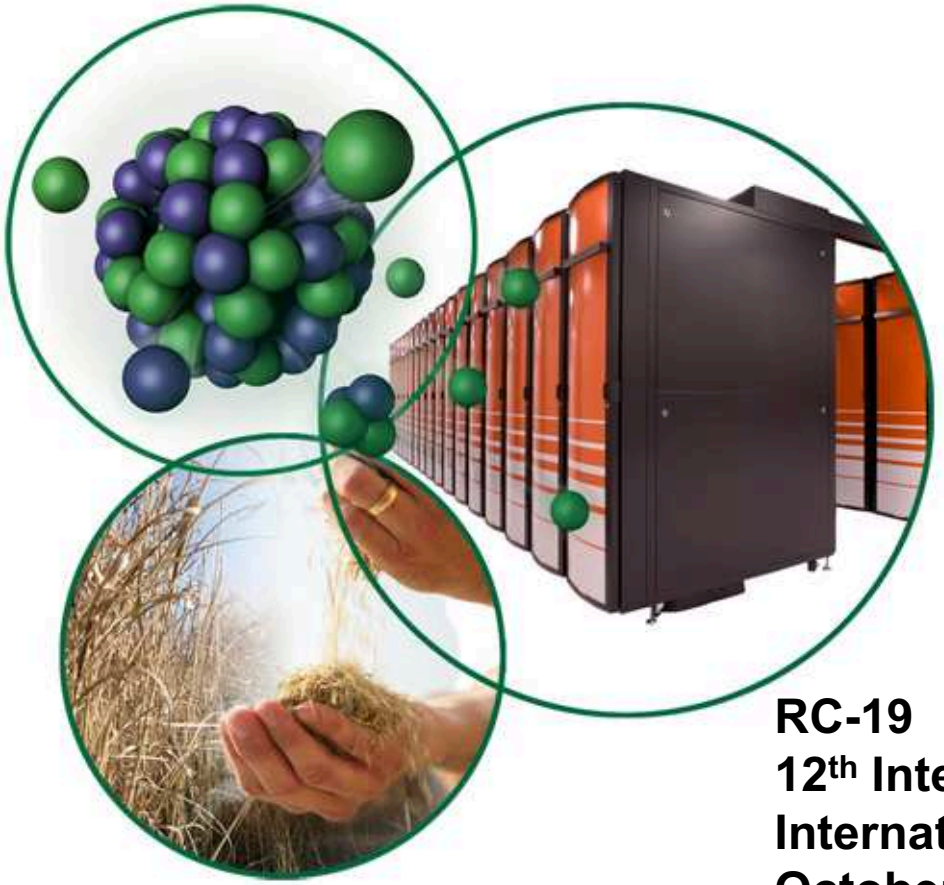
Safe Transport of Radioactive Materials. Security in Transport of Radioactive Materials.



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USA

RC-19
12th International Congress
International Radiation Protection Association
October 2008

Managed by UT-Battelle
for the Department of Energy

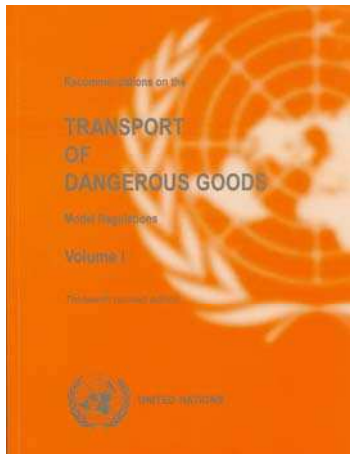
OAK RIDGE National Laboratory

RC-19 Course Overview

1. Radioactive material transport safety
   - History
   - Key safety provisions
2. Security in transport of radioactive material
   - Background
   - Security levels and measures
3. Interfaces between transport safety and security

Transport Safety and Security

- **Safety**
  - A concern since the 1950's
  - Regulations are technically based (deterministic) and continuously reviewed and revised
- **Security**
  - The new kid on the block
  - Post 9/11 concern
  - More difficult undertaking than the safety regulations since the external environment is much more complex (threat based)
- **Interfaces are sometimes complementary and sometimes conflicting**



