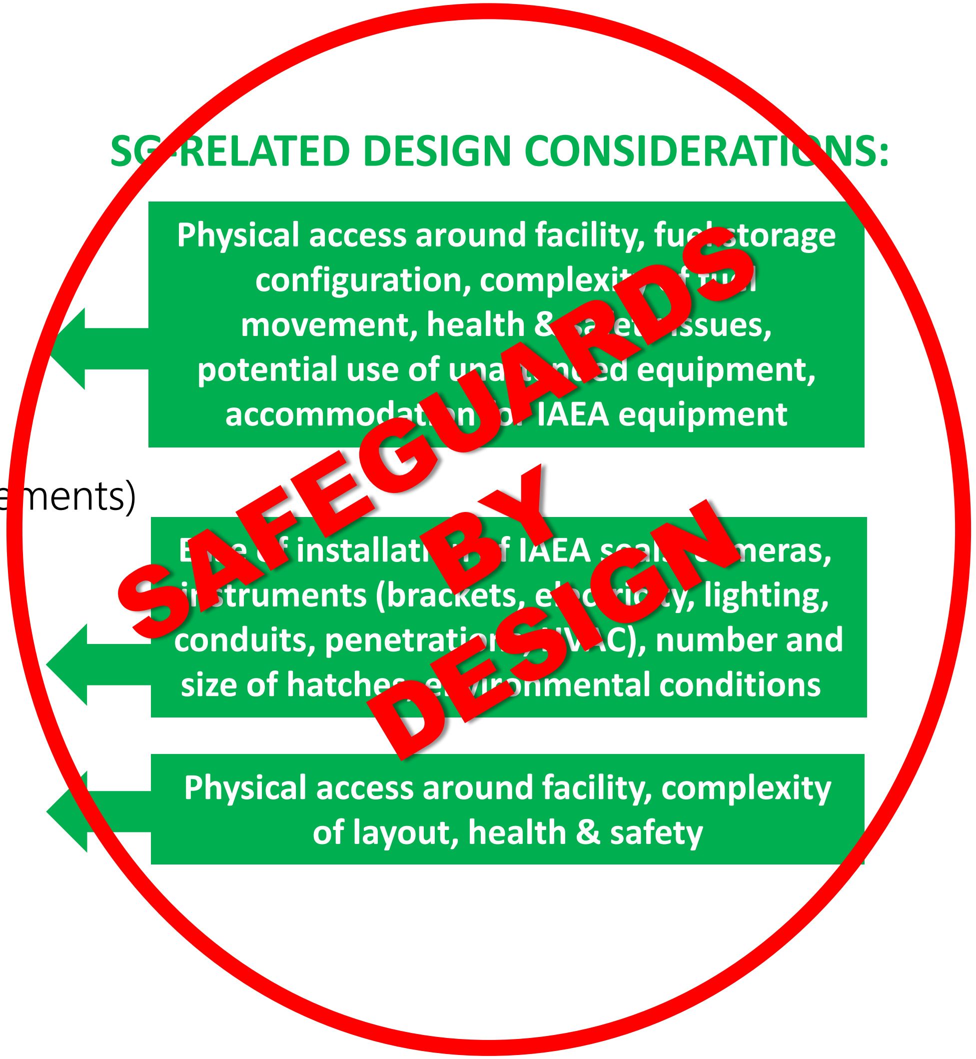
- To verify State's declaration of nuclear material **inventory and flow** (e.g. item counting, weighing, non-destructive assay)
- Can involve **remote monitoring of unattended equipment**

Containment and Surveillance

- To maintain **continuity-of-knowledge** (e.g. cameras, seals, measurements) between inspections
- Can involve **remote monitoring of unattended equipment**

Design Information Verification

- To verify State's **declared facility design** (construction, operation, modification or decommissioning)



