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Nuclear Husbandry Functions

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Abstract

Effective and rigorous controls over highly enriched uranium and plutonium, the essential ingredients of nuclear weapons, are critical if we are to reduce nuclear arms, bring a halt to nuclear proliferation, and to avoid large-scale nuclear violence. Currently an unfortunate and simplistic "one-size-fits-all" attitude about nuclear security is prominent. We have identified seven basic and decidedly distinct nuclear husbandry functions. The analysis leads to some predictions for effective nuclear arms control and nonproliferation, including the idea that domestic nuclear security and safeguards personnel, hardware, approaches, and auditing techniques are not automatically applicable to international arms control efforts.

1. INTRODUCTION

Today, much of the stability created by the nuclear standoff between the two former superpowers has disappeared, replaced by new nuclear proliferation challenges due to excessive quantities of fissile materials [1]. Inadequately protected and poorly controlled weapons-usable material could end up in crude nuclear weapons of "states of concern", or a terrorist organization [2]. The September 11, 2001 terrorist attacks in

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The views expressed are those of the authors and should not necessarily be ascribed to the above-mentioned institutions or to the United States Department of Energy (DOE). The paper is an updated and more focused version of our working paper called "Safeguarding this and Verifying That. Fuzzy concepts, confusing terminology, and their detrimental effects on nuclear husbandry". It also draws on Los Alamos Report LAUR–01–4120, "International Transparency & Treaty Monitoring vs. Domestic Security & Safeguards", written by Johnston.

New York and Washington were carried out with conventional means. Still, the extensive killings and damage resulting from these acts of terrorism serve as a dire reminder of the potential consequences of any failure to deny sub-national groups or new states access to weapons of mass destruction.

While the proliferation of fissile materials and the severe consequences of such chilling scenarios are fairly easy to understand, the problems of fissile weapons-usable material management have proven anything but simple to solve [3]. For example, over the past five years, many of the major U.S.-Russian cooperative nuclear security programs have slowed down, and many activities have been under-funded, or have had their timelines regrettably extended into the future.

Clearly, many of the problems of contemporary global nuclear arms control emanate from its inherent complexities and problems, including distrust, limited access to sensitive facilities, cultural differences, and the lack of genuine political interest and monetary investment. But misunderstandings and confusion about basic concepts and different nuclear husbandry[1] functions have also, we believe, contributed to errors in planning and effective implementation of nuclear arms control measures. Unfortunately, there tends to be a simplistic, "one-size-fits-all" attitude about nuclear security. Far too often nuclear security equipment is fielded without a serious analysis of its intended purpose, overall context, expected performance, or vulnerabilities. This can lead to poor nuclear custodianship, and may lull responsible personnel into a false sense of security. In parallel, the limited funds available for nuclear security are further depleted.

More than a dozen critical security devices or systems are currently in use for domestic safeguards in the U.S. for which no vulnerability assessments or comprehensive analysis have been undertaken. Even something as fundamental as the disparate goals of the "Protection" (P), "Containment/control" (C), and "Accounting" (A) in nuclear Material Protection Control and Accounting, "MPC&A", are not always well recognized.[2] Lumping together arms control activities blurs their separate goals, means, methods, adversaries, and limitations. Consequences may include unrealistic expectations for monitoring hardware and security systems, overconfidence in the power of verification, and failure to appreciate critical security vulnerabilities.

Many of the problems mentioned above can be avoided if we have an appreciation of the disparate character and nature of the various arms control functions. To us, and probably to most people in the audience, the differences should be fairly obvious, yet in practice, they often seem to be overlooked—with potentially serious detrimental consequences for nuclear security.

2. THE SPECTRUM OF NUCLEAR HUSBANDRY FUNCTIONS

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[1] We think of "nuclear husbandry" as encompassing a number of functions in the areas of nuclear security, safeguards, nonproliferation, disarmament and arms control. Webster's II New College Dictionary defines "husbandry" as "careful management of resources". It also has an agricultural connotation that isn't far off the mark in this context: "the cultivation of crops and the breeding and raising of livestock; [involving] the application of scientific principles." The Merriam Webster Collegiate Dictionary defines "husbandry" as "the control or judicious use of resources". A "husband" is a manager or steward, especially one that is prudent and thrifty.

