Designing the Global Threat Reduction Initiative's Nuclear Security Education Program

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ABSTRACT

As part of the National Nuclear Security Administration (NNSA), the Global Threat Reduction Initiative (GTRI) works to prevent the acquisition of illicit radioactive material for use in weapons of mass destruction and other acts of terrorism. This organization has recognized there is a need for nuclear security curricula at universities in the United States. Building on the work of the International Atomic Energy Agency (IAEA), GTRI is working to establish a nuclear security curriculum at Texas A&M University (TAMU), the Massachusetts Institute of Technology (MIT), and Pennsylvania State University (PSU). These universities are collaborating to develop courses that study both policy and technical challenges in nuclear security. A set of five courses are currently under development with each school organizing one or two courses: Threat Analysis and Assessment, Detector and Source Technologies, Applications of Detectors/Sensors/Sources for Radiation Detection and Measurements, Global Nuclear Security Policies, Design and Analysis of Security Systems for Nuclear and Radiological Facilities. Once a course is fully developed at each school, all materials will be shared among the universities. At the conclusion of this project it is envisioned that each school will have a self-sustaining program in nuclear security and that these courses will be available for other universities. This talk will discuss the work currently being completed to establish these courses and how they will be implemented at each school.

INTRODUCTION

The threat of the malicious use of nuclear and radiological materials (including nuclear terrorism) is growing. On April 12-13, 2010, the United States hosted the first Nuclear Security Summit in Washington D.C., bringing together 49 world leaders in an effort to "discuss steps...to secure loose nuclear materials; combat smuggling; and deter, detect, and disrupt attempts at nuclear terrorism."[1] As part of the broader nuclear disarmament goals originally outlined in Prague, President Obama convened this group to foster "an international effort to secure all vulnerable nuclear material around the world within four years."[2] This summit resulted in the production of a Work Plan[3] that outlines the main steps that should be taken to achieve this goal. In addition to encouraging better implementation of existing treaties and programs, the Work Plan urged participating states to more broadly cooperate with international organizations, governments, industries, academic institutions and other stakeholders in an integrated approach to developing the human resources necessary to implement nuclear security measures. Such development would include networking of professionals as well as education and training to establish and maintain an adequate nuclear security infrastructure.

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[1] America.gov, "Press conference by President Obama in L'Aquila, Italy," 10 July 2009, www.america.gov.
[2] "Remarks by President Barack Obama, Prague, Czech Republic," 5 April 2009, www.whitehouse.gov.
[3] Office of the Press Secretary, "Work Plan of the Washington Nuclear Security Summit," 13 April 2010, www.whitehouse.gov.

The Work Plan also provided additional emphasis on cooperation amongst states on programs to enhance nuclear security at sites throughout the world. In the U.S., several agencies and organizations have been actively involved in efforts to combat the threat of nuclear terrorism. One of those organizations is the National Nuclear Security Administration's (NNSA) Office of Defense Nuclear Nonproliferation. On May 26, 2004, the NNSA launched the Global Threat Reduction Initiative (GTRI), a collaborative program aimed at securing vast stocks of dangerous nuclear material scattered around the globe. GTRI is achieving its mission through three key subprograms: Convert, Remove, and Protect. These subprograms provide a comprehensive approach to denying terrorists access to nuclear and radiological materials. The GTRI program has been effective in enhancing security; however, in order to ensure the sustainability of these programs, a pipeline of human resources with sufficient education and skills must be provided. The sustainability of GTRI and other nuclear security programs will also rely upon innovative new ideas for solving their complex problems. Academia provides a proven venue for stimulating these solutions. Thus, there is a degree of synergy between the identified need for nuclear security education and the mature agency programs to implement security measures at sites across the globe.

It has been stated by some that the attention to nuclear security education may be the most novel and potentially significant long-term product of the April 12-13 summit.[4] One would be hard-pressed to find any universities that offer courses that enable students to study the subject of nuclear security. It is largely due to this paucity of course material that the International Atomic Energy Agency (IAEA) recently released a set of guidelines on nuclear security education programs.[5] This set of guidelines was developed through consultation with a number of academics from around the world and consists of a suggested course of study for a certificate or a Master of Science degree in nuclear security. The guidelines suggested a number of courses in an effort to provide an educational framework based on a comprehensive approach to nuclear security. That approach goes beyond the traditional area of physical protection at nuclear sites and includes border monitoring, nuclear forensics, consequence management, and other areas.

