Evaluation of Proliferation Resistance Using INPRO Methodology

Hong-Lae Chang*, Won-Il Ko
Korea Atomic Energy Research Institute, 1045 Daeduk-daero, Yuseong, Daejeon, Korea 305-600
**Corresponding author: hlchang@kaeri.re.kr*

1. Introduction

Within the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), a methodology for evaluating proliferation resistance (INPRO PR methodology) of innovative nuclear energy systems (INS) has been developed [1]. This paper addresses User Requirements of the INPRO PR methodology, including further improvement made during the Phase 2 collaborative project, "Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA)".

2. Proliferation Barriers in Nuclear Energy Systems

The degree of proliferation resistance results from a combination of, inter alia, technical design features, operational modalities, institutional arrangements and safeguards measures [2]. The effectiveness of barriers to proliferation can be categorized as (1) technical difficulty in making weapons (as a state level concern, not related to a specific facility), (2) barriers representing the difficulty in handling and processing materials (both at the State and at the facility level), (3) barriers leading to difficulty/detectability and safeguardability (at a specific facility related pathway level). Therefore, there are three levels of INPRO proliferation resistance assessment with associated indicators: State level, INS level and facility-level including facility specific pathways as shown in Fig. 1.

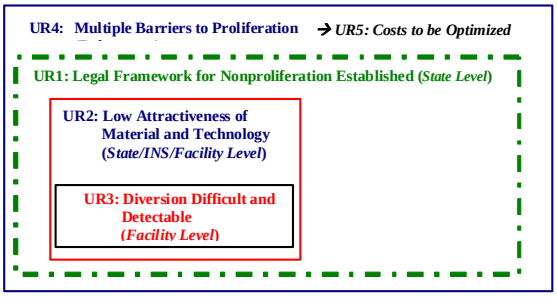

Fig. 1. Schematic showing the three levels of proliferation barriers.

3. User Requirements of the INPRO PR Methodology

The fulfillment of User Requirement 1 (UR1) "States' commitments, obligations and policies regarding non-proliferation and its implementation" has considerable impact on proliferation resistance of an INS. It demonstrates on one hand States' compliance with non-proliferation commitments, and on the other hand establishes the tools to detect noncompliance at the State and INS/facility levels. It has two criteria (CR); legal framework (CR1.1) and institutional structural arrangements (CR1.2) at the State level. CR1.1 asks the State to establish a sufficient legal framework addressing international non-proliferation, i.e., ensuring the adequacy of the States' commitment, obligations and policies regarding non-proliferation, and CR1.2 determines if the implementation is adequate to fulfill international standards in the non-proliferation regime. It also addresses the capability of the IAEA to detect undeclared nuclear materials and activities.

User Requirement 2 (UR2) states that the INS should have low attractiveness of nuclear material and technology for use in a nuclear weapons program. This user requirement refers to key proliferation barriers related to material and technology characteristics at the facility level. The role of the INPRO assessor is to determine whether an INS has achieved a level of attractiveness that is acceptably low by assessing the corresponding criteria. The attractiveness of nuclear material is determined by two intrinsic features, the conversion time and the total mass needed to achieve one significant quantity. The attractiveness of nuclear material increases with shorter conversion time of the acquired material and by smaller mass of nuclear material needed to form one significant quantity.

Currently UR2 results in a table that describes all the proliferation target materials in the system, but not a specific proliferation target material for specific pathways. The assessment table should provide a means for identifying the target being described in a pathway. The proliferator's strategy will also determine the level of detail. Therefore, the tables should reflect the impact of State capabilities on the strength of proliferation barriers to address the different assessment levels. The table should be self-documenting. It should be noted that this process could be performed at higher level in the early design phases, with updates as the design matures.

User requirement 3 (UR3) asks for reasonable difficulty and detectability of diversion of nuclear materials, and is to be fulfilled by the technology holder (developer) at the facility level. UR3 must be seen in the context of UR1 that provides the necessary framework to implement safeguards. The evaluation parameters of UR3 have in principle similar issues as with UR2, and the results in the assessment matrix table

should be related to a specific acquisition pathway and material. All assessments concerning barriers and diversion difficulty should be related to specific proliferator actions. The specific equipment, containment and surveillance measures, etc. involved should be addressed in the evaluation of UR3 for specific acquisition pathways, and therefore, this UR3 is associated with 'safeguards by design'.

Attractiveness of nuclear material and nuclear technology in an INS for a weapons program (UR2) and the detectability and difficulty of diversion of nuclear material (UR3) are not independent parameters. Attractiveness of an INS (or component thereof) decreases with an increase of detectability and/or difficulty of diversion of nuclear material. Indicators (barriers against proliferation) defined under UR2 that might be weak at a facility level can paradoxically increase e.g. the detectability of unrecorded movements of nuclear material. Therefore, some of the characteristics of nuclear material and technology discussed in UR2 are also relevant for UR3.

The evaluation of User Requirement 4 (UR4) on multiplicity and robustness of barriers against proliferation of an innovative nuclear energy system (INS) requires first performing acquisition/diversion pathway analysis. Therefore, a systematic approach for identification and analysis of the acquisition/diversion pathways in a nuclear energy system has been developed and applied to the DUPIC fuel cycle [3]. It was shown that robustness is not a function of the number of barriers or of their individual characteristics but is an integrated function of the whole. UR4 evaluates the multiplicity and robustness of barriers and is correlated with UR5 concerning the cost and optimization of PR features and measures.

The robustness of proliferation barriers as defined in PRADA is measured by determining whether the safeguards goals can be met. This does not imply that proliferation using an INS and its materials that meets safeguards goals is impossible (i.e. that the system is proliferation proof).

4. Conclusion

Evaluation of User Requirements of the INPRO PR methodology leads to the question, *why encourage States, designers and operators to make nuclear materials and technologies reasonably unattractive, if the value of proliferation resistance is determined by the capability to meet the safeguards goals*? The INPRO Proliferation Resistance Basic Principle states in part: "Proliferation resistance intrinsic features and extrinsic measures shall be implemented…. to help ensure that INSs will continue to be an unattractive means to acquire fissile material for a nuclear weapons program…" [1]. Whether or not an INS is an "unattractive means" depends basically on the "risk of early detection", on proliferation cost and proliferation time.

REFERENCES

[1] International Atomic Energy Agency, Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems, INPRO Manual – Proliferation Resistance, Volume 5 of the Final Report of Phase 1 of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), IAEA-TECDOC-1575, IAEA, Vienna (2007).

[2] International Atomic Energy Agency, Proliferation Resistance Fundamentals for Future Nuclear Energy Systems, IAEA STR-332, IAEA department of Safeguards, IAEA, Vienna (2002).

[3] H.L. Chang and W.I. Ko, "Acquisition/Diversion Pathway Analysis for the Assessment of Proliferation Resistance," Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 22, 2009.