[2] The lack of careful thinking may not be as obvious in the literature as in real-world arms control efforts. Through our own work, we have observed first-hand numerous examples of confusion about key concepts by arms control researchers, program managers, and security personnel.

Through a semi-quantitative analysis presented elsewhere, we have identified seven basic and distinct "nuclear husbandry" functions, or key activities for responsible management of nuclear weapons and material.[3] Each of these functions are characterized by a unique set of attributes such as their specific objectives, the means to be applied to meet these objectives, the potential obstacles to their successful implementation, and the distinctive context in with the activity must operate and master (including the adversaries to neutralize). In our view, the seven major nuclear husbandry functions, covering the spectrum of nuclear husbandry activities, consist of: domestic nuclear physical protection, domestic control/containment, domestic accounting of nuclear material, domestic auditing, international auditing, monitoring of international treaties and agreements, and transparency (table 1).[4]

Domestic				**International**		
Domestic Physical Protection	**Domestic Contain-ment & Control**	**Domestic Accounting**	**Domestic Auditing**	**International Auditing**	**Treaty Monitoring**	**Transparency**

Table 1. Seven basic nuclear husbandry functions

These seven functions cover the fundamental activities of domestic and international nuclear husbandry. Because they have limited overlap, reduced ambiguity, and no multiple interpretations, this categorization can help clarify issues and avoid pitfalls. It is particularly important to recognize the distinction between domestic and international nuclear husbandry functions. "Domestic auditing" is for instance meant to check on the adherence to domestic laws and regulations, not international treaties. "International auditing", in contrast, involves corroboration of treaty agreements and declarations.

Note also that we have excluded commonly used nuclear arms control terms like "Verification" and "Safeguards" in our set of basic nuclear husbandry functions. This is further discussed below.

2.1. Domestic Physical Protection, Containment & Control, and Accounting

"MPC&A" (Material Protection, Control, and Accounting) systems are intended to protect material against theft or diversion, and to detect such events if they occur.[5] Generally, all MPC&A activities are domestic in nature. Even under joint US-Russian MPC&A programs to upgrade security at facilities in the former Soviet Union, the sole

[3] For a through discussion of this analysis, please refer to MAERLI, M.B. and JOHNSTON, R.G. "Safeguarding this and Verifying That. Fuzzy concepts, confusing terminology, and their detrimental effects on nuclear husbandry", working paper, pending publication.
[4] While we have doubt that the alternatives we present will be widely applied, this approach may serve as a useful mental exercise and help clarifying the uniqueness of each fundamental nuclear security activity. Our seven nuclear husbandry functions do not explicitly include safety, stockpile stewardship, or environmental monitoring issues, since we focus here on nuclear security.
[5] This is explained succinctly in [4].

responsibility for providing sufficient control of fissile material rests with the hosting nation state. The term "International MPC&A" is thus a promiscuity that should be avoided.[6]

Adding to the confusion and mix of domestic and international nuclear security activities is the fact that the United States is applying the term "Safeguards" to describe its own domestic MPC&A activities. This is likely to blur the differences between international and domestic husbandry functions. We thus support using the less ambiguous term "MPC&A", and to avoid specific misunderstandings, we recommend spelling out the respective functions (P", "C", or "A") in any discussion of MPC&A activities.

2.2. Domestic Auditing

All nuclear facilities must comply with national laws and regulations and are subject to domestic licensing. To control the operation of the plant, including the standard and quality of domestic MPC&A activities, domestic agencies are in place to evaluate performance and to initiate changes when needed.[7] All have the authority to order a wide variety of draconian changes if they detect problems. However, domestic auditors are not "foes" in the traditional sense, but rather fellow countrymen having, at least in theory, the same interests and agenda as the personnel who work inside the inspected facility. A sense of mutual loyalty may be present that will tend to be absent from international inspections or audits.

