Contributions to the Report of the Secretary General on Disarmament and Non-Proliferation Education

The Center for Nuclear Security Science and Policy Initiatives (NSSPI) at Texas A&M University

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Executive Summary

Since its inception in 2006, NSSPI has established itself as a center of excellence in nuclear security, safeguards, and nonproliferation (NSSN) technical graduate education, research, and workforce development. NSSPI’s graduate curriculum combines policy and technical aspects of NSSN, and its innovative program gives students a variety of experiences--from hands-on national laboratory training and internships to international facilities study tours--to enhance their understanding and improve their readiness to perform in the nonproliferation workforce. NSSPI engages students in research that supports their growth as experts in NSSN science and technology. NSSPI offers asynchronous online training with online professional certificates in nuclear safeguards and nuclear security, as well as an online academic graduate certificate in nuclear security. NSSPI has engaged with academic institutions worldwide to support NSSN curriculum development and regularly conducts in-person training for both international and domestic audiences.

NSSPI Education and Training Activities Report: June 2022 – May 2024

1) Academic Degree Programs

   a) Master’s Degree in Nuclear Engineering with Nuclear Nonproliferation Specialization

   The Master’s degree in nuclear engineering with a specialization in nuclear nonproliferation offered by the Texas A&M Department of Nuclear Engineering is designed as a 1½ to 2-year program consisting of nine formal courses. Of these formal courses, seven are required courses and two must be selected from a set of possible electives. One of these electives must be a policy course taught by the Bush School of Government and Public Service. As a Master of Science degree, the students will also complete research of fundamental interest to the field and write a corresponding thesis detailing their research. The Master of Engineering (ME) Degree in nuclear engineering does not require the completion of a thesis and, since the development of the remote detection laboratory, can be completed completely online. During this reporting period, 16 NSSPI students earned nuclear nonproliferation M.S. or M.E. degrees. The outline of the Master’s degree in Nuclear Engineering with Nuclear Nonproliferation Specialization is shown in Table 1.
Table 1. M.S./M.E. Degree with a Specialization in Nuclear Nonproliferation Curriculum

<table>
<thead>
<tr>
<th>Year 1: Fall</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUEN 604 – Radiation Interactions and Shielding</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>NUEN 605 – Radiation Detection and NM Measurement</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>NUEN 650 – Nonproliferation and Arms Control</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Year 1: Spring</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td></td>
<td>NUEN 601 – Nuclear Reactor Theory</td>
<td>3</td>
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<tr>
<td></td>
<td>NUEN 606 – Nuclear Reactor Analysis and Experimentation</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>NUEN 651 – Nuclear Fuel Cycles and Materials Safeguards</td>
<td>3</td>
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</table>

<table>
<thead>
<tr>
<th>Year 2: Fall</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td></td>
<td>NUEN 610 – Design of Nuclear Reactors (capstone)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Seminar</td>
<td>2</td>
</tr>
</tbody>
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| As Needed | Technical Electives and Research                  | 7            |

Students select electives from a set of relevant elective courses, some being provided by faculty in other Texas A&M departments:

- NUEN 630 – Monte Carlo Methods for Particle Transport
- NUEN 657 – Emergency Response Dose Assessment
- NUEN 451 – Nuclear Security Systems Design
- CHEM 681 – Radiochemistry & Nuclear Forensics (Chemistry Department)
- INTA 617 – Deterrence and Coercion (Bush School)
- INTA 620 – International Security (Bush School)
- INTA 652 – The Role of Intelligence in Security Affairs (Bush School)

These electives are designed to enrich students’ educations by focusing their attention on issues that are key to the field; these electives also bring some diversity to the degree program.