Building on the work of the IAEA, the GTRI is working to establish a nuclear security curriculum at a limited number of U.S. universities with strong nuclear engineering programs, on-site facilities, and close ties to domestic and international nuclear/radiological industries. The evaluation methodology used to select the top candidates for the nuclear security graduate program included the following criteria:

1. A top ten ranking in nuclear engineering (based on 2009 U.S. News and World Report rankings) as a basis to integrate nuclear security design, operations, threat analysis and other disciplines.
2. An operating reactor of 1000 kW or higher.

[4] W. Potter, "Bomb School," Foreign Policy, 23 April 2010, www.foreignpolicy.org.
[5] International Atomic Energy Agency, "Educational Programme in Nuclear Security," Nuclear Security Series No. 12, March 2010.

3. Located near Urban Areas Security Initiative (UASI) Tier 1 and/or Tier 2 locations.
4. Synergy with US government nuclear educational grant programs.
5. Establishment of interdisciplinary offerings in policy, nonproliferation, national security, anti/counter terrorism and related programs at the university.
6. Voluntary security upgrades provided by GTRI.
7. Radiological Materials (Category 1 and/or 2) present at site (e.g., irradiators).

Based on these criteria, three universities were selected to develop the nuclear security education program: Massachusetts Institute for Technology (MIT), Penn State University (PSU), and Texas A&M University (TAMU).

COURSE DEVELOPMENT

Over the course of six months faculty from the 3 universities met to propose and develop syllabi for a nuclear security curriculum. Through these meetings it was concluded that the curricula should not only provide technical details of nuclear security, but also policy issues associated with the subject. Working with the GTRI office, the universities narrowed the initial curricula to 5 courses (Table 1). The five courses would constitute a comprehensive specialization in nuclear security for a nuclear engineering graduate student. It is envisioned that they may serve as a nuclear security specialization for a Master of Science degree program or as a graduate certificate in nuclear security.

Table 1. Course title key including school responsible for development.

Course #	**Course Title**	**School Responsible for Development**
1	Threat Analysis and Assessment	TAMU
2	Detector and Source Technologies	PSU
3	Applications of Detectors/Sensors /Sources for Radiation Detection and Measurements	PSU
4	Global Nuclear Security Policies	MIT
5	Design and Analysis of Security Systems for Nuclear and Radiological Facilities	TAMU

The description for each course follows:

1. **Threat Assessment and Analysis --** The purpose of this course is to study the manner in which we should conduct threat assessment of non-state actors in the fields of nuclear and radiological security. This course will teach students to prioritize such threats with a view to ensuring that the installed or initiated counter-measures are appropriate, proportional and cost-effective. The course will examine the history of threats and security issues in an effort to better understand terrorist groupings, their motivations, and attack methodologies. It should be noted that while the *Threat Assessment and Analysis*

Methodology framework which will be taught and utilized throughout the course will focus on nuclear and radiological issues, it also has direct applicability across broad range of government and commercial sectors, entities and facilities. The course will also briefly study the various government entities involved in assessing and addressing these threats.

