



U.S. DEPARTMENT OF
ENERGY

Nuclear Fuels Storage & Transportation Planning Project
Office of Fuel Cycle Technologies

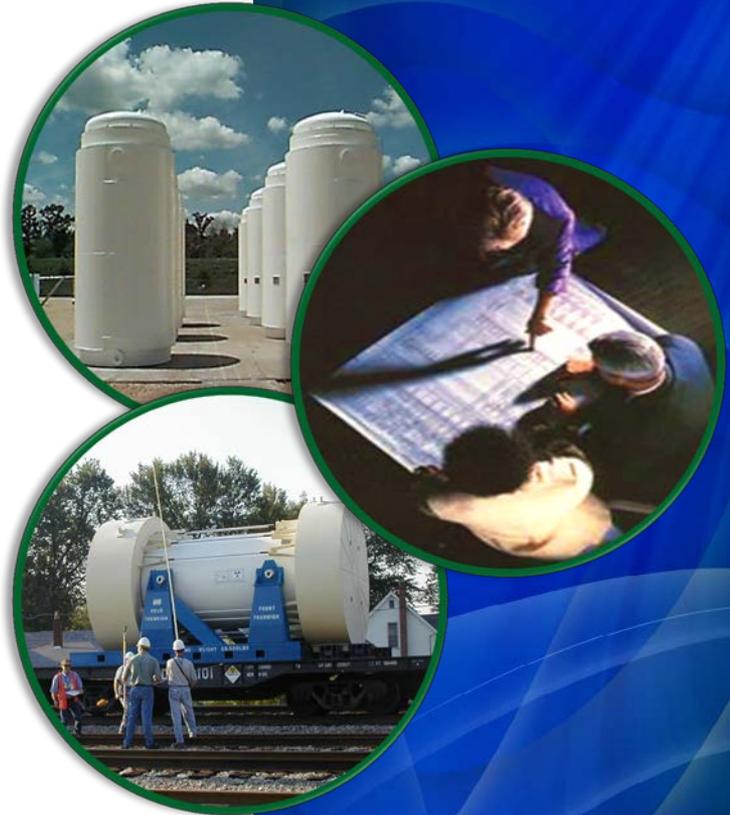
Nuclear Energy

Preparation for Transportation of SNF Stored at Commercial Nuclear Power Plants

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NFST Program Background

- **The mission of the Nuclear Fuels Storage and Transportation Planning Project (NFST) is to lay the groundwork for future consolidated interim storage and large-scale transportation of spent nuclear fuel**
- **This includes:**
 - Technical Analysis – Alternative Interim Storage Configurations and Technologies, Transportation Technologies, Standardized Canisters, Storage/Transportation Systems Analysis, Spent Fuel Data
 - Engagement with Key Stakeholders – National Transportation Stakeholders Forum, NFST Transportation Core Group, Tribal Caucus, Cooperative Agreements with State Regional Groups and the National Conference of State Legislatures (NCSL)



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Nuclear Energy

Spent Fuel Stored at Commercial Nuclear Power Plant Sites



Prairie Island



Kewaunee



Connecticut Yankee

Question i. a.

Nuclear Energy

- **For the SNF inventory stored at operating and shutdown nuclear power plant sites, what operational or regulatory actions will be required prior to transportation of damaged and non-standard SNF from dry-storage systems at the sites?**



Transportation of Damaged and Non-standard SNF

■ What is Damaged Fuel?

