SAND2012-7627C

International Nuclear and Radiological Threat Reduction

role of radiation measurements

Amir Mohagheghi

Physicist/Program Manger
Middle East and South Asia Programs
Sandia National Laboratories

DOECAP 2012
September 18, 2012
Idaho Falls, Idaho

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Presentation Outline

- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Environmental Radiation Detection System (ERDS)
  - Nuclear Forensics
  - Nuclear Safeguards
  - Middle East WMD Free Zone

What's the Problem? What's the Solution?

- "…by developing atomic energy for peaceful uses, you reach the nuclear weapon option. There are not two atomic energies."

  David Bergman, former Chair, Israeli Atomic Energy Commission

- Goal: Reduce the risk that states can acquire the capabilities to develop nuclear weapons; Maintain a separation between peaceful and non-peaceful uses of nuclear energy
  - Reduce the risk that states might believe that their neighbors were acquiring the capabilities to develop nuclear weapons

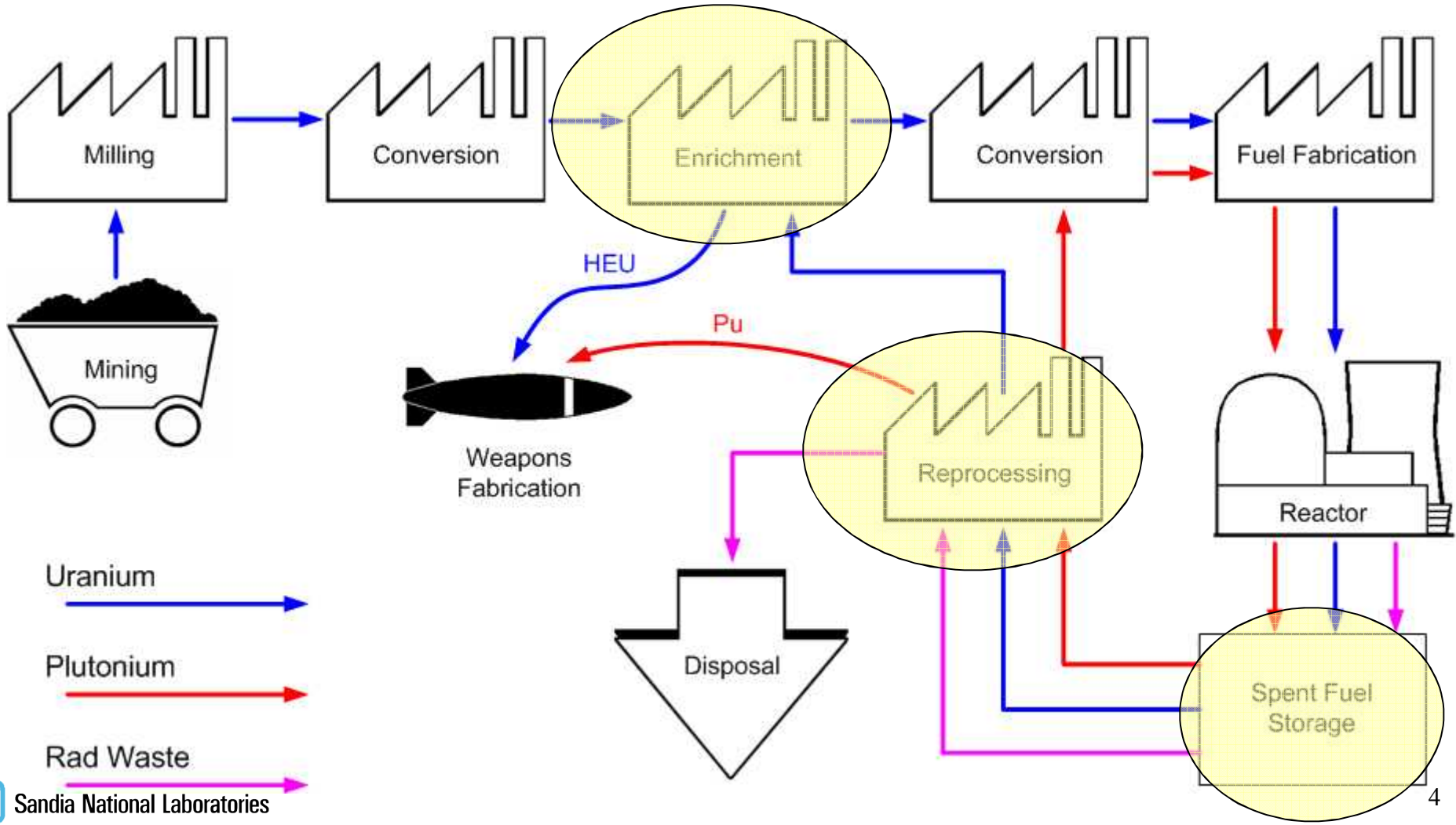
- Elements of a nuclear weapons capability
  - Material
  - Technology
  - Expertise
  - Motivation

- Solutions
  - Restrict access to key elements
  - Monitor the use of key elements
  - Reduce the motivation

