SAND2006-7139P

Overview of Transportation & Facility Safety and Security Work Performed for the NRC

November 13, 2006

Albuquerque, New Mexico

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Sandia National Laboratories
Albuquerque, New Mexico

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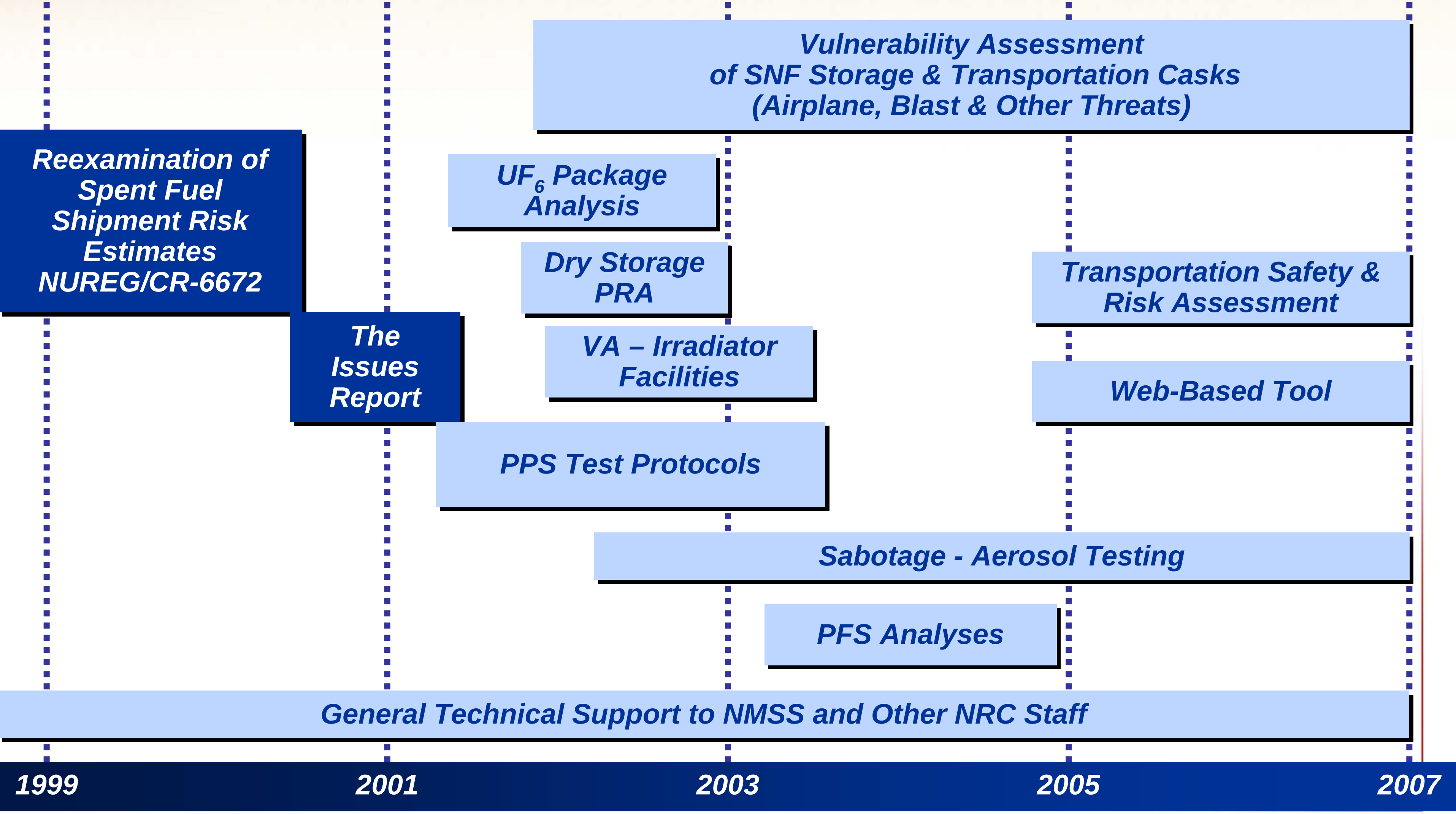
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Transportation Safety & Risk Assessment
The Issues Report
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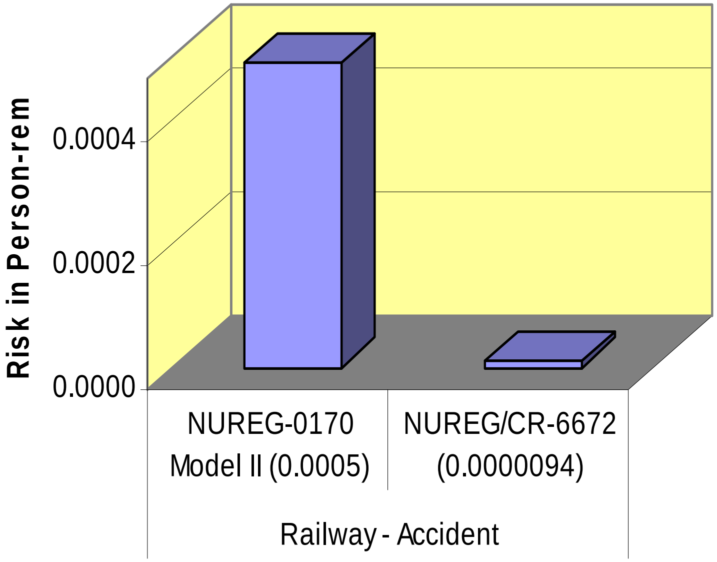
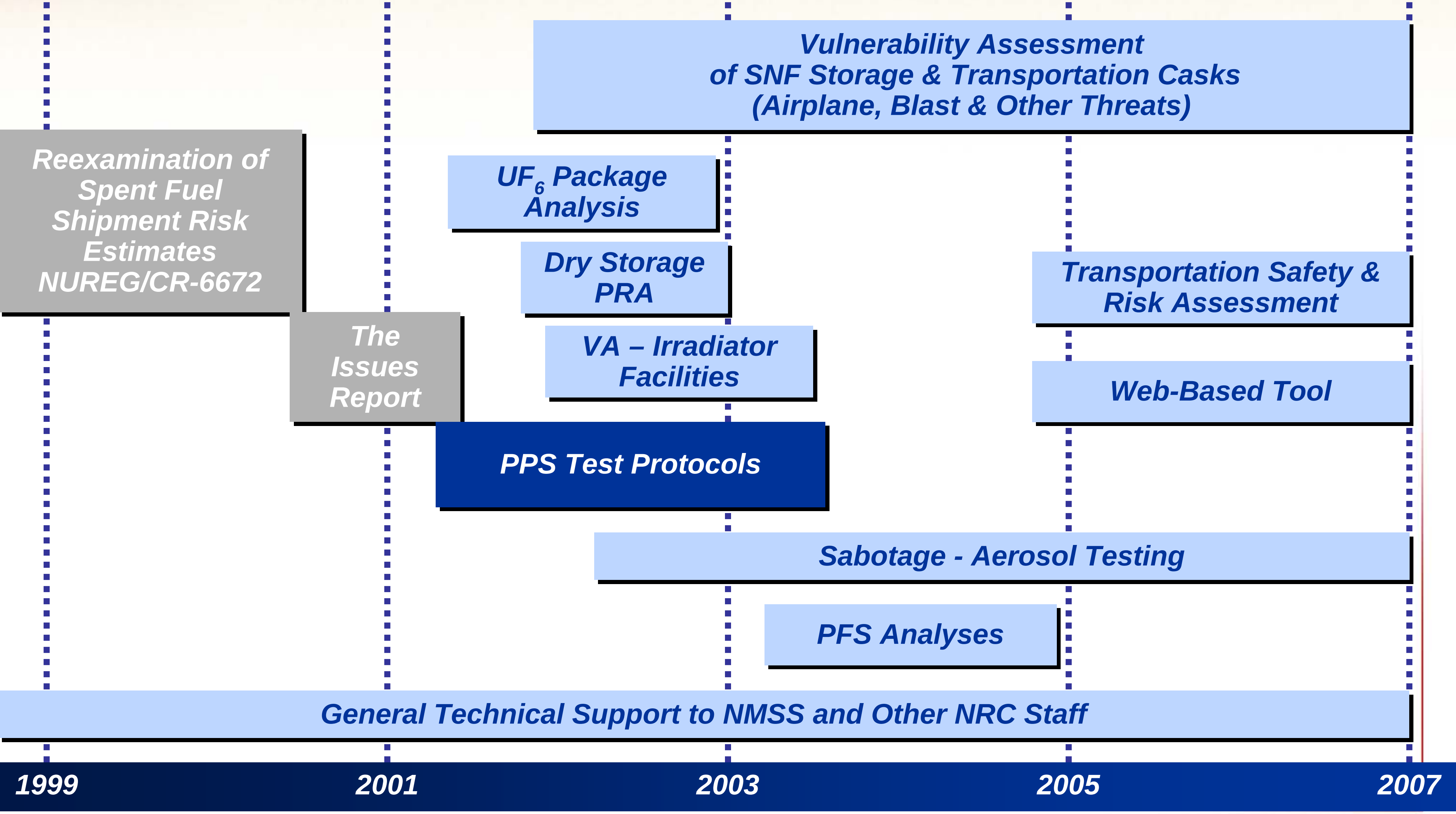
History of Major NRC Transportation Studies