- Damaged fuel is defined by the NRC in ISG-1, *Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function*
- Any fuel rod or fuel assembly that cannot fulfill its fuel-specific or system-related functions

■ Transportation casks

- Designed and certified with provisions for damaged fuel
- If there is a Certificate of Compliance (CoC) from NRC with provisions for damaged fuel, no further regulatory actions are required

■ Damaged fuel can (or failed fuel can)

- A damaged fuel can is a stainless steel container that confines damaged spent nuclear fuel
- Damaged fuel cans are closed at the end by screened openings. Screens allow gaseous and liquid media to escape but minimize particulate dispersal





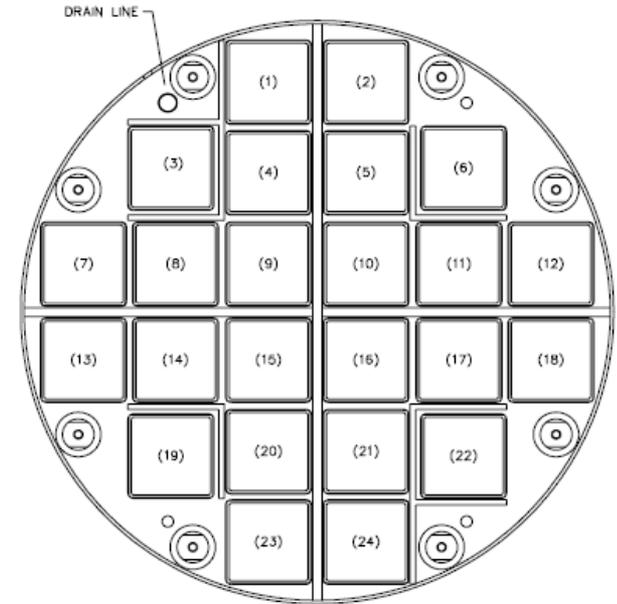
Transportation of Damaged and Non-standard SNF

■ NRC Certificates of Compliance (CoC) for transportation casks

- Allows for a limited number of damaged assemblies (placed in damage fuel cans) in the casks
- Damaged fuel can placement is dictated by each cask's CoC
- Placement is often in the four corner positions of the casks, or in the periphery positions of the casks

■ Non-standard SNF

- Assemblies that are missing rods or fuel debris from assemblies are generally required to be placed in damaged fuel cans





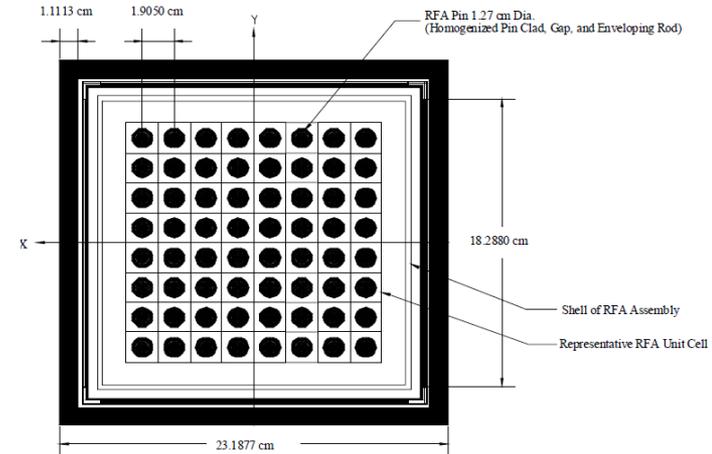
Transportation of Damaged and Non-standard SNF

■ Other Special Packaging

- Containers similar to damaged fuel cans may be required for packaging individual rods, groups of rods, or fuel debris
- Example – Yankee Rowe – Has a reconfigured fuel assembly consisting of a shell (square tube with end fittings) and a basket assembly that supports 64 tubes in an 8 × 8 array, which holds intact fuel rods, damaged fuel rods, or fuel debris

■ Fuel Status Change: Intact to Damaged

- Example – Rancho Seco - Six fuel assemblies in five canisters originally identified as intact were subsequently reclassified as damaged when the definition of damaged fuel was changed
- Additional regulatory actions will be required prior to shipment



Question i. b.