2.3. International Auditing

As for domestic auditing, a designated agency, preferably the IAEA, would be responsible for international performance evaluation during international nuclear audits. International nuclear auditing would differ from "classical" safeguards by being more holistic, more aggressive, and less dependent upon purely quantitative data. It would be better able to decipher the intentions of the inspected nation [5]. Unfortunately, however, true comprehensive international nuclear auditing does not yet exist. The IAEA is moving in the direction of international "nuclear audits" with its strengthened safeguards system. The new Model Protocol, INFCIRC/540 (Corrected), represents an attempt to broaden the scope of safeguards with much more comprehensive declarations.[8] It will permit a far wider range of information gathering and means for assessing the completeness and accuracy of the expanded declarations. However, any future international auditing agency still lacks the jurisdiction to implement direct measures (e.g. sanctions) and/or draconian changes should non-compliance be detected.

2.4. Treaty monitoring

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[6] Though it does not yet exist, there may be true cooperative, international MPC&A in the future. The concept of a "nuclear island", global repository, or international parks for nuclear material could eventually involve international cooperative MPC&A [9]. Presumably such international MPC&A would look a lot like current domestic MPC&A, except with international players. It would probably have many of the same attributes, and (unlike international safeguards) it would be appropriate to use domestic hardware and security protocols.

[7] Consider, for example, a U.S. Department of Energy (DOE) nuclear facility. This facility can be inspected by DOE's internal auditing office, the Defense Nuclear Facilities Safety Board, state or federal Environmental Protection Agencies, or other government agencies.

[8] IAEA, INFCIRC/54 (Corrected), *Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*,

Most multinational or bilateral arms control treaties are accompanied by carefully negotiated schemes for monitoring of treaty compliance. Traditional safeguards is one prominent example of this. However, it may be worth observing that IAEA's number one activity – Non-Proliferation Treaty (NPT) monitoring – is only one out of the seven basic nuclear husbandry functions.

In our minds, "treaty monitoring" may be a more fruitful term than the widely used (and misused) term "Verification". "Verification" is a security concept with strong connotations of an almost absolute sense of security and control. However, the very nature of arms control makes absolute verification a difficult, if not impossible, goal to meet. It will be in the interest of a sovereign state to limit any kind of intrusive revelations on its defensive or offensive capabilities. Clearly, this will work against "true" verification, and "treaty monitoring" may be a less absolutistic and more appropriate term that takes into account the dynamics of the arms control activities.

Moreover, if sanctions are likely, those states engaged in undesirable behavior will have few incentives to supply accurate information themselves [8]. States want the level of intrusiveness to be kept as low as possible, conflicting with the initial verification goals and expectations. New monitoring technologies tend in fact to be quite intrusive and may thus actually work against finding acceptable verification solutions, as they potentially may reveal considerable details about nuclear weapon designs and other secrets [9]. Further complicating the issue, the "verification" process itself involves a series of monitoring steps, each one with costs and vulnerabilities as well as the potential for failure and cheating [10].

2.5. Transparency

The general aims of transparency are to contribute to confidence- and security-building, and to foster public and political support by explaining the rationale of a specific nuclear policy and posture [11]. But a universal understanding of the meaning of transparency does not exist even within the arms control and nonproliferation communities [12]. Transparency is, as we see it, a process in which information about actions, preferences, intentions, and capabilities is made available—or more properly, allowed to flow—to citizens and the international community in an isotropic and unconstrained manner.[9] Where governments choose to engage in transparency, this should be regarded as fundamentally a *unilateral* act performed for an international audience, neighboring countries, or domestic citizens.

Ideally, transparency surpasses required activities, such as reporting obligations mandated by treaty. In fact, voluntary release is the true meaning of transparency; taking extra steps of openness beyond expectations or promises is the true test [13]. The extra steps are likely to promote higher levels of trust. Transparency is "permitted knowledge" [12] and may be viewed as the opposite of secrecy. Secrecy means deliberately hiding intentions, capabilities, and actions; transparency means deliberately revealing them [14]. Transparency and secrecy are not either/or conditions. As ideals, they represent two ends of a continuum. Based on voluntary measures, transparency permits outsiders to accumulate data from a wide range of sources, over an extensive period of time to build confidence that behavior of a country or a collection of countries is consistent with agreements and norms [13].

