RESULTS FROM THE 2010 INTERNATIONAL WORKSHOP FOR USERS OF PROLIFERATION ASSESSMENT TOOLS HELD AT TEXAS A&M UNIVERSITY

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ABSTRACT

A large number of approaches to proliferation assessment have been developed or are currently under development. These tools are used by a number of different types of users for a range of purposes. Continued dialogue about these tools and approaches is a valuable way to help prevent inconsistent application or misuse of the technologies. A workshop was held at Texas A&M University from February 23-25, 2010 to provide a venue for users and developers to explore these assessment methodologies. This workshop was organized by the INMM Standing Committee on Proliferation Assessments and Methodologies and hosted by the Texas A&M University Student Chapter of INMM. The workshop had 65 participants from a diverse mix of organizations including academia, national laboratories, industry, government, and the IAEA. At the workshop, developers discussed the status of the field and current research. Users discussed the current and anticipated needs to which assessment and methodology approaches could contribute. Panel sessions were held to discuss future needs for a path forward for these approaches. The workshop focused heavily on proliferation resistance methods but proliferation risk analysis, material attractiveness assessment, statistical analyses to assess proliferation determinants, and quantitative analysis to estimate the likelihood a State will proliferate were also discussed. This paper presents the workshop structure, questions studied, and findings from the workshop.

1. PURPOSE

This workshop was the first in a series focused on proliferation assessment tools. We define proliferation assessment tools broadly to include proliferation risk and proliferation resistance analysis as well as studies to understand why states proliferate, develop proliferation determinants and indicators, and predict proliferation. A partial list of previous and ongoing efforts in this area is shown in the bibliography later in this report. In this workshop, we focused on proliferation risk analysis with most presentations detailing proliferation resistance analysis tools and results; however, we also included methods to quantify material attractiveness and studies to quantify proliferation determinants.

This series of workshops will focus on particular user groups and attempt to:

1. Improve the user group's understanding of available tools and approaches
2. Improve the user group's understanding of the perspective of other user groups
3. Identify needs of user groups
4. Develop a research agenda to address those needs

For this first workshop in the series, the purpose of the workshop was to:

1. Provide a summary of the state of this technology and a forum for discussing results and current developments;

2. Develop a vision for relating proliferation resistance, nonproliferation assessments, and proliferation risk;
3. Define user needs for these tools (and including regulatory needs); and
4. Discuss directions for future research in this area.

2. WORKSHOP AGENDA

2.1 Wednesday, February 24, 2010

08:15 – 08:30 Registration

08:30 – 08:45 Opening Remarks and Welcome from Chairs (Mike Zentner and William Charlton)

08:45 – 09:15 Introductions of All Participants

09:15 – 10:15 **Opening Plenary Session: Current Role and Future Needs of Proliferation Assessment Tools** (Chair: William Charlton) – Speakers will present the perspectives of their organization on the role of proliferation assessment tools.

Speakers:

09:15 Warren F. Miller, Jr., DOE (represented by Matt Bowen)
09:35 Mark Whitney, NNSA (represented by Ed Wonder)
09:55 Bruce Moran, IAEA

10:15 – 10:30 Break

10:30 – 12:10 **Session I: User Groups Needs & Proliferation Assessment Tools** (Chair: William Charlton) – Panelists will give a set of brief remarks regarding user group needs and how proliferation assessment tools should meet these needs. This will be followed by moderated panel discussion. Questions to discuss include: Do results of PR studies meet the needs of Governmental Officials? How can the results be interpreted, what questions do they answer? How have the use of PR study results affected safeguards design and operation of nuclear facilities?

Panelists:

Ed Wonder, DOE/NA-24
Mark Mullen, LANL
Jeremy Whitlock, AECL
Trond Bjornard, INL
Bruce Moran, IAEA

11:30 Group Discussion

12:10 – 13:30 Lunch (GSC Room 101B)

13:30 – 17:30 **Session II: Proliferation Assessment Methodologies** (Chair: William Charlton) – Speakers will provide overview of proliferation assessment methodologies and address questions regarding the needs of user groups and how these tools could contribute.

