IAEA Safeguards: preparing for SMRs

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Jeremy Whitlock

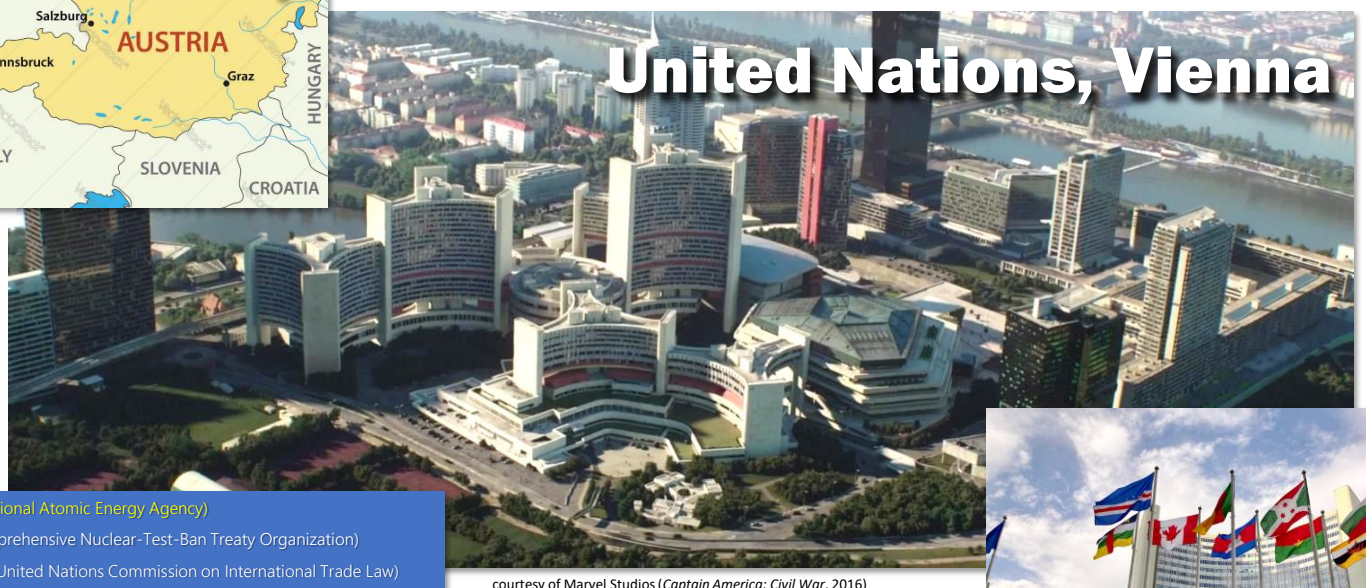
Senior Technical Advisor,
Division of Safeguards Concepts and Planning
International Atomic Energy Agency (IAEA)

J.Whitlock@iaea.org

Topics

- ✓ Brief overview of the IAEA and nuclear safeguards
- ✓ How do safeguards affect SMRs?
- ✓ How can we collaboratively prepare for this?

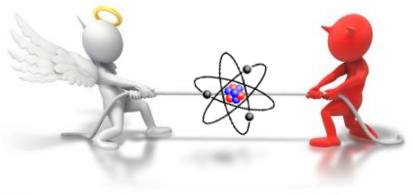
IAEA Safeguards



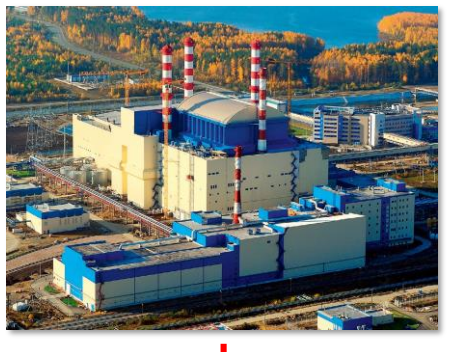
courtesy of Marvel Studios (*Captain America: Civil War*, 2016)

IAEA (International Atomic Energy Agency)
CTBTO (Comprehensive Nuclear-Test-Ban Treaty Organization)
UNCITRAL (United Nations Commission on International Trade Law)
UNIDO (United Nations Industrial Development Organization)
UNODC (United Nations Office on Drugs and Crime)
UNHCR (United Nations High Commissioner for Refugees)
UNOOSA (United Nations Office for Outer Space Affairs)
ICPDR (International Commission for the Protection of the Danube River)

Two sides of nuclear technology



IAEA Safeguards



Nuclear fuel → Energy

→ Irradiated fuel

IAEA →

Safeguards!