[9] This definition is based on [15].

3. DISCUSSION

Increased global nuclear security will require arms control regimes that move beyond mere delivery-vehicle treaties, strengthened physical protection for nuclear material, a fissile material cut-off treaty, and accelerated disposing of excess fissile material. These measures, in turn, will demand more effective domestic MPC&A, improved treaty monitoring and auditing, and increased nuclear transparency.

While the transparency process can involve elements of cooperation and mutual negotiability, transparency is purely decided and performed by a sovereign state in its own territory. As such, it may turn out to be a strong supporting tool for international nuclear arms control, if cultivated and applied in a correct manner. A nation does not need the assistance, cooperation, or permission of another state to engage in transparency, nor to decide the timing or degree of openness that will be allowed. Unfortunately the term "Transparency" has, in our minds, come to mean a grab bag that encompasses all kinds of unrelated nuclear monitoring and disarmament activities that had to be implemented in the first place because there was such little true transparency. All to frequently for instance, we see scholars and arms control experts calling for the use of hardware and inspectors to "verify a transparency regime" [15, 16, 17, 18].

Now of course, it may be desirable to validate the *data* that comes out of a transparent environment. This corroboration can be done with a set of broadly applied, external means, rather than by on-site inspectors or conventional inspection technologies and techniques. The more established transparency becomes, the more it is self-corroborating because there are an increasing number of parallel and redundant channels of information that intrinsically crosscheck each other.[10] Fully established transparency, of course, is an ideal and may never be achieved in any society.

The lack of a rigorous, clear-headed understanding of the specific goals and character of specific nuclear security activities exist for other nuclear husbandry functions than transparency. Today there are for instance at least two distinct and dissimilar uses of the word "safeguards" —domestic (U.S.-type) safeguards, and international (IAEA-type) safeguards. The United States uses "safeguards" in a rather imprecise way, often in combination with "security", to cover a wide range of domestic nuclear non-proliferation activities, from physical protection and containment to accounting of nuclear material ("MPC&A"). The International Atomic Energy Agency (IAEA) uses the terms in an equally ambiguous and open-ended manner, making it hard to assess safeguards effectiveness [5]. The IAEA sometimes adds "international" out front, and generally understands "safeguards" as "nuclear material verification activities at nuclear facilities" [6].

While domestic "safeguards" are designed primarily to detect theft of material by rogue individuals or small groups working at cross-purposes to the state that owns the facility, international "safeguards" are designed to detect diversion by the state itself. If asked, most arms control theorists, nuclear security experts, safeguards program managers, and US national laboratory personnel will readily agree that domestic "safeguards" are not the same thing as IAEA "safeguards". In our experience,

[10] Descriptively, such activities have been denoted "information triangulation" by Ronald Mitchell, "Sources of Transparency", p.189.

however, many nevertheless seem to operate under the implicit (or subconscious) assumption that U.S. domestic MPC&A hardware, methods, and personnel are more or less directly applicable to IAEA applications without critical analysis or significant modification. People with this view tend to believe that domestic safeguards hardware and approaches should be applied in the international context because this is quick, easy, and will save money. This entirely overlooks the fact that the mentioned goals, adversaries, personnel, costs, environment, consequences of a failure, and other factors differ so enormously.

The subject being monitored by the IAEA is the state that signed the treaty—and the owner and operator of the nuclear facilities being inspected. This is a very different kind of adversary from that addressed by domestic safeguards. The resources available to a state to try to defeat international nuclear safeguards may exceed those available to individuals or small groups by six to nine orders of magnitude.[11] Moreover, the operational context for the two types of safeguards varies significantly. For international safeguards, the items being monitored are owned and controlled by the potential adversary (the state itself). For domestic safeguards, the protagonist owns the monitored items.

For international IAEA safeguards, not only will the potential adversary always be present, but the inspected state may itself install some of the means used for the treaty monitoring (e.g. tags and seals), and the state – the inspected subject – can inspect all safeguard equipment. The operational success of the different safeguard activities may be further influenced by (local) external factors such as (unknown) variations in the physical environment, including weather conditions and the need for site-specific training and knowledge. Clearly, the respective abilities of international and domestic safeguards to meet such challenges will inevitably vary.