Regulating Transport Safety

- Radioactive materials: an industry "born regulated"
  - In the late 1940's the unique properties capable of harming health and damaging property (fogging photographic film) were recognized
- 1953: UN Committee of Experts on the Transport of Dangerous Goods was formed
  - Charged to reduce the risks of the rapidly increasing international trade in dangerous goods
  - Created the well recognized classification and labeling system in use today
- 1956: International Atomic Energy Agency formed
  - Charged with "establishing standards of safety for protection of health"

Regulating Transport Safety (con't)

- 1959: United Nations Economic and Social Council (ECOSOC) requested that IAEA be entrusted with drafting recommendations on safe transport of radioactive material
  - Consistent with the Committee of Experts principles for other dangerous goods
  - Formulated in consultation with the UN and relevant specialized agencies (e.g., International Civil Aviation Organization and International Maritime Organization)
- The ECOSOC request complimented the IAEA's mandate to develop safety standards

IAEA Transport Regulations

- **Published in 1961 as the "Regulations for the Safe Transport of Radioactive Material", Safety Series No. 6**

Berlin wall is constructed (some ideas do not stand the test of time!)

- **Revised in 1964**

Specific tests added to simulate severe accident damage

Beatlemania sweeps the USA

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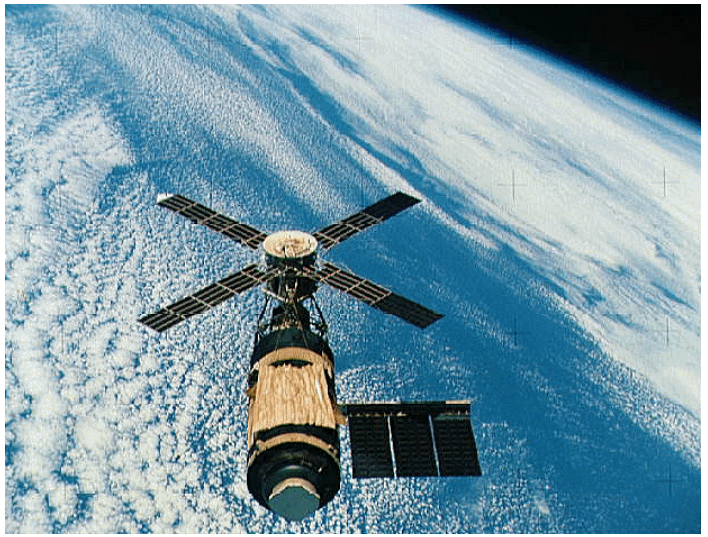
Transport Regulations History

- Revised in 1967

First human heart transplant (South Africa)

- Revised in 1973

Type B(U) and B(M) package distinction made



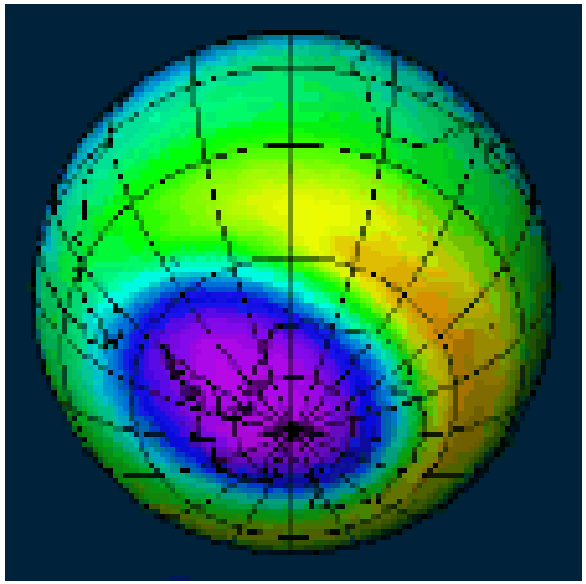
Skylab manned space missions completed (and burns up on re-entry in 1979!)

More History – Where Were You When?

- **Revised in 1985**

200 m immersion test added

Dynamic crush test added



Hole in ozone layer discovered

- **Revised in 1996**

Type C packages introduced

Garry Kasparov beats IBM's Deep Blue (and loses in 1997)

Transport Safety Implementation

- IAEA Transport Regulations issued in 2000 as TS-R-1
- Uniform adoption requires national, regional and international commitment
- The IAEA Transport Regulations are extensively used as the basis for national and international regulations
  - 30 of 31 nuclear power countries and 88% of responding countries use them as the basis for legally binding regulations

