Comparison Between Nuclear Material Accounting and Control for Nuclear Security and a State System of Accounting and Control for Safeguards

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Abstract

States are required under the Nuclear Non-proliferation Treaty safeguards agreements to establish and maintain a State system of accounting and control of nuclear material (SSAC). The United Nations Security Council adopted Resolution 1540 that mandates States establish appropriate domestic controls over material to account for and secure items in production, use, storage, or transport. The synergies between the safeguards and domestic nuclear material accounting and control (NMAC) programs lead to their integration allowing for better optimization of resources and an important benefit from exchange of experience and expertise between the two programs. However, it is important to recognize the differences between the programs understanding that creating an accounting structure for the sole purpose of compliance with safeguards agreements will typically not be able to address domestic goals. These differences will be discussed as well as the significant overlap in functions, efficiencies to be gained, and potential pitfalls found when the differences are not recognized.

1. INTRODUCTION

This paper compares nuclear security to safeguards in relation to NMAC. Many commonalities and differences exist between both programs. At the technical level, overlap in accounting measures allows for significant synergies between both programs. However, significant differences exist, most notably the purpose and goal of each program, as well as the types of controls in place that allow for timely detection from a security standpoint. States are mandated to establish and maintain an SSAC that reports to the International Atomic Energy Agency (IAEA). While the SSAC is safeguards-focused, NMAC is security-focused. In some States, the term ‘safeguards’ has been used interchangeably with ‘security’ causing confusion regarding the

purpose of safeguards and security for NMAC. The confusion is a semantics issue because in some States, the term 'safeguards' means security. However, the IAEA differentiates between both terms with clear differences of each program's purpose (e.g., State versus non-State actor). Furthermore, some States wrongly assume that material under international safeguards has accounting and control that is adequate for security purposes as well, but significant differences require an understanding of the separate functions of each program. It is important to understand that a robust domestic NMAC program allows for more confident and accurate implementation and carrying out of SSAC reporting requirements.

1.1. BACKGROUND

In 1970, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force providing the legal basis for the negotiation of safeguards agreements between the IAEA and States for the implementation of safeguards. Under these safeguards agreements, each State is required to establish and maintain an SSAC [1]. After the NPT entered into force, the IAEA negotiated the text of what would become INFCIRC/153. The outcome of these negotiations resulted in the IAEA taking the stance that control of nuclear material was the exclusive responsibility of the State and that it was beyond the scope of the IAEA to monitor any such measure directly. In 1972, the IAEA issued a booklet entitled "Recommendations for the Physical Protection of Nuclear Material", which later became the basis for INFCIRC/225. This placed the IAEA as an important source on guidance regarding physical security, which is distinct from its role under safeguards agreements [2]. In 2004, the United Nations Security Council (UNSC) adopted Resolution 1540 under Chapter VII of the United Nations Charter which affirms that the proliferation of nuclear, chemical, and biological weapons and their means of delivery constitutes a threat to international peace and security. This resolution obligates Member States to adopt and enforce appropriate legislation to prevent the proliferation of nuclear, chemical, and biological weapons as well as related materials and their means of delivery. It also requires that States establish appropriate domestic controls over material to account for and secure items in production, use, storage, or transport. Specifically, Paragraph 3 (a, b) states:

> "…all States shall take and enforce effective measures to establish domestic controls to prevent the proliferation of nuclear, chemical, or biological weapons and their means of delivery, including by establishing appropriate controls over related materials and to this end shall: (a) Develop and maintain appropriate effective measures to account for and secure such items in production, use, storage or transport (b) Develop and maintain appropriate effective physical protection measures" [3].

In 2013, the IAEA restructured the Office of Nuclear Security into the Division of Nuclear Security. One year later, the Division of Nuclear Security published the Nuclear Security Series Implementing Guide 25-G (NSS 25-G), "Use of Nuclear Material for Accounting and Control for Nuclear Security Purposes at Facilities" [4]. The publication of this guide established the new NMAC Program which now delivers an NMAC course based on the principles of NSS 25-G. A separate domestic controls course has been developed. This course is based on Technical Guidance "Establishing a System for Control of Nuclear Material for Nuclear Security Purposes at a Facility during Use, Storage, and Movement" (NSS 32-T in preparation). The focus of these courses is to instruct Member States on a domestic NMAC program that assists States in meeting their obligations under UNSC 1540. Prior to these courses, the only instruction available were

courses on the SSAC given by the Division of Safeguards which focused on accounting and did not meet the control aspect of a domestic NMAC program.

