Interfaces among Safety, Security, and Safeguards (3S) — Conflicts and Synergies

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ABSTRACT

In recent years, the need to achieve a better understanding of the relationships and interfaces among three disciplines related to nuclear power — safety, security, and safeguards (3S) — has become widely recognized. The challenge is to effectively and efficiently integrate the 3S requirements. All stakeholders could benefit from the integration of 3S: designers and operators, shippers and carriers of nuclear material, national and international authorities, and the world population. To address this challenge, the potential for conflicts and opportunities for synergy among the elements of 3S must be identified. This paper identifies the 3S interfaces that have the potential for creating conflicts and synergies. The main step in developing guidance is to examine where and how 3S requirements interface. We start with the International Atomic Energy Agency (IAEA) model Comprehensive Safeguards Agreement (INFCIRC/153) and Additional Protocol (INFCIRC/540). We then identify two types of access that are the basis for conflicts and synergies in 3S. Finally, we provide recommendations for improving overall efficiency and effectiveness to be considered by designers, operators, shippers, and authorities during the integration of the 3S requirements.

INTRODUCTION

Many published papers address two of the 3S (safety, security, and safeguard) requirements as pairs; for example, safety/security, security/safeguards (material accounting and control, or MC&A), and safeguards/safety. Historically, safety has been given the highest priority, and security has been given almost equal priority following 911. A new paradigm that encompasses all three 3S disciplines is needed that enables the sharing of data and instruments. One reason why addressing 3S integration is such a paramount necessity and challenge is that when one of the three becomes a primary concern, the other two are affected and can become related issues if conflicts are not addressed. The challenge has been characterized as demonstrating that “3S can provide more with less” [1].

The purpose of this paper is to shift attention from addressing only 2S pairs to developing a framework for addressing the 3S family in a holistic manner — from design to implementation. To develop this framework, we began by identifying relationships among threats and corresponding objectives for the family of 3S. We then ascertained that two types of access are at the root of potential conflicts and synergies among 3S: access to nuclear material information and access to nuclear materials. Finally, we used specific international safeguards requirements of the International Atomic Energy Agency (IAEA) model Comprehensive Safeguards Agreement (INFCIRC/153) and Additional Protocol (AP) (INFCIRC/540) as the starting point for identifying where potential conflicts or synergies due to 3S interactions might occur. Figure 1 depicts the family of 3S in a Venn diagram with the various resulting unions and intersections of 3S.

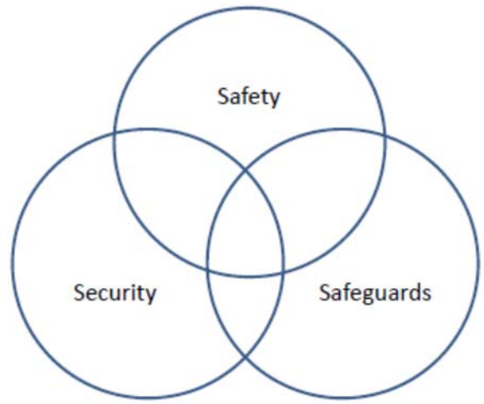

Figure 1. Unions and Intersections of 3S

INTERNATIONAL SAFEGUARDS AND 3S

Examples of each of the three separate cultures for 3S have been reported worldwide, but a single integrated 3S culture is yet to emerge. Upon noting that nuclear nonproliferation safeguards, nuclear security, and nuclear safety are the fundamental principles on which the peaceful use of nuclear energy is based, Japan launched an international initiative promoting the highest possible standards for nuclear nonproliferation safeguards, security, and safety [2,3].

The IAEA identifies 3S as three of the nineteen issues that need to be considered during each of the three major milestones associated with developing civilian nuclear power: commitment, bids, and operator commissioning. The IAEA further notes that demonstrating compliance with international legal instruments and internationally accepted nuclear safety standards, security guidelines, and safeguard requirements is essential for establishing a responsible nuclear power program [4]. The IAEA has elaborated on the importance of including 3S technical requirements in as early a time as the bid invitation specifications (BIS) phase in order to provide information needed by prospective contractors [5]. The consideration of 3S is particularly important to designers and operators in cases where the regulatory framework already recognizes the interactions among 3S.

The 3S concept has emerged in nuclear law and is used to avoid gaps, overlaps, and inconsistencies in the law [6]. Broad international recognition of the need for 3S to avoid conflicts and ensure that all three elements support each other is documented by the IAEA [7]. The IAEA nuclear legislative assistance program, which helps in the drafting of nuclear laws and regulations, recognizes the interfaces associated with the 3S concept [8].