WANTED: Efficient, effective safeguards

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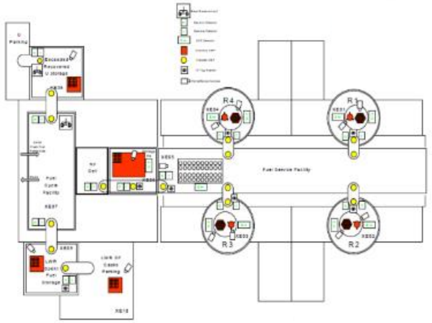
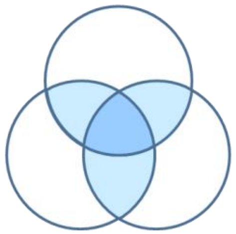
? → Conceptual design for new nuclear facility



Engineering design

Construction & commissioning

Operation



"3S"

Safety

Codes and standards

Operational goals

Security

Safeguards by Design

'Legal' beginning of facility safeguards (nuclear material accountancy)

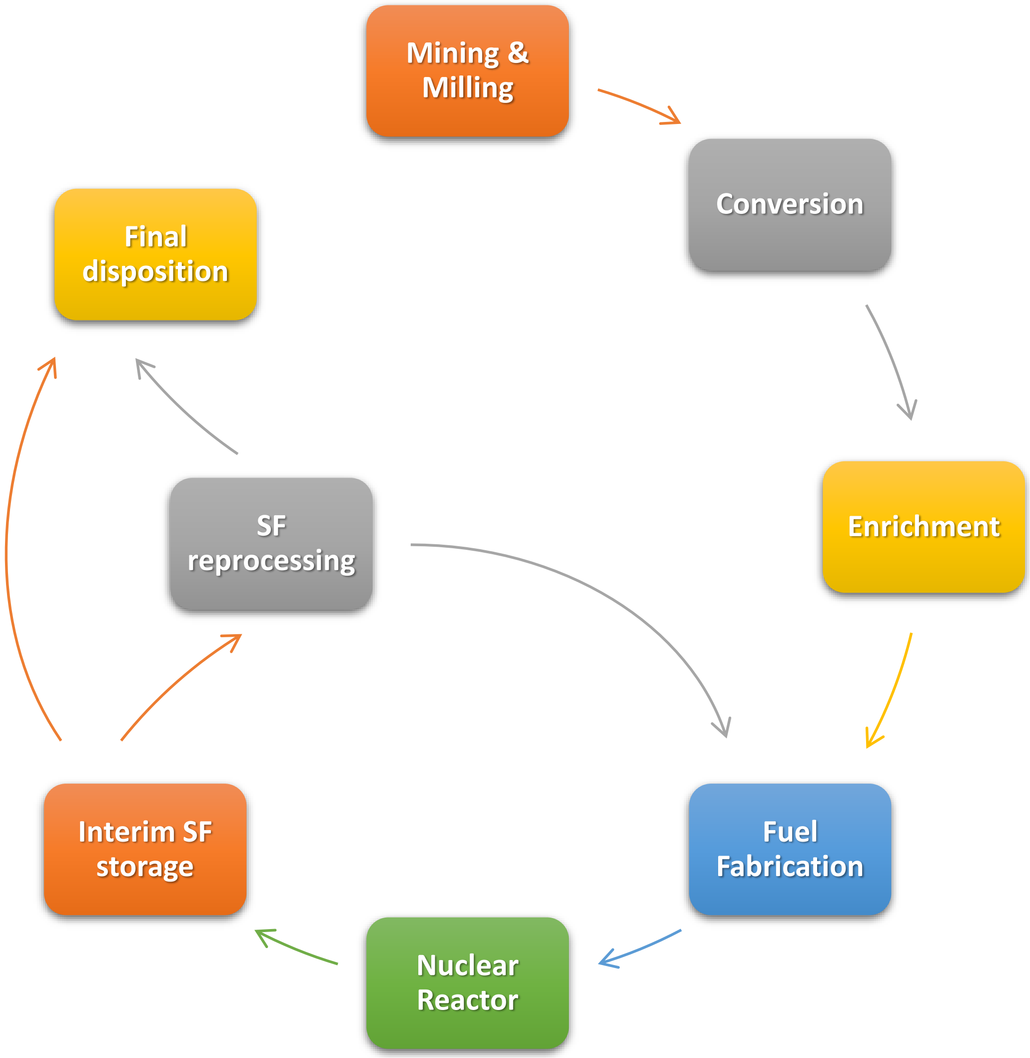
- ✓ **Integration** of safeguards into the design process (3S)
- ✓ **Awareness** by all stakeholders of everyone's obligations
- ✓ **Voluntary** best practice: not a new or replaced obligation

