Nonproliferation and Safeguards Education at Texas A&M University

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TAMU Nonproliferation and Safeguards Education Program

- At Texas A&M University (TAMU), we recognized this growing need several years ago and generated a program to provide technical education focused on nuclear material safeguards and nuclear nonproliferation
- TAMU faculty initiated the generation of a
  - Master of Science degree program specifically designed to educate nuclear engineering graduate students in the field of international nuclear security
- This is a technical degree that teaches nuclear engineering disciplines with a focus on nuclear nonproliferation

Why Texas A&M University?

- TAMU has the largest nuclear engineering department in the U.S.
  - with 400 students and 25 faculty
- TAMU has historically had close ties to national laboratories
  - especially LANL and ORNL
- TAMU has a long tradition of service to the nation
  - an all military institution until 1965

Knowledgeable Faculty

- Probably the most important factor in TAMU's development of a nonproliferation and safeguards education program was the existence of faculty/staff knowledgeable in the area
  - Charlton, Boyle, Nelson, Miller, Poston, Adams, Gariazzo, Solodov, Juzaitis, etc…

History at TAMU

- Our program began through the development of individual courses
  - many developed in collaboration with LANL
  - many taught as summer courses at LANL
- These then grew into a defined degree program
- Program is in its third year
  - classes typically consist of about 7-15 students

Main Program Elements

- 36 credit hour M.S. curriculum
- M.S. *thesis* in nonproliferation, safeguards, or homeland security
- Foreign field experience
- Fall and Spring 1-week training courses at ORNL
- Summer internships at national laboratories
- Extra-curricular learning through student chapter of INMM

M.S. Degree Program

- Students completing this degree will be
  - the next generation of leaders in the fight to detect, prevent, and reverse the proliferation of nuclear and radiological weapons
- This is a 1½ - 2 year program consisting of
  - nine (9) formal courses
    - seven (7) required courses
    - two (2) courses from a set of possible electives
  - plus 1-hour seminar
- Students will also complete *research* of fundamental interest to the field and write a corresponding thesis detailing their *research*
  - six hours (nominally)

Nonproliferation Degree Curriculum

	Course Designation and Title	Credit Hours
Fall Year 1	NUEN 650 Nuclear Nonproliferation and Arms Control	3
	NUEN 601 Nuclear Reactor Theory	3
	NUEN 605 Radiation Detection and Nuclear Materials Measurement*	3
	NUEN 681 Seminar in Nuclear Nonproliferation	1
	NUEN 685 Independent Study	2
Spring Year 1	NUEN 604 Nuclear Radiation Shielding	3
	NUEN 606 Nuclear Reactor Analysis and Experimentation	4
	NUEN 651 Nuclear Fuel Cycles and Nuclear Material Safeguards*	3
	NUEN 691 *Research*	2
Fall Year 2	NUEN 656 Critical Analysis of Nuclear Security Data	4
	Technical Elective	3
	Technical Elective	3
	NUEN 691 *Research*	2

* includes a 1-week practical at ORNL, LANL, or similar venue

NUEN 650 Nuclear Nonproliferation and Arms Control

- Lecture-based course studying the political and technological issues associated with nuclear nonproliferation and arms control
  - history of arms control and treaty verification regimes
  - descriptions and effects of weapons of mass destruction
  - the technology of nuclear weapons
  - proliferation pathways in the nuclear fuel cycle
  - international and domestic safeguards
  - proliferation resistance in the nuclear fuel cycle
  - nonproliferation strategies
  - nuclear terrorism
  - verifying the elimination of weapons programs
  - safeguards techniques for MPC&A

NUEN 605 Radiation Detection and Nuclear Material Measurements

- Laboratory and lecture course covering:
  - gas filled detectors
  - gamma-ray spectroscopy
  - neutron detection
  - uranium and plutonium gamma spectroscopy
  - uranium enrichment measurements
  - uranium holdup measurements
  - total neutron counting
  - coincidence neutron counting
  - active neutron interrogation
  - spent fuel measurements
  - handheld isotope identifiers
  - portal monitors

NUEN 651 Nuclear Fuel Cycles and Nuclear Material Measurements

- Lecture course focusing on safeguards systems for all components of the nuclear fuel cycle and covers
  - legal basis for safeguards
  - international and domestic safeguard systems
  - Nuclear Material Accounting and Containment/Surveillance for fuel cycle facilities
  - Statistics
  - Bulk measurement methods
  - Chemical assay methods
  - Calorimetry
  - Application of NDA techniques to safeguards for fuel cycle facilities
  - Safeguards case studies (enrichment plant, CANDU Reactor, reprocessing plant, complete fuel cycle)