There is increasing recognition that each of the 3S disciplines is not a standalone concept. A number of 3S training courses, workshops, and university courses have been conducted recently. Although the 2S disciplines have been connected, in practice, the 3S disciplines have seldom been interconnected. Specific examples of cases where 2S disciplines have been addressed are the safety/security pair [9-11] and the security/safeguards (MC&A) pair [12-14]. These have been addressed far more frequently than the safeguards/safety pair. The 3S “triplet” is somewhat more complex to address, but doing so is not only necessary but imperative.

THE 3S DISCIPLINES AND INTERACTIONS

The disciplines of safety and security are generally well understood with regard to principles, applications, and culture in the nuclear industry, whereas safeguards is generally not. However, there are direct relationships among the implementation of 3S. Some of these relationships lead to conflicts, and others lead to synergies. Integration of 3S leads to an infrastructure that provides the most effective design and efficient operation of a nuclear facility and handling, transfer, and shipment nuclear materials.

Consideration of the 3S elements has been recognized as being essential for the design, construction, and operation of nuclear power plants [15]. In particular, IAEA Requirement 8, "Interfaces of Safety with Security and Safeguards," states that safety measures, nuclear security measures, and arrangements for a "State" system of accounting for and control of nuclear material for a nuclear power plant are to be designed and implemented in an integrated manner, so they do not compromise one another. The global expansion of nuclear energy will benefit greatly from the integration of safety, security, and safeguards through the 3S concept [16].

The synergies of integrating all 3S by design (3SBD) have been explored, particularly with regard to reducing the extent of operating disturbances caused by inspections [17]. Some specific examples of conflicts and synergies have been published [18]. In particular, synergy among 3S disciplines offers opportunities for cost savings and enhanced efficiency at the facility level. Collaboration on 3S best practices is needed. Institutionalizing 3S requires harmonizing the notions about risk embedded in each of the 3S disciplines.

Unlike their experience in dealing with longstanding safety and security requirements, operators have only a little experience or familiarity with nonproliferation safeguards, and designers have even less. A quantitative analysis/assessment is needed [19]. A systematic and structured approach could lead to greater effectiveness and efficiency for the combined 3S in terms of design, construction, operation, and regulation in the long term.

The three individual disciplines associated with 3S have evolved separately over time. Identifying 3S relationships and interactions on a trilateral basis is necessary. When one 3S discipline becomes a concern (for example, radiation safety during events like those at Fukushima Daiichi, Three Mile Island, or Chernobyl), the other two disciplines (security and safeguards) also are affected and become related concerns. Detecting an unexpected change in the radiation field in an operating facility, on the other hand, can trigger an immediate alert, thus enhancing 3S.

Identifying conflicts and synergies among the 3S disciplines continues to be a challenge because, in part, of the lack of combined technical expertise for all three disciplines. A better combined understanding of 3S, which takes into account the objectives of each of the 3S disciplines, would enable more efficient and effective management and implementation because conflicts would be recognized and synergies could be taken advantage of [20-22]. To better understand the range of potential conflicts, a methodology or framework for analyzing 3S is needed [23, 24].

METHODOLOGY FOR ANALYZING 3S INTERACTIONS

Before defining an approach or methodology for analyzing 3S interrelationships, it is helpful to identify a working definition of the corresponding threats and objectives. The three main aspects of nuclear law for 3S have been reported to be as follows [25]:

- Safety: Unintended conditions or events leading to radioactive releases from authorized activities.
- Security: Intentional misuse of nuclear or other radioactive materials by non-State elements.
- Safeguards/Nonproliferation: Activities by States that could lead to the acquisition of nuclear weapons.

These three legal aspects lead to the following three corresponding threats:

- Safety Threat: Accident due to system failure, human error, or natural disaster.
- Security Threat: Terrorism due to sabotage, external attack, or inside malicious act.
- Safeguards/Nonproliferation Threat: Diversion or misuse for non-peaceful purpose.

The consequent individual objectives have become the following:

- Safety: Protect people and the environment from radiation.
- Security: Protect nuclear materials and facilities from malevolent people.
- Safeguards: Protect people and the environment from malevolent people.

Given these objectives, integrating 3S to extract benefits while preserving the individual functions becomes a complex task. A set of basic principles and a systematic framework helps address this conundrum. Given the objectives for each of the 3S, it is possible to determine some basic principles regarding why and how conflicts and synergies occur based on the need for two types of access:

1. *Access to Nuclear Material Information:* All three disciplines (safety, security, and safeguards) require access to nuclear material information. Thus, sharing this information to the extent possible (rather than collecting and compartmentalizing it) can lead to synergies that result in greater effectiveness and efficiency for each discipline. At the same time, however, access to certain information (particularly that related to physical security and information security) is restricted, so conflicts do arise.