International Application of the IAEA Transport Regulations

- The Transport Regulations serve as the basis for radioactive provisions in the UN Transport of Dangerous Goods – Model Regulations
- The Model Regulations are also applied in
  - Convention on International Civil Aviation
  - International Convention for the Safety of Life at Sea
- Other regional agreements (e.g., MERCOSUR/MERCOSUL, ADR/RID) also use the Transport Regulations as their basis

Results of Widespread Adoption

- No deaths or serious injuries from the radioactive nature of the materials
- Compliance with regulations reported to be "good" by Member States and carriers
- Factors important to consistent compliance
  - Uniform regulations among countries and modal organizations
  - Consistency with other dangerous goods regulations
  - Uniform interpretation and application
  - Avoiding unique regulatory requirements

Purpose-built Regulations From the Start

- Protect persons, property and environment from hazards posed by radioactive material during transport
- Radioactive materials present an enormous range of potential hazards during transport
  - Solid, liquid and gaseous form
  - Short- to long-lived radionuclides
  - All radiation types (α,β,γ and neutron)
  - Insignificant to high decay heat
  - Small to very large activity per package
- All hazards must be protected against during transport

How the Transport Regulations Work

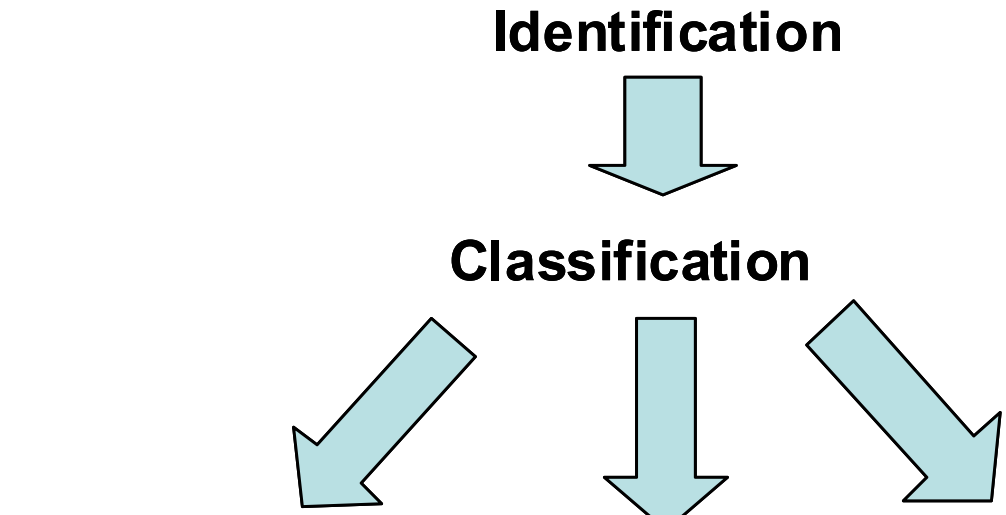
- **Four simple objectives**
  - **Containment to prevent spread of material**
  - **Shielding to prevent harmful radiation levels**
  - **Criticality safety for fissile material**
  - **Heat management to safely dissipate decay heat**
- **Primary responsibility placed on consignor ("shipper") since that entity best knows the material being packaged and shipped**
- **Carrier actions limited to a few simple operational controls**
  - **Limiting accumulation of packages**
  - **Separation from persons and other cargo**

Major Steps in Preparing a Radioactive Material Shipment – a Review

1. Identification
2. Classification
3. Hazard communication
4. Packaging
5. Other controls

ANYONE PREPARING A RADIOACTIVE MATERIAL SHIPMENT NEEDS IN-DEPTH TRAINING!

Preparing a Radioactive Material Shipment



Hazard Communication
- Shipping papers
- Marking
- Labeling
- Placarding

Packaging
- Excepted
- Industrial
- Type A
- Type B
- Type C

Other Controls
- Dose rate limits
- Contamination limits
- Exclusive use
- Criticality controls
- Training
- Stowage and segregation controls

Identification

- **Fully identify and characterize the contents to be shipped**
  - **Form (“special form” or not?)**
  - **Identify and activity of each radionuclide; total activity**
  - **Identity and mass of fissile radionuclides**
  - **Subsidiary chemical hazards**
  - **Activity concentration or surface contamination (fixed and non-fixed) if appropriate**
  - **Special considerations (incorporation into a manufactured item, etc.)**

Classification

- Carefully and fully classify the material to be shipped
  - Is it radioactive by definition?
  - Can it be shipped as an excepted quantity?
  - Can it be shipped as a “low specific activity material”?
  - Can it be shipped as a “surface contaminated object”?
  - Type A, Type B or Type C quantity?
  - Fissile excepted?
  - Uranium hexafluoride?