2. **Detector and Source Technologies** -- The primary goal of this course is to educate the student on the theory behind radiation detection systems, sensors, and source technologies. It is expected that the student will develop a deep understanding of radiation detection instrumentation and measurement techniques with a specific focus on nuclear and radiological materials. The student will develop a working knowledge of instruments and sensors for security-related applications. This course is meant to provide a foundation of understanding into non-proliferation radiation detection technologies. By developing this understanding the student will be able to understand advantages and challenges of radiation detection technologies used in the field.
3. **Applications of Detectors/Sensors/Sources for Radiation Detection and Measurements** -- This laboratory based course builds on the concepts of course #2. This class will provide a hands-on overview of photon, neutron and charged particle detection technologies. Students will be exposed to not only lab based equipment but field deployable devices and portal monitors. Destructive and non-destructive techniques will also be explored.
4. **Global Nuclear Security Policies** -- This course briefly reviews the historical development and examines the current state of American and international policies related to global nuclear security. This course will study US national security strategy in the areas of counterterrorism and nonproliferation. Policies and roles of various agencies, including the Department of Homeland Security, the Department of Energy (including the National Nuclear Security Administration), the Nuclear Regulatory Commission, the Department of Defense and Environmental Protection Agency will be examined. International treaties and conventions on nuclear safeguards, arms control and terrorism will be introduced. Regulations promulgated by the US Nuclear Regulatory Commission and the IAEA will also be studied. The course will consider how these policies are intended to control the actions of both state and non-state adversaries. The role of transnational and domestic groups will be discussed, especially with regard to motivation and potential capabilities ranging from Improvised Nuclear Devices (INDs) to radiological dispersal devices (RDDs).
5. **Design and Analysis of Security Systems for Nuclear and Radiological Facilities** -- This course studies the science and engineering associated with the design, evaluation, and implementation of systems to secure nuclear and radiological materials. This course examines methods for planning and evaluating nuclear security activities at the State and facility level. The course will study the characterization of the adversary, categorization of targets and the consequences associated with failure to protect those targets. Students

will be introduced to detection and delay technologies, on-site and off-site response strategies, evaluation of insider threats, and mathematical methods for evaluating risk due to the threat and the security system design. Methods for risk minimization and system optimization will also be studied. Students completing this course will have a broad picture of nuclear security components and their interconnections into a sustainable nuclear security program, and of the planning of nuclear and radiological security activities at both the State and facility level.

A memorandum of understanding (MOU) has been signed by the deans of the respective engineering schools. This MOU outlines the division of labor of the project, facilitates the open exchange of course material and stresses each school's commitment to the project. To ensure sustainability of the program the MOU also states that each school will attempt to add the courses into their course catalogs.

The final program design was divided into Development, Implementation, Transfer/Adaption, and Institutionalization phases. During the Development phase, course material will be created and tested. During Implementation, course material will be actively taught to students at the university. Transfer and Adaptation involves transfer of course material from the developing university to another university and adaptation of that material for usage by the receiving university. Institutionalization involves making the newly developed curricula fully sustainable by institutionalizing it into a degree or certificate granting program.

All courses will be initially developed and taught at their respective universities. Following the initial offering, the instructors will conduct self evaluations and will review student critiques. Adjustments to the courses will be made at this time. All course materials will be transferred to the other schools at this time. These transfers will be in-person exchanges taking place at the other institutions. How the course is taught as well as course evaluations will be gone over in detail. This will aid in the integration of the courses into the each school's curriculum. Tables 2 - 4 outline the development, teaching and transfer schedule. Classes will begin to be taught Fall 2011. Transfer of all courses will be completed by January 2013. It is envisioned that the first graduates of this program will be realized in the Summer of 2013.

Table 2. Development plan for courses.

May 2011 – Sep 2011	Develop #1 at TAMU
May 2011 – Sep 2011	TAMU will develop portion of #2
May 2011 – Dec 2011	Develop #2 at PSU
May 2011 – Sep 2011	Develop #4 at MIT
Oct 2011 – Dec 2011	Complete development for #5 at TAMU
Oct 2011 – May 2012	Purchase equipment for #3 at PSU
Oct 2011 – Dec 2011	Continue Development of #4 at MIT
Jan 2012 – Aug 2012	Develop #3 at PSU

Jan 2012 – Aug 2012	Installation/lab renovation at PSU for #3
May 2012 – Jun 2013	Purchase equipment for #3 at TAMU and MIT
July 2013 – Dec 2013	Installation of equipment at TAMU and MIT for #3

Table 3. Implementation plan for courses.