- **For the SNF inventory stored at operating and shutdown nuclear power plant sites, what types of dry-storage canisters and casks holding SNF are not currently licensed for transportation and how much SNF do they contain? How much more SNF is planned to be loaded into canisters and casks not currently licensed for transportation?**

Existing Cask and Canister Transport Certification Status

- **Commercial nuclear power plant licensees select their own dry storage systems, without any involvement from DOE.**

- **11,019 SNF assemblies stored in 427 storage-only canisters or casks at 12 sites**

- **SNF is also stored in canisters or casks that are designed for transport but do not have a current transportation certificate of compliance (CoC). Their status is:**
 - Applications for transportation CoCs for some cask designs are undergoing review, while others have yet to be submitted
 - Modifications to the transportation CoC would have to be made before the spent nuclear fuel could be shipped
 - Transportation casks or impact limiters need to be fabricated
 - A total of 325 canisters containing 11,895 spent nuclear fuel assemblies at 14 sites are estimated to fall in these categories



Storage-only Spent Nuclear Fuel Canisters or Casks (1)

Utility	Reactor	Type	License type	Vendor	Cask system	Canister or cask type	Total canisters or casks loaded	Assemblies stored	Storage configuration
Constellation	Calvert Cliffs	PWR ^a	SS ^b	TN ^c	NUHOMS [®]	24P	48	1152	Canister in horizontal concrete overpack
Constellation	Calvert Cliffs	PWR	SS	TN	NUHOMS [®]	32P	28	896	Canister in horizontal concrete overpack
DOE	INL		SS	TN	NUHOMS [®]	12T	29 ¹	177	Canister in horizontal concrete overpack
Dominion	Surry	PWR	SS	GNS	Castor	V/21 and X33	26	558	Bare fuel
Dominion	Surry	PWR	SS	NAC	NAC-I28	NAC-I28	2	56	Bare fuel
Dominion	Surry	PWR	SS	W	MC-10	MC-10	1	24	Bare fuel
Duke	Oconee	PWR	GL/SS	TN	NUHOMS [®]	24P	84	2016	Canister in horizontal concrete overpack
Duke	Oconee	PWR	GL	TN	NUHOMS [®]	24PHB	50	1200	Canister in horizontal concrete overpack
Entergy	ANO	PWR	GL	BFS/ES	FuelSolutions	VSC-24	24	576	Canister in concrete overpack
Entergy	Palisades	PWR	GL	BFS/ES	FuelSolutions	VSC-24	18	432	Canister in vertical concrete overpack
FirstEnergy	Davis-Besse	PWR	GL	TN	NUHOMS [®]	24P	3	72	Canister in horizontal concrete overpack



Storage-only Spent Nuclear Fuel Canisters or Casks (2)

Utility	Reactor	Type	License type	Vendor	Cask system	Canister or cask type	Total canisters or casks loaded	Assemblies stored	Storage configuration
FPL	Point Beach	PWR	GL	BFS/ES	FuelSolutions	VSC-24	16	384	Canister in vertical concrete overpack
PPL	Susquehanna	BWR	GL	TN	NUHOMS [®]	52B	27	1404	Canister in horizontal concrete overpack
Progress	Robinson	PWR	SS	TN	NUHOMS [®]	7P	8	56	Canister in horizontal concrete overpack
Duke	McGuire	PWR	SS	TN	TN Metal Cask	TN-32	10	320	Bare fuel in bolted metal cask
Dominion	North Anna	PWR	GL	TN	TN Metal Cask	TN-32	27	864	Bare fuel in bolted metal cask
Dominion	Surry	PWR	SS	TN	TN Metal Cask	TN-32	26	832	Bare fuel in bolted metal cask
Total							427	11019	
^a PWR = pressurized water reactor ^b SS = Site specific license ^c TN = Transnuclear, Inc. ^d GNS = General Nuclear Services ^e NAC = NAC International ^f W = Westinghouse					^g GL = General license ^h ANO = Arkansas Nuclear One ⁱ BFS/ES = BNFL Fuel Solutions/EnergySolutions ^j FPL = Florida Power and Light ^k PPL = Pennsylvania Power and Light (formerly) ^l BWR = boiling water reactor				



