INITIATIVES TO INTEGRATE NUCLEAR SECURITY WITH RADIATION PROTECTION EDUCATION AND TRAINING

J.T. HARRIS
School of Health Sciences, Purdue University
550 Stadium mall Drive, West Lafayette, IN 47907 - USA

E.T. WALLER
Faculty of Energy Systems and Nuclear Science , University of Ontario Institute of Technology
2000 Simcoe Street North, Oshawa, ON L1H 7K4 – Canada

ABSTRACT

Extensive efforts in developing robust and sustainable educational and training programs in nuclear security have become an international priority due to the growth and interest in the use of nuclear and radiological technologies, coupled with the growing threat of global terrorism since the events of September 11, 2001. Many of these efforts are driven by the activities of the International Atomic Energy Agency (IAEA). Specifically, the IAEA International Nuclear Security Education Network (INSEN) was established in 2010 to enhance global nuclear security by developing, sharing and promoting excellence in nuclear security education. One of the goals of INSEN is to better integrate nuclear security education with other areas of nuclear and radiation science. The integration of safety, security, and safeguards (when applicable) is paramount in this regard. Health physics or radiation protection is often included in safety and is one area where better integration with nuclear security concepts is needed. Many radiation protection professionals have very little knowledge or experience in radiological or nuclear security matters. However, more and more of these professionals are facing increased job responsibilities that include some aspect of security. The role of the radiation protection professional in nuclear security matters is not clearly defined despite the fact that a fundamental understanding of radiological hazards of adversary target material is required for understanding the total risk to the facility and/or material. The authors have begun a program of developing materials and providing professional development workshops specifically for the purpose of integrating nuclear security with radiation protection. Since 2014 the authors have developed 8-hour, 4-hour, and 2-hour workshops catering to radiation protection students and professionals in the medical, industrial, and nuclear energy sectors. The workshop modules range from introductory nuclear security topics to more detailed content. These workshops have been presented at a number of professional conferences and even provided at dedicated workshops throughout the world. Future courses will continue to be offered with the hope of developing even more specialized content to different radiation protection stakeholder groups (i.e. the healthcare industry, nuclear power, etc.). In addition, a dedicated nuclear security curriculum has been developed in the health physics baccalaureate and masters programs at Purdue University. This program, in cooperation with the nuclear engineering and political science departments, will educate these students in nuclear security principles.

1. Introduction

The need for human resource development in nuclear security has been underlined at several International Atomic Energy Agency (IAEA) General Conferences and Board of Governors' Meetings. In successive IAEA Nuclear Security Plans, high priority has been placed on assisting member States in establishing educational programs in nuclear security in order to ensure the sustainability of nuclear security improvements. The current Nuclear Security Plan, covering 2014-2017, emphasizes the importance of existing capacities at international, regional and national levels while designing nuclear security academic programs [1].

One key component in helping member States establish educational programs came about in 2010 when the International Nuclear Security Education Network (INSEN) was formed during an IAEA workshop by a group of experts from academia, international organizations, and professional nuclear material management associations [2]. The INSEN mission is to promote excellence in nuclear security education in pursuit of the identified need for highly qualified nuclear security professionals [3]. INSEN objectives are to promote among universities and other educational institutions worldwide the IAEA Nuclear Security Series No 12 (NSSS-12) – *Educational Programme in Nuclear Security* setting out a model of a Nuclear Security Master of Science curriculum by (1) assisting in the development of comprehensive and up-to-date educational materials; (2) assisting in the development of faculty members in the area of nuclear security; and (3) promoting professional careers in nuclear security as the means of attracting the best and the brightest into the discipline [4].

