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Transport Security for Nuclear and Other Radioactive Materials

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ABSTRACT

The U.S. Department of Energy Packaging Certification Program, Office of Packaging and Transportation, Office of Environmental Management has sponsored a training course on security during transport of nuclear and other radioactive materials, conducted annually by Argonne National Laboratory since 2013. The original pilot course covered both international and U.S. domestic transport security; in later years, it was divided into two separate, week-long courses. In 2015, the course became part of the curriculum of the Graduate Certificate in Nuclear Packaging program at the University of Nevada, Reno. In 2018, the courses were formally designated as Nuclear and Other Radioactive Materials Transport Security – International (ME 694I), and Nuclear and Other Radioactive Materials Transport Security – U.S. Domestic (ME 694D).

The objectives of these two courses are to help participants gain a detailed working knowledge and understanding of international and U.S. domestic requirements, recommendations, and guidelines for security during the transport of nuclear and other radioactive materials by all modes of transport. More specifically, the international transport security course addresses the recommendations and guidance from the International Atomic Energy Agency and the international regulatory requirements and recommendations from relevant international and regional modal transport organizations, whereas the U.S. domestic transport security course addresses the requirements of the U.S. government agencies. Both courses provide guidance on how to develop transport security systems by following a graded approach and applying modern technologies; how to develop transport security plans (TSPs) that satisfy regulatory security requirements; how to apply rules of engagement for escort, guard force, and emergency response personnel; and how to communicate with stakeholders and the public during emergencies, among other topics. Both courses incorporate hands-on exercises involving TSPs, readiness reviews, and corrective actions; use of an audience participation system to enhance dialogue; and a field exercise using the ARG-US remote monitoring systems to track a mock shipment with "staged incidents." Both courses also make extensive use of tabletop exercises to facilitate learning through role-playing, discussions, and group reports. In this paper we provide highlights of recent transport security courses, including lessons learned from participants' feedback and future directions.

INTRODUCTION

As a result of the events of 11 September 2001, significant efforts have been made worldwide toward enhancing security during the transport of nuclear and other radioactive material. Security must apply during preparations for transport, during the transport itself, and during storage that is incidental to transport. These efforts to enhance transport security have generally been given a high priority by regulators, shippers, carriers (operators), and receivers, as well as other entities involved in such shipments, including local law enforcement agencies (LLEAs), emergency responders, border control agencies, and port facility operators. Such efforts have been extensively supported by the actions of relevant international bodies, including the International Atomic Energy Agency (IAEA), the World Institute for Nuclear Security

(WINS), the World Nuclear Transport Institute (WNTI), and the United Nations Economic Commission for Europe (UNECE), which issues recommended transport security requirements in its U.N. Model Regulations [1]. In turn, the U.N. Model Regulations serve as the basis for international air and waterway regulations [2, 3], and the regional modal regulations for road, inland waterways, and rail transport [4-6]. Also, individual countries often use these international regulatory documents to guide the development of their national (State) regulations.

Recognizing that a sound security culture depends upon both the State and the operators, a primary goal of this effort has been to provide training for both State and operator personnel to assist them in developing and applying the necessary transport security regulations, guidance materials, and technology and personnel expertise. Through this training, the establishment of a sound security culture can be fostered, and viable transport systems can be provided for shipments of these materials. Efforts have been focused on having the transport security systems structured by operators follow two key security principles: defense in depth and a graded approach. It is emphasized that those entities involved in shipments of nuclear and other radioactive material must work to ensure that the transport security systems for which they are responsible are adequate and follow appropriate regulatory principles. They must satisfy the security requirements imposed by international conventions, agreements, and commitments, as well as requirements established by the responsible regulatory bodies of each country transited by a shipment.

Furthermore, for such a sound transport security culture to be established, all involved personnel must be properly qualified and trained. Typically, regulators specify that involved personnel must be trained initially in both general security awareness and job-specific requirements, and then retrained periodically (generally every three years), and also when regulatory requirements change.

Thus, it was recognized early that training materials needed to be developed and employed in a manner that engages all personnel involved in the diverse transport activities, and kept up to date as regulations and associated guidance documents mature. These training materials needed to address multiple aspects of the transport security system, including the following:

- How to undertake the initial design of transport security system elements, accounting for both security and safety regulatory requirements;
- The operational procedures for preparing packages, conveyances, escort vehicle when used, and other related transport system elements, while also ensuring that each satisfies the regulatory and system design requirements imposed upon it;
- Methods for the development and implementation of plans and procedures that must be followed by involved personnel, including escorts and guards who may accompany the carriage of consignments of the materials by one or more modes of transport;
- How to establish arrangements for LLEA personnel and emergency response personnel along a transport route who may be called up to respond should a security event, or threat thereof, arise;
- Communication systems between all involved personnel that are secure, reliable, and redundant; and
- The need to establish rules of engagement for involved response personnel so that they are not in doubt as to what actions they have been approved to take should a security event occur, and also so that they and their organizations can be adequately protected from legal liabilities.