2. SYNERGIES OF SAFEGUARDS AND NUCLEAR SECURITY

The SSAC is the required method for reporting to the IAEA. Safeguards uses nuclear material accounting as its basic measure to account for declared material. The system monitors the quantities of nuclear material present in the nuclear facility and the changes in these quantities that take place over time. Meanwhile, the State is responsible to account for and control its nuclear material and report their nuclear materials to the IAEA by way of a State declaration. When an operator has a strong domestic NMAC program, it can protect its inventories and assure the State that the material is accounted for and safe. The State can then fulfill their obligation to the IAEA of accurate SSAC reporting. Figure 1 illustrates the flow of information between the operator, the State and the Division of Safeguards.

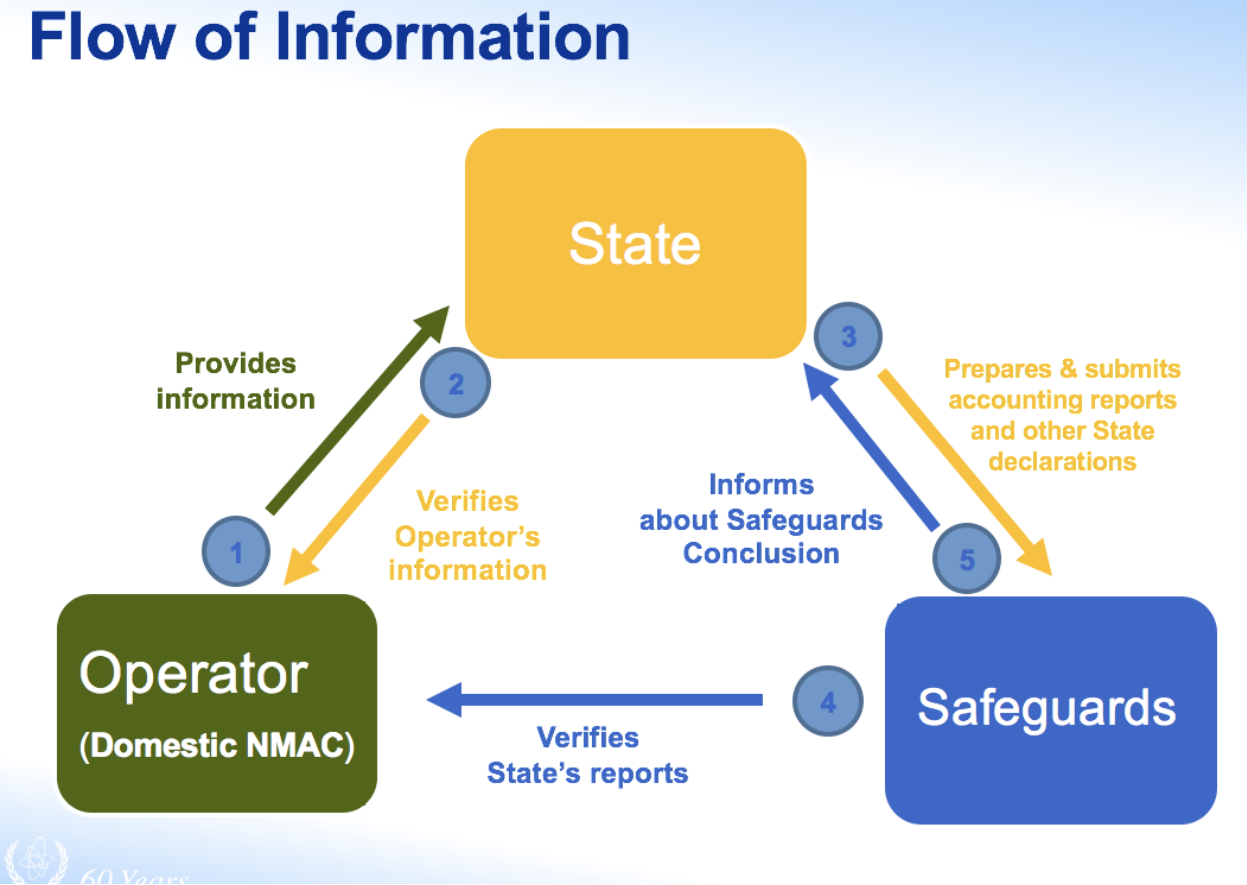

Fig. 1 Flow of Information

The synergies between nuclear security and safeguards lead to their integration allowing for better optimization of resources and an important benefit from exchange of experience and expertise between the two programs.