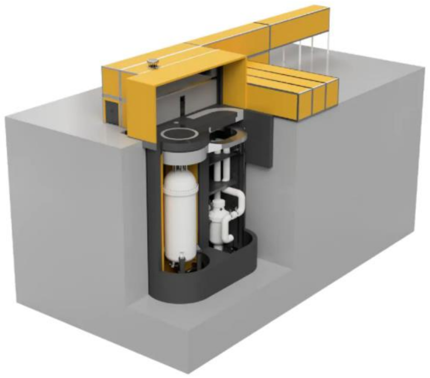
SBD: a facility 'life cycle' concept

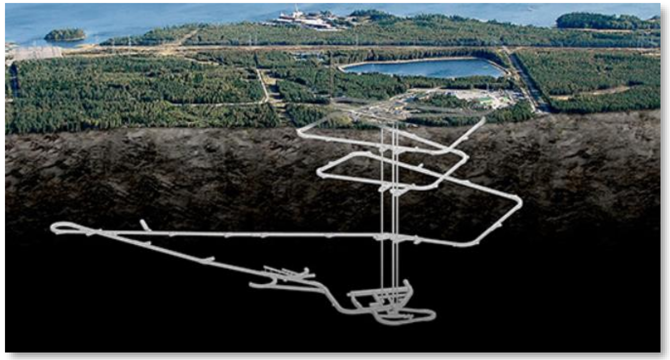
Conceptual Design → Preliminary Design → Final Design → Construction → Operation → Refurbishment → Decommissioning → Waste management

- Whenever a design decision is made (including new processes, components, sub-systems)

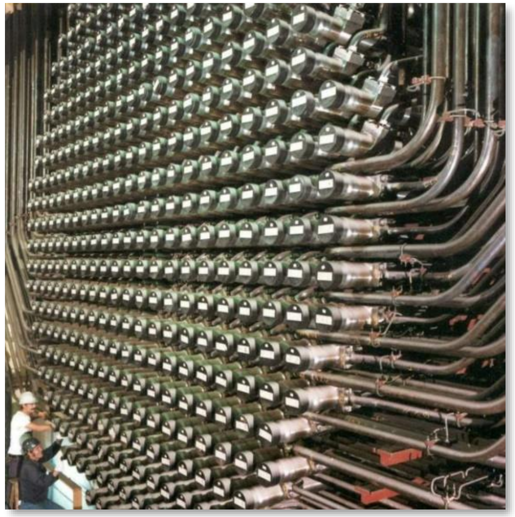
SBD: a State 'fuel cycle' concept







SBD: not a new concept



Rokkasho Reprocessing Facility, Japan:

- ➢ Unattended process monitoring and sampling systems, joint-use equipment

CANDU PHWR reactors:

- Unattended item-flow monitoring systems

SBD: a new priority

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SMRs, advanced reactors:

- **Novel technology and deployment models:** need for new safeguards approaches, measures and equipment

Back-end management:

- **Novel processes, large volumes:** preparation needed for safeguards C/S measures and termination on waste

Safeguards challenges for SMRs

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- **Advanced fuels and fuel cycles:** higher enrichment, pyroprocessing, …
- **Advanced reactor designs:** molten salt, fast reactors, pebble bed, …
- **Longer operation cycles:** continuity of knowledge between refuelling, high excess reactivity of core (target accommodation)
- **New supply arrangements:** factory sealed cores, transportable and floating power plants, transnational arrangements (need for design verification and sealing)
- **New spent fuel management:** storage configurations, waste forms
- **Small footprint:** access, design verification