International bodies such as the IAEA and WINS have made significant progress in providing non-regulatory-binding tools that can be used to enhance such training. To supplement and build upon these efforts, Argonne National Laboratory (Argonne), supported by the U.S. Department of Energy (DOE), Office of Packaging and Transportation, Office of Environmental Management (EM), developed and, beginning in 2013, convened an annual training course on security during the transport of nuclear and other radioactive material.

The following provides background on this training effort; discusses the approach that has been taken as the program has matured; presents lessons learned from previous courses that have been systematically applied to later courses; discusses the views that have been expressed by those who have been trained; and summarizes the structure of the last two training courses, convened in September 2017 and 2018, which focused on international transport. It also provides a link to information on the next in this series of training courses, which is to be convened on 9–13 September 2019 and will specifically address U.S. domestic transport security requirements.

THE INTERNATIONAL TRANSPORT REGULATORY STRUCTURE

Internationally, for transport, all dangerous goods have been placed in one of nine classes by the UNECE in the U.N. Model Regulations [1]. This classification serves as the basis for establishing the international and regional modal regulations and regional modal regulations for all dangerous goods, including Class 7 (radioactive material) [2–6]. Nuclear materials are classified as Class 7 (radioactive material). It is noted that the U.N. Model Regulations and the international and regional modal regulations are updated every 2 years.

Internationally, the U.N. Model Regulations are used to guide the development of international modal transport security regulations by organizations that include the following:

- The International Civil Aviation Organization, which issues *Technical Instructions for the Safe Transport of Dangerous Goods by Air* [2], and
- The International Maritime Organization, which issues the *International Maritime Dangerous Goods Code* [3].

These two international modal regulations become binding upon States that are party to the Chicago Convention and the SOLAS Convention, respectively. Currently, 192 States are parties to the Chicago Convention and 162 States are parties to the SOLAS Convention.

Regionally, the U.N. Model Regulations are also used to guide the development of regional modal transport security regulations, which include the following:

- The European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) [4];
- The European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) [5]; and
- The Convention Concerning International Carriage by Rail (COTIF), Appendix C – Regulations concerning the international carriage of dangerous goods by rail (RID) [6].

The ADR and ADN are agreements rather than conventions; they become binding upon States that are parties to the two relevant agreements, whereas RID is a convention which becomes binding upon States that are parties to it. Currently there are 50 States party to the ADR agreement, 18 States party to the ADN agreement, and 47 States party to the COTIF convention.

Also, as noted above, the U.N. Model Regulations, as well as the international and regional modal regulations, recommendations and guidance documents from the IAEA and best-practice documents from the WINS, are often used by individual countries in establishing their State transport security regulations. Specifically, the IAEA has issued a Fundamentals document [7] which specifically states that "*The responsibility of a State for ensuring that nuclear material and other radioactive material are adequately protected extends to the international transport thereof, until that responsibility is properly transferred to another State, as appropriate.*"

Although nuclear material is a small subset of the radioactive material family, because of the increased attractiveness of nuclear materials, the security requirements and recommendations for them are specified

separately from those for other radioactive material.[1]

The following two subsections summarize the regulatory, recommendation, and guidance documents for transport security for both nuclear and other radioactive materials, all of which are addressed in detail in the international and domestic elements of Argonne's training courses on transport security.

International basis for security during the transport of nuclear material

For the secure transport of nuclear material, States that are party to the Convention on Physical Protection of Nuclear Material (CPPNM) [8] and their operators, including their flag carriers, must ensure that their transport security systems are consistent with the categorization of the nuclear material being shipped and also embody all relevant security provisions that are set forth in the CPPNM, the amendment to the CPPNM [9], and all relevant international modal and State regulations.