b) Academic Certificate in Nuclear Security

NSSPI faculty also support a Certificate in Nuclear Security, which is an official Texas A&M University certificate program open to both degree-seeking and non-degree-seeking students that focuses on providing students with a solid understanding of the policy and technical aspects behind nuclear security, safeguards, and nonproliferation. This multidisciplinary program has courses both in the Department of Nuclear Engineering and at the Bush School of Government and Public Service. To qualify for this certificate, students must complete 12 semester credit hours (SCH) of coursework selected from the following list:

- NUEN 451 - Nuclear Security System Design (3 SCH)
- NUEN 605 - Radiation Detection and Nuclear Materials Measurement (3 SCH)
- NUEN 650 - Nuclear Nonproliferation and Arms Control (3 SCH)
- NUEN 651 - Nuclear Fuel Cycles and Nuclear Material Safeguards (3 SCH)
- INTA 669 - Nuclear Terrorism Threat Assessment and Analysis (3 SCH)
- INTA 617 - Deterrence and Coercion (3 SCH)

2) Online Training and Professional Certificates

NSSPI conducts asynchronous online training through its Nuclear Security and Safeguards Education Portal (NSSEP) to disseminate knowledge in nuclear and radiological sciences, security, and safeguards to a large number of professionals and students across the globe. Developed with support from the NNSA
and the Department of State’s Office of Cooperative Threat Reduction, this resource has the capacity to reach an audience greater than is possible through face-to-face training. In the reporting period, NSSEP delivered more than 2800 course modules to over 1000 registrants. NSSEP modules have also been the basis for two professional certificates offered by the Texas A&M Engineering Experiment Station (Nuclear Security Fundamentals and Nuclear Safeguards Fundamentals), as well as four INMM workshops on the “Technical and Policy Fundamentals of International Safeguards” in 2018, 2020, 2021, and 2023.

3) Experiential Learning Opportunities

The nonproliferation specialization Master’s degree provides an academic underpinning to the education of the students involved with NSSPI. Inside the classroom, students in these courses participate in tabletop exercises, simulations, and hands-on detection labs (both in person and remotely) to augment the theoretical content of the courses in the nonproliferation specialization. However, from the beginning, NSSPI faculty and staff have also worked to provide enriching experiences for students in addition to their classroom education. From annual trips for students to the national laboratories to participate in hands-on safeguards training sessions to student exchanges that give them opportunities to travel internationally and grow their knowledge base, NSSPI provides students with the sort of multi-faceted education required to produce quality nuclear nonproliferation professionals.

The Nuclear Facilities Experience (NFE) is sponsored by the NNSA as a unique opportunity for university students and early career professionals at the national laboratories to visit nuclear fuel cycle facilities and discuss applied safeguards and security measures with actual practitioners and facility operators.

The NFE is conducted both domestically and internationally. The domestic NFE takes Texas A&M students on an organized series of visits to nuclear facilities in the US. The international NFE is organized in conjunction with Argonne National Laboratory (ANL) and gives students from Texas A&M and other U.S. universities the opportunity to visit advanced nuclear fuel cycle facilities, such as reprocessing plants, enrichment plants, and waste facilities, in countries like Japan, the United Kingdom, South Korea, Switzerland, Germany, Austria, the Netherlands, and France. At these fuel cycle facilities, the participants have the opportunity to discuss material control and accounting measures with facility operators and safeguards managers.

In the reporting period, NSSPI conducted two Domestic Nuclear Facility Experiences at Los Alamos National Laboratory (LANL) in March of 2023 and Oak Ridge National Laboratory (ORNL) in April of 2023. At LANL, participants attended a short course on international nuclear safeguards led by LANL staff. At ORNL, they took part in a Fundamentals of Non-Destructive Assay (NDA) short course led by staff in the ORNL Safeguards and toured laboratory facilities.