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Safeguards challenges for SMRs (cont'd)

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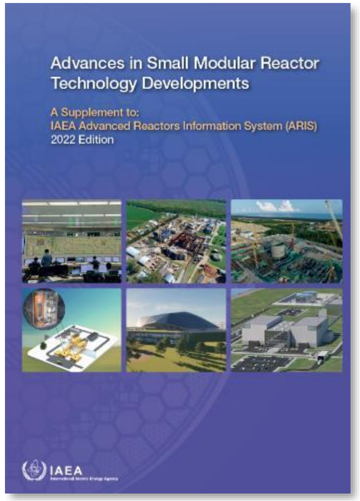
- **Diverse operational roles:** district heating, desalination, hydrogen + electricity
- **Remote, distributed locations:** access issues, lack of "unannounced" visit deterrence, cost-benefit issues
- **Multiple-module plants:** continuity of knowledge, resource issues
- **Sheer number of designs!** (>80 in IAEA 2022 guide)
- **Lack of safeguards awareness** in design community (and difficulty in engaging directly with designers)



➢ Both IAEA and State capabilities **must be ready**

Safeguards needs for SMRs

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- **Unattended monitoring systems** (UMS) and **remote data transmission** (RDT)
- **Digital connectivity** coverage in remote areas (reliable, high bandwidth, secure)
- **Safeguards seals** on factory-sealed, transportable cores
- **Design verification**, particularly under transnational supply arrangements
- **New safeguards approaches**, including (potentially) joint-use instrumentation (e.g., thermal power monitor for microreactors, process monitoring)
- **State-level issues:** e.g., new or expanded nuclear capability
- **Training** for safeguards authority in emerging nuclear energy States

- All of these **need time** for development: SBD provides this

Benefits of safeguards by design (SBD)

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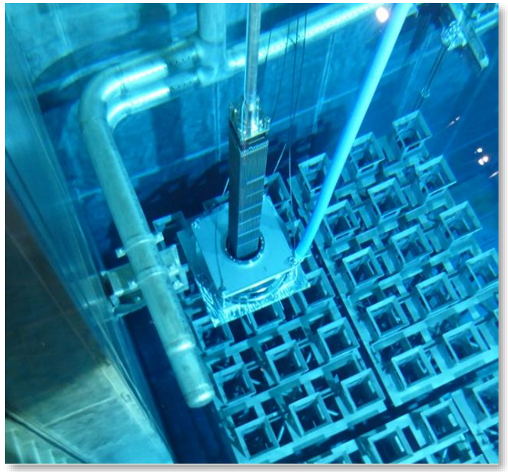
- ✓ Reduce **operator/IAEA burden** by optimizing (reducing) inspections
- ✓ Enhance possibility to use advanced technology like **unattended monitoring systems (UMS)**, and **remote data transmission (RDT)**
- ✓ Reduce need for **retrofitting**
- ✓ Facilitate **joint-use equipment** and **shared process information**
- ✓ **Increase flexibility** for future safeguards equipment installation



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Benefits of safeguards by design (SBD) (cont'd)

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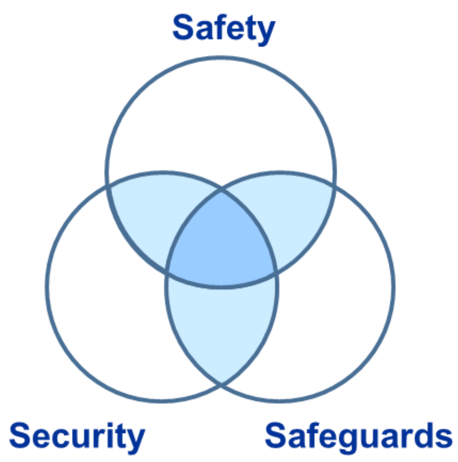
- ✓ **Avoid conflicts and leverage synergies** with safety and security ('3S')
- ✓ **Reduce risk** to scope, schedule, budget, and licensing
- ✓ **Better understanding** by all stakeholders of safeguards obligations (particularly important for embarking countries)
- ✓ Possible **marketing advantages** for vendors?