Further, for nuclear material, it is noted that the current edition of the U.N. Model Regulations specifies that transport security requirements are "deemed to be complied with when the provisions of the" CPPNM and those of the IAEA recommendations document INFCIRC/225/Rev.4 are applied. However, Revision 4 of INFCIRC/225 (which was published in 1999) has been superseded by Revision 5 [10], which was published in 2011. Steps have recently been taken to rectify this disconnect. It was recommended [11] that the U.N. Sub-Committee of Experts on the Transport of Dangerous Goods consider, during its 27 November to 6 December 2017 meeting, the adoption of a proposal to make an editorial amendment specifying that Revision 5 of INFIRC/225 will serve as the basis for applying security requirements for the transport of nuclear material. This step was approved during 2018 [12]. It will be included in the consolidated list of amendments to Rev. 20 of the U.N. Model Regulations and will then appear in the 21st revised edition of the U.N. Model Regulations [13]. This step will align and harmonize the nuclear-material transport requirements in the international and regional regulatory documents with Revision 5 of INFIRC/225. In anticipation of this change being made, and taking a conservative approach to transport security, the training courses at Argonne have assumed that Revision 5 of INFCIRC/225 should be applied to the transport of nuclear material, thereby indirectly applying the requirements of the CPPNM and its amendment.

Finally, in addition to the recommendations in Revision 5 of INFCIRC/225, the IAEA has issued an implementing guide for security of nuclear material in transport [14] which, along with Revision 5 of INFCIRC/225, is intended to "support the application of the CPPNM and its Amendment."

International basis for security during the transport of other radioactive material

For the secure transport of radioactive material other than nuclear material, the international modal regulations and, as applicable, the regional modal regulations apply, as do relevant State regulations. In addition, the IAEA has developed documents that States and their operators and flag carriers may need to consider when developing transport security systems for these radioactive materials. These include the *Code of Conduct on the Safety and Security of Radioactive Sources* [15], which many IAEA Member States have voluntarily made a political commitment to follow. In addition, the IAEA has issued recommendations [16] and an implementing guide [17] on security in the transport of radioactive material. All of these regulatory, recommendation, and guidance documents for transport security for both nuclear and other radioactive materials are addressed in detail in the international element of Argonne's training course on transport security.

THE ARGONNE TRANSPORT SECURITY TRAINING COURSES

Many of the above-mentioned documents specify that all entities involved in the transport of nuclear and

[1] It is noteworthy that nuclear material also has a distinct set of transport regulatory requirements for safety that go beyond those for other radioactive material which must be satisfied. These are set forth in the IAEA *Regulations for the Safe Transport of Radioactive Material* (IAEA SSR-6) and are then incorporated into the U.N. Model Regulations and international and regional modal regulations.

other radioactive material must be properly trained to fulfill their specific assigned functions. These entities include consignor personnel (i.e., shippers); carrier personnel; consignee personnel (i.e., receivers); escort and guard personnel accompanying a shipment; personnel staffing a transportation communications center; emergency responder personnel, including those from LLEAs (who may be large in number for long-distance surface routes, i.e., road, rail, and inland waterways); and, for international shipments, possibly border crossing and customs personnel. For example, para. 1.3.4 of the U.N. Model Regulations [1] specifies that the training "shall be provided or verified upon employment in a position involving dangerous goods transport and shall be periodically supplemented with retraining as deemed appropriate by the competent authority." Generally, this training includes the following:

- Security awareness training for all personnel involved in the transport of these materials,
- In-depth security training for personnel involved in implementing specific parts of a transport security plan, and
- Recurrent training, typically every three years.

These training requirements can be satisfied, in part, through an effort undertaken at Argonne to provide detailed training and hands-on experience for individuals involved in transporting both nuclear and other radioactive materials. The Argonne training focuses on the following:

- Raising awareness and strengthening security during the transport of nuclear and other radioactive materials, and
- Gaining experience in training personnel so that lessons learned can be used to enhance the training experience.

The Argonne training courses have focused on transport security requirements, recommendations, and guidance, both domestic and international, and the promotion and sharing of good practices and their effective application by encouraging a sound, structured, and comprehensive security culture. The training has matured from its initial one-week pilot in 2013, which addressed both international and U.S. domestic transport security, to a one-week course on either international or U.S. domestic transport security. Table 1 summarizes the dates of each week-long course and the topic(s) addressed in each course, including the course scheduled to convene in September 2019.