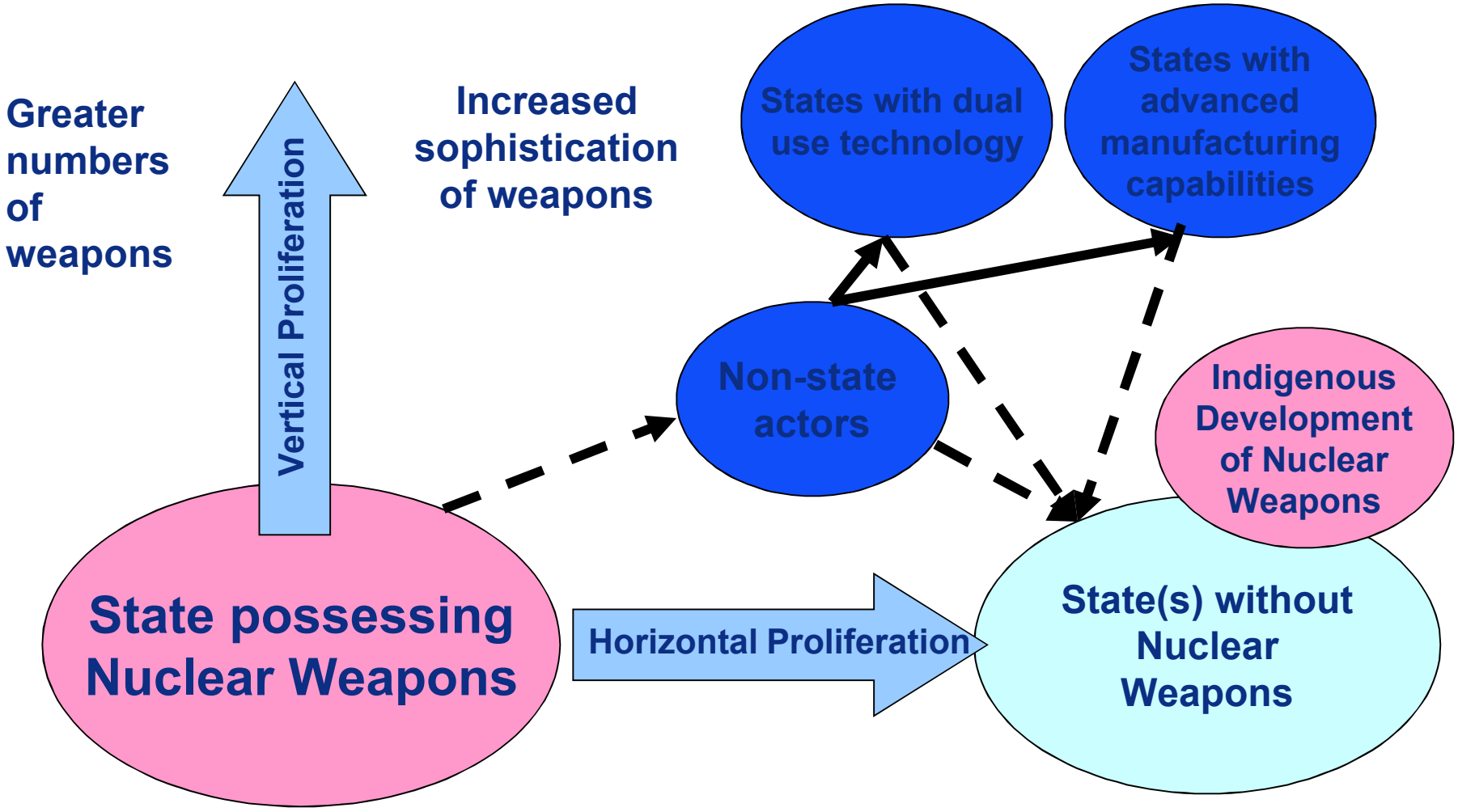
Restricting the dispersion of sensitive materials and technologies can limit opportunities and reduce misperceptions

The Civilian Nuclear Fuel Cycle: A Review

Plutonium and high-enriched uranium might be used to produce nuclear weapons.



A New Kind of Proliferation



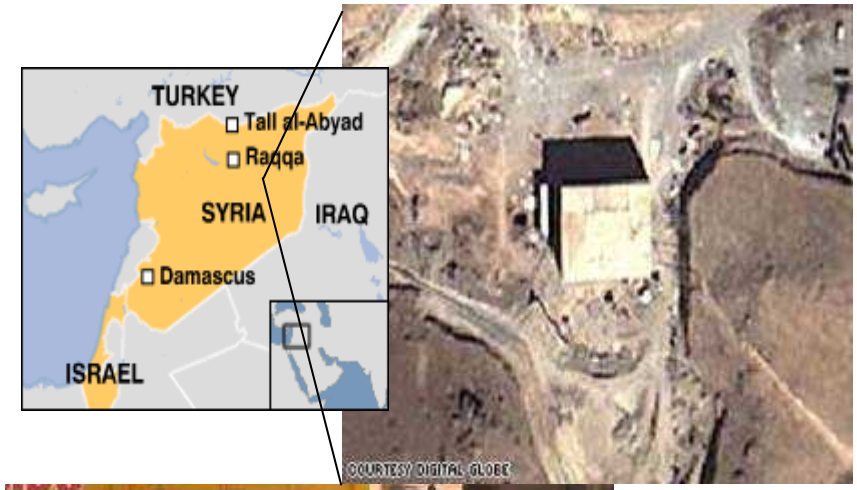
Middle East Geo-Political Background

National Security Issues in the Middle East

Robert Gates on Iraq

Developments in Iraq over the next year or two will, I believe, shape the entire Middle East and greatly influence global geopolitics for many years to come. **December, 2006**