State obligation

Misuse
(Pu production for weapons)

Diversion
(Pu extraction for weapons)

"Atoms for peace"

Canada: founding member (1957)

IAEA Safeguards

- The **International Atomic Energy Agency** (IAEA, est. 1957) uses nuclear expertise to improve:
  - ***Health and nutrition***
  - ***Food and agriculture***
  - ***Water and the environment***
  - ***Industrial applications***
  - ***Nuclear safety & security***
  - ***Nuclear power & fuel cycle***
  - ***Nuclear non-proliferation***

Non-proliferation Treaty (NPT)

IAEA Safeguards

IAEA departments:

Nuclear Energy
Nuclear Science & Applications
Technical Cooperation
Nuclear Safety & Security
Management (administration)

~2200 staff

≠

IAEA Safeguards

~860 staff

Non-proliferation Treaty (NPT)

Canada: founding signatory (1968)

IAEA Safeguards

- **Three pillars:**
  Non-Proliferation, Peaceful Uses & Disarmament
- **Nuclear-weapon States (NWS)**
  commit to share benefits of nuclear energy without spreading nuclear weapons capability
- **Non-nuclear weapon States (NNWS)**
  commit to not acquire nuclear weapons

IAEA Safeguards Requirement

Article III requires NNWS Parties to conclude a **safeguards agreement** with the IAEA, which…

"shall be applied on all source or special fissionable material in all peaceful nuclear activities"

Role of IAEA safeguards

IAEA Safeguards

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

- In safeguards planning scenarios, **the State** itself is the prime 'actor'.
- A State's international safeguards obligations **extend to facility operators**.

Comprehensive safeguards agreements

IAEA Safeguards

- Apply to **all Non-Nuclear-Weapon States** (NNWS) under the NPT
- Safeguards apply to **all nuclear material*** in all peaceful activities

Canada:
2nd country to implement (1972)

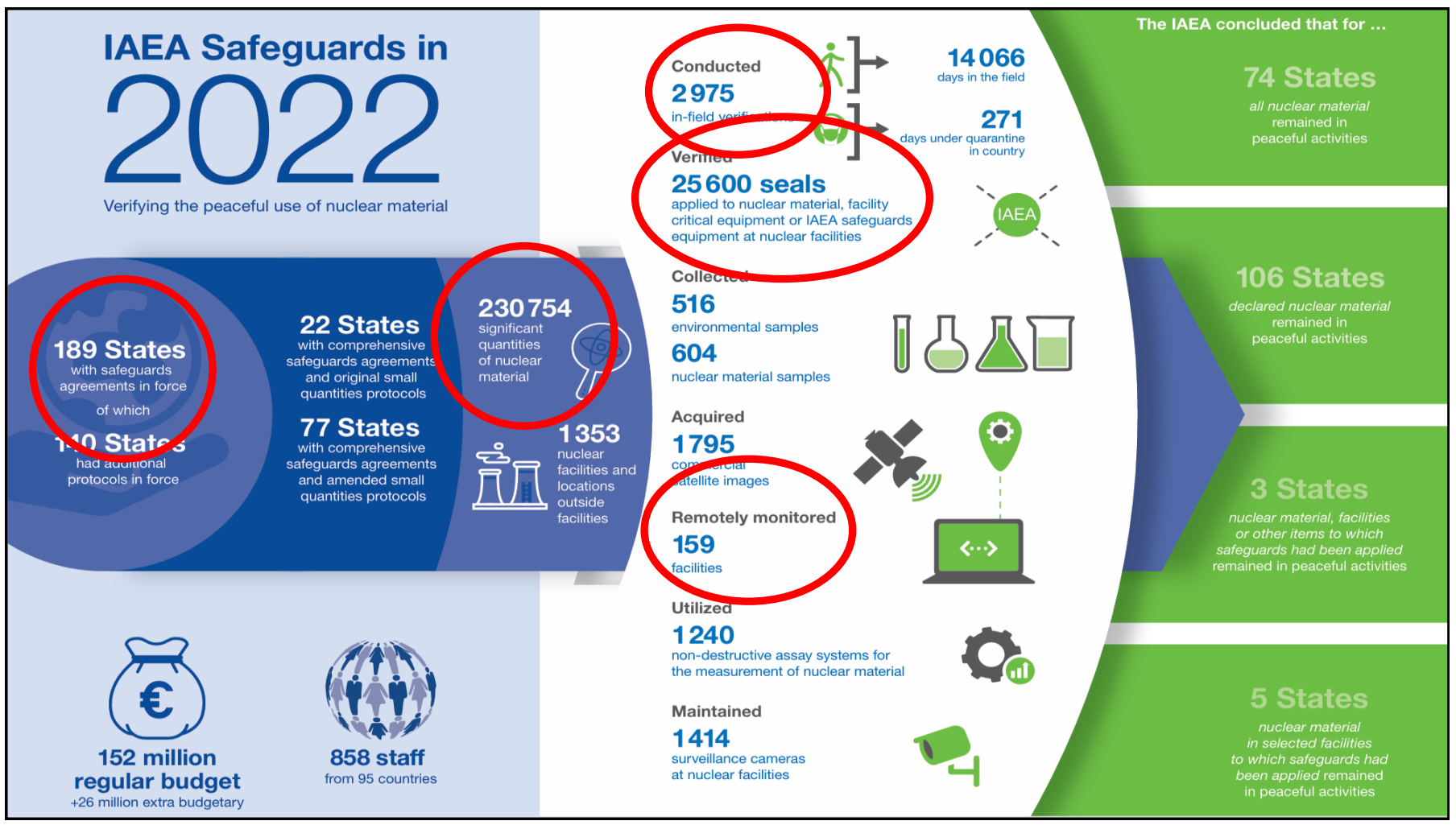
- In non-nuclear weapon states (NNWS) the IAEA needs to verify both **declared material** and **lack of undeclared** material.