NUEN 656 Critical Analysis of Nuclear Security Data

- Project based course in which students must apply knowledge from their other courses to analyzing a particular nuclear security incident

- Small group projects that involve a nuclear security event
  - the students must analyze the data given and then ask for additional data and JIT lecture material to allow them to move forward with each project
  - the students are taught critical analysis techniques, learn how to work in small teams, and study how to use Red Team exercises to move each project forward

Safeguards Technologies Training Course

- TAMU has partnered with the Oak Ridge National Laboratory's Safeguards Laboratory
  - *Nondestructive Assay Technologies for International Safeguards*
  - to provide students with hands-on training of safeguards principles and technologies taught in their courses at TAMU
- Successful practical safeguards courses at ORNL's Safeguards Laboratory
  - March 2007 (graduate students)
  - November 2007 (graduate students)
  - May 2008 (undergraduate students)
    - More lecture-intensive
    - Introduction of the topic to students
  - November 2008 (graduate students)
- Further, maintains faculty skills

NDA Technologies for International Safeguards

- Advanced hands-on training of NDA technologies and instrumentation
- Topics included:
  - Handheld isotope identifiers
  - Uranium holdup measurements
  - Object counting systems
  - Isotopic (uranium) enrichment measurements
  - Tours
    - ORNL facilities
    - Private industry tours

Foreign Field Experience

- During the capstone course (656), students have the opportunity to participate in the FFE
- Includes a week long tour of nuclear facilities in Europe in conjunction with students from MEPhI and Obninsk (INPE)
- Serves to expose the students to
  - commercial nuclear facilities (reactors and fuel cycle facilities)
  - cultural enrichment

The Role of Professional Societies

- Serve an important role in professional development of the student
  - leadership within the local chapter
  - exposure to professionals within the society
  - instilling the love of life-long learning within a professional community
  - learning the broader impacts of technological and political solutions

Recent Theses and Dissertations

- C. Freeman, Aug 2008, “Bayesian Network Analysis of Nuclear Acquisitions”
- E. Rauch, Dec 2008, “Developing a Safeguards Approach for a Small Graphite-Moderated Reactor and its Associated Fuel Cycle Facilities”
- D. Sweeney, Aug 2008, “Reactor Power History from Fission Product Signatures”
- A. Thornton, May 2008, “Development of a Portable Neutron Coincidence Counter for Field Measurements of Nuclear Materials Using The Advanced Multiplicity Capabilities of MCNPX 2.5.f and the Neutron Coincidence Point Model”
- D.G. Ford, May 2008, “Assessment Tool for Nuclear Weapon Acquisition Pathways”
- T. Woddi, Dec 2007, “Nuclear Fuel Cycle Assessment of India: A Technical Study for Nuclear Cooperation”
- J. Miller, Dec 2007, “Analytical Inverse Model for Post-Event Attribution of Plutonium”
- A. Solodov, May 2007, “Use of Open Source Information and Commercial Satellite Imagery for Nuclear Nonproliferation Regime Compliance Verification by a Community of Academics”
- K. Chesson, May 2007, “Nuclear Archaeology of Graphite Moderated Reactor Systems to Determine Historical Plutonium Production”
- N. Johansen, May 2007, “An Active System for the Detection of Special Fissile Material in Small Watercraft ”

NGSI Pilot Program

- Technical Safeguards Component
  - 28 students and summer interns from 3 countries and 14 universities
    - 25 at LANL; 3 at LLNL
  - 56 hours of course work over 10 weeks including a 1-week technical practical
  - Mix of graduate and undergraduate students from various backgrounds
  - Lecturers from LANL, TAMU, LLNL, Univ. of Glasgow, and consultants
  - Interns attended the Annual INMM Meeting

Conclusions

- The TAMU program is well established
  - some elements are still missing
- This program is just now producing its first set of graduates
  - employers have included LANL, ORNL, DIA, CIA, and the U.S. nuclear industry
- One key element for sustainability is strong nuclear nonproliferation and safeguards *research* funding
  - funding for graduate students, especially to perform thesis *research*
- Hosting workshop in 2009 to train faculty on safeguards education
  - to help develop sustainable education programs