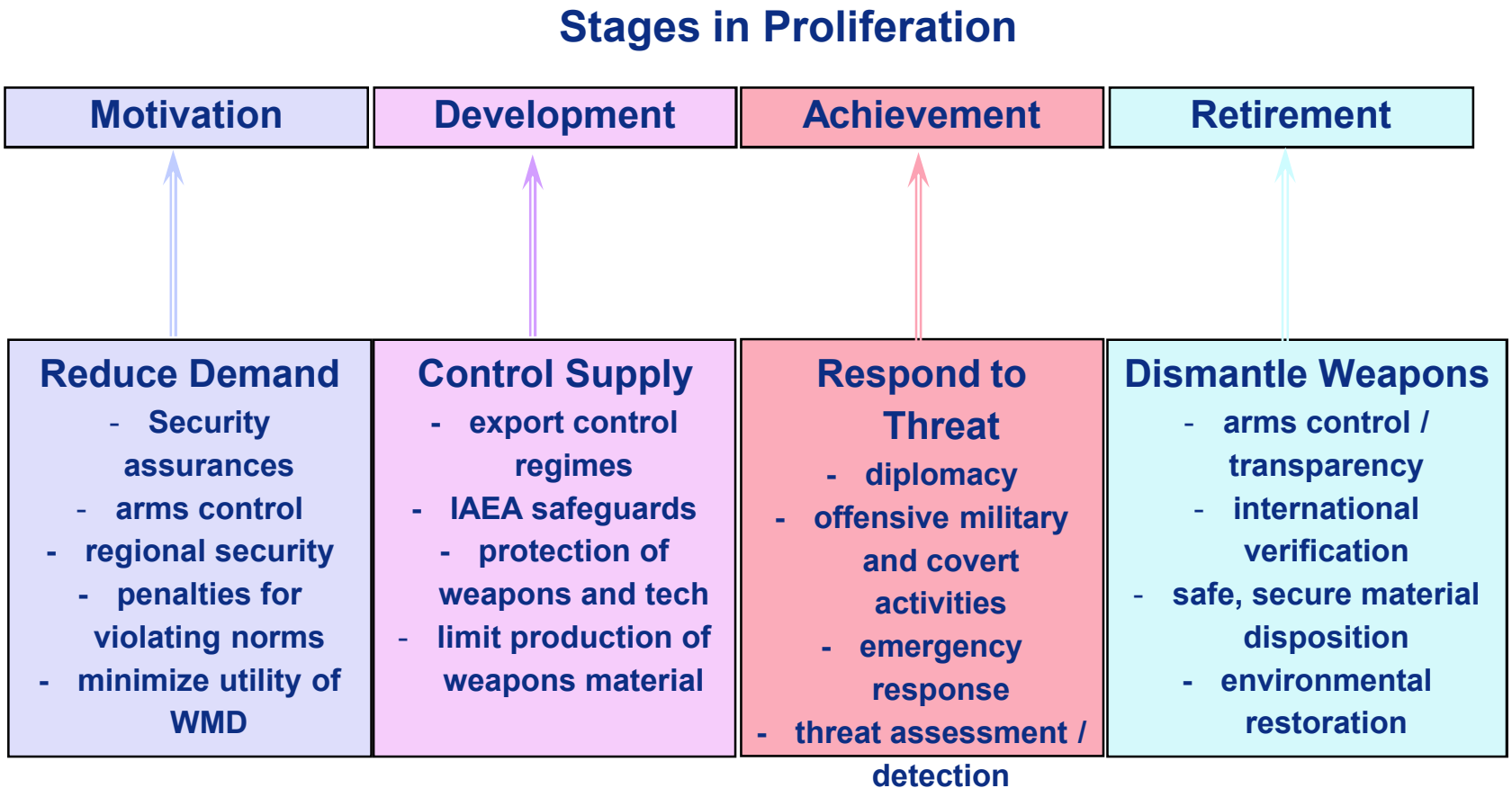
- **Issues:**
  - **Arab Spring**
    - **Rise of Islamist Groups**
  - **Stabilization Afghanistan**
  - **Israeli Arab Conflict**
  - **WMD Proliferation and Iran**
  - **Terrorism and Failed States**
  - **Energy Security**
  - **Resource Management**
    - **e.g. water**



Presentation Outline

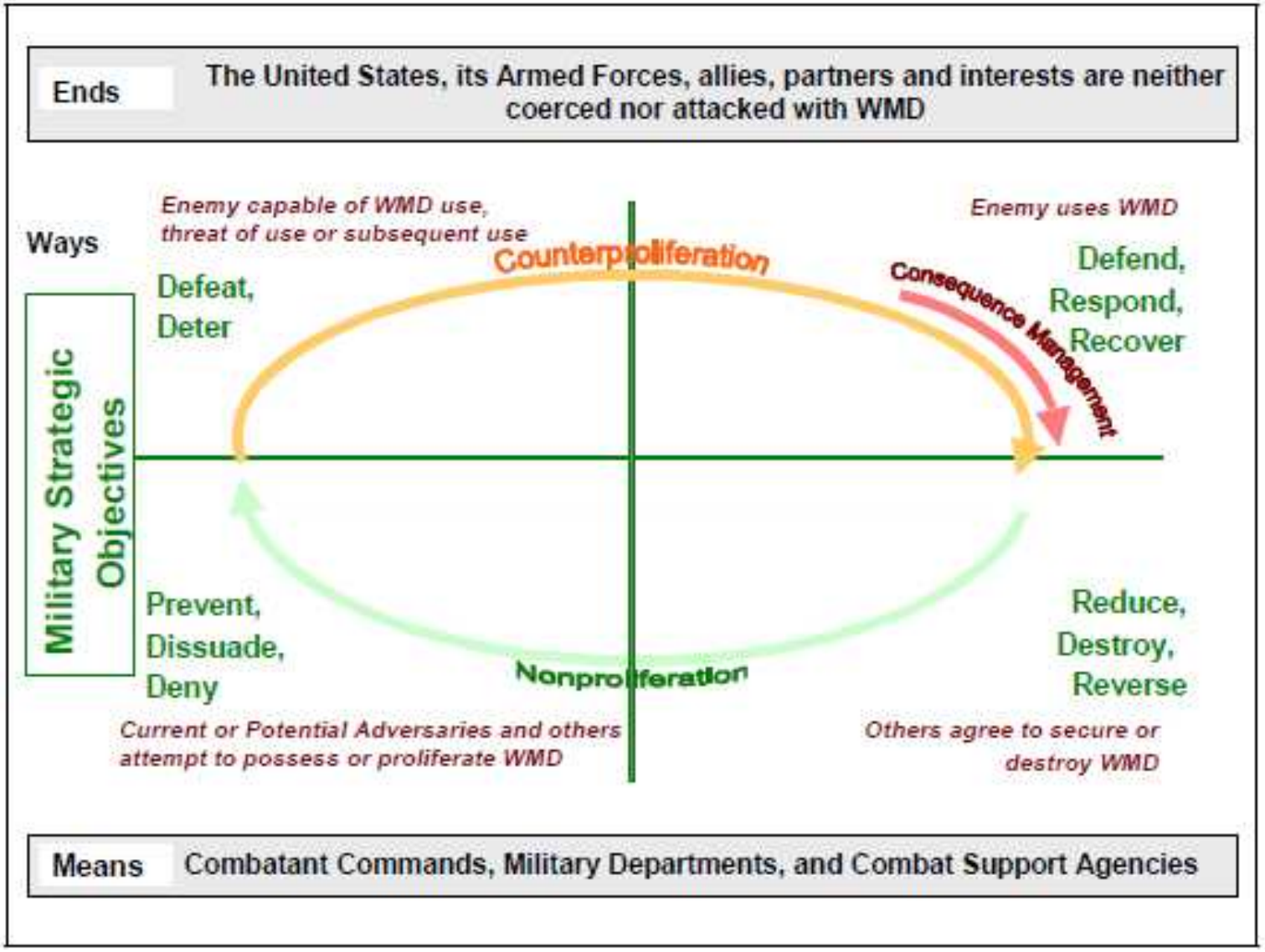
- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Nuclear Forensics
  - Nuclear Safeguards

Different strategies for dealing with proliferation



Strategies to prevent, rollback, or mitigate consequences of proliferation

Strategic Military Framework
National Military Strategy for Combating WMD



What motivates countries to develop nuclear weapons?