*uranium, plutonium, thorium

Independent verification: in-field activities

IAEA Safeguards

- Verification of Nuclear Material Accountancy
  - To verify State's declaration of nuclear material **inventory and flow**
- Containment and Surveillance
  - To maintain **continuity-of-knowledge** between inspections
- Design Information Verification
  - To verify State's **declared facility design** (construction, operation, modification or decommissioning)
- Environmental Sampling, and Complementary Access
  - To assure **"completeness" of declaration**: i.e., absence of undeclared nuclear material or activities



Safeguards awareness: 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 measures and termination on waste

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The challenge:

IAEA Safeguards

- All new nuclear facilities in a non-nuclear-weapon State (NNWS) will need to be safeguarded **when deployed**
  - *regardless of the size, complexity, accessibility, owner/operator or supplier of the technology*
- Many vendors are not aware of the significance of this **customer requirement**
  - *lack of awareness of international safeguards, or perception that it doesn't impact design*
- Advanced reactors may require **advanced safeguards** (which requires R&D)
  - *new core/fuel designs, plant layouts, SF management, fuel cycle facilities, IAEA equipment*
- Enhanced security and 'inherent' PR **do not necessarily mean simpler safeguards**
  - *'safeguardability': often overlooked external component of PR*

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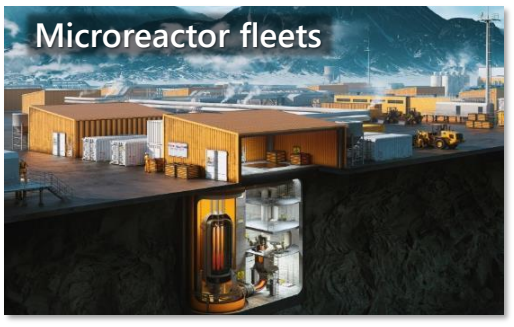
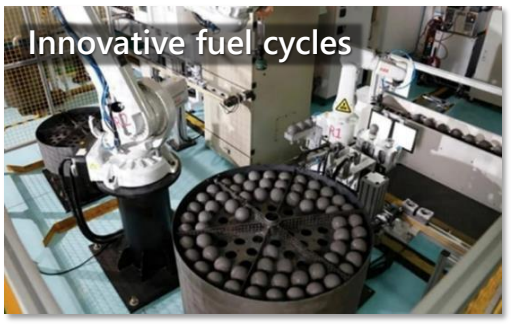
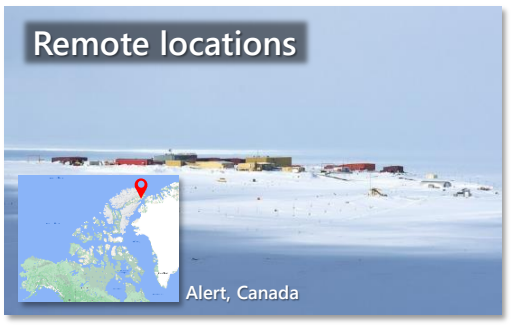
We need to be ready to safeguard these:

IAEA Safeguards







Safeguards challenges for SMRs

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- **New fuels and fuel cycles:** higher enrichment, pyroprocessing, …
- **New 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 power plants, transnational arrangements (need for design verification and sealing)

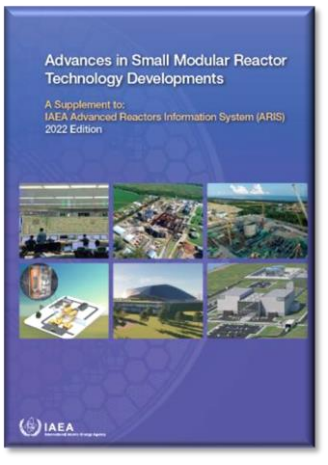
(cont'd)

Safeguards challenges for SMRs (cont'd)

IAEA Safeguards

- **New spent fuel management:** storage configurations, waste forms
- **Diverse operational roles:** district heating, desalination, hydrogen + electricity
- **Remote, distributed locations:** access issues, lack of "unannounced" visit deterrence, cost-benefit issues
- **Sheer number of designs!** (>80 in IAEA 2022 guide)

➢ IAEA verification capabilities **must be ready**



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...Therefore: important needs for SMRs

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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

(cont'd)

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Important needs for SMRs (cont'd)

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- **New safeguards approaches**, including (potentially) customized Agency or joint-use instrumentation (e.g., thermal power monitor for microreactors, process monitoring)
- **State-wide issues:** 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***" provides this time.

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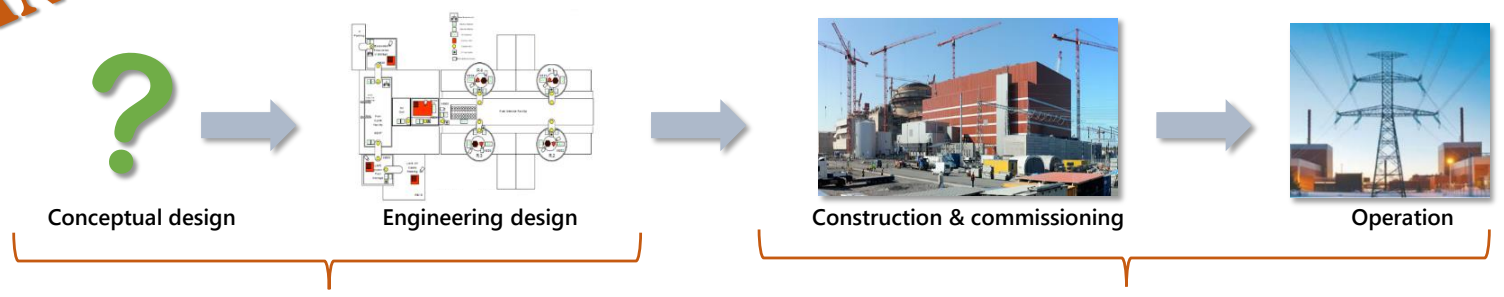
Efficient, effective safeguards

WANTED:

IAEA Safeguards



Safeguards by Design

National safety requirements

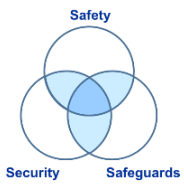
National security requirements

Other national design codes and standards

Operational goals

CUSTOMER REQUIREMENTS

International safeguards obligations:
Provision of design information
Nuclear material accountancy



"3S"

- ✓ **Integration** of safeguards needs into the design process
- ✓ **Awareness** by all stakeholders of safeguards obligations
- ✓ **Voluntary** best practice: not an enhanced obligation
- ✓ **Life-cycle & fuel-cycle tool:** any design process

‘Safeguards by design’: not a new concept

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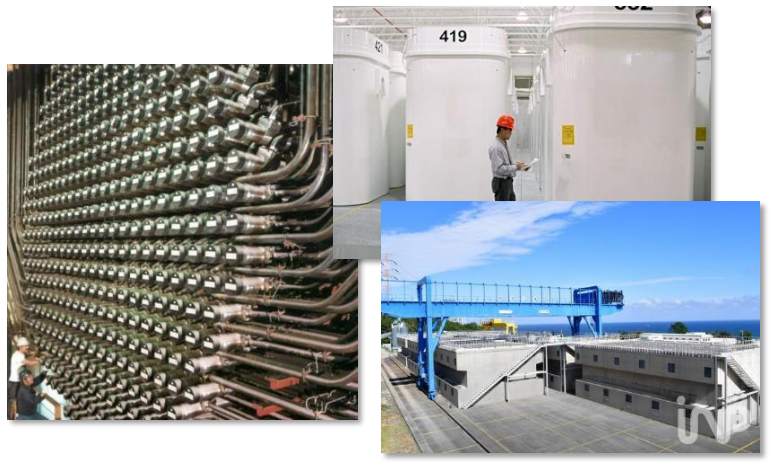