- **NUREG-0170, 1977 - Transportation of Radioactive Materials by Air and Other Modes**
- **NUREG/CR-6672, 2000 - Reexamination of Spent Fuel Shipment Risk Assessments**
- **NUREG/CR-6672 was prompted by:**
  - **Spent fuel shipments will increase**
  - **Routes and transport cask differ from those previously studied**
  - **Better risk assessment and cask response analysis tools available**
- **Issues Report**
  - **Translated public comments on the review of NUREG/CR-6672**

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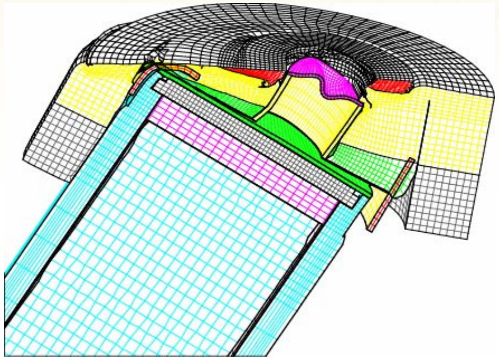
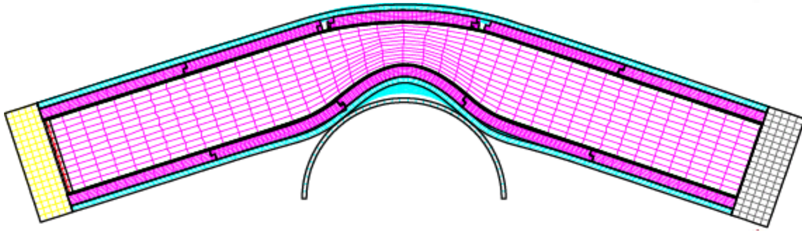
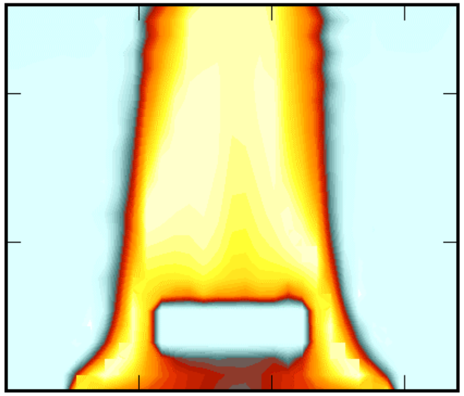
Package Performance Study

- **Description**
  - Advance safety assessments of spent fuel transport through finite element analyses, testing, and risk analyses
  - Demonstrate the ability to properly capture cask response to severe thermal and mechanical environments through analyses
  - Validate existing regulatory framework
- **Accomplishments**
  - The draft Test Protocols document was submitted to the NRC in January 2002
  - The first internal Expert Review Panel meeting was held April 2002
  - The revised Test Protocols document were published as NUREG-1768 on February 2003







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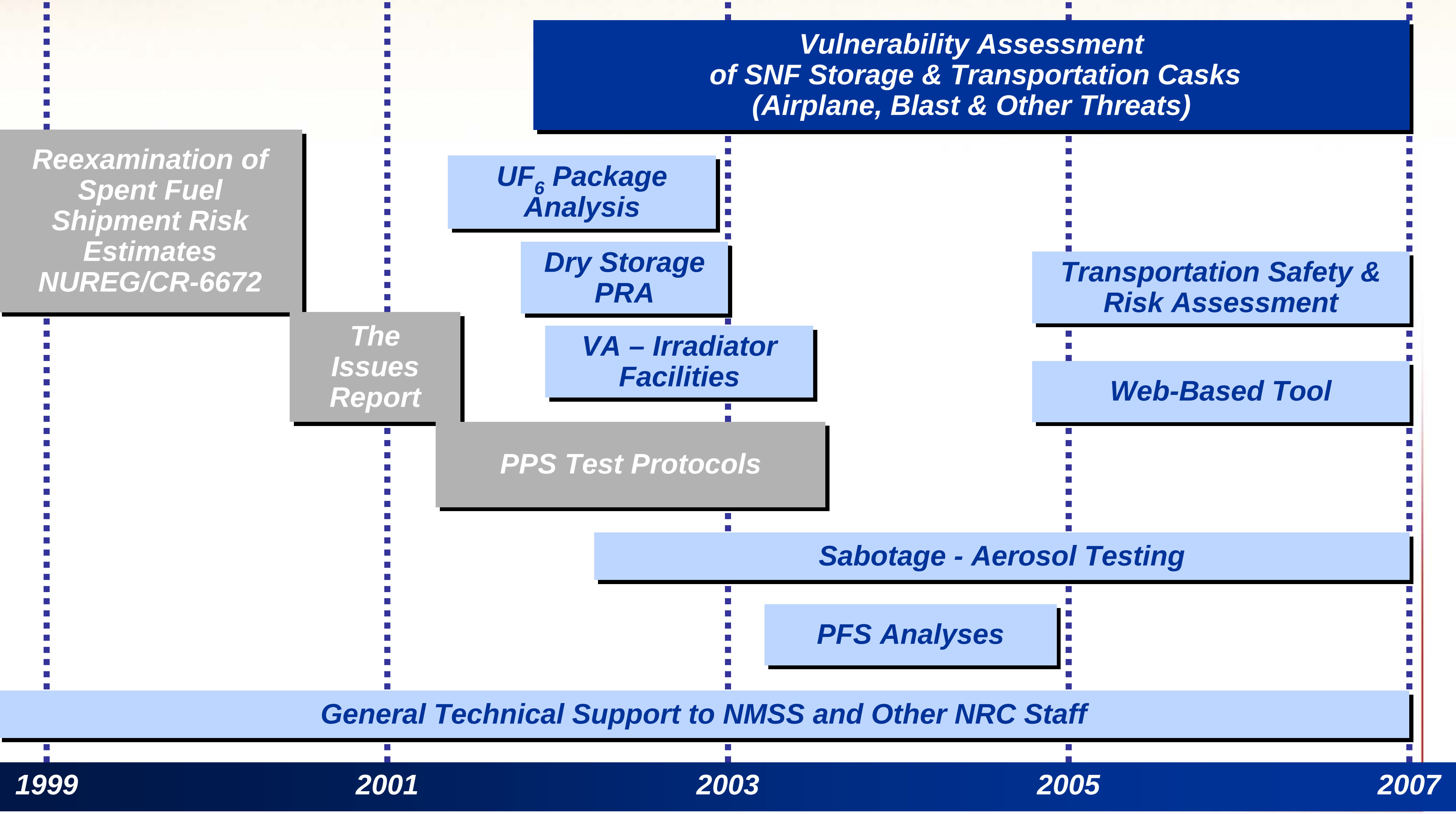
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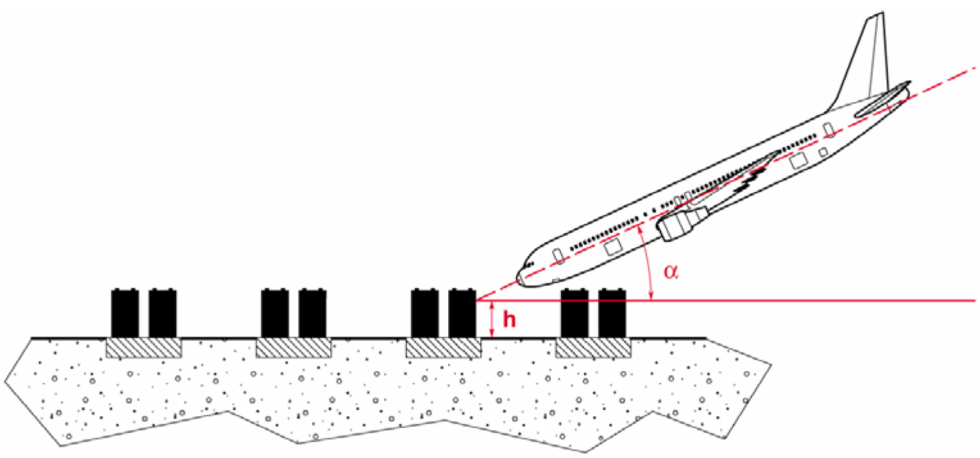
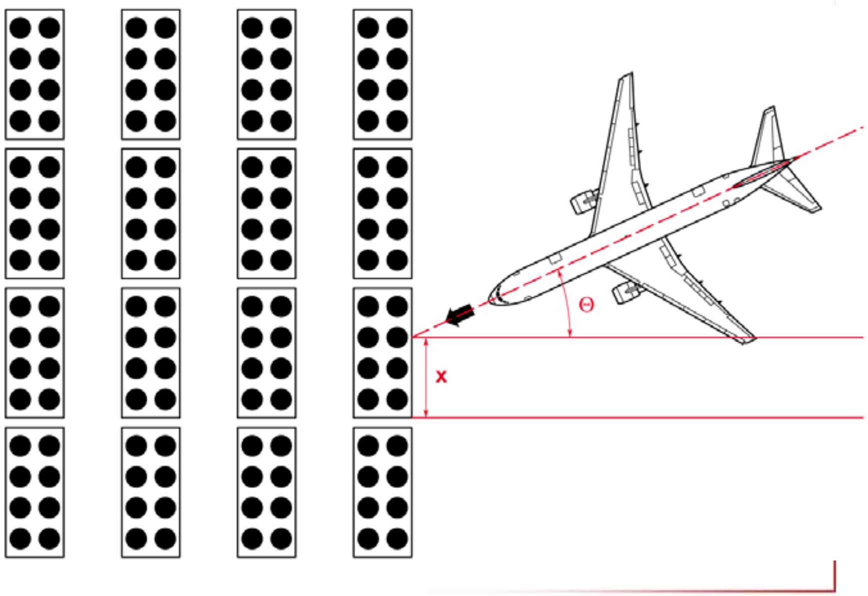
Vulnerability Assessments for Transportation and Storage of SNF & other RAM