Speakers:

13:30 Chuck Bathke, LANL
13:55 Bob Bari, BNL
14:20 Mike Zentner, PNNL
14:45 Break
15:05 H.L. Chang, KAERI
15:30 Mike Golay, MIT
15:55 Man-Sung Yim, North Carolina State University

16:20 Sunil Chirayath, TAMU
16:40 Group Discussion

17:30 – 18:00 Summary and Concluding Remarks
18:30 – 21:30 Banquet at the Messina Hof Winery

2.2 Thursday, February 25, 2010

08:30 –08:45 Opening Remarks (Mike Zentner and William Charlton)

08:45 –11:30 **Session III: Path Forward to Meet User Needs** (Chair: Mike Zentner) – Panelists give a set of brief remarks (5-10 minutes) regarding areas of research needed to improve proliferation assessment tools. This will be followed by moderated panel discussion. Questions to discuss include: Are we looking in the right areas? Are the results really usable as they are? What areas do we need more work on and why?

Panelists:

Chris Way, Cornell University
Bart Ebbinghaus, LLNL
Bob Bari, BNL
William Charlton, TAMU

10:00 Break
10:15 Group Discussion

11:30 – 12:15 Lunch (GSC Room 101B)
12:15 – 14:00 Facility tours of either Nuclear Science Center or Disaster City (Buses will take participants to tour location and back to GSC.)

14:00 – 16:00 **Session IV: Development of Research Agenda for Path Forward** (Chair: Mike Zentner)
14:00 Chairs will present draft results of workshop
14:30 Group Discussion
15:15 Review consensus on research agenda and path forward

15:30 – 17:00 Summary and Closeout

Electronic copies of all workshop presentations are available at http://nsspi.tamu.edu/INMM.

3. PARTICIPANTS

The participants convened for the workshop included experts in nuclear energy, nuclear nonproliferation, nuclear security, nuclear safeguards, radiation safety, radiation detection, reactor design, and international affairs experts. The participants represented a wide range of organizations including national laboratories, industry, academia, and government institutions. A vast array of experience and knowledge was represented by this group. The workshop included sixty-seven registered participants. The demographics of those participants by institution is shown in Figure 1.

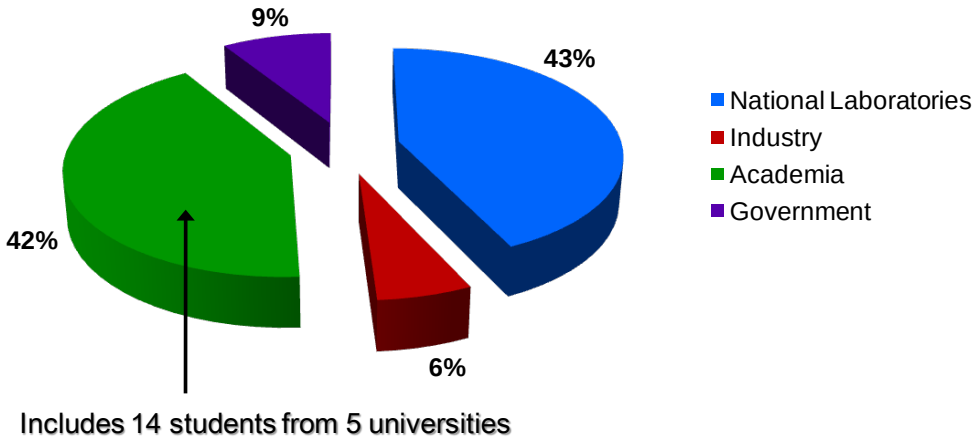

Figure 1. Workshop participant institutional demographics.

4. KEY WORKSHOP RESULTS

Several key points were identified by the workshop participants. In this section, we present the primary results of the workshop and discuss the key findings.