➢ SBD **benefits all parties** involved, not just the IAEA



New builds: informing the IAEA

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10-year look-ahead:

“Pre-licensing”:

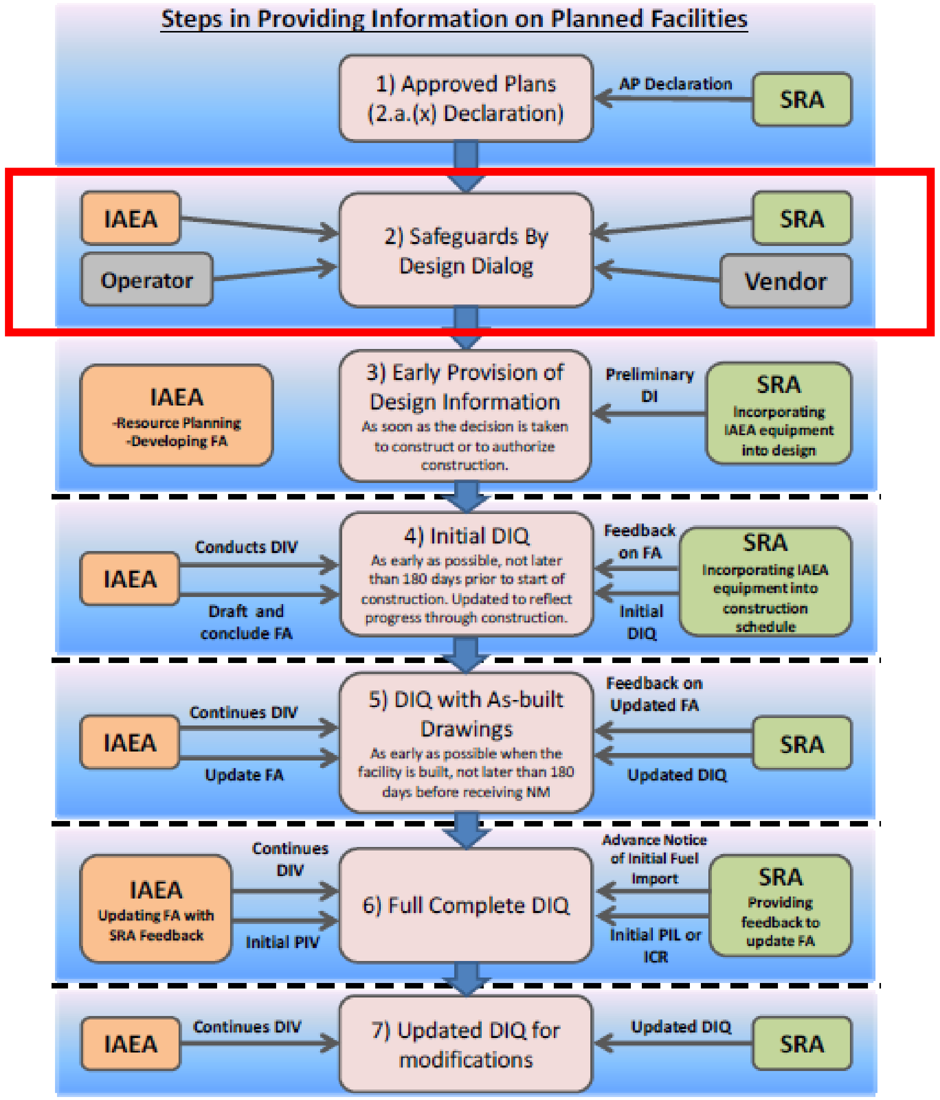
Licence to construct:

6 months before construction:

6 months before receipt of fuel:

Receipt of fuel:

Modifications during operation:



Safeguards by design (voluntary)

“DIQ” = Design Information Questionnaire

From: *Safeguards Implementation Practices Guide on Provision of Information to the IAEA*, IAEA Services Series 33, 2016