- **Estimate SNF package response to airplane impacts and large blast events in response to 9/11**
- **Analyses of real casks conducted using benchmarked codes**
- **Potential source term and consequences estimated**
- **Develop source term guidance for potential sabotage events**
  - **Spent fuel transport and storage packages**
  - **Non-SF packages**
  - **Expert panel provided independent review**
- **SNL and NRC worked together to define threat scenarios**

Vulnerability Assessments: Field of Casks

- **Aircraft could attack from a variety of directions and angles of descent**
- **Cask-to-cask interaction is very chaotic**
- **Evaluated transfer of momentum and impact by the hardest structural components of the aircraft**

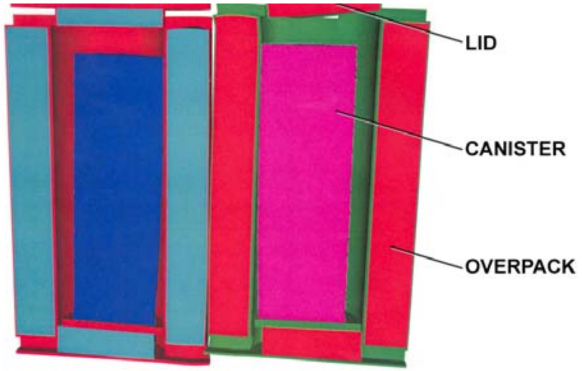




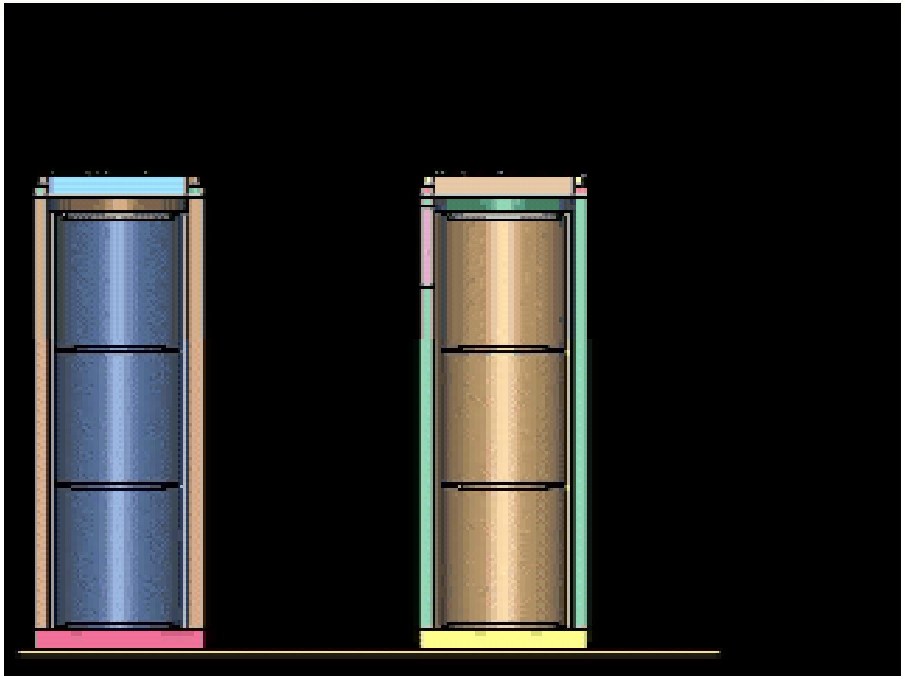
Vulnerability Assessments: Analysis Methodology

- Global analyses evaluated overall crash response
  - Transient force on cask
  - Cask velocity & displacement
  - CTH was used for these calculations

- Local analyses evaluated cask and canister detailed response
  - Cask integrity to impacts from aircraft & components
  - Penetration from hard components
  - Cask-to-cask impacts
  - Canister response
  - Analyses conducted using FEM



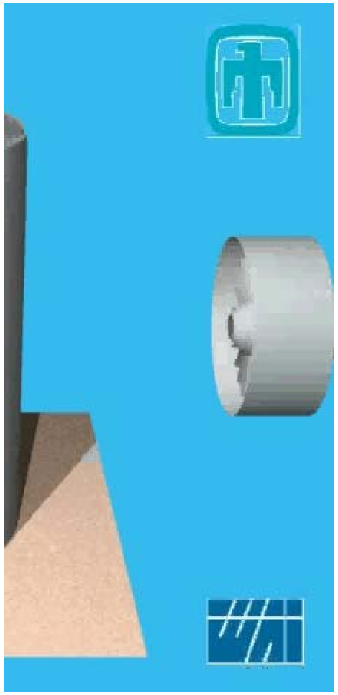
Vulnerability Assessments: Aircraft Impacting Typical Cask