• **Security**	■ **Nuclear weapons are considered to be an effective deterrent against nuclear and non-nuclear enemies.**
• **Prestige**	■ **States that possess nuclear weapons have greater influence across a range of forums (e.g., permanent membership in UNSC)**
• **Power**	■ **Nuclear weapons confer inordinate destructive and political power and can give weak states global influence.**

Can approaches to reducing demand be tailored according to the "connectivity" of states to global systems and institutions?

Connected	Marginally Connected		Disconnected	
Japan	Argentina	Indonesia	Libya	Somalia
South Korea	Brazil	Vietnam	Columbia	Sudan
Germany	South Africa	Thailand	Algeria	Syria
Sweden	Egypt	Malaysia	Iran	Afghanistan
Canada	Jordan	Saudi Arabia	Iraq	DPRK
Italy	Bangladesh	Qatar		
Australia		Kenya		
New Zealand		Nigeria		
……		…….		

Possible "connectivity" categorization scheme

Connected States: Assuring Continued Commitment to Nonproliferation Norms

- **Address regional security concerns**
  - **Resolve DPRK nuclear standoff**
  - **Reinvigorate US security alliances in East Asia**

- **Refrain from further restrictions on nuclear fuel cycle technology**
  - **High dependence on nuclear energy**
  - **Outstanding record on compliance with nonproliferation norms**

Marginally Connected States: Strengthen commitments to nonproliferation norms and accelerate global connectivity

- Nuclear weapon states act to decrease the perceived value of nuclear weapons
- Nuclear weapon states act to increase prestige of "connected" non-nuclear weapon states
- All "connected" states act to raise status of non-nuclear, non-weapons technology as symbol of technological excellence
- "Connected" states developed nonproliferation partnerships with "marginally connected" states
- Assist "marginally connected" states acquire nuclear power in ways that reduce proliferation risk
- Consider providing security assurances in key regions

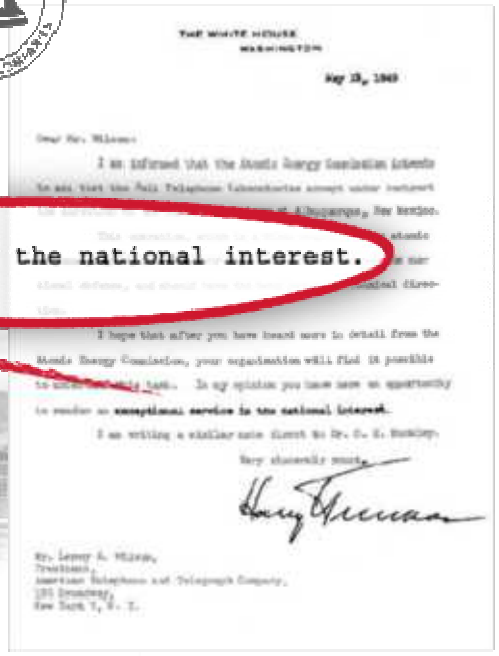
Disconnected States: Decreasing support (tacit or explicit) for terrorist organizations or black-market networks

- Build capacity of legitimate governments
  - Governance
  - Public health
  - Security for citizens
  - Border control
- Accelerate global connectivity
  - Military to military partnerships
  - Educational partnerships
  - Economic partnerships

Presentation Outline

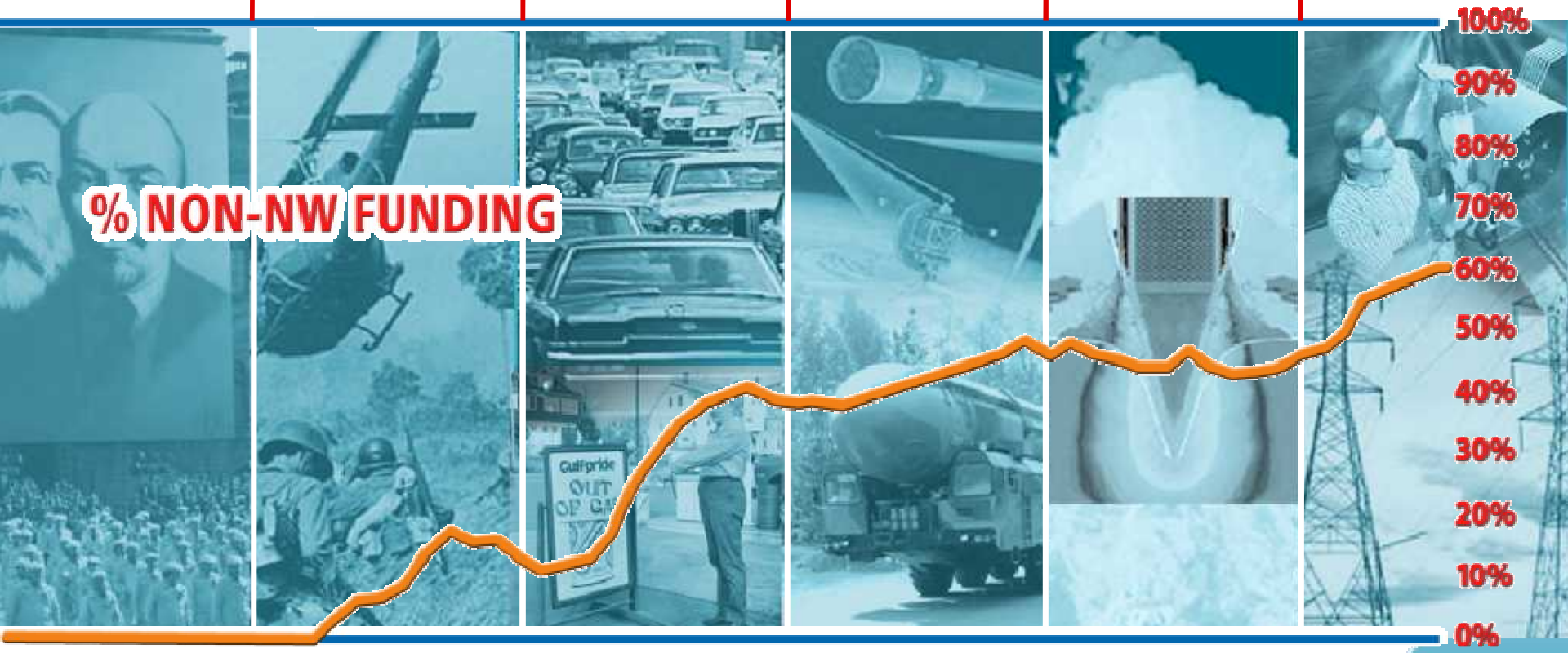
- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Nuclear Forensics
  - Nuclear Safeguards