The achievements and progress made by INSEN since its inception has been nothing but remarkable. INSEN has grown from an initial membership of about 20 to over 150 (159 members as of April 1, 2017). Fifty-six IAEA member states are represented and over 90% of the members represent academic institutions. Of the educational institution members, most have developed a nuclear security program or added a nuclear security component to an existing program. No less then 15 institutions have actual programs leading to a degree or concentration in nuclear security. Through its three working groups (WGs), INSEN has developed a number of textbooks, presentations, and other educational materials, has taught or developed several dozen professional development workshops and courses, and has presented at least 100 papers on nuclear security topics. [5] The seeds of nuclear security educational infrastructure were planted not long ago, yet the growth has already been significant. [6]

Although nuclear security education infrastructure development has been established and expanded throughout the world, its integration in areas of overlap with related disciplines has been slow or nonexistent. One particular area where overlap and integration is crucial and missing is in radiation protection or health physics. In a recent published paper, Waller and van Maanen discuss the advantages that health physicists would have in a nation's overall nuclear security programme. In this article they present how health physicists can contribute expertise in the roles of establishing the threat assessment and design basis threat, informed risk management, response force strategies in light of potential radiation exposure, dose guidance, training and demonstrable competence for the nuclear security response force and with effective communications of the radiological component of an event [7]. Using this paper as a springboard, members of INSEN, including the authors of this paper embarked on a program to integrate nuclear security education with radiation protection. The first phase of this program involves developing and presenting professional enrichment courses to introduce radiation protection professionals to nuclear security.

2. Background

Radiation protection, also known as health physics or the physics of radiation protection, is the science concerned with the recognition, evaluation, and control of health hazards to permit the safe use and application of radiation [8]. Health physics professionals promote excellence in the science and practice of radiation protection and safety and have broad experience in physics, biology and environmental science that can be used in nuclear security. These professionals principally work at facilities where radionuclides or ionizing radiation are used or produced, including medical institutions, government laboratories, academic and research institutions, nuclear power plants, regulatory agencies and industrial manufacturing plants. Worldwide, it is estimated that there are over 15,000 individuals that hold the title of health physicist or radiation protection professional.

Radiation protection is an essential function in most nuclear and radiological facilities and the primary responsibility is a safety function. Nuclear security is, however, extremely important in the post-9/11 environment for all of these facilities. The role of the radiation protection professional in nuclear security matters is not clearly defined despite the fact that a fundamental understanding of radiological hazards of adversary target material is required for understanding the total risk to the facility and/or material. Radiation protection can be integrated into nuclear security culture during design basis threat definition, through risk management exercises, participation in response force activities, developing dose guidance criteria, radiological training and in communicating hazard and risk to security personnel, facility operators and regulatory bodies. When integrating radiation protection into nuclear security culture, it is important that radiation protection management or the responsible/senior health physicist establish dialogue early with nuclear security personnel in generating the design basis threat. The dialogue must include the advantages of considering radiological hazard as part of the comprehensive response plan. Health physicists and other radiation protection professionals are multi-capable scientists, engineers and systems integrators that can contribute greatly at multiple levels for effective and efficient nuclear security. To be an effective partner in the nuclear security objective, health physicists must embrace the nuclear security culture but they also must be aware that it exists.

3. Methods

3.1 Motivation

The authors of this paper have education and professional experience in both health physics and nuclear security. Along with Dr. Craig Marianno from Texas A&M University in the USA, the authors began by developing professional development, awareness, and enrichment courses to be taught to health physics / radiation protection professionals and students alike. The course materials were taken from the authors' own materials developed at their universities and integrating them with materials developed by INSEN. Additional information about the process and delivery of these professional meetings can be found in an article recently accepted by the *International Journal of Nuclear Security* [8] and a paper and presentation delivered at the 2016 IAEA International Nuclear Security Conference [9]

Health physicists are a motivated group for professional development, and courses in nuclear security that cover both nuclear and radiological material management are desirable. The reason for this is that many of these professionals hold some sort of credential that requires continuing education. For example, in North America, the American Board of Health Physics (ABHP) offers the Certified Health Physicist (CHP) credential and requires a certain number of credits per certification cycle (5 years) in order to retain the certification. Eligible professional development courses are an ideal and often preferred way for these individuals to obtain their credits. Other bodies offering certification credentials, such as the World Institute for Nuclear Security (WINS) Certified Nuclear Security Professional (CNSP), have similar requirements for certification maintenance.

Professional enrichment course offerings for societies, such as the Health Physics Society (HPS) in the USA, have a competitive selection process in which proponents of a topical course must submit an abstract and proposed duration of the training. For the offerings of professional enrichment program courses at HPS meetings, the ABHP assignment is generally 4 continuing education credits (CEC) per 2 hr. course. The ABHP requires 80 CEC be obtained over a 5 year recertification cycle. It is important to note that there are other ways to obtain CEC aside from attending a course.