In this period, NSSPI/ANL conducted four International Nuclear Facilities Experiences.

a. In November 2022, NSSPI Director Dr. Sunil Chirayath and Dr. Claudio Gariazzo of ANL led an INFE to the United Kingdom (UK). The group of participants included five graduate students from Texas A&M University, North Carolina State University, Pennsylvania State University, and the University of Michigan, along with young professionals from the NNSA and Argonne, Pacific Northwest, and Oak Ridge National Laboratories. In the UK, they followed the nuclear fuel cycle
from enrichment to storage with technical visits to the URENCO-UK gas centrifuge enrichment plant, the Westinghouse Springfields fuel fabrication facility, and the Heysham nuclear power plant, and a briefing on the Sellafield nuclear waste processing and storage facility.

b. In March 2023, NSSPI/ANL conducted an INFE to Japan led by Dr. Claudio Garaiazzo of ANL. The participants included nine graduate students from Texas A&M University, the University of Illinois, the University of Tennessee, and the Middlebury Institute for International Studies, a professor from the University of Illinois, and five professionals from Brookhaven National Laboratory, Sandia National Laboratory, Lawrence Livermore National Laboratory, Pacific Northwest National Laboratory, and the National Nuclear Security Administration. The 2023 Japan INFE began with a technical visit to Japan Nuclear Fuel Limited’s Rokkasho nuclear site, which consists of a reprocessing plant, a uranium enrichment plant, a vitrified waste processing and storage facility, and the J-MOX construction site. The group then toured the Japan Atomic Energy Agency’s (IAEA) Tokai Reprocessing Plant and Plutonium Fuel Production Facility, followed by Kansai Electric Power Company’s Mihama Nuclear Power Station.

c. In May 2023, NSSPI/ANL conducted an INFE to Europe for students only led by Dr. Claudio Garaiazzo and Mr. Zachery Beauvais of ANL. The group included ten graduate students from Texas A&M University, the University of Michigan, the University of Wisconsin-Madison, Oregon State University, and North Carolina State University. The students visited International Atomic Energy Agency (IAEA) safeguards laboratories in Seibersdorf, Austria and at the Vienna International Center, the Jaslovské Bohunice Nuclear Power Plant in Slovakia, the Czech Research Centre Rez near Prague, the Framatome Advanced Nuclear Fuels (ANF) fuel fabrication facility in Germany, the URENCO-Nederlands uranium enrichment facility, and the neighboring Enrichment Technology Company (ETC), both in the Netherlands.

d. In April/May 2024, NSSPI/ANL conducted an INFE to South Korea led by Dr. Claudio Garaiazzo of ANL and Dr. Farheen Naqvi of NSSPI. Participants included ten graduate students from Texas A&M University, Georgia Institute of Technology, Virginia Commonwealth University, the University of Florida, and the Middlebury Institute for International Studies, along with a faculty member from Virginia Commonwealth University and staff from Argonne National Laboratory, Idaho National Laboratory, Oak Ridge National Laboratory, Savannah River National Laboratory, and the National Nuclear Security Administration. The group visited the Demilitarized Zone, the KEPCO Nuclear Fuel Company, the Korea Atomic Energy Research Institute, the Korean Advanced Institute of Science and Technology, the Wolseong Nuclear Power Plant, the KORAD Low/Intermediate Level Waste Disposal Center, and the Doosan large-scale nuclear component manufacturer.

4) Research in Support of Nonproliferation Education

Research undertaken by NSSPI faculty and students supports in tandem two of its missions: (a) to conduct policy-informed technical research in collaboration with national laboratories and other partners to develop and apply science and technology to detect, prevent, and reverse the proliferation of nuclear and radiological weapons and (b) to educate the next generation of leaders in the field of nuclear security and nonproliferation. To meet these twin missions of research and education, NSSPI has developed
experimental laboratories at Texas A&M with the needed equipment to conduct research in its focus areas. The research facilities under NSSPI’s purview include the Nuclear Forensics and Radiochemistry Laboratory, the Nuclear Security and Emergency Response Laboratory, and the Radiation Detection and Measurements Laboratory. Some of NSSPI’s key research projects have focused on nuclear safeguards instrumentation, nuclear forensics methods, neutron detector design, radiation detector simulation, proliferation pathways analysis, plutonium source attribution, advanced reactor safeguards, nuclear weapons latency, advanced safeguards measurement techniques, border monitoring methods to prevent nuclear material smuggling, anti-neutrino measurements, proliferation resistance analysis for advanced reactor types, and consequence management. Most of NSSPI’s research endeavors are policy-informed through collaboration with the Bush School and the Texas A&M Department of Political Science. Research partners include relevant federal agencies, national laboratories, the IAEA, universities, and non-governmental organizations.