Sandia's History



The Mission Has Evolved for Decades

1950s	1960s	1970s	1980s	1990s	2000s
Production engineering & manufacturing engineering	Development engineering	Multiprogram laboratory	Research, development and production	Post-Cold War transition	Broader national security challenges



Global Security Program
A 40-plus year history

1960s-70s

Nonproliferation Treaty
Nuclear Nonproliferation Act
Proliferation Detection Technologies

- Satellite Verification
- Safeguards Technology
- Ground-based Sensors
- IAEA Physical Protection Missions

1980s

INF Treaty
Conv. on the Physical Protection of Nuclear Materials

- Verification strategy (Treaty On-Site Inspection)
- Arms Control Technology Options
- IAEA unattended monitoring technologies

1990s

START I and II
Nunn-Lugar Cooperative Threat Reduction
Warhead Safety and Security Exchange

- Russian MPC&A Program
- FSU Threat Reduction

- Fissile Material Monitoring

- Cooperative Monitoring Center
- Regional Security
- Visiting Scholars

2000s

Multilateral cooperation on interdiction (PSI)
UNSCR 1540, GICNT
DPRK Denuclearization

- MPC&A Transition
- Second Line of Defense
- Megaports
- Warhead Monitoring
- Bilateral Transparency

- Radiological Threat Reduction
- IAEA Support
- Next Generation Safeguards
- WMD Detection

Global Security Program
Our mission is focused on a broad threat

Mission: Reducing proliferation and terrorism threats to U.S. national security through global technical engagement

Multi-Threat Risk Reduction

- **Limit the spread of sensitive materials and technologies by:**
  - **Reducing motivation to acquire/use WMD**
  - **Impeding access by proliferators to WMD expertise**
  - **Securing borders and ports**
  - **Securing critical materials and facilities**

Nuclear and Radiological Risks

- **Reduce the threat from malevolent use of nuclear and radiological materials by:**
  - **Enabling global reductions in NW arms and supporting infrastructure**
  - **Reducing fissile material inventories**
  - **Securing weapons and material**
  - **Strengthening international safeguards and nonproliferation regimes**
  - **Detecting / interdicting nuclear smuggling**

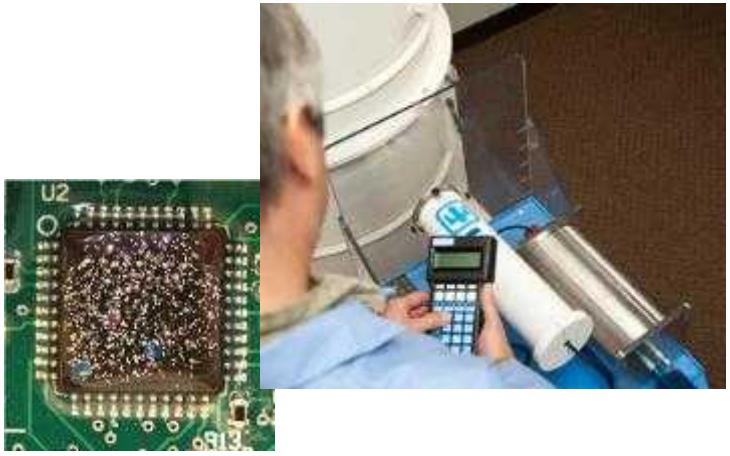
Biological and Chemical Risks

- **Reduce the risk from the malevolent use of biological and chemical materials by:**
  - **Enhancing the safety and security of high-risk pathogens, chemicals, and facilities**
  - **Strengthening capacities to detect and control dangerous infectious diseases**

International Treaties and Negotiated Agreements
Example: Considering a treaty involving nuclear warheads

START Radiation Detection Equipment

Warhead Technology Monitoring Project

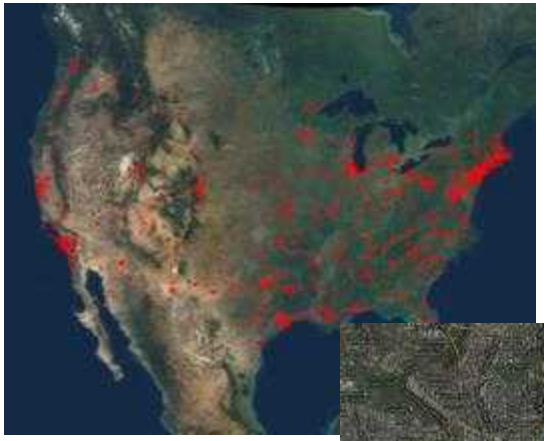


Radiation Detection Equipment

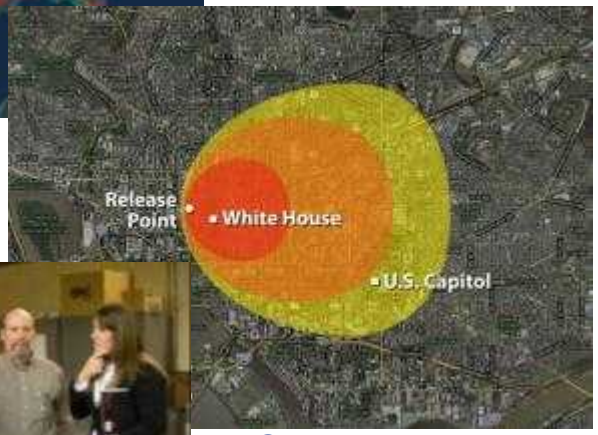
The TOBOS simulated storage facility in St. Petersburg, RU.