Rokkasho Reprocessing Facility, Japan:

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

CANDU PHWR reactors:

- Unattended fuel-transfer monitoring systems
- Dry storage accommodation of seals and reverification

Benefits of safeguards by design

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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 **shared used of operator equipment** and **process information**
- ✓ **Increase flexibility** for future safeguards equipment installation

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Benefits of safeguards by design (cont'd)

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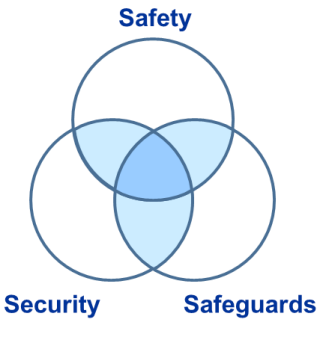
- ✓ **Avoid conflicts and leverage synergies** with safety and security ('3S')
- ✓ Facilitate **termination of safeguards** on radwaste
- ✓ **Reduce risk** to scope, schedule, budget
- ✓ **Better understanding** of customer's needs (operator, State authority): "***it's just good design engineering***"

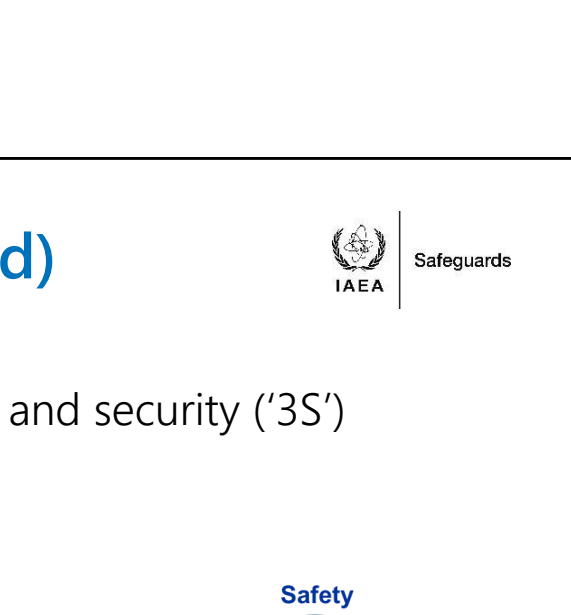


➢ SBD **benefits all stakeholders**, not just the IAEA

Canada: a busy SMR environment!

IAEA Safeguards

- 9 SMR designs submitted to CNSC's pre-licensing Vendor Design Review (3 completed)
- First commercial contract for grid-scale SMR in North America (BWRX-300 at Darlington + 3 more)
- Seen as 'testing ground' for feasibility of new technologies, **including international safeguards**



SBD: IAEA activities

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Canada:
3 SMR companies working with the IAEA on SBD, facilitated by the CNSC

- **SMR Member State support program tasks:**
  - *Russia, South Korea, US, UK, Canada, Finland, France, China*
  - Technologies include FNPP, integral PWR, MSR, PB-HTR
  - Goal is to work with Member States to:
    - evaluate design aspects that 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 (e.g., 3S interfaces in Design Safety Reviews)

- **External engagements:**
  - Raising awareness with stakeholders through third-party interactions and collaborations

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IAEA safeguards-by-design (SBD) guidance

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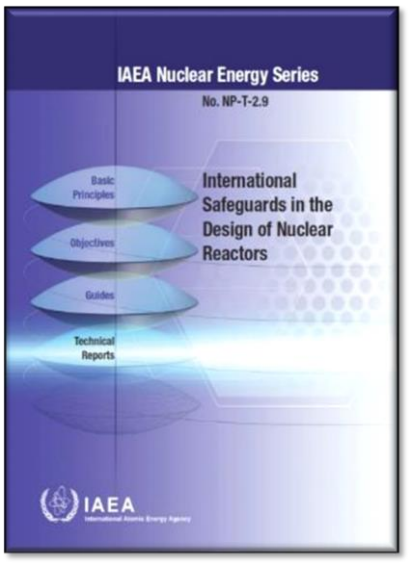

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IAEA
International Atomic Energy Agency

Thank you for your attention!

J.Whitlock@iaea.org

IAEA Safeguards

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