SAND2014-17676C

A Global Perspective on Continuity of Knowledge: Concepts and Challenges

International Safeguards Session at 2014 INMM Annual Meeting

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At the 55th annual meeting of the Institute of Nuclear Materials Management (INMM) in Atlanta, GA, July 2014, a panel discussion addressed the topic "*A Global Perspective on Continuity of Knowledge: Concepts and Challenges.*" The session began with informed presentations by panel members followed by a discussion in which questions from the audience were addressed. The panel included: Robert Bean, Research Faculty, Purdue University, Kelsey Hartigan, Program Officer for the Material Security and Minimization Program and Nuclear Security Project at the Nuclear Threat Initiative (NTI), Olli Heinonen, former Deputy Director for Safeguards at the International Atomic Energy Agency (IAEA), Willem Jassens, Head of the Nuclear Security Unit at the Institute for Transuranium Elements of the Joint Research Center of the European Commission at Ispra, Italy, Shirley Johnson, former safeguards inspector at the IAEA and currently founder of Tucker Creek Consulting, and Irmgard Niemeyer, head of the International Safeguards Group in the Institute of Nuclear Waste Management and Reactor Safety at Forschungszentrum Juelich. Dianna Blair, Manager of the International Safeguards and Technical Systems Department at Sandia National Laboratories and Nathan Rowe, Oak Ridge National Laboratory, moderated the panel session.

The impetus for the panel discussion was to better understand the often used but rarely defined concept of Continuity of Knowledge (CoK). A series of papers have been written exploring the concept[1,2,3] and the panel discussion was intended to broaden the conversation beyond that presented in the those papers. The presentations and discussions brought forth a number of points. The definition for safeguards that "CoK is a system of data or information regarding an item that is uninterrupted and authentic and provides the IAEA with adequate insight to draw definitive conclusions that nuclear material is not being diverted from peaceful purposes," was put forth. With this perspective CoK is an outcome not a process and that you must first attain CoK and then maintain it to have confidence that the knowledge can be used to draw a valid conclusion. Safeguards knowledge is a function of many things including prior knowledge, the technical capability to collect, authenticate, and verify information, the age of the information and an understanding of what is and is not known about a system or process. It was stressed that you must have confidence that the data and information are relevant and valid. Confidence is a function of time since last verification activity, equipment performance, and adverse actions. The principles of correctness and completeness applies to the individual data sources used to attain and maintain CoK. The data is then focused or filtered in the process that generates knowledge. Ultimately the goal is to have confidence in the resultant knowledge. Interruptions in the CoK of information are a reality and must be addressed by reestablishing baseline knowledge and using other sources of information to best reconstruct the missing information. Using obsolete hardware/software to sustain CoK is an ongoing and challenging problem.

However, CoK applies to more than discrete items or pieces of data. It applies to items, facilities, and locations that pose proliferation risks and therefore should take on a broader definition and utilize broader approaches than previously proposed. From confirming declarations using containment and surveillance (C/S) of items (e.g. sealing/verification technologies) and facilities (e.g. process monitoring/modelling that requires data authentication) to verifying absence of undeclared activities and/or facilities (e.g. trace detection of fuel cycle signatures) to analysis of proliferation concerns (e.g. export control and trade analysis) to detecting illicit acts involving nuclear material (e.g. nuclear forensics) CoK poses challenges at different levels and relies heavily on technology to successfully execute. For example, the pattern of rare earth metals in ore, and how they carry through to the final fuel is an intrinsic signature that allows material to be tracked, a method of CoK. Conformity of operator signal (self-correlation for process steps) and coherency between signals (cross-correlation) can build trust in support of CoK at bulk handling facilities that activities are as declared. Utilizing an integrated approach of process, enrichment, and item tracking, is another approach to CoK that can be applied at gas centrifuge enrichment plants. It could be accomplished through real-time monitoring of load cells, on-line enrichment monitoring, modelling of cascade, RFID cylinder tagging, UF_6 cylinder identification and authentication, portable mass spectrometers, and NDA for enrichment verification in product cylinders. At the State level, utilization of open source information, could provide knowledge continuation for the analyst versus CoK.

