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Safeguards-by-Design: An Element of 3S Integration

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Abstract. In 2008, the “20/20 Vision for the Future” background report by the IAEA Director General identified the possibility of integrating certain activities related to safeguards, safety, and security. Later in the year, the independent Commission report prepared at the request of the IAEA Director General noted that the Agency’s roles in nuclear safeguards, safety, and security (3S) complement and can mutually reinforce each other. Safeguards-by-Design (SBD) is a practical measure that strengthens 3S integration, especially for the stage of nuclear facility design and construction, but also with ramifications for other stages of the facility life-cycle. This paper describes the SBD concept, with examples for diverse regulatory environments, being developed in the U.S under the U.S. Department of Energy (DOE) Next Generation Safeguards Initiative (NGSI) and the Advanced Fuel Cycle Initiative. This compares with related international SBD work performed in the recent IAEA workshop on “Facility Design and Plant Operation Features that Facilitate the Implementation of IAEA Safeguards”. Potential future directions for further development of SBD and its integration within 3S are identified.

1. Proposed Safeguards-by-Design Process developed by IAEA Workshop

In 2008, the “20/20 Vision for the Future” background report by the IAEA Director General identified that “in view of their mutually reinforcing effect, the IAEA might even in the long term explore the possibility of integrating certain activities related to safeguards, safety, and security. This could create potential synergies and efficiencies.” [1] Later in the year, the independent Commission report prepared at the request of the IAEA Director General noted that “The Agency’s roles in nuclear safeguards, safety, and security complement each other: measures to strengthen any of these “three S’s” can have important benefits for the others and all of the three S’s are essential to the future growth of nuclear applications.” [2]. Safeguards, safety and security roles and definitions differ between the IAEA and the State level regulatory system in different countries, so that without a clear definition of these, the objective and means of its attainment may become unclear. The Agency has defined the components of 3S as follows:

Nuclear safeguards: The means applied to verify a State’s compliance with its undertaking to accept an IAEA safeguards agreement on all nuclear material in all its peaceful nuclear activities and to verify that such material is not diverted to nuclear weapons or other nuclear explosive devices.

Nuclear safety: The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards. It concerns the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks.

Nuclear security: The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear or other radioactive substances or their associated facilities. It includes ‘physical protection’ as understood from consideration of the Physical Protection Objectives, Fundamental Principles, etc.

The IAEA already emphasizes the complementarities of safety and security, and safety and radiation protection. The Agency also states that safety measures and security measures must be designed and implemented in an integrated manner to avoid adverse interaction. The IAEA is already performing pair-wise integration from amongst the S’s. Whilst the IAEA implements international safeguards using monitoring and verification, its role in nuclear safety and security is advisory and supportive. States implement and control national safeguards, safety, and security within their own regulatory environments. The IAEA conceptualized and developed "integrated safeguards facility approaches" for the detection of undeclared nuclear materials and activities. The IAEA expresses this as the need for international safeguards to provide assurance of the completeness of a State's declaration as well as its correctness for the activities declared. Here "integration of safeguards" means the activity of fitting together appropriate aspects or parts of safeguards that work well together and form an optimized system. The IAEA adopts a flexible framework to tailor fit-for-purpose measures for each State.

The "Facility Design and Plant Operation Features that Facilitate the Implementation of IAEA Safeguards" workshop was conducted from October 28-31, 2008, at IAEA Headquarters in Vienna, Austria, with participants from Member States, the European Commission, nuclear industry, and the IAEA [3]. The workshop participants defined a proposed "*IAEA SBD*" process as an approach wherein *international safeguards* are fully integrated into the design process of a nuclear facility - from initial planning through design, construction, operation, and decommissioning. The workshop strongly endorsed the integration of safeguards into the design of new facilities earlier than is presently done. A series of recommendations were made including: revising the IAEA Safeguards Manual to include the SBD initiative. The proposed integration of IAEA, State system of accounting and control (SSAC), operator, and designer actions is summarized in Fig. 1.