3. DIFFERENCES BETWEEN SAFEGUARDS AND NMAC

3.1. PURPOSE

The safeguards inspection regime monitors Member States subscribing to the NPT. The purpose of IAEA inspection is to confirm States are not making use of nuclear materials outside of their commitments and agreements under the NPT. The purpose of the SSAC focuses on the State being the 'actor' (the entity involved in the diversion and misuse of nuclear materials).

In contrast, domestic NMAC focuses on the non-State actor – an individual or entity, not acting under the lawful authority of any State in conducting activities (e.g., criminal or terrorists). The IAEA Division of Nuclear Security is assisting Member States to develop a domestic NMAC system within individual Member States with the purpose of assisting Member States in protecting, controlling, and accounting for its own nuclear materials. A domestic NMAC system runs under the authority of the State's government, in which the concern is theft of nuclear material that could result in weapons proliferation by a non-State actor. An NMAC system allows a State to demonstrate that it has an appropriate system in place to detect the unauthorized removal of nuclear material by a non-State actor from a nuclear facility. Figure 2 illustrates the purpose of both programs in relation to the defined risk of the State actor versus the non-State actor.

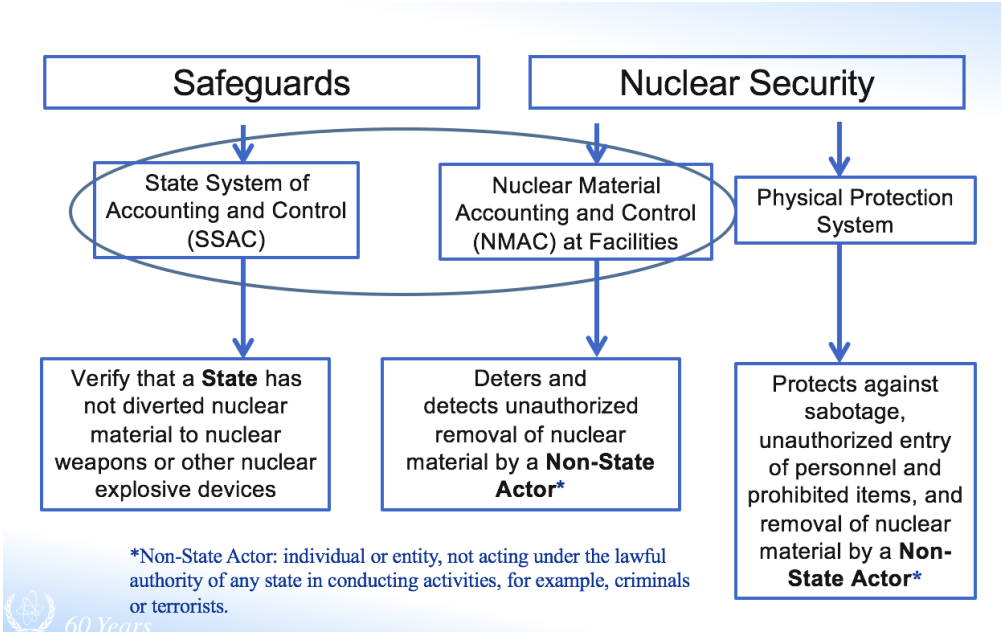

Fig. 2 Purpose in relation to defined risk

In addition to the domestic NMAC security function, NMAC has a role in supporting the facility's operational mission. Safety, security, and operational aspects are considered when implementing NMAC as overall risk is managed from multiple perspectives. The system is designed to quickly detect and localize a loss and bring the material back under control. Consequently, a domestic

NMAC system's design will typically include data elements and functions exceeding those required for safeguards reporting.

