Transportation of Radioactive Materials

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Types of Radioactive Shipments

- Uranium ores
- Isotopes
  - Medical
  - Industrial
  - Research
- Weapons-related materials
- Unused Reactor Fuel (fresh fuel)
- Radioactive “waste”
  - Spent fuel (SNF)
  - High level waste (HLW)
  - Transuranic waste (TRU)
  - Low-level waste (LLW)
  - Mixed low-level waste
  - Reactor components
  - Uranium mill tailings
Current Locations of Spent Nuclear Fuel and High-Level Radioactive Waste

129 Sites in 39 States

Commercial Reactors including:
- operating reactors
- shutdown reactors at operating reactor sites
- shutdown reactors at shutdown reactor sites
  where SNF could be removed after repository opening

Commercial SNF Storage (Away-From-Reactor)
Commercial Dry Storage Sites
Highly Enriched Uranium at Shutdown Site

Research Reactors including:
- operating reactors
- shutdown reactors with SNF on site

DOE-Owned SNF and HLW
Commercial HLW
Surplus Plutonium
Naval Reactor Fuel
Cargo Waste Forms & Package Designs

- **Commercial Spent Nuclear Fuel**
  - Boiling Water Reactor
  - Pressurized Water Reactor
  - Savannah River
  - Idaho National Engineering & Environmental Laboratory
  - Hanford
  - West Valley

- **High-Level Waste**
  - DOE Spent Nuclear Fuel
  - > 250 Types of Fuel
  - DOE SNF Canister

- **Naval Spent Nuclear Fuel**
  - Naval Canister

- **Commercial Spent Nuclear Fuel Waste Package**
- **Codisposal Waste Package**
- **Naval Waste Package**

Drawing Not To Scale
00240DC_LA_0127b.ai
Nuclear Fuel Cycle Options

Source: Nuclear Waste Technical Review Board
The Transportation Challenge

- Spatial diversity of shipping origins
- Many waste forms
- Varying volumes to be shipped
- Uncertainties
  - Where to ship?
  - When to ship?
**Topics of Interest**

- Transportation system infrastructure
- Radioactive shipment regulators
- RAM Package Certification
- Responsibilities of shippers & carriers
- Mode selection
- Routing
- Operational issues
- Institutional considerations
- Experience to date
- Risk perception
Transportation System Infrastructure

- Transportation networks
- Rolling stock
- Transportation casks
- Loading/unloading facilities
  - Wet/dry storage handling
  - Crane capacity
- Maintenance facilities
Radioactive Materials Transport Regulators

- **U.S. Department of Transportation**
  - Training
  - Packaging
  - Labeling/placarding
  - Shipping papers
  - Loading/unloading

- **Nuclear Regulatory Commission**
  - Package design & performance
  - Safeguards & security

- **Others** (DOE, USPS, OSHA, EPA, IAEA, IMO, ICAO)
In the United States, packages for shipping large amounts of radioactive materials are certified for use by the U.S. NRC and U.S. DOE.

Applicable regulations are found in 10 CFR 71 (NRC).

Packages are classified based on amount of radioactive materials carried (Industrial Packages, Type A, Type AF, Type B, Type C).

Required testing for Type AF, B and C packages includes Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) tests.
Responsibilities of Shippers & Carriers

- **Shipper**
  - Classifies & packages radioactive materials
  - Marks & labels packages
  - Completes & signs shipping papers
  - Selects carrier

- **Carrier**
  - Reviews shipping papers
  - Placards vehicle
  - Stows & secures package
  - Complies with driver training and routing requirements
  - Follows vehicle safety requirements
  - Reports incident (if one occurs)
Mode Selection

- Rail
  - Regular train
  - Dedicated train

- Truck
  - Legal weight
  - Overweight
  - Heavy haul

- Barge

- Intermodal
Factors Affecting Mode Selection

- Container size & weight
- Characteristics & composition of radioactive contents
- Shipping distance
- Availability of transportation facilities & infrastructure
Routing

Highway (DOT HRCQ Routing Regulations)

- Vehicles operate over preferred routes
  - TRAGIS
  - Interstate highway system, including bypasses or beltways
  - A state or tribe may designate alternative routes

- Alternative route selection based on multiple criteria
  - Travel time
  - Accident rate
  - Population density & special events
  - Temporal considerations (time of day, day of week, season)
  - Continuity of operations

Rail

- There are no federal rail routing regulations

- Standard rail industry practices
  - TRAGIS
  - Minimize time, distance, number of carriers, interchange points
  - Maximize use of best track
Operational Issues

- Permits and fees
- Advance notification
- Inspections
- Security
  - Accessibility
  - Vulnerability
- Tracking & communications
- Safe parking
- Contingencies
- Emergency response
  - First response
  - Qualified response
- Recovery & cleanup
Institutional Considerations

- Transportation organization and culture
- Management processes
- Stakeholder identification & interactions
- Issue resolution
Experience to Date

- Roughly 3,000 shipments of SNF and HLW in the U.S. during the past 30 years
- 738 Navy container shipments, over 1 million miles since 1957
- Average 650 nuclear materials shipments per year in France and Britain
- There has never been a release of radioactive material during transport harmful to the public or the environment
Perceived Relative Risks of Energy Sources

Considering the risks of normal operations and potential accidents, how do you rate the risks to society and the environment from these sources of energy?

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<tr>
<th>Source of Energy</th>
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<td>Fossil Fuels</td>
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<td>Nuclear Energy</td>
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<tr>
<td>Renewable Sources</td>
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<td>2.35</td>
</tr>
</tbody>
</table>

$p = 0.0003$  
$p = 0.0007$  
$p < 0.0001$

Source: Hank Jenkins-Smith
Perceived Risks vs. Benefits of Nuclear Energy

How do you rate the overall balance of risks and benefits of nuclear energy in the US?

Source: Hank Jenkins-Smith
Support for WIPP by Proximity

Figure 4: Predicted Percent Support for WIPP, by Distance from Facility, among New Mexico Residents

Source: Hank Jenkins-Smith
Percent Vote to Open WIPP: State-Wide New Mexico Surveys 1995-2001

Figure 5: Percent Vote to Open WIPP

Source: Hank Jenkins-Smith
Thank You

Questions?