4.1 Identification of Possible Users of Tools and Tool Results

The workshop participants identified the following groupings as possible users of proliferation assessment tools and the results from those tools:

1. Government officials (including Energy Ministry officials, Foreign Ministry officials and Legislative officials responsible for program approvals and funding appropriations, Research and Development Managers)
2. National licensing and regulatory authorities and export control authorities
3. Intelligence analysts
4. IAEA safeguards authorities and other safeguard inspectorates
5. Industrial designers/producers/vendors
6. Utility owners and operators
7. The Public

It was clear that not all questions are appropriate for all users and that the presentation of results should be specific to each user group. A brief discussion of which questions were appropriate for which user sets occurred during the workshop; however, conclusions to this question were not made. It was expressed that care must be taken in the usage of these analysis tools. Many of the tools presented were suitable for developing insights into R&D priorities, technology vulnerabilities, and exploitability of various technologies for proliferation purposes. However, the use of risk analysis to determine risk goals or performance criteria was deemed a much more daunting task.

4.2 Adversaries Considered

The workshop participants identified a number of potential adversaries:

1. Host state
2. Neighboring state (i.e., a state stealing material or technology from another state)
3. Non-state actor acting alone or in collusion with other non-state actors

4. Non-state actor aided by a state
5. State with weak laws that allow black market networks that can enable a non-state actor
6. State with weak laws that allow black market networks that can enable a state actor

We focused our discussion on the host state and non-state actor adversaries during the workshop, and it was the general consensus of the workshop participants that these two adversaries were the most appropriate adversaries to be considered in the use of proliferation assessment tools.

4.3 Relationship between Proliferation Risk Analysis, Proliferation Resistance, Nonproliferation Assessments

Many of the presentations given at the workshop were focused on proliferation resistance methodologies. However, there was vibrant discussion at the workshop on proliferation risk and methods for predicting proliferation. The participants concluded that proliferation resistance methodologies were much more mature than either proliferation risk analysis or methods for predicting proliferation. Proliferation resistance (both as a concept and as a quantitative methodology) has been much more heavily studied than either of the other two areas.

Proliferation resistance has a generally agreed upon definition whereas proliferation risk does not have such a consensus definition. Proliferation resistance is that characteristic of a nuclear energy system that impedes (a) the diversion or undeclared production of nuclear material or (b) misuse of technology by States in order to acquire nuclear weapons or other nuclear explosive devices. This definition has been used to formulate several methodologies for quantifying the degree of impediment that exists for a nuclear energy system. A number of these methods were reported on at the workshop and while some differences existed between the methods, it was agreed by the workshop participants that the exercising of the methods had led to a significant understanding of how to characterize proliferation resistance. It was suggested that a set of benchmark cases should be developed to help facilitate comparison between methodologies and to aid in developing insights in to proliferation resistance characteristics. It was also acknowledged that having a method of uncertainty quantification for the assessment tools would be valuable. This would also help to make users cognizant of the impact of uncertainty on conclusions, and comparisons between evaluations, and not implying a false precision in the presentation and interpretation of results. The participants were concerned about presentations in which too much credibility was given to small differences in calculated values.

A basic formula for proliferation risk (R) was proposed

$$R = \sum_{i=1}^{I} L^i P^i C^i \qquad (1)$$

where L^i is the probability that an adversary might choose to attempt to proliferate along path i, P^i is the probability that the adversary will be successful at proliferating without timely detection given that they have chosen to proliferate along path i, and C_i is the consequence of adversary proliferation without detection along path i.

It was agreed that proliferation resistance methodologies primarily focused on P^i and that they were reasonably well developed for calculating some version of that quantity.

The material attractiveness calculations had demonstrated the ability to quantify at least some portion of the value of C^i but that perhaps they did not include all of the possible consequences of interest to some stakeholders.

The nonproliferation assessment social science methodologies focused on calculations of L^i, but it was agreed upon that this was likely the least developed of the components of Eq. (1). The workshop participants were even hesitant to suggest that calculations of L^i using any of the approaches studied to date was wise. Those studies were generally performed to have a better understanding of why states choose to proliferate, not to act as a predictive tool. The practitioners warned against trying to make point predictions. Social science tools find patterns of proliferation, and offer insights into which factors appear to have the greatest explanatory power. These studies typically look at historical data (which is generally sparse) and could be hindered by the fact that the observed events considered took place under significantly different circumstances. This complicates comparison and drawing generalized propositions across multiple decades of historical record. It was agreed that predicting an adversaries likelihood of choosing to proliferate in any given unit of time was extremely difficult and likely impossible to do with any absolute value. It is of course possible to calculate a conditional risk by assuming the adversary will choose to proliferate and setting $L^i=1$. There was not a consensus among the participants on the value in this, and it was determined that more study was needed before any recommendations could be made. It was agreed upon by the participants that any analysis must consider the characteristics of the adversary (e.g., country context) in order to provide relevant results. There are a number fo ways that this threat information could be incorporated into a methodology and that it did not have to occur through a quantification of L^i.