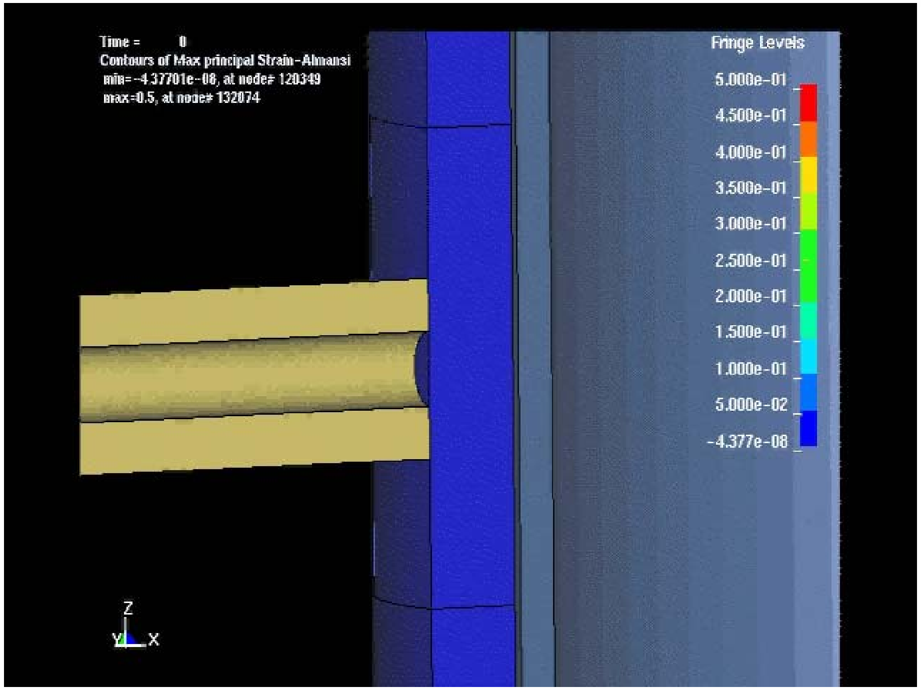


Animation

Vulnerability Assessments: Example Hard Component Analyses

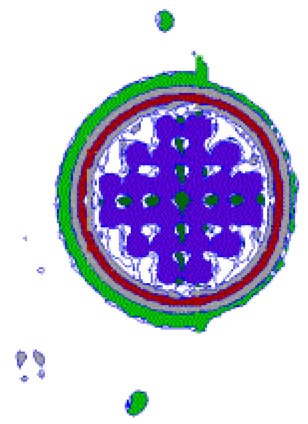
Animations

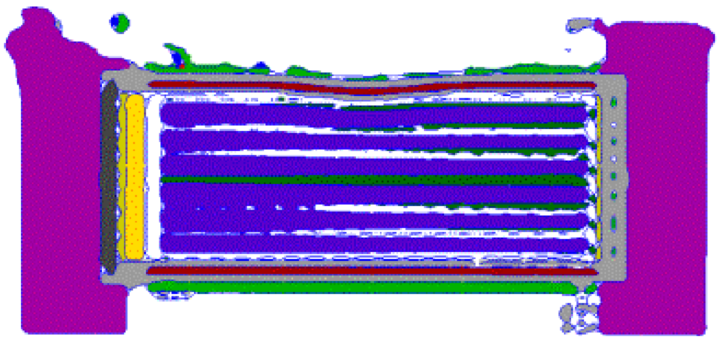




Vulnerability Assessments: Blast Analyses

- **Loading and standoff specified by NRC**
- **Standoff representative of a realistic delivery scenario**

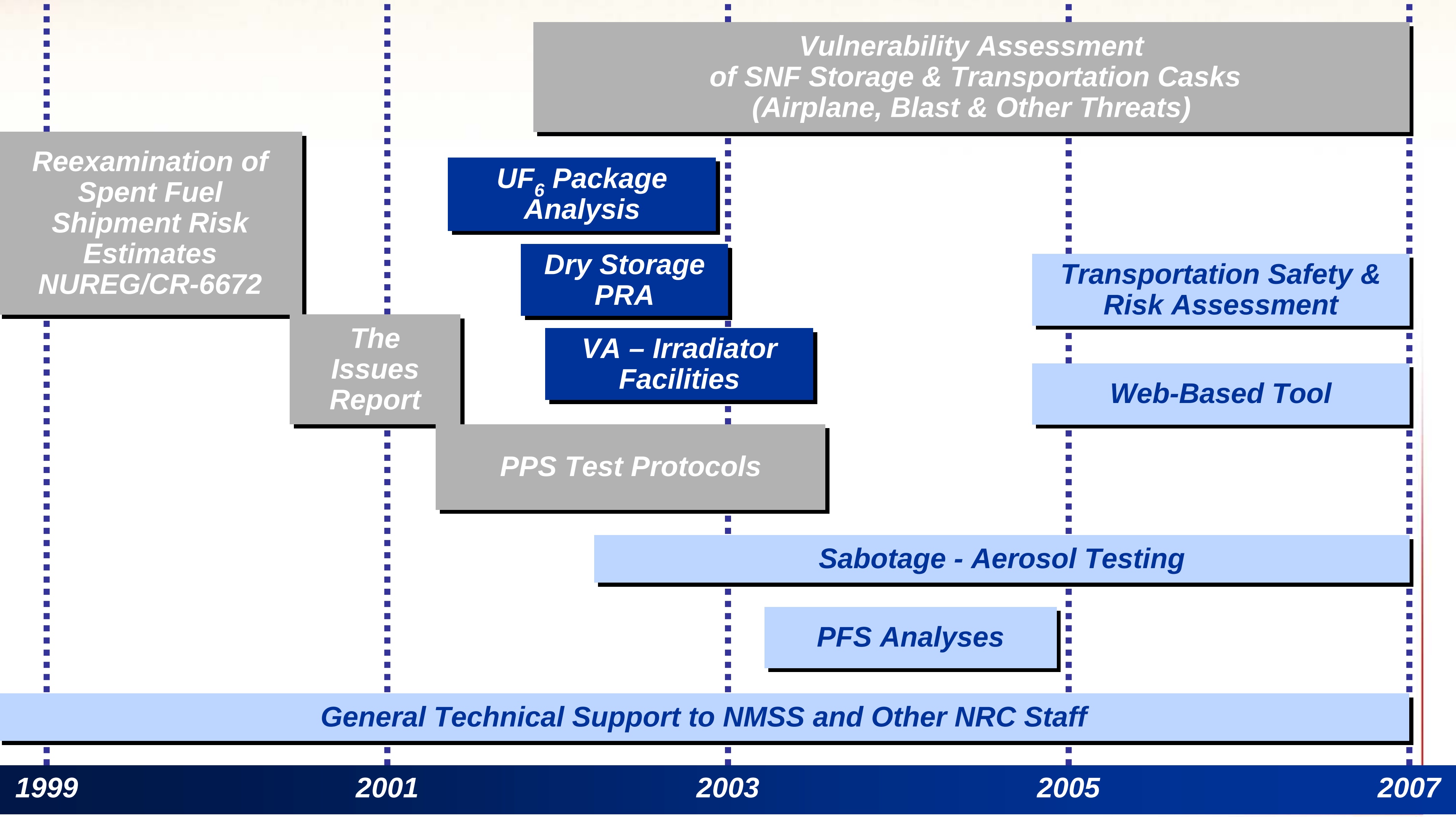




Guidance Documents & Vulnerability and Threat Assessments

- **Non-Spent Fuel Radioactive Materials Source Term Guidance Document**
  - **6 packages, 180+ scenarios, August 2004**
- **Spent Fuel Source Term Guidance Document**
  - **7 packages, 150+ scenarios, November 2004**
- **16 scenarios were included in these evaluations**

➢ **Documents provide basis for estimating public health consequences**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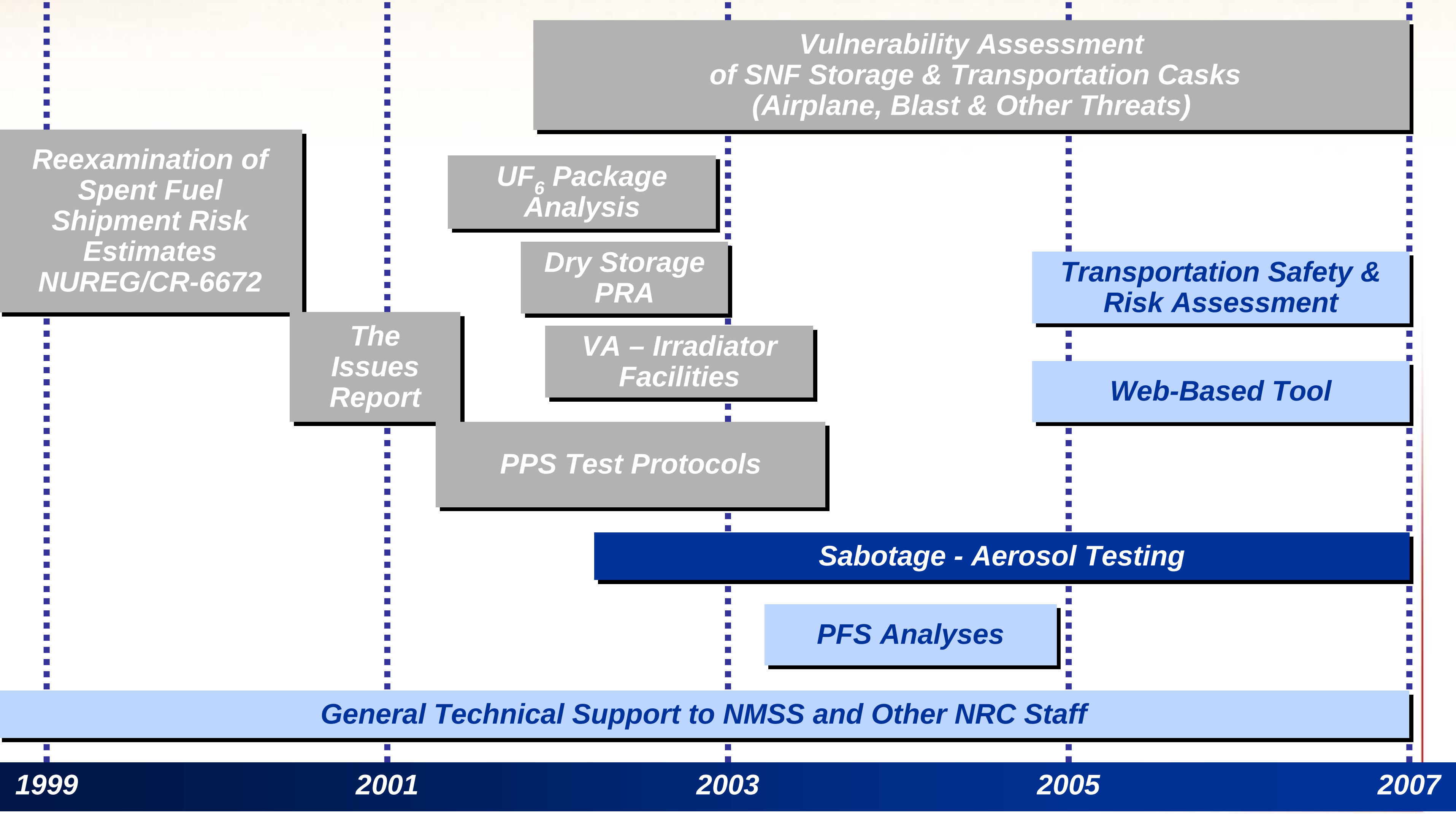
UF_6 Package Analysis, Dry Storage PRA & VA of Irradiator Facilities