3.2. TIMELY DETECTION

Safeguards requires timely detection when a significant quantity (SQ) of material is diverted to a state-run, clandestine program. Inspections are performed at regular or random intervals based on the 'conversion time' (the time required to convert different forms of nuclear material to the metallic components on a nuclear explosive device). Conversion time does not include the time required to transport diverted material to the conversion facility or to assemble the device, or any subsequent period. The diversion activity is assumed to be part of a planned sequence of actions chosen to give a high probability of success in manufacturing one or more nuclear explosive devices with minimal risk of discovery until at least one such device is manufactured. Safeguards applies a concept called 'detection time' (the maximum time that may elapse between diversion of a given amount of nuclear material and detection by the IAEA). Given the complexities and cost to develop a weapons program, timely detection to the IAEA is measured in months.

Conversely, a domestic NMAC system aims to detect removal of smaller quantities (i.e., grams) of material more quickly as well as provide routine assurances that nuclear materials are being used for their intended purposes. For NMAC, timely detection occurs with accounting, control, and physical protection.

3.3. ACCOUNTING MEASURES

Accounting includes clearly defined material balance areas, strong inventory procedures, records and reports, and accurate measurements of materials along with a program of measurement control. Both safeguards and domestic NMAC use accounting as a basic measure to account for material. While both programs use accounting measures, the difference is in the defined area for application of these measures known as material balance areas (MBAs).

Both nuclear security and safeguards use the term material balance area, however, the difference lies in how each program defines the boundaries of a material balance area. A robust domestic NMAC program starts with the basic accounting structure. This necessitates the creation of an MBA. MBAs are established based on criteria such as material types, processes, and functions. The intent is to define geographical areas around the nuclear material processes in such a way as to allow material-unaccounted-for (MUF) or inventory differences (ID) and their causes to be identified and localized. It is important that each MBA is a single geographical area centered around an integral operation. If an integral operation includes more than one geographical area, all areas are administratively controlled by the same person. No MBA boundary should cross process area boundaries or a physical security boundaries such as protected areas. And lastly, all nuclear material entering or leaving an MBA must have an accountability value assigned in the accounting system. From a domestic security perspective, increased numbers of MBAs allow for better localization-of-loss, a key security principle. Since much of inventory-taking involves statistical sampling, a larger number of MBAs consisting of smaller sizes creates a situation in which a response to a defective item minimizes the level of effort and increases the likelihood of localizing the loss and resolving the discrepancy in a timely manner. In other words, the inference made in statistical sampling should allow for rapid response and localization of loss. Additionally,

facilities should choose MBAs based upon material categorization and assign an individual responsible for the activities and inventory in that MBA. A larger number of MBAs, therefore, allows a facility to take advantage of areas where lower categories of materials are processed or stored, thus reducing administrative burdens such as frequent inventories and higher level oversight.

From a safeguards perspective, the IAEA is not the responder if an irregularity is found, they simply need to make a statement or declaration about the inventory and the activities of the State. Therefore, it serves their purposes to utilize larger and fewer MBAs, possibly even making an entire site into a single MBA. This reduces inventory requirements as the typical sampling scheme does not require a proportional sample size to the size of the inventory (i.e., the larger the inventory from which the sample is taken, the smaller the relative sample size required to make a statistical inference on the population). The goal of accounting of material and providing a loss-detection methodology is the same for both programs, however for safeguards, the goal is to verify that the State has not diverted nuclear material; for nuclear security, the goal is to account for and protect material from unauthorized removal by non-State actors as well as resolve inventory discrepancies and respond to unexplained losses. Since both perspectives, NMAC for security and SSAC, apply common, similar accounting functions and principles and both utilize the same language, this has the potential to create confusing and potentially conflicting operating principles if not fully understood.

3.4. CONTROL MEASURES

Control measures are perhaps where the biggest difference between safeguards and domestic NMAC lies. Accounting measures alone do not achieve the fundamental security needed for immediate detection in order to have a timely response to a malicious act. Nuclear material controls are used to physically monitor the use of nuclear material. Controls in concert with physical protection allow for timely detection and response. These controls are used in a manner known as defense-in-depth (the combination of multiple layers of systems and measures that have to be overcome or circumvented before physical protection is compromised [5]). As stated above, safeguards measures timely detection in months owing to the fact that their main risk concern is the State actor and the amount of time and complexities of a clandestine State-run diversion of material. From the outset of the NPT safeguards agreement, nuclear material control is not a safeguards mandate and is the responsibility of the State, therefore safeguards does not focus on controls to allow for a security definition of timely detection. While safeguards does use tamper-indicating devices (known as seals) that are surveilled, it lacks the defense-in-depth that nuclear security employs for timely detection. Furthermore, the focus of controls for safeguards typically is a licensing system, or system of permits.