3.2 Professional Development Course Offerings

Since 2014, the authors, individually and in tandem, have offered a total of eight professional enrichment courses to health physics and radiation protection professionals, both nationally and internationally. Five have been through the Health Physics Society (HPS) meetings, two through the International Radiation Protection Association (IRPA) meetings, and one (1) at the Massachusetts Institute of Technology (MIT). Not included in this list are the dozens of presentations given at meetings and conferences throughout the world by the authors on this topic.

The first three course offerings were introductions to nuclear security and nuclear security for the health physicist. Subsequent courses provided more specific topics in nuclear security such as physical protection, cyber security, and consequence management. A summary of the courses offered is presented in Table 1.

COURSE TITLE	VENUE, LOCATION, YEAR	DURATION (HR.)	COURSE PARTICIPANTS
1 Introduction to Nuclear Security I & II	47th HPS Midyear Meeting, Baton Rouge, Louisiana, USA, 2014	4	20
2 Introduction to Nuclear Security for the Health Physicist	59th HPS Annual Meeting, Baltimore, Maryland, USA, 2014	8	40
3 Workshop on Strengthening Security of Radioactive Sources in Medical and Industrial Facilities	4th Regional Congress of IRPA for Africa Region (AFRIRPA04), 2014	4	50
4 Physical Protection for Nuclear and Radiological Security	60th HPS Annual Meeting, Indianapolis, Indiana, USA, 2015	2	25
5 Terrorist Threat and Consequence Management in Radiological Security	60th HPS Annual Meeting, Indianapolis, Indiana, USA, 2015	2	25
6 Introduction to Nuclear and Cyber Security for the Health Physicist	60th HPS Annual Meeting, Indianapolis, Indiana, USA, 2015	2	25
7 Nuclear Security, Alternative Technologies and Consequence Management for the Health Physicist	MIT, Cambridge, Massachusetts, USA, 2015	20 (3 DAYS)	25
8 Nuclear Security for the Health Physicist	14th IRPA Congress, Cape Town, South Africa, 2016	4	50

Table 1: Summary of Nuclear Security Courses Offered to Radiation Protection Professionals from 2014-2016.

Mapping of lectures against specific course offerings in nuclear security are presented in Table 2. The modules taught for these courses reflect the time available and the approved course proposals to the venue organizers. For formatting purposes, the eight courses are represented by the numerals presented in Table 1. These numerals correspond to the sequence in which they were offered, starting with the first course offered and moving forward in time.

MODULE	COURSE							
	1	2	3	4	5	6	7	8
Basic elements & definitions of nuclear security	X		X					
Introduction to nuclear security		X	X			X	X	X
Interrelationships between safety, security and safeguards (S^3)	X	X	X			X		X
International nuclear security framework								
Threats by non-state actors & terrorism	X	X			X			
Planning nuclear security at the state level	X							
Role of the health physicist in nuclear security	X	X	X			X		X
Design Basis Threat (DBT)		X		X				
Physical protection systems		X		X			X	X
Consequence management		X			X			
Facility, border and source security		X		X				
Exercise on detection		X			X			
IT/Cyber security		X	X					X
US NRC and DOE nuclear security regulations		X				X		
High Activity Sources and Alternatives in Medicine							X	
Alternative Technologies: Policies and Paths Forward							X	
Nuclear security culture			X					X

Table 2: Modules Taught in Nuclear Security Courses Offered to Radiation Protection Professionals from 2014-2016.

3.3 Lectures and Presentations

As mentioned earlier, the authors have given a number of individual presentations and lectures not associated with the professional development courses described in Section 3.2. For these presentations, the intent was to raise general awareness of nuclear security issues that may be pertinent to their jobs and duties. Although not exhaustive, presentations have been given at the following workshops, meetings and conferences on nuclear security for radiation protection:

- HPS Annual Meeting (2014-2016, USA)
- HPS Midyear Meeting (2014, USA)
- NATC ISOE ALARA Symposium (2015, USA)
- AFRIRPA04 (2014, Morocco)
- 14th IRPA Congress (2016, South Africa)
- John Horan Memorial Symposium: Topics in Health Physics (2015, USA)
- INSEN Annual Meeting (2015, Austria)