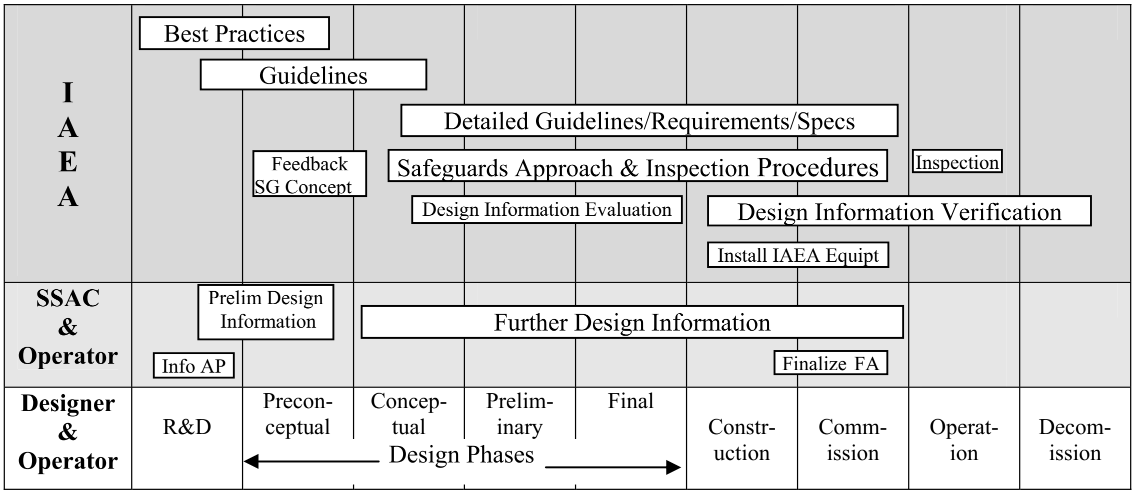

FIG. 1. IAEA Proposed Safeguards-by-Design Process [3]

The IAEA approach differs and complements that under development by the DOE where the SBD process is defined in terms of integrating the wider scope of *international and national safeguards, physical security, and other nonproliferation objectives* [4, 5]. In contrast with the IAEA, the DOE, as a State level U.S. nuclear operational and regulatory agency, which participates in the U.S. SSAC of nuclear material, defines: [6]

Nuclear safeguards: An integrated system of physical protection, material accounting, and material control measures designed to deter, prevent, detect, and respond to unauthorized possession, use, or sabotage of nuclear materials.

Nuclear security: An integrated system of activities, systems, programs, facilities, and policies for the protection of classified information and/or classified matter, unclassified controlled information, nuclear materials, *etc*, and/or the Department's and its contractors' facilities, property, and equipment.

The DOE National Nuclear Security Administration (NNSA), the DOE Office of Nuclear Energy, the DOE Office of Health, Safety and Security, and the U.S. Nuclear Regulatory Commission (NRC) have major responsibilities for nuclear safeguards, safety and security in the U.S.A. There are differing regulatory environments for DOE facilities and for commercial ones as licensed by the NRC. The former tends to be prescriptive and deterministic whilst the latter is rule-based with deterministic requirements but also possesses an increasingly risk-informed, performance-based probabilistic component. Both approaches seek to integrate safeguards and security. The structure of nuclear operational and regulatory organizations in the U.S.A. may differ from other State nuclear structures but all are likely have similar interface arrangements, i.e. SSAC, due to their functional relationships with the IAEA. This paper focuses on how the proposed SBD process developed under a U.S. regulatory environment is adaptable to the needs of other State nuclear organizational structures, complementary to the proposed SBD process within the international safeguards environment coordinated by IAEA, and supportive to the IAEA integrated 3S concept.

2. Safeguards-by-Design within a State Regulatory Environment

2.1 Development of SBD in USA

For the remainder of this report and except where mentioned otherwise, the terms “safeguards” and “SBD” cover the wider definition from the U.S. regulatory environment given in Section 1. The application of a SBD process for new nuclear facilities has the potential to reduce proliferation risks as the use of nuclear energy expands worldwide. To this end, DOE sponsored a multi-laboratory team to propose a SBD process and determine how it could be incorporated into existing facility design and construction processes. The result could ultimately help form the basis for a new international norm for integrating international safeguards into facility design. Here, SBD is defined as a structured approach to ensure the timely, efficient and cost effective integration of international and national safeguards, physical security and potentially other nonproliferation objectives into the overall design process for a nuclear facility, from initial planning through design, construction and operation, i.e. using the U.S. wider definition. A key objective is that security and nonproliferation issues are considered along with safety and other factors when weighing facility design alternatives.