- **Performance Study of NRC Approved UF_6 Packages**
  - **Evaluate the performance of 3 NRC-approved UF_6 packages to conditions of potential accidents**
  - **Results: Probability of a real accident exceeding regulatory conditions is very low**
  - **SAND Report published on January 2003**

- **SNL Peer Review of NRC Dry Cask Storage PRA Report**
  - **Technical peer review of a dry cask storage PRA using ASME PRA guidance**

- **Conduct Vulnerability Assessments of 3 U.S. Irradiator Facilities**
  - **Physical Protection Vulnerabilities Assessment and Guidance Development for 10CFR36 Licensees, September 2003**
  - **Develop guidance needed to implement any new physical protection requirements**
  - **Scope: Consider only explosives and not required to consider a thermal driver in the analyses**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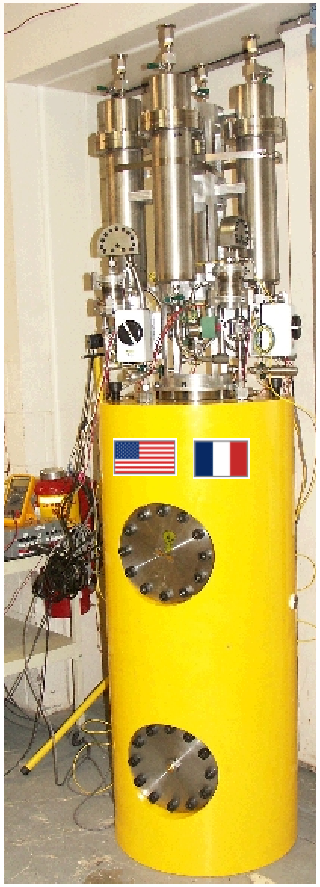
Sabotage - Aerosol Testing

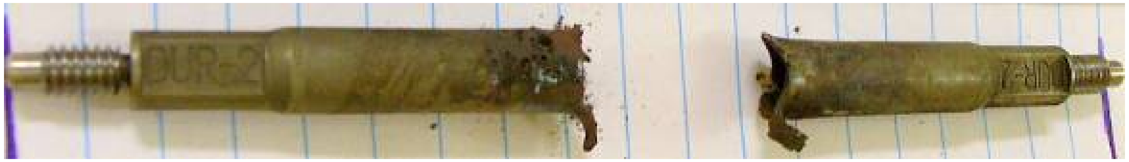
- **SCENARIO: plausible sabotage attack on nuclear transport casks by HEDD**
- **GOALS: Quantify source-term data and conduct aerosol analyses on CeO_2, DUO_2, and SNF to determine:**
  - **Measure respirable fractions**
  - **Calculate enrichment factors**
  - **Determine spent fuel ratio**
- **Supported jointly by DOE & NRC**
- **Collaboration with an International Working Group**
- **Four Phase Test Program:**
  - **Phase 1: CSC characterizations, glass targets (2001-2002)**
  - **Phase 2: CeO_2 ceramic pellet rodlets, ~ 30 tests (2002-2005)**
  - **Phase 3: DUO_2 pellets/rodlets, 6 tests (2006-2007)**
  - **Phase 4: SNF rodlets, 8 tests (2007-2008)**
- **FY07 - modeling studies & safeguards support**



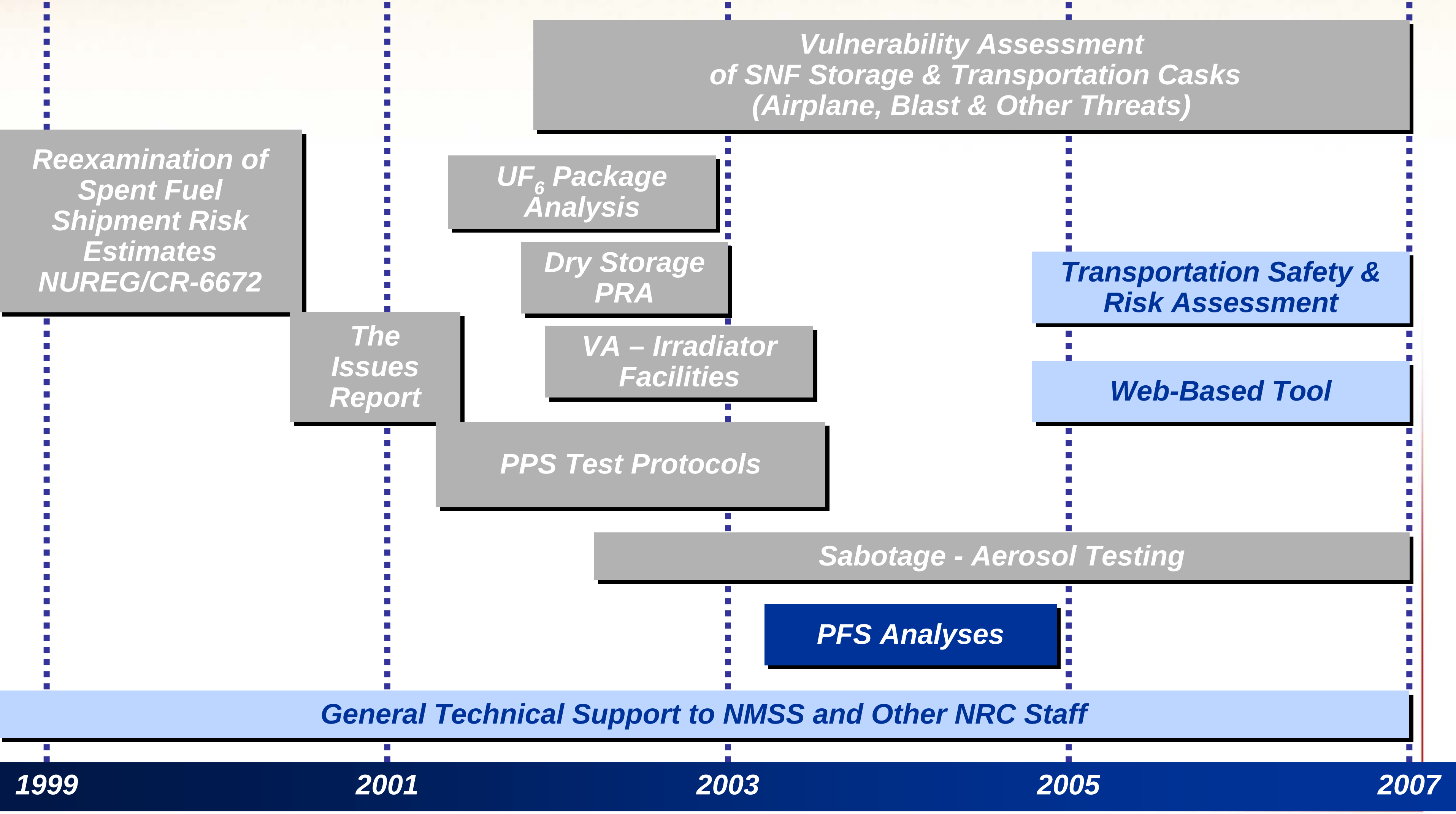
DUO_2 Aerosol – Explosive Test Chamber

Sabotage - Aerosol Testing (cont.)