SBD example: molten-salt SMR

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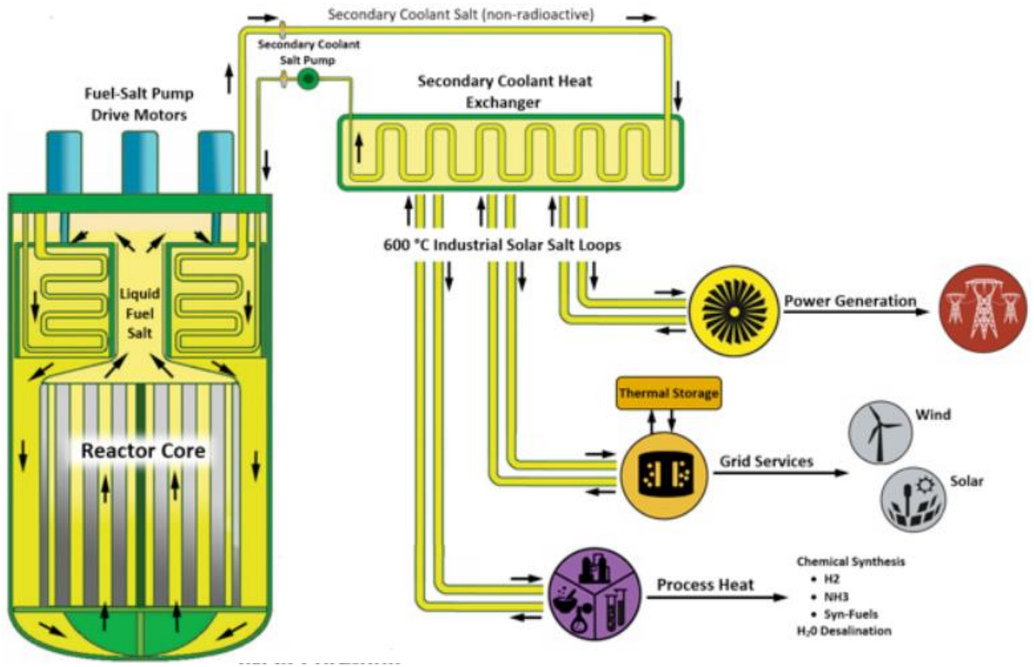
1. A designer of a molten-salt SMR, *as recommended in the 'pre-licensing review' process of the State nuclear regulator*, engages in early SBD discussions with the State safeguards authority (SRA) and the IAEA.
2. Safeguards measures are negotiated, involving IAEA unattended measurement systems (UMS), remote data transmission (RDT), and the secure sharing of operational data.
3. The designer works with the IAEA, SRA, and operator to incorporate these requirements, including development of customized equipment and analysis methods.
4. A prototype of the molten salt SMR is built, and an optimized, effective safeguards approach is implemented.



SBD: challenges to implementation

- IAEA lacks a **direct channel for initiating communication** with designers, particularly at the earliest stages of design when greatest SBD potential exists.
- Lack of an **'engineering requirements' document** for safeguards – only 'best practices'.
- Designers lack a **uniform understanding** of safeguards requirements.
  - Many nuclear designers are new to the industry, often relatively small with limited scope of capabilities
  - Many nuclear design companies are located in Nuclear-Weapon States, where IAEA safeguards are typically of concern when exports are anticipated (lack of "safeguards culture")
- Safety and economics are priority design drivers; safeguards **not seen as a design driver** at all – of relevance toward end of build process
- **Inconsistent licensing practice** in addressing safeguards requirements
- **Proprietary / commercial concerns** with early sharing of detailed design information