The laboratory team examined facility design processes, best practices and lessons learned from previous facility projects, developments in nuclear safety, and project and systems engineering, in order to propose the essential elements of SBD and a framework for its institutionalization (ISBD) [5]. The SBD framework consists of three pillars (requirements definition, design processes, and technology and methodology) standing on the foundation of institutionalization and needed to support the achievement of a global SBD standard, see Fig. 2.

FIG. 2. Categorization under high-level framework

Historically, safeguards issues are often deferred until late in the design and construction process, resulting in added costs, and schedule and operational impacts associated with retro-fitting the facility. Modern design practices are increasingly front-end loaded, and the possibility to significantly influence major design features, such as intrinsic safeguards, process selection, plant layout, and SSC (systems, structures and components), largely ends with the conceptual design step, when the majority of the lifecycle cost has already been committed [7]. Therefore, the principal focus of SBD was on the early inclusion of safeguards requirements, and the early identification of beneficial design features (i.e. intrinsic) with the intent to reduce or eliminate late adverse impacts in future facilities.

In the central study, the laboratory team proposed a SBD process in the context of the DOE regulatory environment, including the DOE facility acquisition process [8], as an example of a State environment. Since IAEA inspectors verify formal declarations made by the State, the laboratory team considered the incremental overlay of international safeguards requirements on top of requirements for a national safeguards system. DOE's current acquisition process already mandates certain steps relevant to SBD, for example, for physical protection and cyber-security. The laboratory team identified the elements that could be added to support both the national security and international safeguards elements of SBD. The DOE study enabled the development of a "SBD design loop" that is suitable for use in any facility design process.

From experience with the SBD study for the DOE regulatory environment, the laboratory team identified a proposed generic SBD process, which is described in Section 3. As seen below, important features of the generic process include the early incorporation of prescriptive safeguards requirements into the project requirements, early appointment of a SBD design team, participation in facility design options analysis in the conceptual design phase to enhance intrinsic features, definition of new safeguards deliverables akin to safety reports, and formal communication of risks and management strategies to decrease the cost and schedule uncertainties.

Most recently the differences in application of SBD within prescriptive, deterministic and risk-informed, performance-based regulatory environments have been examined conceptually. Many studies point to the value of probabilistic risk assessment (PRA) in its ability to provide an integrated assessment of the performance of a complex system [9]. This may have application to the future integration of safeguards, safety, and security whether they have IAEA or State regulatory origin.

2.2 Development of SBD Process in DOE Regulatory Environment as Exemplar

2.2.1 Safeguards Requirements

Requirements definition forms the first pillar of the proposed ISBD framework, see Fig. 2. Since design requirements drive project execution, these are proposed for the formulation of the SBD process itself and specified for the facility to which the design and construction management process including SBD process will apply. Confirmed methodologies are also needed to decide whether requirements are met by proposed designs. Firstly, the proposed high-level requirements pertaining to the SBD process (i.e., performance-related requirements) within the context of a modern project for which proliferation risk reduction and international safeguards are also to be applied. These proposed high-level requirements for the SBD process are mainly qualitative, at present, and concern its effectiveness, robustness, and flexibility for safeguards design. They have not been derived from fundamentals, nor validated through trade studies. Such work is suggested for later. Future lower-level requirements, such as specifications for performing particular safeguards assessments, are likely to be considerably more definitive and prescriptive. Secondly, current safeguards directives (i.e., prescriptive requirements) for the nuclear fuel cycle must be taken into account. The combination of proliferation risk reduction, including international safeguards, together with national considerations has not routinely been applied within a Nuclear Weapons State.

Areas for prescriptive requirements as derived from DOE directives include: national safeguards, physical protection, and international safeguards. Other areas under study, whilst not accepted internationally in terms of requirements or their corresponding assessment methodologies, include proliferation risk reduction and safeguardability [10-13].