- **Reliable source-term data and supporting analyses will determine the release of respirable aerosol particles**
  - **YMP EIS conservatively assumed 5% respirable fraction**
- **Guide and validate the technical basis for transport & storage regulations (10 CFR Parts 71, 72, and 73)**
- **Support security/safeguards procedures & mitigation strategies**
- **Provide basis for evaluating appropriate levels of physical protection for SNF shipments & site operations**
- **Significant results to date:**
  - **CeO_2 respirable fraction = 1.4% +/- 0.6%**
  - **DUO_2 respirable fraction = 1.3% +/- 0.4%**
  - ➡ **Results predicting reduced consequences**



⬅ **post-test DUO_2 rodlet**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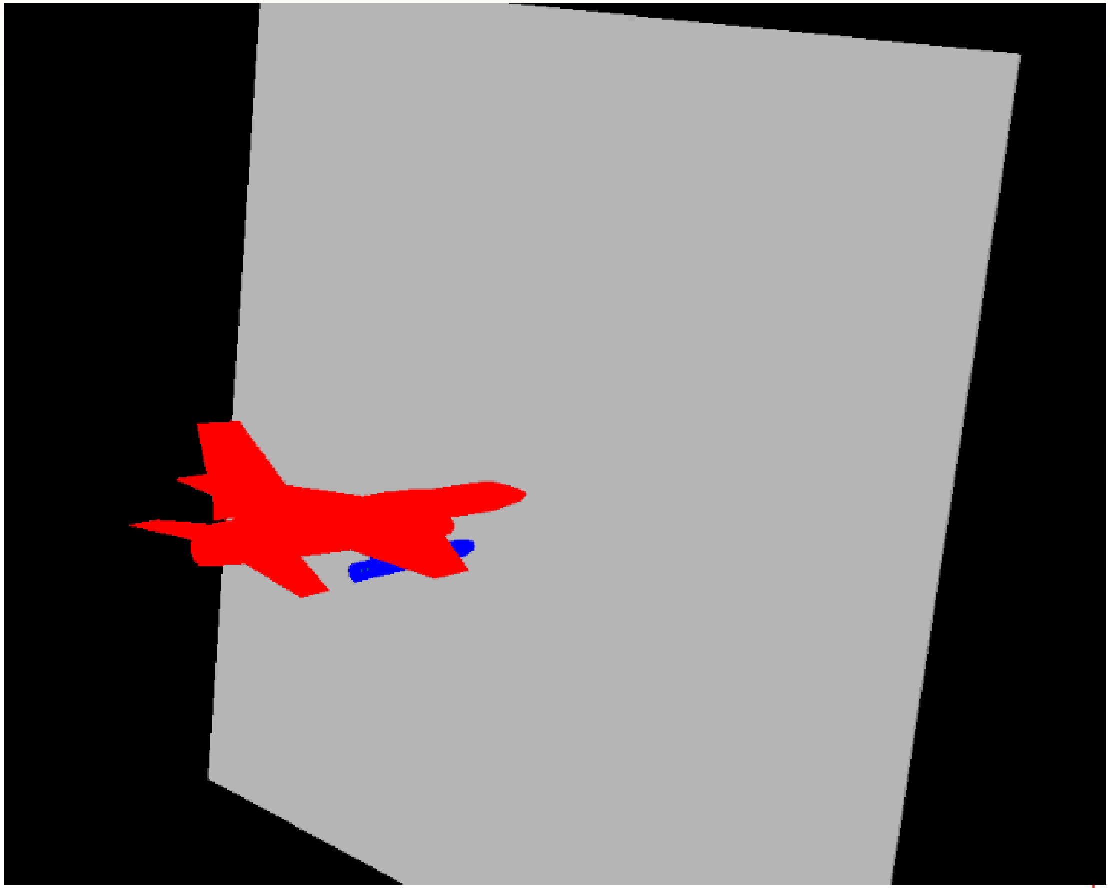
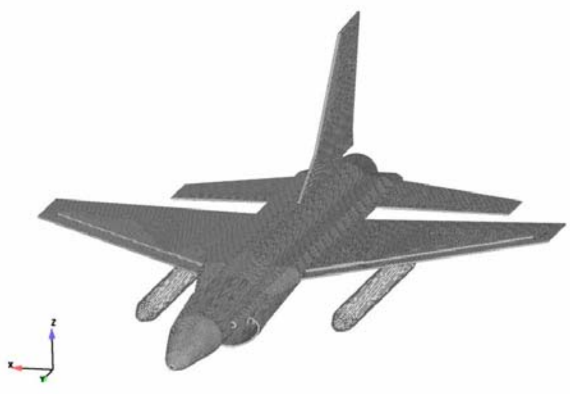
Independent Analysis for Licensing of PFS