Hazard Communication

- Carriers, emergency responders, consignees and other personnel need to be aware of the hazards presented by the package
  - Shipping documentation (available for inspection and consideration during emergencies)
  - Marking on package (identifies the type of package, consignor/consignee, etc.)
  - Labeling on package warns of the presence of radioactive material and indicates the radiation level (Yellow-III, Yellow-II, White-I)
  - Placarding on conveyance warns of the presence of radioactive material at a distance

Packaging

- Proper packaging is key to hazard control
- Unpackaged (very low hazard materials)
- Non-accident resistant
  - Excepted
  - Industrial
  - Type A
- Accident resistant
  - Type B
  - Type C
- Fissile
- Uranium hexafluoride

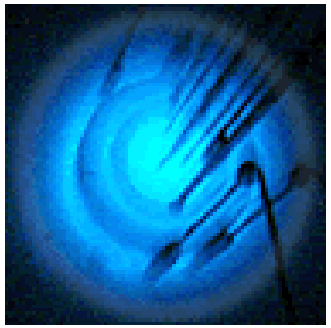
Other Controls

- **Other controls assist in limiting hazards to personnel and property**
  - **Dose rate limits**
  - **Contamination limits**
  - **Exclusive use requirements (high dose rates)**
  - **Criticality controls (limits on package accumulation)**
  - **Training**
  - **Stowage and segregation controls**

Transport Safety Results

- The combined effect of the transport requirements on consignors and carriers results in a very high level of safety by all modes of transport
- Radioactive material shipments can move internationally without serious impediment due to consistent national and international regulations
- Diligence by consignors and carriers is key to maintaining this ability

"Four Faces of Nuclear Terrorism[1]"



1. Acquire and use a nuclear weapon
2. Acquire sufficient material, fabricate and use a crude nuclear weapon
3. Strike nuclear power plants and other nuclear facilities
4. Acquire material, fabricate and use a radiological dispersion device (a.k.a, "dirty bomb")

[1] C.D. Ferguson, et al, Center for Nonproliferation Studies, USA

Transport Security for Radioactive Material

- Fissile ("nuclear") material has been secured under the Convention on the Physical Protection of Nuclear Material since 1979 – including during international transport
- Similar internationally binding security provisions do not apply to non-fissile radioactive material

The Transport Security Aspects of the "Four Faces"

- 1 and 2 – physical protection of weapons-usable materials
  - International Convention on the Physical Protection of Nuclear Material
  - INFCIRC/225, Rev. 4 (corrected)
- 3 – not applicable to transport (sabotage of facilities)
- 4 – transport security needs to be addressed thoroughly to prevent adversaries acquiring radioactive material during transport

Addressing Transport Security

- UN Committee of Experts addressed security of all dangerous goods in 12th Edition of the Model Regulations
  - Consulted IAEA for definition of "high consequence" radioactive material and exceptions (nuclear material covered by INFCIRC/225)
- IAEA began a review of transport security to determine if additional measures were needed
- International basis
  - No convention like nuclear material
  - Security is traditionally a State responsibility (aversion to additional obligations)
  - Code of Conduct on the Safety and Security of Radioactive Sources includes some requirements but is voluntary

Establishing Transport Security Requirements for Non-nuclear Material

- IAEA initiated efforts in 2003 to
  - Determine appropriate transport security levels and thresholds
  - Recommend appropriate security measures for each security level
- Resulted in drafting, Member State review and publication of “Security in the Transport of Radioactive Material”, Implementing Guide, IAEA Nuclear Security Series No. 9, 2008

Radioactive Source Security is Being Addressed Already

- "Code of Conduct on the Safety and Security of Radioactive Sources" and "Guidance on the Import and Export of Radioactive Sources"
- Builds on an activity-based categorization
  - D-values calculated on basis of ability to cause "severe deterministic effects"
  - Category 1 ≥ 1,000 D
  - Category 2 ≥ 10 D

Considerations in Setting a Transport Security Threshold

1. Current UN Model Regulation threshold
   - 3,000 A_1 or 3,000 A_2
   - Uses well established Q-system and A-values
2. Code of Conduct applicable to radioactive sources

What basis should be used for specifying security thresholds for non-fissile radioactive material in transport?