Non-nuclear weapon States, that are a party to the Treaty on the Non-proliferation of Nuclear Weapons, are obliged to conclude an international safeguards agreement with the IAEA. The agreement establishes requirements for such States and associated builder/operators of nuclear facilities that impact the design, startup, and operation of the facilities. As a weapon State and under the U.S. Voluntary Offer Agreement (VOA), the U.S. is only obligated to place facilities on the eligible (nuclear) facilities list (EFL) if they do not have activities associated with Direct National Security Significance to the United States. The VOA offers access to IAEA to carry out inspections of facilities listed under the EFL and these may apply during the potential many decades of facility design, construction, operation, and decommissioning. Following selection by IAEA of an eligible facility for the application of safeguards, the four main elements of the IAEA process to develop and apply a facility-specific international safeguards approach are:

1. Receipt by IAEA of the design information questionnaire (DIQ) from the State authority
2. Negotiation of the facility attachment (FA) by the IAEA with the State authority
3. Design information verification (DIV) by IAEA during construction and operation of the facility
4. Preparation of the facility safeguards approach document by IAEA.

There are many detailed requirements provided in the IAEA Safeguards Manual. These facility-specific requirements must ultimately be translated into actual designed and engineered equipment and features in the facility to perform the requisite activities to the level as specified in the criteria. This poses a challenge to the facility designer in interpreting the IAEA Safeguards Criteria, providing minimal but adequate facilities and minimizing impact on operational procedures and costs. For this reason an earlier and more complete interaction and collaboration between the facility designer, SSAC, and IAEA is recommended.

2.2.2 DOE Design and Construction Management with SBD Design Process

SBD design processes form the second pillar of the ISBD framework, see Fig. 2. To progress the study, the development of the proposed SBD design process within a particular regulatory system was needed and the DOE environment was selected for the initial study due partly to the detail of the DOE directive system. DOE uses a phased design and construction approach [8], which is shown schematically in Fig. 3. The project management group operates as a guiding body for the entire project. The project engineering group uses guidance from the project management group and further specifies or facilitates the execution of the project by interacting with various specialist engineering teams including the SBD team and safety team. The specialist teams also interact and share some team members. Actions are performed by the SBD team, and interactions occur with the other teams for project engineering, and project management.

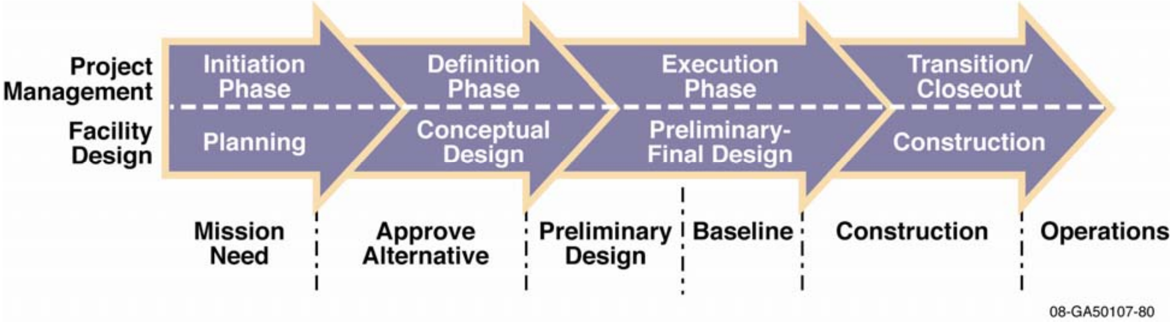

FIG. 3. Typical phases of project management and design processes [8].

The SBD study generated a single proposed process covering DOE national regulatory requirements and international (IAEA) safeguards. The proposed SBD process shows not only the interactions of the SBD team and counterparties but also the resulting actions and deliverables. However, the study was performed in two stages: first, developing a process using DOE national safeguards requirements and SBD team's proposed performance requirements only and, second, modifying the first results by integrating the additional effects of incorporating international (IAEA) requirements. The step-wise approach was to simplify the study and facilitate its visual representation using flowcharts [4,5]. Consistent with the developing design approach, similar cycles of design are performed in each phase of design from the planning, conceptual, preliminary through to final design; followed by that in the construction phase. The SBD proposed process made use of methodology and flowcharts as developed for safety-in-design as described in a recent DOE Standard [14].