The workshop participants only briefly discussed the issue of proliferation occurring over a multi-decade time frame. It was acknowledged that this significantly complicated this type of risk analysis but no conclusions were drawn on how to confront this issue. It was left as an area for future study.

4.4 Identification of Key Questions that these Methodologies Should be Capable of Answering

The participants of the workshop spent considerable time discussing the key questions that proliferation assessment and proliferation risk methodologies should be capable of answering. These questions naturally grouped into the following areas:

1. Questions related to the design and operation of nuclear energy systems (NES) and fuel cycle architectures
2. Questions related to the design and implementation of safeguards systems and other international commitments.
3. Questions focused on the use of proliferation assessments as one component of a larger decision process.

An overarching question that was posed is whether we should be studying the concept of proliferation risk or proliferation resistance as a means to help answer the questions posed below. It was generally agreed upon that some questions lend themselves better to one concept or the other and that likely both technologies are needed. This tended to suggest that multiple tools would be needed to answer the broad set of questions posed below.

In the area of questions related to NES design and operation, the following were deemed to be the key questions that these tools should be designed to answer:

1. Does this nuclear energy system (NES) provide access to material or technology of significant interest to a nuclear weapons program?
    a. Does the spread of technology have a large impact on proliferation? (i.e., does it matter)
2. Does the design and operation of this NES provide information or develop skills related to sensitive technologies that could be used in a nuclear weapons program (esp. in terms of breakout)?
    a. How can the NES design be optimized to ensure that its operation will minimize the development of skills or technologies that could be used in a nuclear weapons program?

b. What are the desirable design features that could impede proliferation?
c. Does this result in a new latent threat (e.g., exploitation of technology and know-how)?
d. How can the global nuclear enterprise be designed to minimize proliferation opportunity?

In the area of questions related to the safeguards system and other international commitments, the following were deemed to be the key questions that these tools should be designed to answer:

1. Are appropriate international commitments (regulations, obligations, and policies) in place that will provide credible assurance that the NES will continue to be used for peaceful purposes?
2. Is the design of this NES such that it can be safeguarded effectively and efficiently in a safe and economic fashion, while ensuring early detection and/or delay of diversion or misuse?
    a. How can the design and operation of this NES be optimized to ensure that it can be safeguarded effectively and efficiently in a safe and economic fashion, while ensuring early detection and/or delay of diversion or misuse?
    b. How can the allocation of safeguards resources at a global or State level be optimized?

In the area of questions related to using these methodologies as a component of a larger decision process, the following were deemed to be the key questions that these tools should be designed to answer:

1. On what do we spend the next dollar to minimize proliferation opportunity?
    a. When do we spend the next dollar?
2. How can results be effectively presented, explained, defended, and justified?
3. When choosing technology options, can PR assessments be used to assist in making those decisions (along with economics, sustainability, safety, etc.)?
4. Can PR assessments provide insight into the dynamics between the safeguards official and the proliferator?
    a. If so, how?

The participants also formulated a number of questions that these methodologies might be able to answer but that the priority for this capability was much lower. These questions included:

1. How might proliferation assessment tools be used to understand the characteristics of the adversary?
2. How can the insights provided by a PR assessment be effectively communicated to decision makers?
3. How can confidence in decisions be assured?
4. Is there a simpler approach to analyze the problem?

