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Success Through Safety, Security, and Safeguards by Design (3SBD): From Concept to Application Workshop
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3SBD Workshop Overview

- How does the 3SBD paradigm change for different nuclear infrastructures and across the entire nuclear fuel cycle?
- What is the role of *intrinsic* versus *extrinsic* measures for 3SBD?
- What is the role of traditional probabilistic risk assessment (PRA) in 3SBD and resultant impact on risk management?
- Are there particularly unique opportunities for implementing 3SBD?
- How much will cyber concerns drive the 3SBD process in the future?

3SBD Workshop Recap

- Session I
  - Institutional and Educational Challenges with 3S
- Session II
  - Application of 3SBD – Risk Assessment and Resource Allocation
- Session III
  - Application of 3SBD – A Facility Design Perspective
- Session IV
  - Lessons Learned and Moving Forward

Institutional and Educational Challenges with 3S

- Implementation of Safeguards by Design at AREVA’s MELOX Fuel Fabrication Facility
- Integrating Safety, Security and Safeguards into Nuclear Education in the UK
- Managing Safety, Security, and Safeguards Risks: A Regulatory Perspective
- Ensuring Optimal Safeguards, Security, and Facility Safety Operations at URENCO USA

Institutional and Educational Challenges with 3S Key Points and Observations

- The interaction between EURATOM and the design/construction of the MELOX facility is an early practical example of safeguards by design
- Industrial applicability was a component of the UCLAN course structure and is key to the program's success
- The regulatory environment is a tool to integrate safety, safeguards, and security, but timely and active participation among principals involved in the design process is key
- Fluid coordination and communication between those working on the 3Ss is vital to their successful implementation in a facility

Application of 3SBD – Risk Assessment and Resource Allocation

- Probabilistic Risk Assessment: An Insufficient Tool to Manage Tradeoffs in 3SBD
- Game Theoretic Security Analysis: Methodology and Application to Reactor Security
- Addressing the Insider Threat for Nuclear Facility Operations
- Fuzzy cognitive mapping and decision making under deep uncertainty: A case study of the Fukushima nuclear accident

Risk Assessment and Resource Allocation Key Points and Observations

- Elements and characteristics comprising risk include scenario definition and likelihood, initiators, human factors, likely causes, and precursors.
- Game theory can provide a means for cost benefit analysis of security measures and allows a sensitivity analysis of consequences
- Explicit consideration of facility operations provides more effective protection against the insider threat
- Fuzzy Cognitive Mapping (FCM) provides a formalism for performance and/or impact assessment.

Application of 3SBD – A Facility Design Perspective

- Civil Design of Nuclear Infrastructure for Safety and Security: Seismic Initiators Versus External Threats
- Optimization of a Commercial Electrochemical Reprocessing Facility through Integration of Safety, Security and Safeguards
- Managing Used Nuclear Fuel: In the Context of 3S

A Facility Design Perspective Key Points and Observations

- In civil engineering, aspects of reactor design, safety and security events can have differing initiators so that optimization for one could possibly have detrimental effects on the other.
- Safeguards and security model developed for electrochemical facilities to assess materials diversion detection scenario dependence on material detection and accountancy accuracy
- SMRs offer a promising environment for application of integrated the 3S approach for design

How 3S's Differ Across the Nuclear Fuel Cycle

Fuel Cycle Step	Nuclear Safety (not including industrial safety)	Security	Nuclear Safeguards
Mining, milling, conversion	Low	Low	Low
U enrichment	Low	Med-High	Med-High
UO_2 Fuel Fab	Low	Medium	Medium
Reactor (LWR)	High	High	Medium
Interim Storage	Low	Medium - High	Medium-High
Reprocessing	Low-medium	High	High
MOX Fuel Fab	Medium	High	High
Disposal	Low	Low	Low-medium

3SBD Implementation

Key operations	Material Measurements	Containment	Radiological safety	Physical Security
Benefits provided by S3BD	Operations are complimentary and mutually- enforcing	Improvements in each area can benefit all	If considered early enough maximum synergies can be realized	Early identification of diversion pathway strengths and weaknesses
Tools/methods that can realize benefits	Optimized NDA instruments placed at key locations during design phase	Building design for tag/ seal effectiveness and tracking/ interrogation capability	Construction design for safety (accident consequence and rad release containment/ mitigation)	Cross-train staff in multiple disciplines and give them rotating assignments
Can be applied during or after design or both	NDA can be added but is better designed in	Unattended monitoring systems can be more tamper resistant if designed during construction	Maximum safety benefit will be realized if designed-in	Management practices can be added-on
Steps needed to demonstrate/ optimize tools	Analyze proposed layout and use of instruments or seals to demonstrate benefits			

Lessons Learned and Moving Forward

- Better definition of the goal(s) of 3SBD and payoffs are needed.
- Need effective communication
- Standardize data in each of the 3S areas
- Highlight the beneficial impacts on the cost and/ or operation of a nuclear facility
- Monitoring instrumentation and integrated data networks should be incorporated from the start
- Enhance the integration between nuclear and civil engineering efforts
- Cyber security will increase in importance in the development and application
- Advanced (nontraditional) approaches (game theoretic, fuzzy logic, discrete event simulation) are ripe for application into the 3SBD process