2. *Access to Nuclear Material:* Two disciplines (safety and security) restrict physical access to nuclear materials, but the third discipline (safeguards) requires access to nuclear materials, so conflicts do arise. At the same time, however, safety and security may synergistically benefit from the joint sharing of information collected during access to material for safeguards purposes obtained from nondestructive and destructive analyses, seals, cameras, or remote radiation monitoring.

By applying these two principles and referring to the specific safeguards requirements under the IAEA CSA (INFCIRC/153) and AP (INFCIRC/540) as a framework, the potential conflicts (C) and synergies (S) among 3S can be ascertained for each safeguards requirement. Some requirements entail only a minor 3S consideration (denoted by NA for non-applicable). Determining the potential for conflicts and synergies at this level is subjective and ultimately depends on specific factors, such as the facility type, design, and operations, as well as on specific safety and security requirements. Also, the more specific the requirement is, the clearer is the conflict or synergy. Tables 1 and 2 show under IAEA CSA and AP, respectively, the framework for and results from using this approach.

Table 1. Interactions for Potential 3S Conflicts (C) and Synergies (S) under the IAEA Model CSA (INFCIRC/153) Framework

Required Safeguards	Required Security	Required Safety	Comment
Model CSA (INFCIRC/153) Part I, General Understanding			
1 Basic Undertaking	S	S	INFCIRC/140 (Treaty on the Non-Proliferation of Weapons or NPT)
2 Application of Safeguards	S	S	IAEA right and obligation
3 Implement Safeguards	S	S	Cooperate
4 Implement Safeguards	S	S	Avoid interference; prudent management
5 Implement Safeguards	S	S	Protect information
6 Implement Safeguards	S/C	S/C	Full account of technology
7 Establish State System of Accounting for and Control of Nuclear Materials (SSAC)	S/C	S/C	Refers to Part II
8 Provide Information	S/C	S/C	Refers to Part II
9 Designate Inspectors	S/C	S/C	State consent
10 Privileges and Immunities	S	S	INFCIRC/9
11 Terminate Safeguards	S	S	Consume or dilute
12 Terminate Safeguards	S	S	Exports
13 Terminate Safeguards	S	S	Non-nuclear activities
14 Non-application of Safeguards	C	C	Example: nuclear propulsion
15 Finance	NA	NA	Each party's expenses
16 Third-Party Liability	NA	NA	Liability regarding nuclear damage
17 International Responsibility	NA	NA	Claim for damage
18 Verify Non-diversion	NA	NA	Board of Governors (BOG) call on State
19 Verify Non-diversion	NA	NA	BOG report to United Nations
20 Interpretation and Disputes	NA	NA	Parties consult on questions
21 Interpretation and Disputes	NA	NA	BOG considers questions
22 Interpretation and Disputes	NA	NA	Arbitration
23 Final Clauses	NA	NA	Amend agreement
24 Final Clauses	NA	NA	Suspend other agreements
25 Final Clauses	NA	NA	CSA entry into force
26 Final Clauses	NA	NA	Remain in force
Model CSA (INFCIRC/153) Part II, Specific Procedures			
27 Introduction and Purpose	C/S	C/S	Specify procedures
28 Objective of Safeguards	C/S	C/S	Timely detection and deterrence
29 Objective of Safeguards	C/S	C/S	Use of material accountancy, containment, and surveillance
30 Objective of Safeguards	C/S	C/S	IAEA technical conclusion
31 SSAC	C/S	C/S	IAEA use and avoid duplication
32 SSAC			Material balance areas(MBAs) & measures
a Measurement system	S	S	" " " " " "
b Measurement uncertainty	S	S	" " " " " "
c Shipper/Receiver (S/R) measurements	S	S	" " " " " "
d Physical inventory	S	S	" " " " " "
e Unmeasured losses	S	S	" " " " " "
f Records and reports system	S	S	" " " " " "