Transportable Storage Systems and Transportation Casks

Site	Type	Storage System/Canister	Transportation Cask	Canisters	Assemblies	Status
Zion	PWR	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN	61 (Current)	2226	Application for transportation CoC under review.
Kewaunee	PWR	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN	24 (Estimated)	887	Application for transportation CoC under review.
Catawba	PWR	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN	5 (Current)	185	Application for transportation CoC under review.
McGuire	PWR	NAC MAGNASTOR/TSC-37 canister	MAGNATRAN	6 (Current)	222	Application for transportation CoC under review.
Humboldt Bay	BWR	HI-STAR HB/MPC-HB canister	HI-STAR HB	1 (Current)	44	Transportation CoC must be modified to reduce enrichment to 2.08%.
Rancho Seco	PWR	TN NUHOMS/FO-DSC, FC-DSC, and FF-DSC canisters	MP187	5 (Current)	6	Transportation CoC must be modified to allow shipment of 6 damaged fuel assemblies in 5 canisters
San Onofre	PWR	Holtec HI-STORM UMAX/MPC-37	HI-STAR 190	73 (Estimated)	2668	Application for transportation CoC has not been submitted
Callaway	PWR	Holtec HI-STORM UMAX/MPC-37	HI-STAR 190	48 (Estimated)	1776	Application for transportation CoC has not been submitted
Clinton	BWR	Holtec HI-STORM FW/MPC-89	HI-STAR 190	8 (Estimated)	712	Application for transportation CoC has not been submitted
Summer	PWR	Holtec HI-STORM FW/MPC-37	HI-STAR 190	18 (Estimated)	666	Application for transportation CoC has not been submitted
Watts Bar	PWR	Holtec HI-STORM FW/MPC-37	HI-STAR 190	10 (Estimated)	370	Application for transportation CoC has not been submitted
South Texas	PWR	Holtec HI-STORM FW/MPC-37	HI-STAR 190	12 (Estimated)	444	Application for transportation CoC has not been submitted
Rancho Seco	PWR	TN NUHOMS/FO-DSC, FC-DSC, and FF-DSC canisters	MP187	21 (Current)	493	Transportation CoC must be updated to -96 before fabrication of cask or impact limiters
Big Rock Point	BWR	Fuel Solutions W150 Storage Overpack/W74 Canister	TS125	7 (Current)	441	Transportation CoC must be updated to -96 before fabrication of cask or impact limiters
San Onofre-1	PWR	TN Standardized Advanced NUHOMS/24PT1 canisters	MP187	17 (Current)	395	Transportation CoC must be updated to -96 before fabrication of cask or impact limiters
Prairie Island	PWR	TN Metal Cask	TN-40HT	9 (Current)	360	Application for transportation CoC has not been submitted
Total				325	11,895	

Question i. c.

Nuclear Energy

- **For the SNF inventory stored at operating and shutdown nuclear power plant sites, what problems or challenges exist in designing and fabricating systems and components needed for transportation of SNF? How will the challenges be addressed? How are you incorporating consensus standards into the design of these components?**

Challenges with Components Needed for SNF Transport

■ No insurmountable technical challenges have been identified

- Long-lead time activities have been identified and initiated

■ Transportation casks

- Most casks needed for de-inventory of the shutdown sites are already designed and certified
 - Some cask's certificates need updating
 - No known issues with making these updates
 - MAGNATRAN certificate application is under review by NRC (Zion, Kewaunee)
 - HIGH-STAR 190 certificate application not yet submitted (San Onofre)
- Global demand for high-pedigree (ASME Section III) metals for cask fabrication and for shops capable of building to Section III requirements could affect lead-time for cask procurement
- NFST has not yet evaluated the needs for transportation casks at operating reactor sites
 - Task Order 17 provided preliminary designs of re-usable casks for transporting bare fuel from both EnergySolutions and AREVA
 - No indication of issues regarding fabrication of these designs
 - NFST will begin looking at conditions and needs at operating sites as funding becomes available