Another facet of CoK is maintaining continuous knowledge of the flow or location of nuclear or other material, or the status of a nuclear facility or equipment. It is normally considered continuous and unattended, recorded for later review or transmitted for on-demand review and evaluation, but it was proposed that it could be maintained through random, short- or no-notice activities. Typically seen as C/S or monitoring, CoK could also include other inspection activities as well. It is needed in design information verification (DIV) activities, verifying inventories, process flows (within and across material balance areas (MBAs) and non-nuclear material flows), operations, and IAEA property and equipment. The challenges of maintaining confidence regarding status and location of nuclear material in spent fuel throughout it various stages was discussed. Since spent fuel remains practically inaccessible during many decades of storage, baselining what goes into dry storage and then ensuring subsequent CoK until retrieval is needed for efficient and effective safeguards. The Digital Cerenkov Viewing Device could be useful tools for verification during loading, equivalent to the common Ion Fork Instrument. Measures, such as remote data transmission of surveillance information (e.g. video, data from electronic optical sealing system (EOSS)) from a cask storage facility to inspectorate could support CoK, resulting in less on-site inspections. The evaluation of various technologies and measures could be explored by organizations such as the Member State Support Programmes (MSSPs).

Verification activities include tracking of items across space from one location to another, through time in static storage, or as the material is transformed. There are times when the inspecting party has physical control of a treaty accountable item, resulting in Chain of Custody (CoC) of the item through time or space, and other times where the inspectorate collects continuous information regarding the item, CoK. These conditions may exist at different points in a verification regime and knitting together at the interfaces presents challenges.

The extent of equipment deployed for a CoK system comes down to a cost/benefit analysis-the cost of equipment and analysis versus reverification requirements. Cost brought about the need for dual C/S systems but in some cases loss of CoK is not acceptable. There are some situations, such as operations, where the information lost with loss of CoK cannot be adequately replaced. In those cases, defense in depth, such as multiple independent systems without a single mode failure, is needed. The basis for judging whether CoK has been achieved involves tracing knowledge to something that is known to be true. If you cannot connect data you trust to a conclusion you are making then you have lost CoK. It is not about the volume of data collected but rather the relationship such data has with anomalous behavior. Data analytics can reduce 1000s of pieces of data to those that need to be examined more closely. It can be difficult to determine when you have positively maintained CoK but it is easy to identify when you have lost it.

Various technologies and tools are used to maintain CoK and include: radiation sensors (gamma and neutron), solution monitors (flow, volume, density, levels, and temperature), unattended or remote surveillance cameras, chemical component analyses, reactor power monitors, portal monitors, heat and motion sensors, entry and exist alarms, C/S, unique identification devices (UIDs), tamper-indicating enclosures (TIEs), environmental sampling/monitoring. The possible benefits of CoK were said to include reduction in the need for material re-measurement, reduction of the cost, frequency and length of inspections, reduction in radiation exposure for both operator and inspector, and reduction in intrusiveness to the operator. Whereas there are a number of technologies available to build and maintain CoK it was stated that there are technology needs. Developing a strategy and technology roadmap for cooperative research and development on the tools and procedures to ensure CoK of relevant items could be valuable. Specifically, there is a need for more relative, robust, sensitive and affordable equipment and systems, remote and unattended systems, secure remote transmission of information, and automatic detection of loss of CoK, data handling and reporting.

Since nuclear proliferation is a technology based activity, treaty inspectors/analysts must have a toolbox of knowledge and experience that allows them to recognize deviations from declared activities. Historical knowledge of past proliferation efforts can provide insight and clues into future proliferation attempts and therefore requires that inspectors have a CoK of these experiences. The value of such knowledge should be recognized based on similarities in proliferation attempts by different countries. Training and well documented procedures are also vital. Historically these have not been done well. Teamwork allows for distribution of knowledge and can help with on the job training. Exit interviews of inspectors and critical personnel should also be done to pass on lessons learned with the intent of acting on the information that is gathered. It should not just be collected and filed. The role of technology to reduce the need for human transfer of the knowledge should be examined. Technology could also help in the training and preparation of inspectors. Tools can help in the shortcomings of new inspectors at complex facilities. Recognizing that the human element is extremely important, looking across the organizations that perform inspection activities could be useful. There are also rotation policies that move individuals to different facilities and activities which can be detrimental to maintaining valuable knowledge and insight key to particular locations/activities. Having guidance documents and adequate training provides a good basis for educating and bringing newcomers up to speed. Proliferation should be approached from a systems perspective based on inspector knowledge, not from a nuclear material accountancy perspective. However, safeguards continues to be a material centric effort so nuclear measurements will continue to be a key element of that regime with CoK used after declaration verification. For arms control regimes, though, where measurements may not be allowed, CoK and CoC will be extremely important.

References

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