g Accounting system	S	S	“ “ “ “ “ “
h Reports to IAEA	S	S	“ “ “ “ “ “
33 Safeguards Starting Point	NA	NA	After mining and ore processing
34 Safeguards Starting Point	S	S	Reporting at starting point
35 Safeguards Termination	S	S	Consumed, diluted, non-nuclear
36 Safeguards Exemption	S	S	Limited use
37 Safeguards Exemption	S	S	Limited quantities
38 Safeguards Exemption	S	S	Reapplication of safeguards
39 Subsidiary Arrangements	C/S	C/S	Specify procedures
40 Subsidiary Arrangements	NA	NA	Entry into force
41 Inventory	S	S	IAEA unified State inventory
42 Design Information	NA	NA	When to provide
43 Design Information	C/S	C/S	What to provide
44 Design Information	C/S	C/S	Other information (safety and security)
45 Design Information	C/S	C/S	Change to design information
46 Design Info. Examination	C/S	C/S	Purpose of examination
47 Design Info. Re-examine	C/S	C/S	Changes by operator or IAEA
48 Design Info. Verification	C/S	C/S	Onsite verification
49 Material Outside “Facility”	C/S	C/S	Example: radioisotope information
50 Material Outside “Facility”	C/S	C/S	Example: radioisotope visit
51 General Records System	S	S	SSAC records system exists
52 General Records System	C	S	Examination by IAEA
53 General Records System	NA	NA	Retention for 5 years
54 General Records System	S	S	Accounting and operating
55 General Records System	S	S	Measurement standards
56 Accounting Records System	C	S	What information by MBA
57 Accounting Records System	C	S	What information by MBA
58 Operating Records System	C	S	What information by MBA
59 General Reports System	C	S	States shall provide reports
60 General Reports System	NA	NA	Official language
61 General Reports System	S	S	Based on records system
62 Accounting Reports System	NA	NA	Initial report timing
63 Accounting Reports System	C	S	What information by MBA
64 Accounting Reports System	C	S	What information by MBA
65 Accounting Reports System	C	S	What information by MBA
66 Accounting Reports System	C	S	IAEA reports to State
67 Accounting Reports System	C	S	What information by MBA
68 Special Reports to IAEA	C	S	Incident or loss
69 Clarification to IAEA	C/S	S	For any report
70 Inspections – General	C/S	C/S	IAEA right to inspect
71 Inspections – Purposes	C/S	C/S	Ad hoc inspections
72 Inspections – Purposes	C/S	C/S	Routine inspections
73 Inspections – Purposes	C/S	C/S	Special inspections
74 Inspections – Scope of IAEA inspection activities	C/S	C/S	Records, measurements, calibration, surveillance, and containment.
75 Inspections – Scope of IAEA inspection activities	C/S	C/S	Observe and ship samples; take measurements and calibrations; and install equipment and seals
76 Inspections – Access	C/S	C/S	Access to materials and information
77 Inspections – Access	C/S	C/S	Access to materials and information

78 Inspections – Routine	C/S	C/S	Number, intensity, duration, and timing
79 Inspections – Routine	C/S	C/S	For continuity of knowledge
80 Inspections – Routine	C/S	C/S	Maximum routine inspection effort
81 Inspections – Routine	C/S	C/S	Criteria
a Nuclear material form	C/S	C/S	“
b SSAC effectiveness	C/S	C/S	“
c Nuclear fuel cycle	C/S	C/S	“
d International interactions	C/S	C/S	“
e Safeguards developments	C/S	C/S	“
82 Inspections – Routine	C	C	IAEA/State consultations
83 Inspection Notice – Yes	S	S	Advance notice of inspection
84 Inspection Notice – No	C	C	Unannounced inspections
85 Inspectors – Designation	NA	NA	IAEA proposed; acceptance
86 Inspectors – Visas	NA	NA	Granted by State
87 Inspections – Conduct	C	C	Avoid hampering operation safety
88 Inspections – Conduct	C	C	State facilitates services
89 Inspections – Escorts	C/S	C/S	Accompany inspectors
90 IAEA Statement	C/S	C/S	Inspection results/conclusions
91 International Transfers	NA	NA	Who is responsible
92 International Transfers	C/S	C/S	Exports notified to IAEA
93 International Transfers	C/S	C/S	Exports verified by IAEA
94 International Transfers	C/S	C/S	Notification of export received
95 International Transfers	C/S	C/S	Imports notified to IAEA
96 International Transfers	C/S	C/S	Imports verified by IAEA
97 International Transfers	C/S	C/S	Special report of incident
98–116 Definitions	NA	NA	For Articles 1–97

Table 2. Interactions for Potential 3S Conflicts (C) and Synergies (S) under the IAEA Model AP (INFCIRC/540) Framework