SBD: IAEA activities

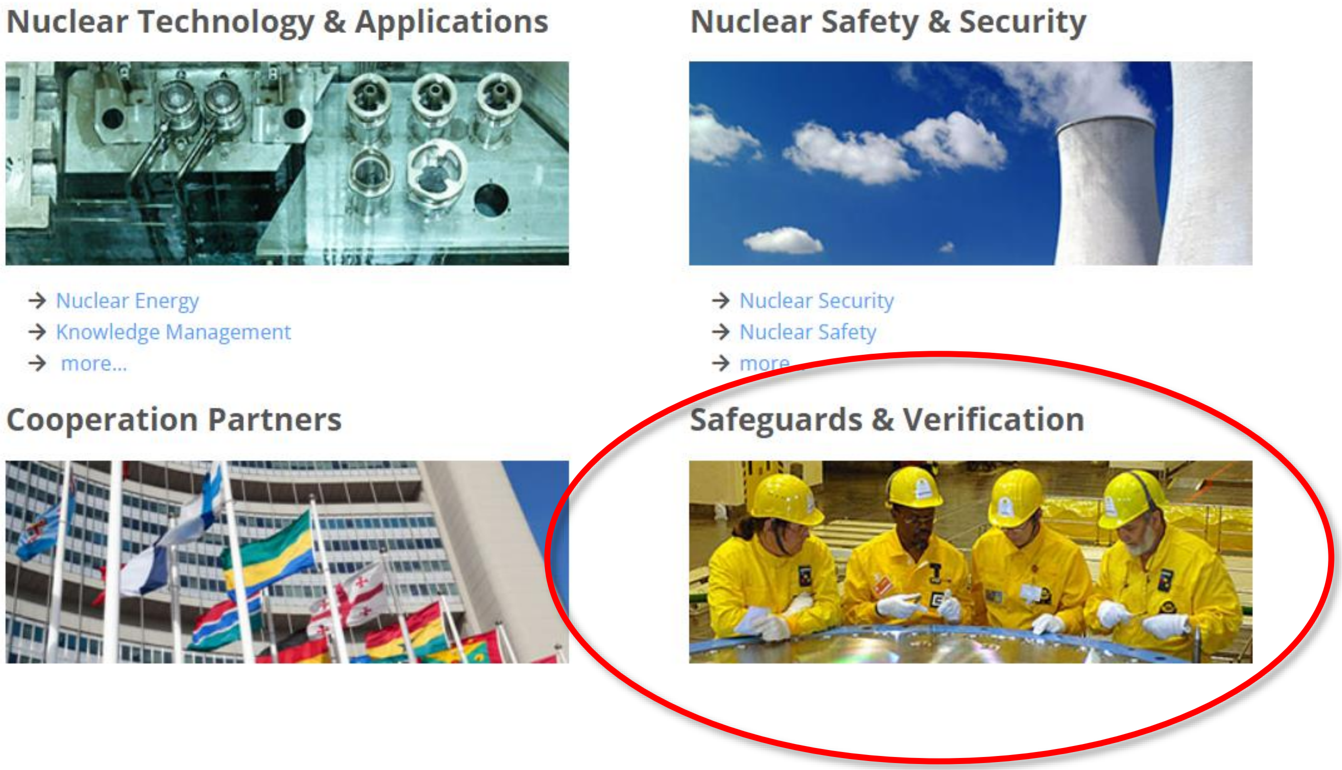
- **SMR Member State support program tasks**
  - Russia, South Korea, US, Canada, Finland, France, China
  - Technologies include floating reactor, integral PWR, molten-salt reactor (MSR), pebble-bed reactor, microreactor (district heating)
  - Program is extendable to other Member States
  - Goal is to work with Member States to:
    - raise awareness of safeguards with technology designers
    - evaluate design aspects (changes?) that could impact safeguards
    - investigate safeguards implementation strategies

- **Internal IAEA collaborations:**
  - **IAEA SMR Platform** (single point of contact for Member States)
  - Dept. of SG **SBD Working Group** (Safeguards, Nuclear Energy, Nuclear Safety and Security)
  - Other internal collaborations with NE and NS initiatives
- **External engagements:**
  - **Raising awareness** with stakeholders through third-party interactions and collaborations