Possible Malicious Use Exposure Pathways

- Radiation exposure - surreptitious placement of a source
  - Pubic area
  - Private area (targeted)
- Dispersion of material
  - Internal exposures (inhalation and plume dose, resuspension, etc.)
  - External exposures
  - Evacuation/resettlement
    - Social disruption
    - Economic disruption (denial of use, cost of cleanup, etc.)
- RDDs are most effective as "weapons of denial"

Dispersion Consequence Evaluation

- A simple planar model was used to examine potential malicious dispersion consequences
- Chosen parameters
  - 1 km^2
  - 1,000 mSv lifetime dose (ICRP 82)
  - IAEA TECDOC-955 dose conversion factors for long term dose from deposition

Transportation Security Consequence Evaluation

$$A = \frac{D \times Area}{CF_4 \times RF}\left[\frac{1}{(OF \times SF)+(1-OF)}\right] \times \frac{1TBq}{10^9\, kBq}$$

A = activity (TBq)
D = ICRP lifetime dose value (1000 mSv)
CF_4 = long term dose conversion factor for deposition
Area = surface area covered (10^6 m^2)
OF = occupancy factor (0.6)
SF = shielding factor (0.16)
RF = release factor (0.1)

Transport Security Thresholds

- Many considerations were taken into account
  - Need for consistency with the Code of Conduct for radioactive sources
  - Draft security guidance in TECDOC-1355 for radioactive sources
  - Need for consistency with already familiar radioactive transport safety concepts and terminology
  - Results of the widespread dispersion calculation
- IAEA meetings concluded
  - 3,000 A_2 except for radionuclides included in the Code of Conduct
  - 10 D (Category 2) for radionuclides included in the Code of Conduct

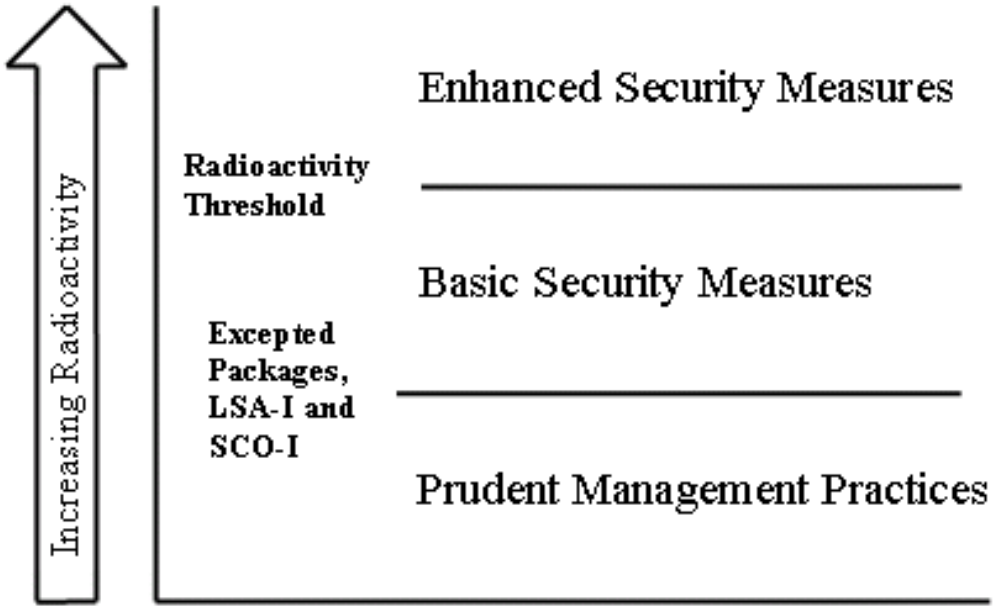
Example Radioactivity Thresholds

Radionuclide	Security Threshold (TBq)
Am-241	0.6
Cf-252	0.2
Cs-137	1
Hg-203	3,000*
I-131	2,100*
Mo-99	1,800*
Pu-238	0.6
U_{nat}	Unlimited*

* Limited by 3,000 A_2

Security Levels

- The threshold can be used to define materials requiring "basic" and "enhanced" security measures
- Some materials do not need specific security measures