A robust NMAC program uses control measures in conjunction with accounting measures to enhance the timeliness and effectiveness of detection of any loss or diversion of nuclear material. Nuclear material control is a set of technical and administrative measures that a regulatory body and operators engage in to ensure that nuclear material is not removed from its assigned location, modified, or used without proper approval and accounting [6]. These measures include but are not limited to:

- *Administrative checks* – a program that supplements traditionally 'late detection' material accounting (e.g., physical inventory) by providing continued assurance of item integrity between periodic material accounting activities.
- *Two-person rule* - the primary purpose is to ensure that no individual is in a position to divert, remove, or sabotage nuclear material without timely detection.
- *Compartmentalization* – individuals have access only to the areas, materials, and information required to perform their jobs.
- *Separation of duties* – a process that involves nuclear material and related information is divided into steps which are performed by different persons acting independently.
- *Checks during movements of nuclear material* – ensures that the packaging and shipping documents including nuclear material parameters (e.g., nuclear material, quantity, isotopic content, element concentration, enrichment of each item (if required) and gross weight) are sent to the receiver include unique identification of all nuclear material items to be shipped and that the information is checked before leaving the MBA is correct.
- *Item monitoring* – the purpose is to detect irregularities in a timely manner to improve the reliability of and confidence in the reliability of the NMAC system. Item monitoring is intended to address all nuclear material that is not subject to process monitoring.
- *Access control* – used to positively identify personnel who have authorized access to facilities and nuclear materials.
- *Restraints/tie-downs* – used to delay access to nuclear material. Examples include: high-strength storage room doors, razor tape, double-layer steel cages, and use of heavy packages fitted with locks or bolts.
- *Tamper indicating devices (TIDs)* – consists of seals or other technologies used to provide evidence of unauthorized access to nuclear material. For high-priority targets, these devices should be uniquely identifiable and controlled through a program that tracks their issuance, application, and eventual destruction. TIDs should be coupled with appropriate surveillance systems. While safeguards uses TIDs (known as seals), the function of TIDs for safeguards and nuclear security differs regarding the defined risk threat (State vs. non-State actor).
- *Manned nuclear material portal monitors with hand-held monitoring equipment* – used to detect nuclear material and metal (used as potential shielding for nuclear material). Most effective when located near target material and manned by trained personnel. Portal monitoring must be used in conjunction with physical protection.

4. CONCLUSION

When establishing both an SSAC and an NMAC program, maintaining awareness of the different purposes of each program is essential to allow for the best utilization and leveraging of resources. As previously stated, a key factor is the makeup of the MBA structures for each objective. Of equal importance is the need to fully understand the purpose and defined risk for which the

programs are meant to address. Maintaining this awareness allows facilities to establish robust programs integrating with other security functions where appropriate, while continuing to provide the assurances needed for each program.

Specifically, a robust domestic NMAC program is critical for a comprehensive nuclear security program. It provides detection mechanisms for theft or diversion of nuclear materials by non-State actors based on lower quantities, shorter timelines, and allows a more granular localization of loss for the accounting of nuclear material assets. It will almost naturally leverage the relationships between Safety and Operations to accomplish these goals creating the structure needed to securely and safely conduct the nuclear mission.

For nuclear newcomers, creation of such a robust NMAC program will not only provide stronger protection and assurance against non-State actors intent on theft or diversion of nuclear assets, but will also provide the majority of infrastructure needed for establishing an SSAC. The converse is not true. Creating an accounting structure for the sole purpose of compliance with safeguards agreements will typically not be able to address domestic goals.

While this integration is recommended for nuclear newcomers, it is equally valuable for States with established nuclear programs. Much duplication can be avoided, stronger statements can be made about the loss detection of each program if leveraging resources from the other. In the end, such awareness and integration strengthens both the nuclear regime of the State as well as the assurances demanded by the IAEA.

5. REFERENCES

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