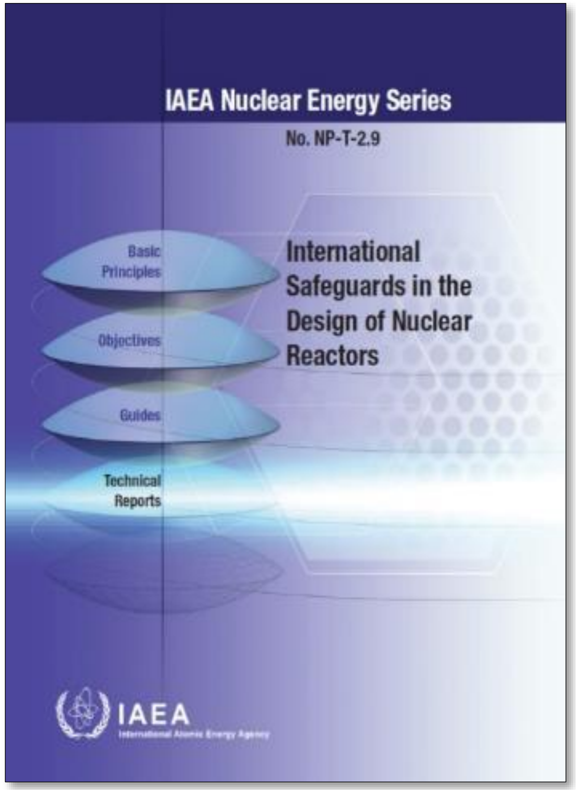
IAEA general safeguards training

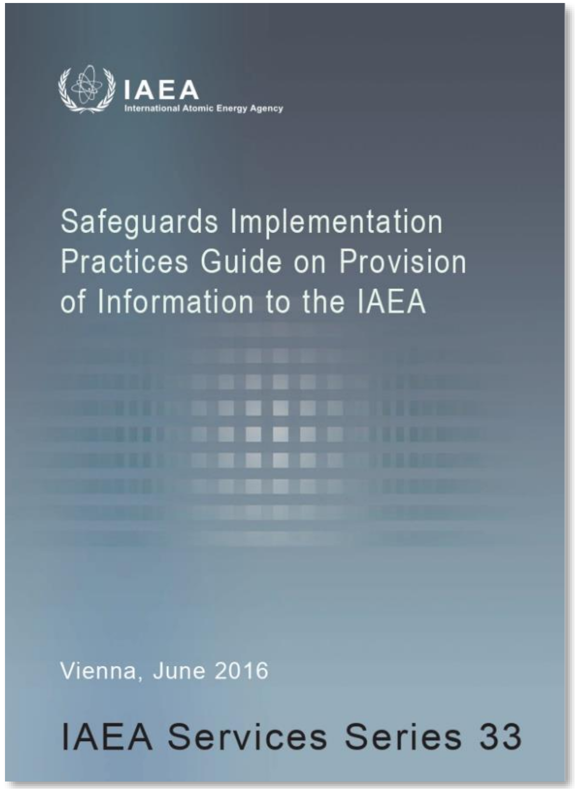
IAEA Open Learning Management System:

https://elearning.iaea.org



IAEA safeguards-by-design guidance





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Thank you for your attention!

J.Whitlock@iaea.org

Dr. Jeremy Whitlock is a Senior Technical Advisor in the Department of Safeguards at the IAEA, with three decades' experience as a scientist and manager in the Canadian and international nuclear community. Prior to moving to the IAEA in 2017 he spent 22 years at Canadian Nuclear Laboratories as a reactor physicist and manager of non-proliferation R&D.

Dr. Whitlock received a B.Sc. in Physics from the University of Waterloo (1988), and an M.Eng. and PhD in Engineering Physics (reactor physics) from McMaster University (1995).

Dr. Whitlock is a Past President, Fellow, and former Communications Director of the Canadian Nuclear Society. Since 1997 he has maintained *The Canadian Nuclear FAQ* (www.nuclearfaq.ca), a personal website of frequently-asked questions (FAQs) on Canadian nuclear technology.

Dr. Whitlock lives in Vienna, Austria, and feels that canoes are the closest humans have come to inventing a perfect machine.

J.Whitlock@iaea.org