3.4 Nuclear Security Curriculum at Purdue University

Purdue University (Purdue) offers world-class undergraduate and graduate programs in nuclear science and engineering, specifically in nuclear engineering and health physics. The School of Nuclear Engineering (SNE) in the College of Engineering administers baccalaureate, master, and doctoral degrees in nuclear engineering. The School of Health Sciences (HSCI) in the College of Health and Human Sciences administers baccalaureate, master, and doctoral degrees in health physics. Currently the School of Nuclear Engineering has approximately 75 declared undergraduate (junior and senior level) and 50 graduate students. There are 16 tenured/tenure-track faculty and 2-research faculty. The School of

Health Sciences has 13 tenured/tenure-track faculty and a number of lecturers and adjunct faculty that contribute to Radiological Health Sciences (RHS) at Purdue. Within RHS are the programs of health physics, medical physics, and imaging science. In RHS, there are approximately 25 graduate students and 20 undergraduate students.

With the recent hiring of key faculty in both Schools, including the author, Jason Harris (2015), Purdue has committed itself to build its programs in nuclear nonproliferation and nuclear security. Both Schools are creating educational tracks or minors in nuclear nonproliferation and nuclear security and have established relationships with faculty in the Political Science Department that have teaching and research interests in nuclear nonproliferation, terrorism and counter terrorism, and arms control. Recently Purdue University has also committed to these important areas by establishing a Policy Research Institute, starting a new Master's degree program in Security Policy, and announced the creation of the Institute for Global Security and Defense Innovation. All three of these endeavors will include nuclear and radiological source security.

Due to these initiatives, Purdue University was chosen in 2017 to implement the US Department of Energy (DOE) Defense Nuclear Nonproliferation (DNN) Office of Radiological Security (ORS) Nuclear Security Education (NSE) program. The program includes six courses in nuclear security: Introduction to Nuclear and Radioactive Source Security, Nuclear Security Threat Assessment and Analysis, Nuclear Security Science, Nuclear Detection Technologies, Nuclear Nonproliferation and Arms control, and Nuclear Security Systems Design. These courses will become the core of a new graduate major in the School of Nuclear Engineering, a new undergraduate track in the School of Nuclear Engineering, a new track in the RHS program in the School of Health Sciences, and a new graduate certificate in nuclear nonproliferation and security. Although four other universities have this program already in place, Purdue was chosen so that it can implement this program specifically within health physics. Also, Purdue will develop the first of its kind module on Alternative Technologies. The module will be available to other universities to incorporate into their programs. The program at Purdue will offer its first course starting in August 2017.

4. Results

Since 2014, a number of courses and presentations have been delivered focusing on introducing nuclear security concepts to radiation protection professionals. A key emphasis that was presented in all of these endeavors was the importance of integrating nuclear and radiological source security with radiation protection (or more broadly, radiological safety). From importance and usefulness standpoints, it is crucial to know how the participants valued the content. Ideally all the courses would have required participant feedback, but only three of the courses offered (all from the Health Physics Society courses) included any formal evaluation process.

The Health Physics Society has standard course evaluation forms that are distributed to course participants. Completion of the form is voluntary and as is often the case, course evaluation and feedback tends to suffer from low participation (therefore poor statistics) and weak inferences. The most useful feedback is often obtained by talking with participants after the training; however, this is highly unscientific and may suffer from bias (selective presentation of feedback). Overall, across several categories, the instructors and course content was generally viewed as “Excellent” or “Very Good”.

A consistent message that was relayed to the instructors very early was that the course participants were very pleased that a course in nuclear security was being offered to them in the context of health physics. The authors perceived this had as much to do with a general interest in the subject material as it did with the introduction of a new topic to the continuing education training cohort. One might infer that there is, therefore, a general desire for radiation protection professionals to increase their awareness about nuclear security and determine where they may actively participate. This was determined as a very good indication because it demonstrated a willingness of health physicists and others involved primarily in radiation protection to broaden their horizons and look beyond a “safety silo”. Similar feedback was received for many of the separate presentations given at meetings and conferences.

Feedback and course evaluations will be utlizied as well for the nuclear security courses to be offered at Purdue University. Disseminaiton of results will be presented at a future date.