During design, the proposed SBD process forms a SBD team to assist the SBD team lead. The SBD team takes information from the facility functional and operational requirements to support an iterative graded process called the SBD design loop. The facility concept or design is passed to the SBD team for modification and reviewed internally until the SBD team is satisfied that it meets the established facility requirements. The design exits the design loop to enter a project design review process, conducted by project peers, which ensures that the safeguards design is in alignment with the overall design. Throughout this process, interaction with the project design, i.e., other design teams, especially safety, is vital, so that the outcome is optimized. The project management system must "at a minimum conduct a Preliminary and Final Design Review, in accordance with the Project Execution Plan. For nuclear projects, the design review will include a focus on safety and security systems." [8]

During design phases, the DOE requires the preparation of two safeguards documents; the vulnerability assessment report and the cyber-security plan. The proposed SBD process develops an overall safeguards design strategy. It projects two additional analyses to support the early identification of the design features relied on to meet safeguards performance requirements. One of the proposed analyses is the material control and accountancy (MC&A) Process Analysis, which identifies the design features and associated system performance requirements needed to meet the established nuclear MC&A standards, commensurate with the maturity of the design. This analysis is tailored to the complexity of the facility and the safeguards significance of the nuclear material housed at the facility. The second proposed analysis is the proliferation barrier/safeguardability analysis, which identifies the design features and associated performance requirements needed to meet intrinsic and extrinsic proliferation risk reduction requirements. The safeguards design strategy identifies the design approaches that the project proposes to meet the safeguards requirements from the DOE directives and performance requirements from vulnerability assessment, MC&A process analysis, proliferation barrier analysis, and cyber-security planning. The latter is an existing DOE requirement and is included here because of its increasingly close relationship to safeguards and security that is evolving toward increased use of integrated, computer-based systems.

The SBD team summarizes the requirements from these four analyses, and documents the design requirements and the applicable DOE directives in a document referred to as the safeguards design functions and specifications. This provides the complete set of safeguards requirements used in the facility functional & operational requirements document and system engineering analyses. The SBD team identifies areas where new or unproven technology or design approaches are planned to meet the applicable safeguards requirements. Working with the project risk management team, the SBD team evaluates the project risks, associated with each of these unproven systems or design approaches and develops measures to mitigate these, e.g., by use of technology development efforts. This analysis is documented in a safeguards design risk and opportunity assessment for review by the customer's safeguards organization to verify completeness, and the reasonableness and feasibility of the risk estimates and mitigation measures. When a project risk cannot be mitigated to an acceptable level, it may be necessary to modify the safeguards design strategy to reduce or eliminate risk.

By the end of each design phase, the SBD team prepares a safeguards effectiveness report. This report documents the implementation of the safeguards design strategy and provides an evaluation of the safeguards effectiveness of the design. Portions of the report evolve into the facility MC&A plan and the facility specific section of the site safeguards and security plan. The customer reviews the safeguards effectiveness report, etc, and issues a conceptual safeguards validation report certifying that all the potential safeguards design issues have been resolved sufficiently so that the project can proceed to the next phase.

For facilities included in the EFL and potentially subject to IAEA safeguards, the SBD process mandates notifying the IAEA of the intent to construct the facility as early as practicable in conceptual design. After the IAEA has selected a facility for the application of safeguards, the SBD process encourages collaboration with the IAEA early in conceptual design regarding the information in the

DIQ. This will require a timely decision from the IAEA concerning selection for IAEA safeguards. Where the preferred design alternative is not selected until the end of conceptual design, collaboration may need to be deferred until preliminary design.

Development of the proposed SBD process in the DOE regulatory environment, as an exemplar, tested the adaptability and assessed effectiveness of the SBD process in an appropriate setting. The methodology used is also relevant to the tailoring of the SBD process to other environments such as that for commercial facilities regulated by the NRC. Further work with stakeholders is underway to obtain broader review of the proposed SBD process.

2.2.3 Technology and Methodology supporting SBD

Supporting technology and methodology form the third pillar of the ISBD framework, see Fig. 2. This includes methodologies for assessing facility designs for compliance with design requirements. Currently no methods are formally accepted, domestically or internationally, for assessment of proliferation barriers and safeguardability of nuclear facilities as needed for application of the SBD process [12,13]. Without accepted methodologies, safeguards requirements cannot be quantitatively evaluated and no strong case can be made for safeguards-driven selection of fundamental design options, e.g. SSC and layout. SBD, whether for State or IAEA environments, then has limited influence on the selection of facility alternatives unless they are cost neutral. The laboratory team also addressed the future development of SBD guiding principles and performed a study of best practices and lessons learned from major nuclear fuel cycle facilities.