Considerations in Setting Transport Security Measures

- **Consistency with the UN Model Regulations**
  - **Two security levels (basic and enhanced) determined to be sufficient**
  - **Minimizes additional costs and complexity**
  - **Minimizes likelihood of denial of shipments**
- **Thresholds based on consequence evaluation and consistency with the Code of Conduct**
  - **Strong beta/gamma emitters used in significant quantities are included in the Code of Conduct**
  - **Other radionuclides captured at the 3,000 A_2 level**

Basic Transport Security Measures

- General security provisions
  - Competent Authority, at its discretion, should provide threat information to operators
  - Operators should consider security requirements commensurate with their responsibilities
  - Transfers limited to appropriately identified carriers/consignees
  - Use of appropriate security measures at in-transit storage sites
  - Procedures to initiate inquiry for overdue shipments and, if lost or stolen, to initiate efforts to locate and recover

Basic Transport Security Measures (continued)

- Security locks
  - Secure and closed conveyances or sealed packages >500 kg secured to the vehicle
- Security awareness training
- Personnel identity verification
- Security verification (inspection) of conveyances
- Written instructions with required security measures
- Security related information exchange by operators
- Trustworthiness verification

Enhanced Security Measures

- Apply to packages exceeding threshold
- Competent Authority should identify carriers and consignors
- All operators should develop, implement and periodically review a security plan
  - Allocation of responsibilities
  - Records of packages/materials transported
  - Review of operations and assessment of vulnerability
  - Identification of measures used to reduce security risks
  - Procedures for reporting and dealing with security threats, breaches, and incidents
  - Evaluating, testing and review/update of security plan
  - Measures to ensure information security
  - Measures to limit distribution of sensitive information
  - Measures to monitor the shipment

Enhanced Security Measures (continued)

- State should assign responsibility for security plans (may be incorporated into other plans)
- Operators should ensure appropriate response plans
- Advance notification
  - Consignor should notify consignee of planned shipment, mode, and expected delivery time
  - Consignee should confirm receipt/non-receipt
  - Consignor should notify receiving/transit States (if required)

Enhanced Security Measures (continued)

- **Tracking devices**
  - When appropriate, transport telemetry or other tracking methods or devices should be used
    - Ranging from bar code to more sophisticated near real-time tracking systems
- Carrier should provide ability to **communicate from conveyance**
- Additional provisions for road, rail, and inland waterway
  - Carriers should **ensure operational readiness** of devices, equipment, etc.
  - Continuous **attendance or secure parking** of road conveyance

Additional Security Measures

- States should consider enhancing measures based on a DBT, prevailing threat or nature of the material, inter alia:
  - Additional training
  - Carrier licensing, approval of their security plans, and auditing
  - Use of automated real-time tracking
  - Use of guards
  - Evaluation of potential for sabotage
  - Transfer of security responsibilities during shipment
  - Review of security plans, holding exercises, etc.

Transport Safety and Security Interfaces

Component	Safety	Security
Identification	√	√
Hazard communication	√	X
Packaging	√	√
Other controls	√	√

Safety and Security Interfaces

- Most interfaces are complementary (i.e., are neutral or helpful to the other discipline)
  - Classification (hazard & potential consequences)
  - Packaging (robust packages & delay)
  - Exclusive use vehicle (radiation protection & access control)
- Some interfaces must be carefully managed
  - Information security (written, verbal, cyber)
  - External communication (labeling, marking, placarding)
- Where warranted, pragmatic approaches may be needed (e.g., escorts providing hazard communication “as needed”)

Efforts Are Underway to Implement Transport Safety and Security Requirements

- Many countries already use TS-R-1 as the basis for safety requirements
- Many countries base their dangerous goods regulations on the Model Regulations/ICAO/IMO/etc. so security requirements are being emplaced
- Efforts are underway to assist other countries to do likewise
  - IAEA missions (both safety and security)
  - United States (NNSA Global Threat Reduction Initiative) security support
  - EU, Australia and other regional support
- Assistance available to countries includes
  - Detailed training course (NNSA/IAEA)
  - Security assessment and upgrades (national- and operator-level): both NNSA and IAEA

The Challenge is in the Future

- Countries need to address transport security for radioactive material
- IAEA implementing guide provides a good basis
- An understanding of the transport threat environment must be developed to inform the regulatory process
- Regulatory staff, shippers and carriers must be trained to implement security requirements (licensing, inspection, etc.)
- **Transport must be made secure to prevent "weak link" access to high-risk radioactive material!**