Required Safeguards	Required Security	Required Safety	Comment
Model Additional Protocol (INFCIRC/540)			
Preamble	C/S	C/S	More effective and efficient
Preamble	C/S	C/S	Do not hamper economics, cooperation, and technology
Preamble	S	S	Health, safety, and security
Preamble	C	C	Commercial, technological, industrial, and confidential information
Preamble	C/S	C/S	Activities frequency/intensity
1 Relationship	C	C	CSA and AP
2 Provide information			Information:
a Information	C	S	Government nuclear R&D without nuclear material; nuclear operations with nuclear material; use of each building; manufacture of nuclear equipment; U mines; U and Th concentration; impure source material, exports, and imports; high-level waste (HLW), highly enriched uranium (HEU), and U-233; exports &

			imports of nuclear equipment & non-nuclear materials; 10-year plan
b Information	C	S	Non-government nuclear R&D without nuclear material; persons
c Information	C	S	Amplify and clarify
3 Provide Information	NA	NA	Timing and updates
4 Complementary Access			Access to:
a Access to locations	C	C	Any location regarding undeclared nuclear material, activities, information, decommissioning
b–f Advance notice	NA	NA	Time; reason; explanation
5 Complementary Access			Access to:
a–b On nuclear site	C	C/S	Any place
c Off nuclear site	C	S	Local environmental sampling
6 Complementary Access – Activities	C	C/S	Visual, radiation detection, environmental samples, nondestructive assay (NDA), sampling, seals, records
7 Complementary Access – Managed Access	C	C	Protect sensitive, proprietary, and commercial information; meet safety and security rules
8 Complementary Access	S	S	State may offer access
9 Complementary Access	C/S	C/S	Wide area environmental sampling
10 Complementary Access	NA	NA	Activities, results, conclusions
11 Inspector Designation	NA	NA	IAEA proposed; acceptance
12 Visas	NA	NA	Granted by State
13 Subsidiary Arrangements	NA	NA	Entry into force
14 Communications	C	C	Permitted freely: inspectors, headquarters, unattended/attended
15 Protect Confidential Information	C	C	Commercial, technological, industrial secrets
16 Annexes	NA	NA	Integral part of AP
17 Entry into Force	NA	NA	AP entry into force
18 Definitions	NA	NA	For Articles 1–17
Annex I	NA	NA	IAEA activities for Article 2
Annex II	NA	NA	Export/import list for Article 2

DISCUSSION AND RECOMMENDATIONS

Tables 1 and 2 are designed with international safeguards requirements embodied in the IAEA model CSA and AP in the first column, followed by an evaluation of whether there is a conflict and/or synergy with the security and safety requirements in the second and third columns, respectively. As mentioned before, determination of the potential for conflicts and synergies at this level is subjective and ultimately will depend on specific factors, such as the facility type, design, and operation, as well as on specific safety and security requirements. However, the usefulness of this evaluation is already evident in helping to focus on areas where attention is needed to resolve potential conflicts and take advantage of synergistic interactions. Although the identified Cs (conflicts) in 3S merit further attention, certain areas marked with C/S (conflict/synergy) for both security and safety also represent opportunities for efficient and effective integration of 3S. The areas shaded in Tables 1 and 2 indicate where safeguards share multiple C/Ss or Cs in security and safety.

A holistic integration of "3S can provide more with less" (1). We recommend taking the following actions to achieve this goal:

- *Recognize 3S interfaces and interactions early*. During the design and operation phases, taking this step should help avoid conflicts and costly retrofitting later and in the integration of 3S.
- *Foster 3S guidance from national and international regulatory authorities.* This strategy is needed to identify potential 3S conflicts and synergies.
- *Conduct 3S workshops and develop "Best Practices".* This activity is best performed by practitioners and industry groups and organizations, such as the World Institute for Nuclear Security (WINS).
- *Provide 3S cross-training and certification.* Cross-training and certification are beneficial for practitioners and stakeholders in industry, national laboratories, and universities, as well as for authorities.
- *Share, to the extent permissible, 3S nuclear material measurement and inventory data.* A key strategy is to avoid conflicts of information security while reducing duplication and repetition.
- *Share, to the extent permissible, 3S equipment.* Sharing equipment could reduce duplicate and repetitive generation of nuclear material information.
- *Rely, where operational circumstances allow, more on unattended remote monitoring (NDA, seals, surveillance, and sensors).* Greater reliance on unattended remote monitoring could enable greater overall 3S effectiveness and efficiency.
- *Conduct studies to determine the feasibility of 3S cost sharing and savings.* The results of research could enable incentives for 3S integration.

ACKNOWLEDGMENTS

This work is supported by the U.S. Department of Energy, Office of Packaging and Transportation, Office of Environmental Management under Contract No. DE-AC02-06CH11357. The submitted manuscript has been created by UChicago Argonne, LLC as operator of Argonne National Laboratory ("Argonne") under contract no. DE-AC02-06CH11357 with the U.S. Department of Energy. The U.S. government retains for itself, and others acting on its behalf, a paid-up, nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the government.

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