The potential consequences of violating the different sets of safeguards differ both in nature and severity. Adversaries trying to defeat the MPC&A system at a facility may face severe criminal penalties, or even injury or death with direct confrontation. The corresponding consequences for a state violating its international safeguards obligations are more obscure and less pronounced. The international community is likely to react to treaty violations, but *a priori*, formalized sanctions have yet to be invoked for treaty non-compliance. The time frame for response further differentiates the deterring effects of the two types of safeguards. While the response time for domestic safeguards violations could be minutes international safeguards inspection intervals tend to be in the range of months to years.

Through its treaty monitoring activities, the IAEA is doing international compliance corroboration, not MPC&A or U.S.-type domestic nuclear auditing. Thus, we should not assume that U.S. domestic MPC&A hardware, procedures, or personnel are automatically suitable for IAEA-like inspections. Yet this is exactly what is often assumed [19,20]. The "knee-jerk" tendency to insist that (unmodified) seals, radiation monitors, intrusion detectors, portal monitors, personnel, and security procedures used by the U.S. for its own domestic nuclear MPC&A purposes make the most sense for IAEA "safeguards" or trilateral verification and treaty monitoring should thus be avoided.

[11] A nation has millions of people versus the one or relatively few rogue individuals who are the primary focus of domestic MPC&A. See [7].

Given the differences, we should also be suspicious of the idea that domestic auditors or domestic MPC&A experts are automatically the correct personnel to assist with international compliance monitoring. This lesson should in deed be taken into account with regards to a future Fissile Material Cut-Off Treaty, where the IAEA is likely to play a prominent monitoring role. It will no doubt be tempting to use familiar domestic MPC&A husbandry technologies and approaches for dealing with FMCT compliance corroboration, even though the nuclear husbandry functions are extremely different. These temptations need to be avoided. Any FMCT monitoring equipment and approach fielded should be optimized to meet a specific and new set of adversarial capabilities. Moreover, new potential obstacles against its successful implementation should be taken into consideration.

Treaty monitoring is definitely more related to international auditing, than to any of the domestic functions (P, C, A, or domestic auditing). This is to be expected, as the latter (international auditing) is basically a more comprehensive and aggressive form of the former (treaty monitoring). Moreover, the inspected subject (the state) is the same. The inherent, intrinsic differences between the two nuclear husbandry functions, however, make international auditing much more than a trivial extension of treaty monitoring. Due to the different adversaries and potential obstacles international nuclear audits is something completely different than domestic nuclear audits. The strengthened safeguards system (future nuclear audits) should therefore be based more on the traditional safeguards system, i.e., treaty monitoring, than on domestic auditing or domestic MPC&A activities. Shared attributes of treaty monitoring and (future) international nuclear auditing should be examined in detail so that the international community can utilize what is already known about treaty monitoring for developing effective international nuclear auditing.[12]

4. Conclusion

We have raised concerns in this paper that the existing arms control concepts are fuzzy and in practice, become lumped together in an unfortunate and simplistic way. This may negatively impact how we as arms controllers think about and try to solve different practical nuclear security problems. Seven fundamental nuclear husbandry functions for the responsible management of nuclear weapons and nuclear material have been identified. We have attempted to argue that these basic husbandry activities are indeed quite different, with there being a particular disparity between domestic and international nuclear husbandry functions.

Despite the differences, however, traditional MPC&A-approaches have e.g. been uncritically used for international safeguards, sometimes with a few modest changes. Given the extreme discrepancies between the goals, operational context and potential adversaries of the two, such easy solutions may be detrimental to long-term nuclear security. Domestic MPC&A personnel and hardware are not automatically appropriate for international treaty monitoring or for international auditing. International inspectors, such as used by the IAEA, need tools and training specific (and optimised) for their treaty monitoring mission, not just duplicated from (U.S.) domestic MPC&A approaches.

[12] Examples of synergies may include environmental sampling techniques used for the CTBT and the non-intrusive monitoring for weapons-usable material in the Trilateral initiative.

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