Storage Monitoring Collaboration Field Trials

Global Cooperative Threat Reduction
Example: Global Threat Reduction Initiative



Threat



Consequence

Prevention

Global Cooperative Threat Reduction
Example: Gulf Nuclear Energy Infrastructure Institute (GNEII)

Regional Scoping Trip: November 2009

GNEII at KHALIFA UNIVERSITY

LOI Signed: 16 Mar. 2010

Pilot Course Begins: 20 Feb. 2011

Mission: **GNEII seeks to develop a responsible nuclear energy culture and institutionalize key safety, safeguards, security, and nonproliferation norms in the future decision-makers of Middle East region nuclear energy programs through professional development and training.**

MOU Signed: 20 Feb. 2011

Module 1: Fundamentals

Week 1 Critical Thinking, the Scientific Method & Systems Thinking	**Week 2** Basic Nuclear & Reactor Physics	**Week 3** Nuclear Fuel Cycle: Front End, Production Cycle, Back End
Week 4 Nuclear Material Control : History, Policy Issues, Technical Issues	**Week 5** Nuclear Power Plant Management and Operations	**Week 6** Radiological Materials Management
Week 7 Nuclear Safety: Reactor Safety Systems	**Week 8** Nuclear Safety: Accident Modeling & Emergency Preparedness	**Week 9** Nuclear Safeguards: Terminology, technology, Systems & Measurements
Week 10 Nuclear Safeguards: Export Control, the Fuel Cycle & Sub-State Threats	**Week 11** Nuclear Security: Physical Protection System Design, Implementation & Evaluation	**Week 12** Nuclear Security: Vulnerability Assessments for Nuclear Facilities

Module 2: Capstone

GN605

Independent student work to identify, structure, and conduct a research project analyzing a regional nuclear energy issue

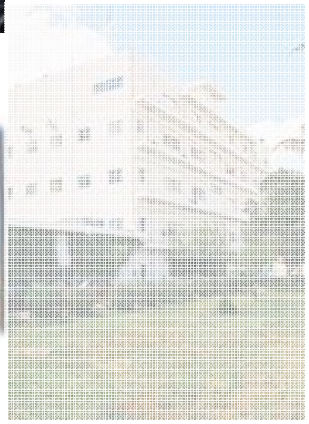
Integrated "3S" Approach Curriculum Finalized: January 2011

Cooperative Monitoring Centers (CMC)

Enabling International Technical Cooperation on Critical Security Issues

Technology integration and operation

Technology testing and demonstration



Technology training courses and workshops

Technical collaborations and experiments

Visiting scholars program, research, and analysis

Examples of Current Projects in the Middle East and South Asia

- Middle East Scientific Institute for Security (MESIS)
  - Borders, Energy, Environmental Security
- S&T Engagement
  - Iraq S&T Engagement
  - Radiation Measurements Cross Calibration (RMCC) Project
  - Qatar – Radiological Baseline Study
  - Egypt/Morocco – Rad Waste Management
  - Regional Radiological Early Warning System
- Infrastructure Development for Safe, Secure, and Safeguarded Nuclear Energy
  - Gulf Nuclear Energy Infrastructure Institute (GNEII)
  - Bilateral Capacity Building Cooperation
- Policy Dialogue and Studies
- Securing Radiological Sources
- Radiological Detection Systems at Border Crossings
- Nuclear, Radiological, Chemical, and Biological Consequence Management (US DOD Central Command)
- Border Security and Export Control Training
- Reducing Tensions and CBMs in South Asia

CMC-Amman's Official Inauguration, October 2003

RMCC Workshops

Presentation Outline

- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Nuclear Forensics
  - Nuclear Safeguards

Radiation Measurements Cross Calibration (RMCC) Project

- All countries in the Middle East have radiation measurement capabilities associated with:
  - Power and research reactors
  - Radioactive sources in medicine, commerce, industry
  - Responding to accidental or intentional radiation releases
  - Environment, health and safety
  - Detecting the presence of radioactive sources
  - Preventing the illicit use of radiological materials
  - Disposing of radioactive sources
- Improving and standardizing nuclear monitoring and measurement capabilities in the Middle East are essential elements of developing an approach to such concerns

The First Step

- As a first step, develop a set of internationally recognized standards for laboratory radiation measurements in the Middle East
- The project consists of
  - Signup for the DOE proficiency testing program (MAPEP)
  - Receive test samples
  - Analyze and report
  - Follow-up with regional workshops to discuss the results and identify technical assistance needs
  - Participate in targeted studies by the IAEA labs in Seibersdorf
  - Annual workshops

RMCC Workshops

Kuwait 2004

Qatar 2005

Oman 2007

Bahrain 2008

Bahrain 2010

Jordan 2011

Morocco 2012

The RMCC Project Benefits

- Increased confidence in data quality across the region
- Availability of a network of qualified labs for radiological measurements
  - Build up the capacity in the region to produce reliable radiological data
- Improved scientist-to-scientist communication
  - Provides a mechanism for sharing of agreed upon information
  - Enables scientists in the region to work cooperatively to create indigenous solutions to the problems in the region
  - Fosters the development of a network of scientific experts in the region
- Training Opportunities
  - Austria – The IAEA Labs in Seibersdorf
  - Germany – Federal Bureau for Radiation Protection
  - USA – Sandia National Laboratories
  - Regional Opportunities
- Next
  - Advisory Council
  - Regional Ownership: Arab Atomic Energy Agency (in partnership with IAEA)

