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Safeguards Instrumentation for Future Nuclear Fuel Cycles

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Nuclear Power – A Growing Concern

- Increased discussions on the civil use of nuclear energy
- Driven by economical and environmental concerns
- Proliferation of sensitive nuclear technologies and materials
- Need for alternative approaches to support the Nuclear Renaissance:
  - New nuclear reactor technologies that include built-in proliferation resistance features (GIF, INPRO)
  - Multi-national fuel cycle models (MNA, GNEP)
  - Must take into consideration both safety and economic profitability
  - Determine the impact on future international safeguards and treaty verification support, as well as the instrumentation that will support it
- Long-term perspective
  - Challenges
  - Opportunities

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Overview

- Factors impacting future non-proliferation and safeguards policy
- Future safeguards instrumentation
- The safeguards instrumentation development path
- Conclusions

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Future Non-proliferation and Safeguards Policy

- **Increase use of nuclear power – Nuclear Renaissance**
  - **Increasing energy need of industrializing/industrialized states**
  - **Economic advantages and sustainability**
  - **CO_2 emission free**
- **Globalization of energy markets, including nuclear**
- **Growing proliferation concerns**
- **New challenges for non-proliferation policy**
  - **Atoms for Peace, Non-proliferation Treaty**
  - **Concentration of sensitive technologies (enrichment, reprocessing)**
  - **Broadening safeguards approach**

Multi-national Approaches (MNA)

- **Concentration of sensitive technologies**
  - **Enrichment**
  - **Reprocessing**
- **Multi-national framework**
  - **Supplier countries**
  - **Recipient countries**
- **Success dependent on credible assurance of supply**
- **Impact on non-proliferation and safeguards policy:**
  - **Safeguards in NWS?**
- **Shift towards safeguards as universal standard in ALL countries?**

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Integrated Safeguards

- Shift from traditional safeguards to AP and IS
  - From quantitative to information-driven, qualitative approach
  - Correctness and completeness of declarations
  - State-level conclusions to focus efforts and resources
- Use of broader information sources to complement traditional safeguards
- Shift to continue through next two decades
- How to adapt it over time?
  - Geopolitical changes, e.g. European Community

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New Nuclear Technologies

- **Fourth generation nuclear reactors**
  - **Proliferation Resistance**

  That characteristic of a nuclear system that impedes the diversion or undeclared production of nuclear material, or misuse of technology, by States in order to acquire nuclear weapons or other nuclear explosive devices

  - **Safeguardability**

  Ease of which a system can be effectively and efficiently put under international safeguards

- **Emerging technologies of sensitive nature**
  - **E.g., advanced laser enrichment techniques**

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Future Safeguards Instrumentation

- Implementation of non-proliferation and safeguards policy supported by the IAEA inspection regime
- IAEA inspectors supported by safeguards instrumentation
  - Traditional safeguards: attended, unattended, remote
  - AP (Complementary Access): portable, versatile
  - Very user specific
- Policy changes impact set and use of instrumentation
  - Opportunities – new and emerging technologies
  - Challenges – effective and efficient development and use

AP Instrumentation

- **Instrumentation significantly different from traditional safeguards equipment**
  - **Not verifying declared values**
  - **Not knowing what to expect**
  - **Location tagging important for integrated analysis/cross matching**
- **Fundamental difference in philosophy**
  - **Wide-ranging capabilities**
  - **(Near) Real-time data acquisition/analysis**
  - **System combination (NDA + sample analysis + …)**
  - **Ease of use**

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4^{th} Generation Reactor Safeguards Instrumentation

- **Safeguards by Design**
  - **Planning of cabling**
  - **Efficient on-site inspection time**
  - **Ease of maintenance access**
  - **Remote monitoring**
  - **Wireless safeguards**
- **Synergies beyond safeguards**
  - **Physical Protection**
  - **Personnel safety**
  - **Management tools**

Multi-customer Approach

- Independent authentication of separate data sets
- Wide-ranging synergies not only in the use but also in the development/procurement of systems
  - Example: UF6 sample measurement
  - Real-time laser measurement vs. destructive analysis with mass spectrometry
  - Operator at least as interested in solution as safeguards authorities
- Need for traditional safeguards measures
  - Shift towards IS and state-level conclusions
  - But: infrastructure might be needed in case of political changes
  - Infrastructure can support both traditional and AP safeguards
  - Multi-customer approach mitigates cost implication

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Future Development Path

- Question: do new needs call for new development infrastructure?
- Today: outsourcing of research and development with support of extra-budgetary assistance of MSSPs
  - Niche market
  - High reliability, unique requirements
- Shift towards multi-customer approach might call for changes
- Possible venues:
  - IAEA as champion of development in-house w/ later commercialization
  - Shifting more responsibilities to operator/nuclear industry while providing oversight
  - "Traditional" approach most effective?
- Novel Technologies Approach
  - Information-driven safeguards will expand, need for new solutions
  - New/novel technologies need to be integrated into safeguards approach
  - Strong network of partners (R&D, private sector) needed

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Conclusions

- Dilemma: implementation lies up to 20 years ahead but decisions have to be made in the near future
  - Safeguards by design
  - Synergies
  - Multi-customer approach
- Safeguards authorities cannot act in a vacuum
- Early involvement of all parties
- Continuous process
- Balanced approach
- Goal: new, synergetic, effective and efficient standard for nuclear safeguards