Aug 2011 – Dec 2011	Teach #1 at TAMU
Jan 2012 – May 2012	Teach #4 at MIT
Jan 2012 – May 2012	Teach #5 at TAMU
Jan 2012 – May 2012	Teach #2 at PSU
Aug 2012 – Dec 2012	Teach #3 at PSU
Aug 2012 – Dec 2012	Teach #2 at TAMU and MIT
Aug 2012 – Dec 2012	Teach #1 at PSU, MIT, and TAMU
Jan 2013 – May 2013	Teach #5 at TAMU, MIT, and PSU
Jan 2013 – May 2013	Teach #3 at TAMU and MIT
Jan 2013 – May 2013	Teach #4 at PSU, MIT, and TAMU
Aug 2013 – Dec 2013	Teach #2 at MIT, PSU and TAMU
Aug 2013 – Dec 2013	Teach #1 at PSU, MIT, and TAMU
Jan 2014 – May 2014	Teach #4 at PSU, MIT, and TAMU
Jan 2014 – May 2014	Teach #3 at MIT, PSU and TAMU
Jan 2014 – May 2014	Teach #5 at PSU, MIT, and TAMU
Aug 2014 – Dec 2014	Teach #1 at PSU, MIT, and TAMU
Aug 2014 – Dec 2014	Teach #2 at PSU, MIT, and TAMU

Table 4. Transfer of course material.

Jan 2012 – May 2012	Transfer #1 and #5 to PSU and MIT
May 2012 – Aug 2012	Transfer #4 to PSU and TAMU
May 2012 – Aug 2012	Transfer #2 to TAMU and MIT
Oct 2012 – Jan 2013	Transfer #3 to TAMU and MIT

FUTURE WORK

The courses mentioned in this report should build a foundation for further work in nuclear security curriculum development. Other classes may be developed which focus on specific topics in nuclear security. These classes could include, but not be limited to:

- **Consequence Management** – A class to discuss the response efforts behind a radiological incident
- **Counter Terrorism** – Building on course #1 this class would focus on counter terrorism tactics and analysis

- **Nuclear Forensics –** This course would focus on the science of determining the physical, chemical, elemental and isotopic characteristics of nuclear (or radiological) material of unknown origin. This course would include a radiochemistry laboratory component.

Small course modules could also be developed. Each module would be approximately 1 to 2 weeks in length and would be designed to compliment current courses taught in both the graduate and undergraduate nuclear engineering curriculum. These modules would provide brief overviews of areas of interest in nuclear security and would include:

  - Civilian/ Military Fuel Cycles
  - Fuel Chemistry
  - Separation Chemistry – Actinide/Lanthanide Properties Waste Management
  - Forensic Science Fundamentals
  - Introduction to Nuclear Forensics and Attribution
  - Physical Protection Systems and Technologies
  - Radiation Safety and Protection
  - Risk Assessment and Nuclear Security Measures
  - Vulnerability Assessment of Physical Security Systems for Nuclear Installations
  - Nuclear Materials in Transportation (Transportation Security)
  - Security Fundamentals
  - Protection Against Sabotage

More courses and modules could be added as determined appropriate by GTRI staff. To supplement course work a dedicated internship program could also be established with national lab partners. In addition, distance learning and web-based training will also be explored.

CONCLUSION

There is a growing need for trained individuals in nuclear security. Today, most training begins once a student joins the workforce. Building on work of the IAEA, GTRI is ensuring that at least an introduction to the wide ranging field of global nuclear security is started at the university level. Since August 2010 TAMU, PSU, and MIT have worked collaboratively with GTRI to develop a set of courses that could serve as a sustainable education program in nuclear security with a specific focus on the needs of the GTRI program. An MOU has been signed by all three universities to facilitate development and the exchange of information. Classes will begin to be taught in Fall of 2011. Students will begin to graduate from this program as early as Spring 2013.

References

1. IAEA Nuclear Security Series No. 12, "*Technical Guidance: Educational Programme in Nuclear Security*", International Atomic Energy Agency (2010).

2. W. Charlton, C. Marianno, K. Unlu, R. Lanza, G. Kohse, *"GTRI Nuclear Security Education Initiative Design",* Internal Report to GTRI office. March, 2011.

3. A. Contreras, "*Statement of Work: GTRI Nuclear Security Education Initiative Design*", Pacific Northwest National Laboratory. April 20, 2011.