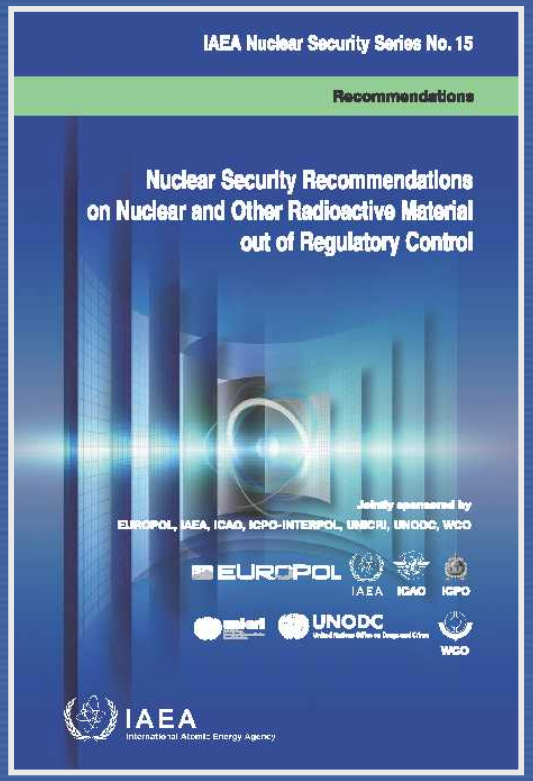
The RMCC Project – Next Steps

- Advisory Council
- Regional Ownership: Arab Atomic Energy Agency
  - Next Tentative Meeting: Tunisia
- Possible Technical Cooperation Project with the IAEA
- Spin Off Projects:
  - The Middle East Environmental Radiation Detection System
  - Confidence Building Measures Project with the Comprehensive Test Ban Treaty Organization (CTBTO)
  - Southeast Asia RMCC

Presentation Outline

- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Nuclear Forensics
  - Nuclear Safeguards

Nuclear forensics is positioned at the centre of nuclear security recommendations for nuclear and other radioactive material out of regulatory control: IAEA Nuclear Security Series #15



Published in 2011

Preventative Measures

- "Deterrence"

Response Measures

- "The State should apply nuclear forensic in it designated laboratories to seized material … taking into account preservation of evidence. Seized materials should be categorized and characterized"

International Cooperation

- The State should apply nuclear forensics techniques to determine the source and route of transfer and to investigate loss of regulatory control…"
- "States should assess it capabilities to perform nuclear forensics and potential needs for forensic support..."

"

IAEA

Nuclear forensics exploited an array of isotopic, chemical and physical evidence

Traditional forensics

- Wax material fingerprint
- Wax colorant
- Paper origin
- Lead metallurgy
- Lead isotopics
- Ampoule material

Nuclear forensics

- Morphology
- Chemical form
- Impurity elements
- Residual radionuclides
- Age-dating
- U & Pu isotopics

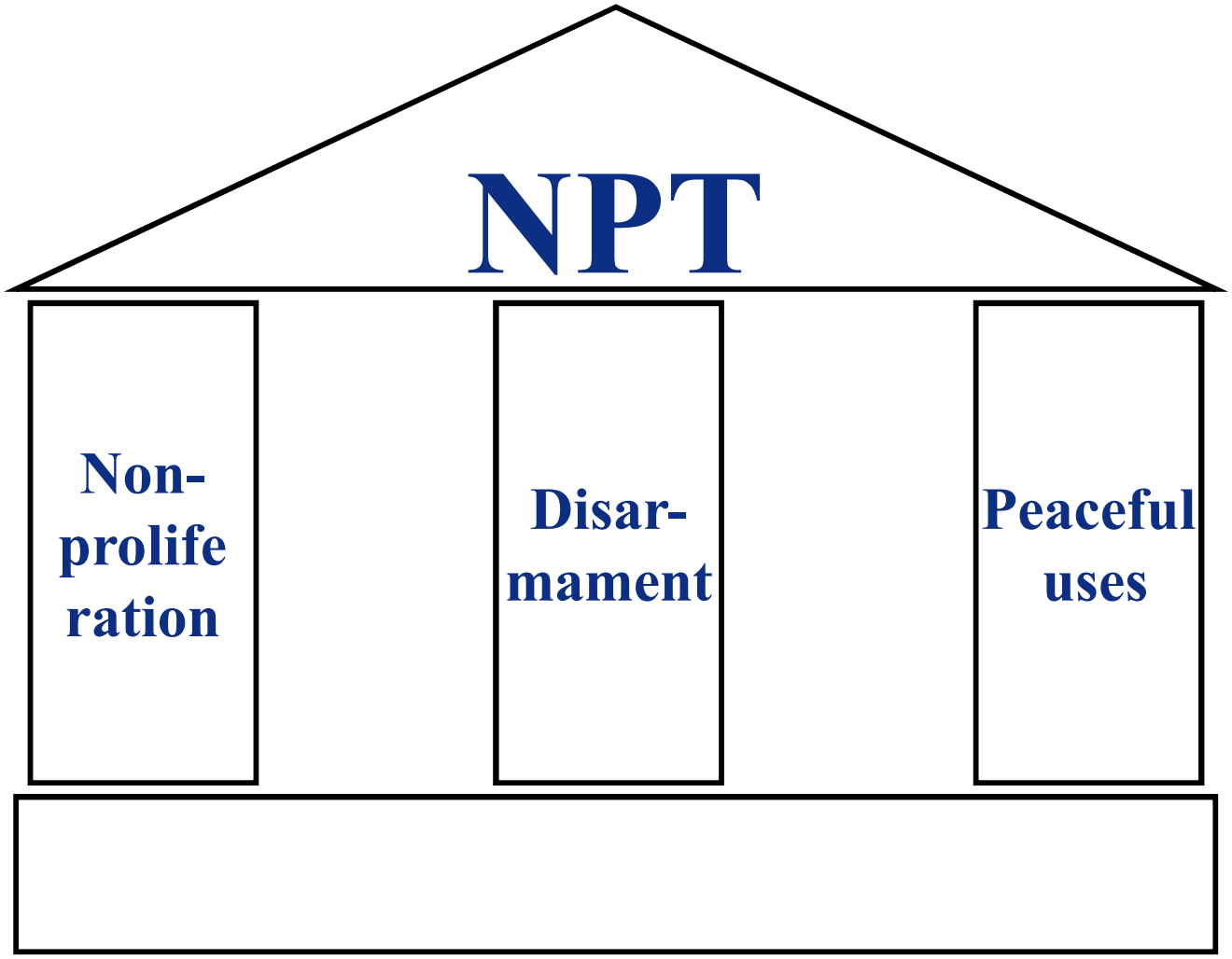
Highly-enriched uranium (~3.96 grams uranium oxide)
Trace plutonium (2.8 parts per billion)

IAEA

Presentation Outline

- National Security Issues: What is the problem?
- Strategies to Combat WMD Proliferation
- Sandia's Global Security Programs
- Role of Radiation Measurements
  - Radiation Measurements Cross Calibration (RMCC)
  - Nuclear Forensics
  - Nuclear Safeguards

Non-Proliferation Treaty



Definition of Safeguards

"International accounting and verification system designed to ensure that fissile material is only used for peaceful purposes."