2.2.4 Institutionalizing SBD

Institutionalization is the foundation supporting and implementing the three technical pillars of the ISBD framework, see Fig. 2. The entire framework directly supports the goals of the NNSA NGSI in its international safeguards aim of establishing a new global standard for effective application of SBD. A strategy is being developed to transfer the ISBD framework and the SBD process into international safeguards activities under NNSA and IAEA participation. This is applicable to State and IAEA environments. Technical collaboration activities potentially include training, shared methodology testing and document drafting.

3. Generic SBD Process

After the experience of developing the proposed SBD process within the DOE regulatory environment, the laboratory team quickly identified the SBD essentials in the form of a basic generic process. This documents the process essentials in a generic State design and construction environment. Creation of the generic process had several benefits including recognizing assumptions, enabling testing by comparison, and facilitating the formulation of SBD within other U.S. and foreign regulatory environments. The key features of the generic SBD process are as follows:

1. Early involvement of the SBD team in the design effort
2. Early identification of the safeguards requirements for the facility and intrinsic features benefiting the design
3. Closer integration of safeguards with project design leading to improved cost estimates and schedules
4. A clear and simple interaction plan between safeguards and the formal design process, especially safety, that identifies required activities and their timeline and provides detail and design analyses at each phase of the design project
5. Owner/stakeholder approval of safeguards design approaches and risks at key decision points
6. Flexibility to accommodate all regulatory environments and to incorporate all regulatory requirements into the design of nuclear facilities

In general, there is unlikely to be a unique “best way” to integrate requirements and assessment methodologies, so that flexibility and judgment in application of the generic SBD process is important.

The optimal locations for SBD process steps can vary depending on the design and construction pattern chosen. Future work may be worthwhile to identify a minimal set of baseline safeguards performance requirements, as seen within the physical protection, MC&A, and international safeguards requirements of NNSA, DOE, NRC, and IAEA, together with other States. Within this basic set, the minimal process steps for SBD and their optimal positions could be established. These SBD activities may then be integrated more easily within a generic project management sequence that might incorporate as many as a dozen hold points or as few as one or two. This additional work may bring greater flexibility to institutionalize SBD within any safeguards oversight regime.

4. Future Developments for Safeguards, Safety, and Security Integration

DOE and IAEA are developing timelines for activities performed within the proposed SBD processes. The DOE SBD concept specifically includes activities to meet State requirements for MC&A and physical security, with close integration with safety, as well as IAEA safeguards. The timeline developed in the IAEA workshop focuses on activities of the operator, SSAC and Agency for timely development of efficient and effective IAEA safeguards. A future important task is to integrate these two timelines into a single agreed timeline with all activities required for State and Agency roles and interactions.

Both safeguards and safety studies use checklist, qualitative risk assessment and quantitative probabilistic risk assessments (PRA); the latter especially for nuclear power plant (NPP) safety. The Gen IV PR&PP methodology [11] calls for a holistic, risk-informed analysis that examines the relative performance of whole nuclear energy systems, while INPRO [10] has been developing a check-list approach. Both are useful now, proving to be complementary in their use, and continuing to evolve [12].

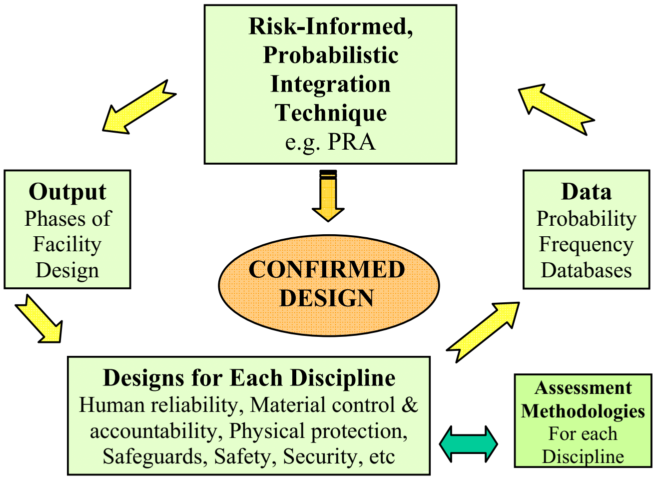

FIG. 4. Potential Application of Risk-informed, Probabilistic Integration to 3S

A wider methodological application for the 3S domain is required to integrate safeguards, safety, and security; each of these comprising many technical disciplines. The use of a risk-informed, performance-based model may be a powerful tool for achieving the integration objectives of the 3S concept, see Fig 4. PRA, with a simplified systems analysis model and with standardized assumptions such as the SPAR model employed by NRC for NPP licensing [15], provides a strong example and is consistent with recent NRC research [9]. The value of PRA is in its ability to provide an integrated assessment of a system's performance, taking into account factors that an analyst considers to be significant. This assessment can include the effects of uncertainties, sensitivities, and the importance of the various factors affecting the results provided. It provides a systematic approach for identifying vulnerabilities and for guiding resources to mitigate them.