Table 1. Overview of the Argonne Training Courses on Security during the Transport of Nuclear and other Radioactive Material

Year	Topic	Date
2013	U.S. Domestic and International Transport Security	December 2–6
2014	International Transport Security	December 8–12
2015	U.S. Domestic Transport Security	June 22–26
2016	U.S. Domestic Transport Security	August 22–26
2017	International Transport Security	September 11–15
2018	International Transport Security	September 10–14
2019	U.S. Domestic Transport Security	Scheduled for September 9–13

The pilot training course: 2013

One of the main objectives of the 2013 pilot course was to assess how best to proceed in providing meaningful and effective training on transport security for participants both from within the U.S. and from international entities. The detailed comments provided by participants at the conclusion of the pilot course included many statements that the course was very beneficial. Other comments submitted by participants in the course evaluation sheets, and the lessons learned, can be found in the paper by Pope et. al. [18].

Possibly most significantly, the participants reported that combining international and domestic transport security into a single, one-week course was too ambitious, providing too much information to cover in such a short time.

The follow-on training courses

In accordance with the experience gained in the 2013 pilot course and the lessons learned from it [18], the December 2014 course focused only on international transport security, whereas both the June 2015 and August 2016 courses focused only on U.S. domestic transport security. In each case, the courses addressed transport security requirements, recommendations, and guidance for all nuclear and other radioactive material, as issued by relevant international or U.S. domestic regulatory bodies, as applicable to the course scope.

By reducing the scope of each course, enough time was provided for participants to gain greater in-depth understanding and to benefit from the use of learning tools that allowed for interaction among the participants and between the participants and the lecturing staff.

Beginning with the 2014 international course, participant interaction was greatly enhanced through the use of an electronic, anonymous audience participation voting (e-voting) system that utilized carefully designed sets of questions to elicit responses on various topics. This audience participation system has been used since, as follows:

- To survey, at the beginning of each course, the participants' knowledge and background, which were then used to guide lecturers on the extent to which emphasis needed to be placed on certain topics;
- To enhance discussion of issues during the course, obtaining the personal views and insights of participants, which effectively moved the course further away from a lecture-only environment and facilitated broadened discussion on key topics; and
- To survey, at the end of the course, the participants' views on the adequacy of the course, which have proven to be useful in guiding the development and enhancement of follow-on courses.

For each of the courses, the participants' responses to the end-of-course queries were very encouraging. A large majority reported that they experienced a significant or reasonable increase in their knowledge of transport security, and that they would definitely or probably recommend future courses to their colleagues. These results, as well as inputs from detailed course assessments completed by the participants, have continued to be used to further enhance the training courses year by year.

The two U.S. domestic courses (in 2015 and 2016) addressed transport security requirements for all types of nuclear and other radioactive material shipments that may be undertaken in the U.S., except for those shipments that involve materials that are required to be transported in systems operated by the DOE Office of Secure Transport (OST), and those shipments that the U.S. Department of Defense (DoD) performs. The domestic courses also addressed international shipments that came into the U.S. from another country or went out of the U.S. to another country or were transiting the U.S. from one country to another country. In order to provide a balanced view of these latter requirements, international requirements for air and maritime transport were introduced, since these are the modes that typically lead to additional security measures in the U.S. beyond those mandated by U.S. regulatory bodies; that is, by the U.S. Department of Transportation, the U.S. Nuclear Regulatory Commission (NRC), the U.S. Coast Guard, and DOE for DOE shipments that are not related to OST or DoD.

The agenda for the international courses changed significantly from the 2014 course to the 2017/2018 courses. The following lists the lecture topics addressed in the 2017/2018 courses, which took advantage of the lessons learned from previous courses. The list illustrates the breadth and depth of topics covered.

- Comparative Risk Assessment of Terrorism and Natural Hazards;
- Possible Terrorist Acts, Risks, Consequences, and the Need for Transport Security;
- The IAEA's Role in Worldwide Nuclear and Other Radioactive Materiel Security during Transport;
- The Roles of International Organizations—Relevant International Safety and Security Documents;
- Key Transport Safety Requirements;
- Transport Security Systems versus Facility Security Systems—Why Transport is Unique;

- Interfaces between Transport Safety and Transport Security;
- Interfaces between Transport Safeguards and Transport Safety and Security Requirements;
- WINS Efforts Assisting Practitioners in Enhancing Worldwide Transport Security (delivered from Vienna via webcast);
- Basic Security Principles and Functions;
- The International Requirements and Recommendations for Security during the Transport of Radioactive Material;
- The Graded Approach to Classifying Radioactive Material other than Nuclear Material for Transport Security;
- Tools for Defining Security Measures for Transport of Radioactive Material other than Nuclear Material;
- Requirements for Security during the Transport of Nuclear Material;
- Recommendations for Security during the Transport of Nuclear Material;
- Tools for Defining Security Measures for Transport of Nuclear Material;
- Ministerial Policy Initiatives: Next-generation Security;
- The WNTI Experience with Transport Security;
- Planning Shipments, Establishing Safe Havens;
- Operational Capabilities for Response Forces along Transport;
- Response to Transport Security-related Incidents;
- Security Communication;
- Crisis Communication;
- Overview of Security Technologies;
- Transport Operational Communications, Command, Control and Rules of Engagement;
- Interfacing Transport Security and Safety for Low-activity Radioactive Material; and
- Transport Security Plans, Readiness Reviews, and Corrective Actions.