Every year NSSPI also advises one to two Stanton Nuclear Security fellows to conduct policy-relevant nuclear security research with NSSPI and Texas A&M political science faculty. Stanton fellows during this reporting period have done work on a) developing a two-PMT directional detector for radiation source localization, b) assessing radioactive dispersion from a terrorist attack on a nuclear power plant, c) evaluating the proliferation and security risks of nuclear trade for nuclear newcomer countries seeking to implement small modular reactors (SMRs), and d) addressing the nuclear security and nonproliferation concerns in the introduction of SMRs in Sub-Saharan Africa. NSSPI Stanton fellows present their research and interact with the other technical and policy fellows at the annual Stanton fellows conference in Washington, D.C.

5) Training Programs and Workshops

As part of its mission to serve as a public resource for knowledge and skills to reduce nuclear threats, NSSPI partners with countries and organizations around the world to help develop safeguards capabilities and enhance global nuclear security culture. NSSPI faculty frequently present lecture series and workshops at universities in other countries and serve as experts for IAEA training activities. Some of the countries that have benefitted from NSSPI-led training include Algeria, Brazil, the Czech Republic, Ghana, India, Indonesia, Japan, Jordan, Kenya, Malaysia, Nigeria, South Africa, Thailand, Ukraine, and the United Arab Emirates. NSSPI holds observer status with the IAEA and became one of the founding members of the International Nuclear Security Education Network (INSEN).

The following is a list of training programs and workshops conducted by NSSPI during the reporting period.

a) June 2022 - Workshop on the applications of nuclear security—NSSPI faculty and graduate students traveled to Amity University in India to help conduct a workshop focused on nuclear security for materials out of regulatory control. The workshop was attended by twenty-two participants and included sessions on using radiation detection instruments for characterization and identification, as well as hands-on exercises using the equipment to search for hidden sources.

b) July 2022 - Consolidated Nuclear Security (CNS) Training Program – CNS sponsored 36 of their summer interns to participate in a nuclear security training program. The participants completed an online nuclear security certificate program and attended a day-long live session on nuclear security with Dr. Craig Marianno at the Pantex facility.

c) July 2022 - Professional Development Course for Remote Teaching Laboratories – Dr. Marianno gave a professional development course on remote laboratories for teaching at the International Atomic Energy Agency’s annual INSEN meeting.

d) December 2022 - IAEA Train-the-Trainer radiation detection workshop for the CARICOM Community - NSSPI conducted a weeklong Train-the-Trainer workshop for Caribbean Community (CARICOM) Member States in coordination with the International Atomic Energy Agency
(IAEA). The event brought twelve radiation protection professionals from nine Caribbean Member States to Texas A&M University for hands-on training in radiation detection led by Dr. Craig Marianno.

e) February 2023 - Core-Group Meeting on Human Reliability Programs – NSSPI conducted a core-group meeting on human reliability programs in industries of national importance in conjunction with the National Institute of Advanced Studies (NIAS) in Bengaluru, India led by Dr. Sunil Chirayath of NSSPI and Dr. Magapu Sai Baba of NIAS.

f) March 2023 - Advanced Workshop on the Practical Applications of Nuclear Security for Amity University – NSSPI faculty provided support to Amity University in Noida, India to conduct a workshop on nuclear security at their new radiation detection laboratory.