Sandia F-4 Crash Test & F-16 Simulation

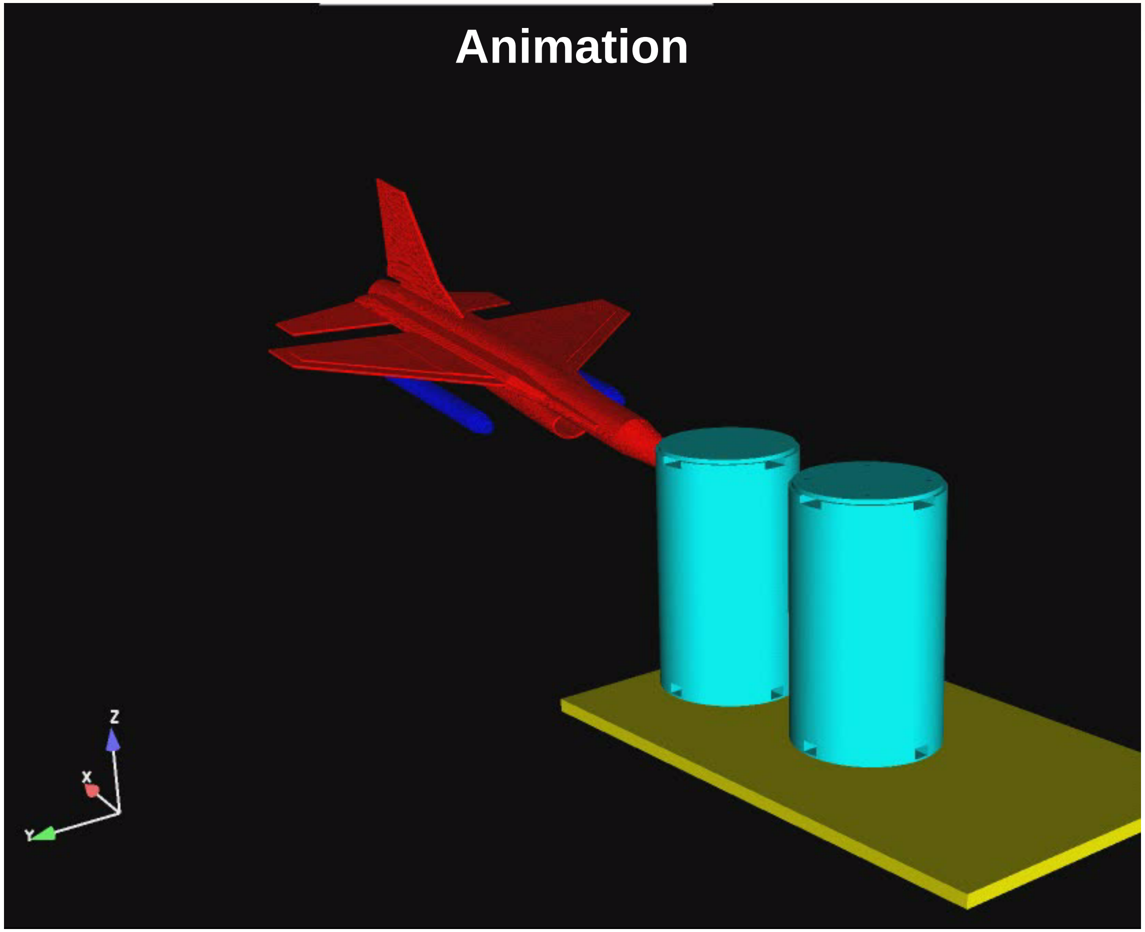


PFS: PRONTO SPH Aircraft Impact



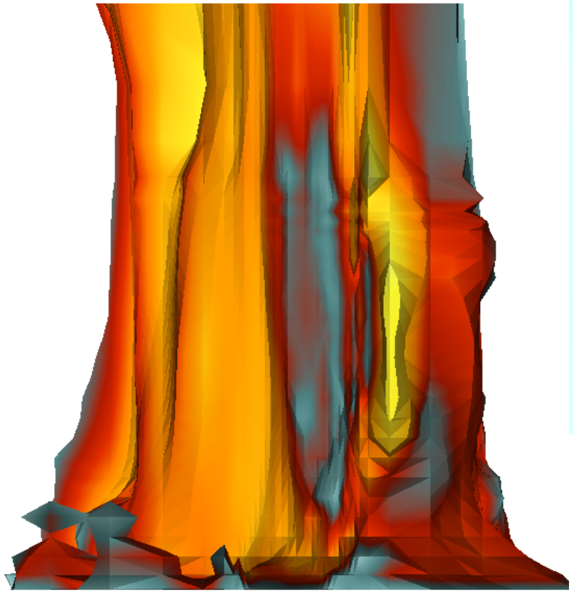
SPH Model

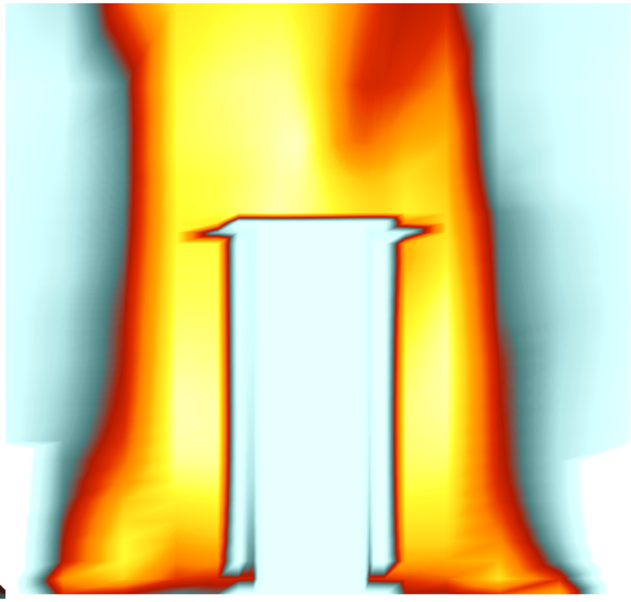
SPH Model
(Fuel Tanks and Engine)