In addition to the lectures, the 2017/2018 courses included the following:

- Various team exercises to assist in learning how to apply material categorization and the use of the graded approach to establishing security measures, and to foster open discussion.
- Three tabletop exercises dealing with the following approaches:
  - Formalizing concepts, plans, procedures, arrangements, and systems for a typical road shipment where unplanned events occur;
  - Developing and testing concepts for an international, multi-modal shipment involving adversary activity; and
  - A "battleboard," turn-based exercise with the students and lecturers divided into four teams: (a) a transport team, (b) a protective force team, (c) an opposition force team, and (d) an umpire/observer team.
- Two facility tours:
  - The ARGUS Command Center, where the ability to remotely monitor the state of health of packages in facilities and the tracking of conveyances shipping those packages was demonstrated; and
  - The Argonne Nuclear Energy Exhibit Hall, where the discovery of atomic energy in the U.S. and Argonne's roles is illustrated.
- A field exercise using a staged shipment where students performed a readiness review and determined deficiencies in the transport system in anticipation of undertaking corrective actions.
- A 45-min real-time demonstration of the tracking and monitoring of a vehicle's movement using the ARG-US RFID system [19], including a "staged incident" by way of a field exercise using the ARGUS Traveler system [20].
- A discussion of recent case studies on tracking and monitoring of a rail shipment and on multi-modal shipment of large components.

- Homework problems and a final exam.

CERTIFICATION OF THE COURSE FOR UNIVERSITY GRADUATE-LEVEL CREDIT

Argonne has worked with the University of Nevada, Reno, and the DOE Office of Packaging and Transportation, EM, to develop an accredited graduate-level program in nuclear packaging, known as the Graduate Certificate in Nuclear Packaging (GCNP) program. The DOE's Radioactive Materials Packaging website (https://rampac.energy.gov/home/education/packaging-university) describes the GCNP program as follows:

> ***University of Nevada, Reno Graduate Certificate in Nuclear Packaging:*** *The U.S. Department of Energy's Packaging Certification Program (DOE PCP) has been working with the University of Nevada, Reno (UNR) Mechanical Engineering Department since 2013 to develop an accredited graduate-level nuclear packaging program. The Graduate Certificate in Nuclear Packaging (GCNP) provides a curriculum in packaging for nuclear and other radioactive materials that complements graduate programs in Mechanical Engineering and Materials Engineering and is more applied-knowledge-based than research-based. The admission requirement is an earned baccalaureate degree in mechanical, materials, nuclear or a closely related engineering field, or a baccalaureate degree and background in project management related to packaging of nuclear and other radioactive materials. The Certificate and its courses have been approved by the Northwest Commission on Colleges and Universities (NWCCU), Redmond, WA.*

The two transport security courses are part of this GCNP program. Additional information on the GCNP program from the university perspective can be found at https://www.unr.edu/degrees/nuclear-packaging/certificate, while additional information on the forthcoming (September 2019) transport security training course can be found at http://rampac.energy.gov/home/education/packaging-university#FY2019.

CONCLUSIONS

The goal of this transport security training effort is to improve the ability of the participant to prevent those with malicious intent from stealing, diverting, or attacking shipments of nuclear and other radioactive materials. Those trained have come from North America, Europe, the Middle East, and Asia. Participants have included representatives from regulators; consignors, carriers, consignees, and shipping brokers; and State/regional inspection, escort, enforcement, and response personnel.

Training-course lecturers have included experts from U.S. domestic organizations, including the NRC, DOE, and FBI; and from international organizations, including the IAEA, WINS, WNTI, and Risk Management Solutions. The breadth of experience and knowledge developed through these training courses has also been used to contribute significantly to two WINS Best Practice Guides focused on transport security [21, 22], the case study on electronic tracking [19], and the WINS Academy training module on Transport Security Management [23].

The knowledge and experience base developed through the convening of the transport security training courses that have been discussed in this paper could be used to leverage future transport security educational efforts worldwide to support capacity building [24] and next-generation security [25].

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