5. Discussion

The authors believe that the generic SBD process could be usefully applied today with tangible benefits for most nuclear design projects, within virtually any regulatory system. However, the SBD process is unlikely to be broadly applied in the absence of formal requirements, e.g., regulations to do so, or compelling evidence of its value. Neither exists today. A formal instrument to require the application of SBD is needed and would vary according to both the State and regulatory environments. Industry motivation to voluntarily embrace SBD will depend on the demonstrated benefits of doing so. Consequently, demonstrations or other activities that illustrate the benefits of applying the generic SBD process could be of particular value.

Other challenges remain. The SBD process relies on the incorporation of international safeguards, MC&A and security requirements that derive from existing laws, regulations, stakeholder interests, industry standards, and elsewhere. To the extent that related requirements are incomplete or difficult to translate into meaningful design requirements, they must be amended and improved. Also, there are presently no broadly agreed design standards or formal design requirements for proliferation risk reduction beyond those for international safeguards. Finally, there are numerous barriers to the implementation of SBD. These include the lack of a strong safeguards culture, the sensitive nature of safeguards information, and the potentially divergent or conflicting interests of participants in the process. Efforts to institutionalize SBD must address these issues.

The authors envision a more ambitious set of objectives for the further development and implementation of SBD leading into 3S. The multi-decade long evolution of the risk-informed approach to safety provides a parallel for future development of the design approach to safeguards, safety, and security – 3S. Systems analysis offers a means for identifying vulnerabilities and evaluating efficient alternatives. Further development appears to be warranted, though the history of safety methodology development suggests that expectations should remain modest regarding timescales. It is not yet clear if the added effort will prove to be economically justified.

6. Conclusions

Conclusions are drawn as follows:

1. A DOE multi-laboratory team proposed a conceptual framework for Safeguards-by-Design for formalizing the development and deployment of the SBD process in the State environment. This supports the DOE Next Generation Safeguards Initiative (NGSI) and key IAEA safeguards objectives, and may be useful internationally in helping to establish a high-level global standard for nuclear facility design.
2. The SBD process focuses on the early design phases, facility requirements definition, safeguards design assessment, selection of major design options, intrinsic safeguards features, life-cycle cost and schedule risk management, and design and risk communication with major stakeholders.
3. The SBD process applies beneficially today using existing prescriptive requirements and methodologies. The results obtained are likely to be improved as more of the SBD framework is utilized and assessment methodologies improved.
4. Future developments of design principles, guidelines, and best practices are seen as valuable near term objectives.
5. The generic SBD process for the State regulatory environment, proposed using the DOE regulatory environment as exemplar, is a necessary precursor and complement to the IAEA's proposed SBD process for international safeguards.
6. SBD is important at the State level, where facility design takes place, and is effective at the international safeguards level as co-ordinated by IAEA.
7. The generic SBD process developed by DOE is an element of the 3S concept in that it integrates international safeguards, national safeguards, physical security, other nonproliferation objectives and safety for the State environment and for facility design and construction stages in particular.
8. The distinct SBD processes for State environment and for Agency environment can used to develop a single timeline covering all relevant State and Agency activities and interactions.

9. The SBD effort within the DOE NGSI supports the IAEA proposed expert working group(s) to be tasked with defining the SBD process for the Agency's role, developing an implementation strategy, and developing new design guidelines organized by facility type that can be published as part of the IAEA's Nuclear Energy Series.
10. Pilot testing of the SBD process is needed to seek confirmation of the expected benefits during facility design and construction and encourage its adoption through industry initiatives or regulatory directives.
11. The use of a risk-informed, probabilistic technique, applied to a simplified systems analysis model with standardized assumptions, should be explored in the longer term for quantitative integration of safeguards, safety, and security – 3S.

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