PFS: Fire and Heat Transfer Analyses

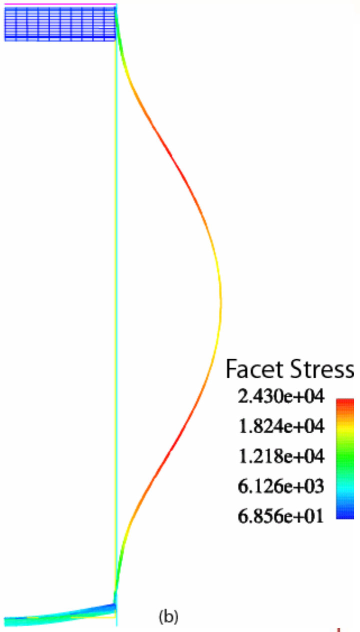
Fire

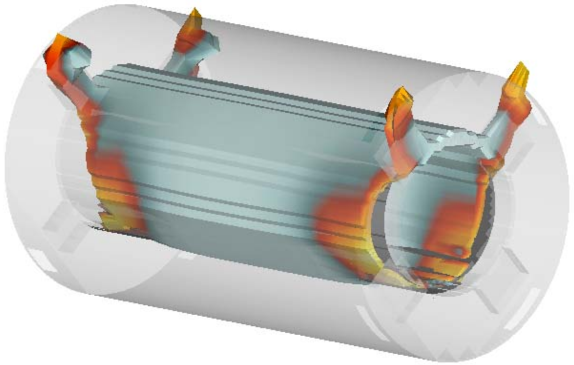


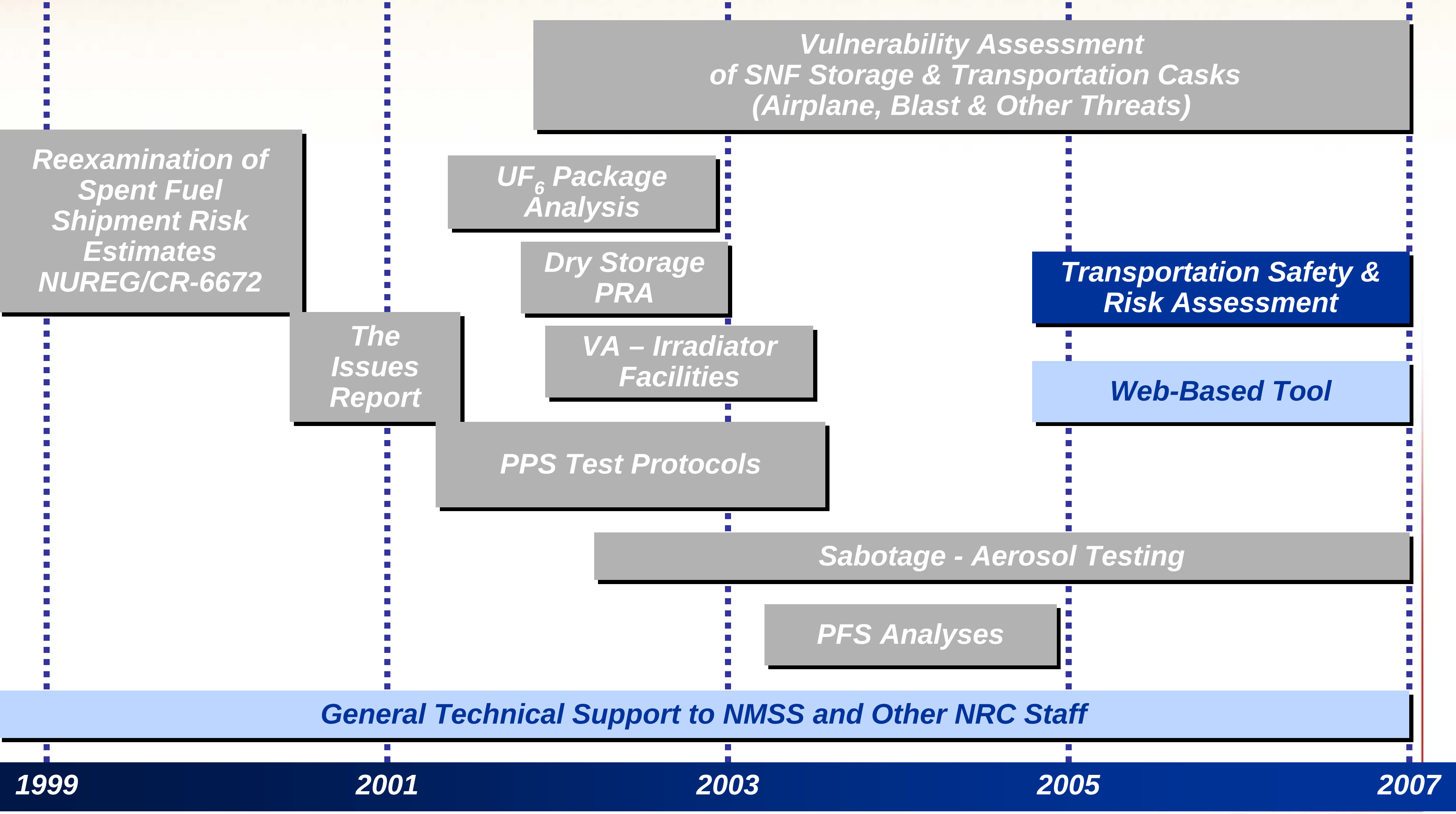


Heat Transfer

Thermo-Mechanical



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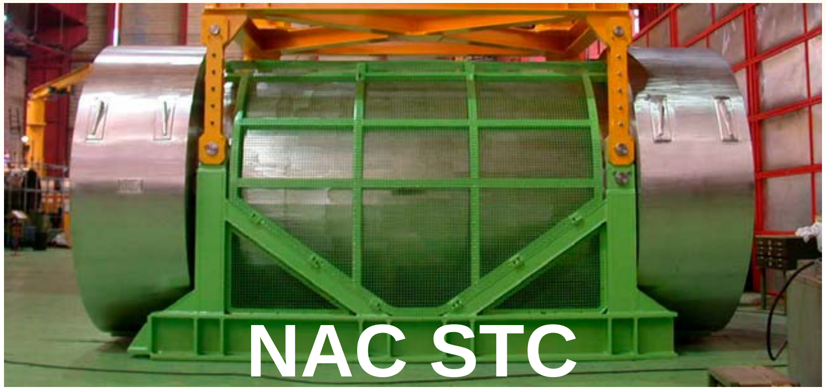
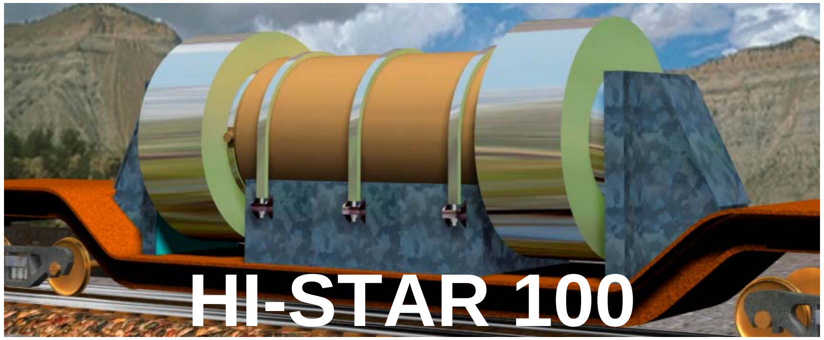
Transportation Safety & Risk Assessment

- **Analyses to be Performed:**
  - **Accident probability**
  - **Extra-regulatory impacts onto an unyielding target**
  - **Extra-regulatory engulfing fires**
  - **Source term generation**
  - **Radioactive material dispersion (if there is any release)**
  - **Consequence**
  - **Risk Assessment**





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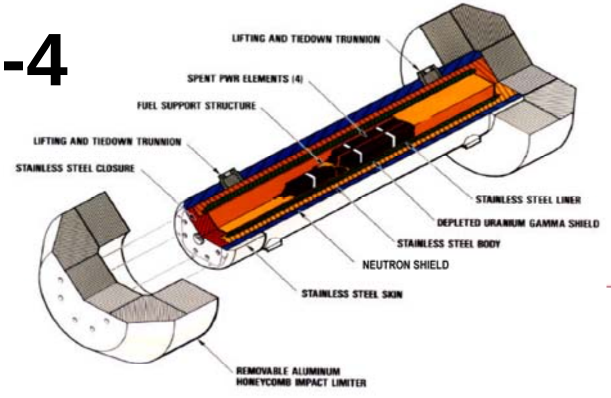

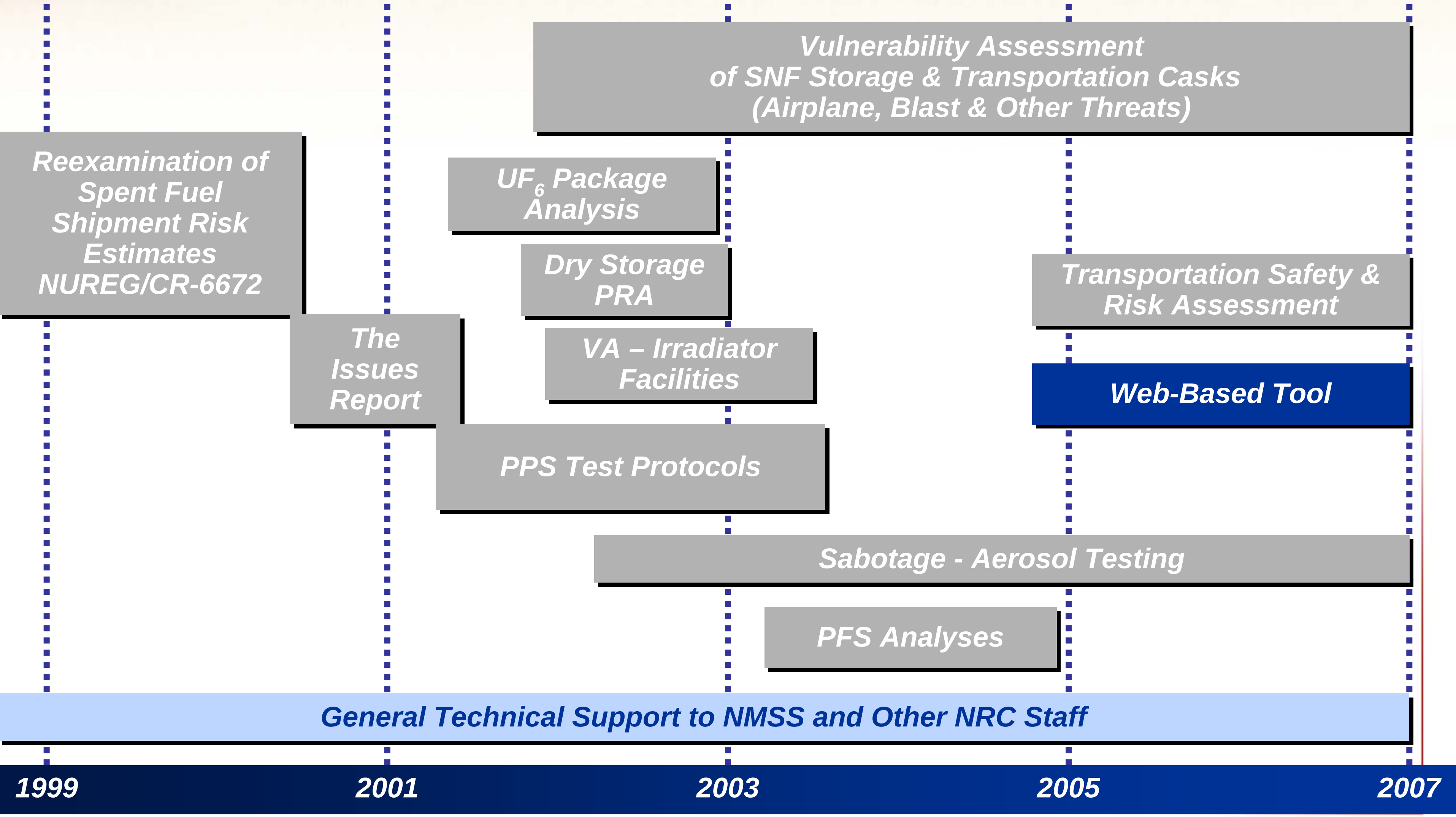
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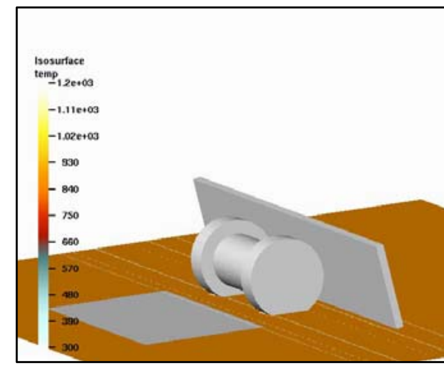
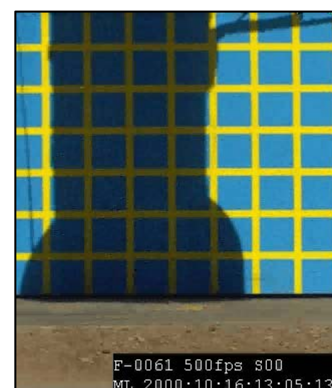
A Web-based Educational Tool Demonstrating the Severity of Regulatory Testing for Spent Nuclear Cask Safety

SEVERE TESTING

COMPUTER ANALYSIS



WEB INTERFACE



REGULATORY TESTING

NNSA National Nuclear Security Administration

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Potential Future Work

- **Fuel behavior in the transport environment**
  - **Mechanical response to impact loadings**
  - **Behavior in transitional high thermal, oxidizing environments**
- **Technical support for 10CFR73 rule-making**
  - **Support technical base development for rule-making associated Cat I&II shipments**
  - **Support technical base development for rule-making associated with IAEA Code of Conduct shipments**
- **Full-scale testing of a rail cask to demonstrate safety, validity of scaling laws, and adequacy of the regulations**