5. Future Work

Since 2014, several nuclear security courses, lectures, and presentations have been developed and delivered for radiation protection professionals. It is the intent of the authors to continue to provide these valuable offerings to the radiation protection community. In addition to covering the more introductory topics, the authors intend to develop more advanced topics including:

- integration of nuclear security and radiation protection/safety culture;
- radiation protection roles in nuclear and radioactive source emergency management and insider threat;
- nuclear security management for the health physicist;
- radiation detection design and use for safety and security applications; and
- health physicist’s role in safety and security design of facilities

While most of the courses and presentations have been delivered at general health physics/radiation protection meetings and conferences (i.e. HPS meetings, and IRPA congresses), the authors have also begun to target their deliveries to specific sectors that use nuclear and radioactive materials. The sectors that have the least amount of experience and knowledge of nuclear security matters and integrating radiation protection include the medical and educational/academic communities.

Up to this point, lecture and course development and delivery has been seen as very valuable to both the authors and the participants. But, since both authors are professors, they recognize the need for incorporating this content into educational programs to better integrate the two disciplines of radiation protection and nuclear security. The authors will look into developing content to be distributed to educational radiation protection programs across the world. Finally, from an academic perspective, research needs to be performed within and across these two areas. Both authors have begun to look into research opportunities that tie the two areas together. For example, assessment of nuclear security and its integration with safety/radiation protection culture among different sectors (i.e. nuclear power, health care, academia) is an area of research not explored. There is also a need to look into alternative technologies in health care to evaluate the safety and security benefits and risks of source vs. device use. The latter two initiatives have already begun at Purdue University. For example, the author and his research group are performing a nuclear security culture assessment among authorized users of radioactive materials at the University (using about 600 subjects). Results will be published and an assessment tool will be developed to use at other universities and eventually extended to other sectors, such as health care.

6. Conclusions

Health Physicists and radiation protection professionals, with their diverse experience in radiological sciences, can play vital roles in nuclear security. To reach out to this community eight enrichment courses were presented at both national and international professional society meetings since 2014. These courses were focused on giving the health physics professional a greater insight into the many challenging areas of nuclear security and how they might participate. In conjunction to these activities, a number of presentations and lectures have also been given. This paper described the courses, their objectives and how they were delivered. These courses were well received by the attendees. However, there was limited documented proof of the success of these courses. The authors acknowledge that a more active effort should be used to distribute and collect course evaluation. In the future, presentations and courses are being considered for more targeted audiences and with more specialized content. From an educational perspective, this content should be incorporated into both nuclear security and radiation protection programs and expanded to research activities for faculty and students. Such a program has begun at Purdue University.

7. References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Plan 2014-2017 GOV/2013/42-GC(57)/19, IAEA, Vienna (2013).

[2] BRAUNEGGER-GUELICH, A. et al., International Nuclear Security Education Network, INMM Annual Meeting, Proceedings of the 52nd Annual Meeting of the INMM, 2011.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, International Nuclear Security Education Network (INSEN). Available at https://nusec.iaea.org/portal/UserGroups/INSEN/AboutINSEN/tabid/627/Default.aspx. Accessed on 1 October 2016.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Educational Programme in Nuclear Security, IAEA Nuclear Security Series No. 12, Vienna (2010).

[5] HARRIS, J., HOBBS, C., STERBA, J., Course Material and Curriculum Development Activities of the International Nuclear Security Education Network (INSEN), Proceedings of the 54th Annual Meeting of the INMM, 2013.

[6] HARRIS, J., International Trends in Nuclear Security Education, Proceedings of the 55th Annual Meeting of the INMM, 2014.

[7] WALLER, E., VAN MAANEN, J., The Role of the Health Physicist in Nuclear Security, Health Phys. 108(4): 468-476 (2015).

[8] WALLER, E., HARRIS, J., MARIANNO, C., Experiences with Teaching Nuclear Security Professional Development Courses for Health Physicists. International Journal of Nuclear Security. 2(1): 89-97 (2016).

[9] HARRIS, J., WALLER, E. Educational Initiatives to Integrate Nuclear Security and Radiation Protection. In: Proceedings of the IAEA International Conference on Nuclear Security: Commitments and Actions, Vienna, Austria, December 5-9, 2016. (IAEA, Vienna, 2016). Paper 125.