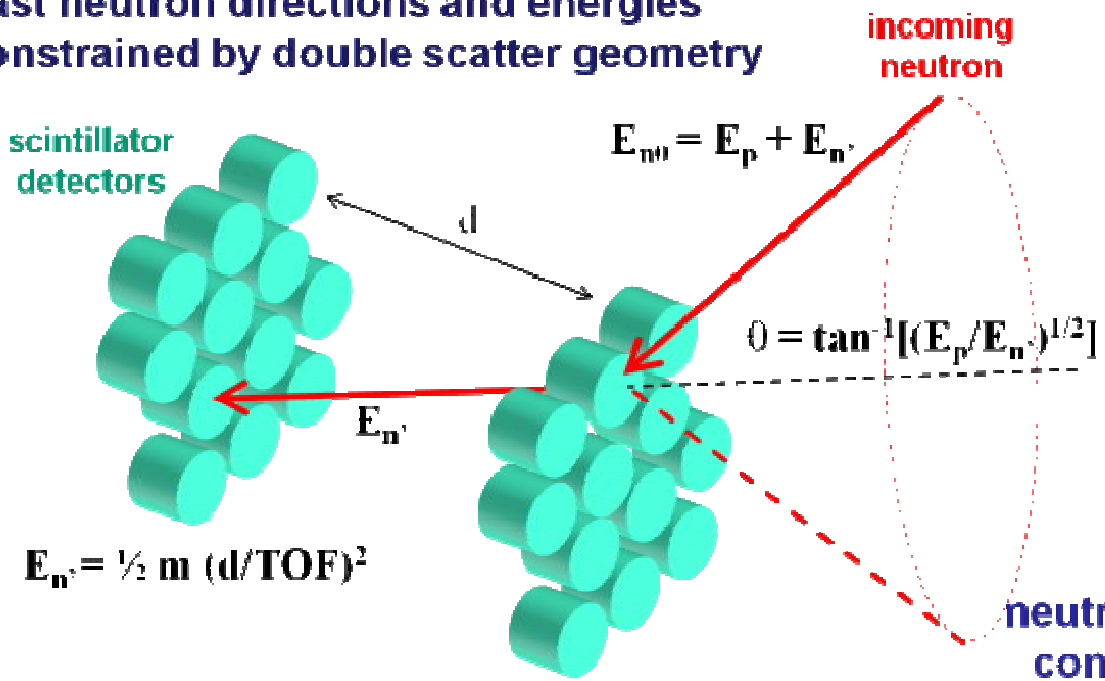
Safeguards Methods

- The safeguards approach can include several different types of IAEA systems
- These systems fall into several typical categories
  - Tamper Indicating Devices (Seals)
  - Containment and Surveillance (Cameras)
  - *Radiation Monitors (Nondestructive Analysis)*
    - *Can be passive (receiving) or active (emitting)*
  - *Very small nuclear materials sampling (Destructive Analysis)*
  - *Swipe samples from the environment*
  - Process Monitoring systems to watch the operating parameters of a chemical process
  - Advanced Systems

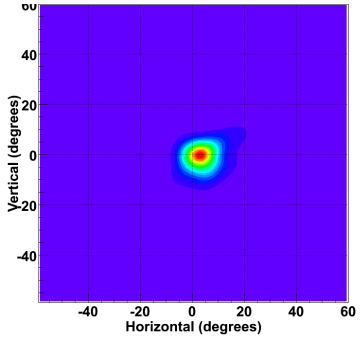
Neutron scatter camera

- Fast neutron imaging spectrometer
- Variable plane separation allows tradeoff of effective area, image resolution

Fast neutron directions and energies constrained by double scatter geometry



neutron direction constrained to cone surface

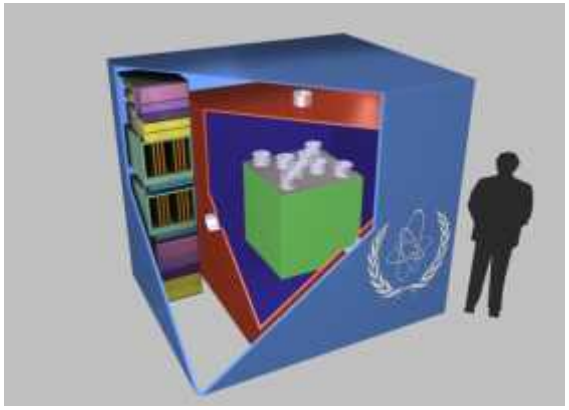


An MLEM-reconstructed neutron point source image.

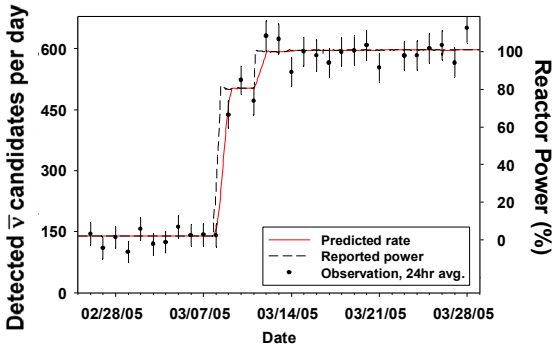
Multimode capability includes
- *Neutron energy spectrum.*
- *Compton imaging.*

Antineutrino Monitoring of Reactors

- **Attributes**
  - Independent measurements of thermal power and fissile inventory
  - Non-intrusive with no connection to plant systems
  - Continuous remote monitoring
  - Highly tamper resistant and cannot be shielded



- **Potential Applications to Safeguards**
  - Independent confirmation of operator declarations
  - Reduction in needed Inspector visits
  - Provide fissile content information for next-generation fuel cycles (MOX, Th, bulk process)



Thank You For Your Time