g) May 2023 - IAEA School for Radiation Emergency Management – NSSPI conducted the IAEA School for Radiation Emergency Management in coordination with IAEA experts. The purpose of this event was to train the participants in the development and management of sustainable emergency preparedness and response (EPR) programs, based on IAEA safety standards, technical guidelines, EPR tools, and training materials. It included lectures by IAEA and local experts, field exercises led by Dr. Craig Marianno and NSSPI graduate students, and technical visits to support the objectives of the training.

h) May 2023 - INMM Workshop on the Technical and Policy Fundamentals of Nuclear Safeguards - NSSPI organized a workshop in conjunction with the INMM/ESARDA Annual Meeting directed at students and early career professionals working in nuclear safeguards. It featured an online portion and a half-day in-person session in Vienna, Austria, with presentations by safeguards experts. Dr. Sunil Chirayath organized the event and moderated the in-person session.

i) June 2023 - Professional Training Course on Nonproliferation Characteristics of Advanced Nuclear Reactors – NSSPI, along with ANL and Badan Riset dan Inovasi Nasional (BRIN), the Indonesian National Research and Innovation Agency, jointly conducted a professional training course titled “Non-proliferation Characteristics of Advanced Nuclear Reactors” in Jakarta, Indonesia. The course was intended to help the Indonesian civil nuclear energy sector make informed and responsible decisions regarding civil nuclear reactor technology selections by considering the nuclear nonproliferation characteristics, including nuclear security. The course also presented methodologies to quantify the proliferation resistance of various nuclear technologies. It was funded as part of the US Department of State’s Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology (FIRST) program.

j) June 2023 - Advanced Workshop on the Applications of Nuclear Security: Detection Equipment and Methodologies – NSSPI faculty member Dr. Farheen Naqvi, along with NSSPI students, provided support to Amity University in Noida, India to conduct this workshop on radiation detection for nuclear security. The purpose of this workshop was to give participants who attended an earlier workshop at Amity University a more focused experience in radiation detection techniques used in Nuclear Security.

k) August 2023 - Consequence Management Laboratory Capabilities Exercise for NNSA - NSSPI conducted a contamination field exercise at the TEEX Disaster City facility to provide training and experience to assets from the NNSA Nuclear Emergency Support Team (NEST). NSSPI Deputy Director Dr. Craig Marianno planned the exercise, which utilized a short-lived radioactive source to temporarily contaminate a contained facility on the Disaster City Campus.

l) October 2023 - Workshop on Gamma Spectrometry for National Security – NSSPI conducted the Workshop on Gamma Spectrometry for National Security with the NNSA Office of Nuclear Smuggling Detection and Deterrence (NSDD). Workshop participants were Algerian government experts and first responders responsible for nuclear safeguards, research and development, and emergency response. Experts included Dr. Craig Marianno and NSDD team members from Los Alamos and Sandia National Laboratories.

m) October 2023 - Training Event for NSDD-SET – NSSPI worked with leadership from the NSDD Office to conduct a series of hands-on challenges for NSDD science and engineering team (SET)
staff. Utilizing the unique facilities on the TEEX Disaster City campus, the training event presented ten separate challenges over two days focused on applying SET tools, technology, and expertise to scenarios in the field. Participants included staff from seven national laboratories, including Brookhaven, Idaho, Los Alamos, Lawrence Livermore, Oak Ridge, Pacific Northwest, and Sandia National Laboratories.

Conclusions

Over the past two years, NSSPI has continued to support the education and training of many individuals globally in nuclear security and nonproliferation. Key elements of NSSPI's program—education, experiential learning, research, and professional development—are focused on giving students in the program the tools they need to become leaders in the field. Training and professional development activities conducted by NSSPI both online and in person in the last two years reached an audience of over 1500 participants. NSSPI's contributions to strengthening human resource capacity in NSSN, both domestically and internationally, have had a significant impact in promoting nuclear security and nonproliferation knowledge and skills worldwide.