4.5 Questions that Should be Answered but Not by these Methodologies

A number of other important questions were identified but these questions would not be answered by any of the methodologies considered by the workshop participants. These questions included:

1. How much risk is acceptable? What is a tolerable risk? What is the de minimus acceptable risk?
    a. Does the current safeguards system perform to your expectations?
    b. Does it exceed required performance?
    c. Are improvements only of interest when aligned with cost decreases?
2. Are there States willing to accept a less optimal nuclear explosives yield either intentionally or unintentionally?
    a. Are there non-State actors willing to accept a less optimal nuclear explosives yield either intentionally or unintentionally?
3. What are the PR performance requirements?
    a. For example, performance target for safeguards effectiveness and efficiency

4.6 Identification of Future Work for Proliferation Resistance

While proliferation resistance was deemed relatively mature, the participants were able to identify a number of areas for future efforts that would provide significant benefit. These included:

1. Effectively communicate results to different audiences
    a. Is there a better way to express/describe the phrase "proliferation resistance"?
    b. Outreach to other communities to bridge communication gap
    c. Provide a forum for informed information
    d. Enhanced transparency of Expert Elicitation as well as other details of methodologies
2. Test cases and "benchmark" standards that these methodologies can be tested against (prototypic cases and small systems studies)
    a. As a benchmark working group
    b. To help facilitate verification of methodologies
    c. Can methodologies be validated?
    d. Gap analysis and are there better methods?
3. Ability to estimate uncertainties (and sensitivity analysis)
4. Systems Study on Expert Elicitation
5. Better understanding of how proliferation resistance and risk relate to export control

4.7 Identification of Future Work for Proliferation Risk

The area of proliferation risk analysis was much less developed than proliferation resistance and a large number of possible efforts were identified. These include:

1. Definitions of proliferation risk and all terms used in its mathematical formulation
    a. What is success?
    b. What is failure?
    c. What are the undesired consequences?
2. What is the time frame?
3. How to quantify consequences?
    a. Is material attractiveness a part of this?
4. Proliferation resistance provides a basis for calculating probability of success
    a. Need modification to be specific to risk
    b. Game methods and others
5. Risk of "Do Nothing" Option

5. SUMMARY

During the workshop, developers discussed the status of the field and current research. Users discussed the current and anticipated needs to which assessment and methodology approaches could contribute. The workshop focused heavily on proliferation resistance methodologies; however, proliferation risk analysis, material attractiveness, statistical analyses to assess proliferation determinants, and quantitative analysis to estimate the likelihood a State will proliferate were also discussed. Panel sessions were held to assess the utility of current tools and identify future needs in a path forward for these approaches.

The results from this workshop identified numerous questions to be answered by current and developing proliferation resistance methodologies. This is important to ensure that the methods developed will produce results that meet the needs of the of the intended user group. It is important that we first understand the decisions that have to be made and the questions that need answers to facilitate the decision making process. The participants also had two general comments: (1) subjective methods are useful but need to be applied

honestly and transparently and (2) that method developers need to be wary of false quantification (i.e., giving too much importance to small differences in numbers).

The workshop results identified several areas for future proliferation resistance tool development. These include:

- Develop means to effectively communicate results to different audiences via outreach to other communities to bridge the communication gap and provide a forum for informed information
- Develop test cases and "benchmark" standards that can be tested against (prototypic cases and small systems studies) to help facilitate verification of these methodologies
- Perform systems study on expert elicitation
- Obtain a better understanding of how proliferation resistance and risk relate to export control

The workshop participants also discussed proliferation risk analysis and identified several areas for future work including:

- Develop a better understanding of the definition of proliferation risk and all terms used in its mathematical formulation.
- Study the time frame over which an analysis can be reliably performed.
- Determine how to fully quantify consequences (esp. beyond material attractiveness).
- Determine how proliferation resistance relates to proliferation risk.
- Understand the risk of the "Do Nothing" option (i.e., the risk associated with choosing to take no action or make no decision.

This workshop was the first in a series of workshops that will attempt to improve the user group's understanding of available tools and perspectives of other user groups, identify specific needs of user groups, and develop a research agenda and path forward to address those needs.

6. ACKNOWLEDGMENTS

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1. Los Alamos National Laboratory
2. Sandia National Laboratory
3. INMM Southwest Chapter
4. Canberra Albuquerque

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