Challenges with Components Needed for SNF Transport

■ Designing and fabricating a railcar

- No known issues, see railcar discussion in subsequent slides

■ Consensus standards: Railcars

- The railcars (cask car, buffer car and escort car) will all meet Association of American Railroads (AAR) S-2043 requirements
 - After a successful development, analysis, and testing program, AAR will grant **conditional approval**, which means that the railcars can be used for actual shipments of SNF
 - Between 50,000 and 100,000 miles of service, AAR requires additional testing of the railcars. If the railcars pass these tests, then AAR will grant **full approval** of the railcar design

Challenges with Components Needed for SNF Transport

■ Consensus standards: Transportation Systems

- ANSI N14 has developed standards applicable to spent fuel packages:
 - Two current standards are directly applicable (N14.5, N14.36)
 - Two applicable standards are being developed (N14.6, N14.33)
 - NFST is evaluating the need for N14 spent fuel-related projects that have been terminated over the past few years due to lack of activity
- ASME Boiler and Pressure Vessel Code requirements (Sections III and VIII) are used for design and fabrication of transportation packages
- Fire testing of transportation packages conforms to ASTM E2230-13
- NFST has staff involvement in development of ANSI N14, ASME B&PVC, and ASTM consensus standards related to transport packages

Question i. d.

- **In the design of the new railcar for the transport of commercial SNF, what features of existing rail cars are being changed or upgraded and why?**

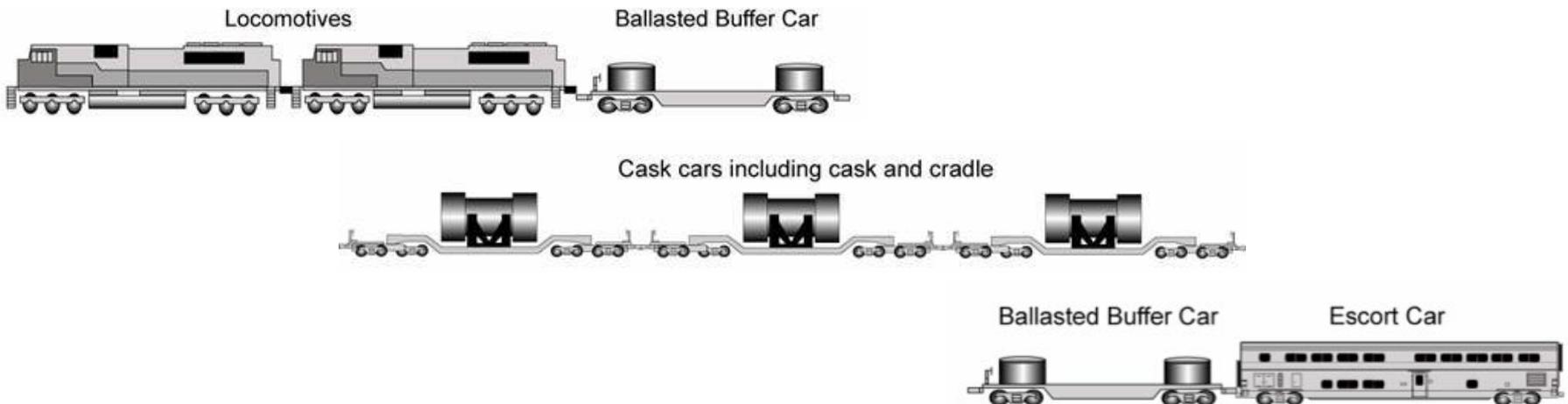


Railcar Design

■ Development of the cask and buffer railcars is currently in a procurement sensitive state

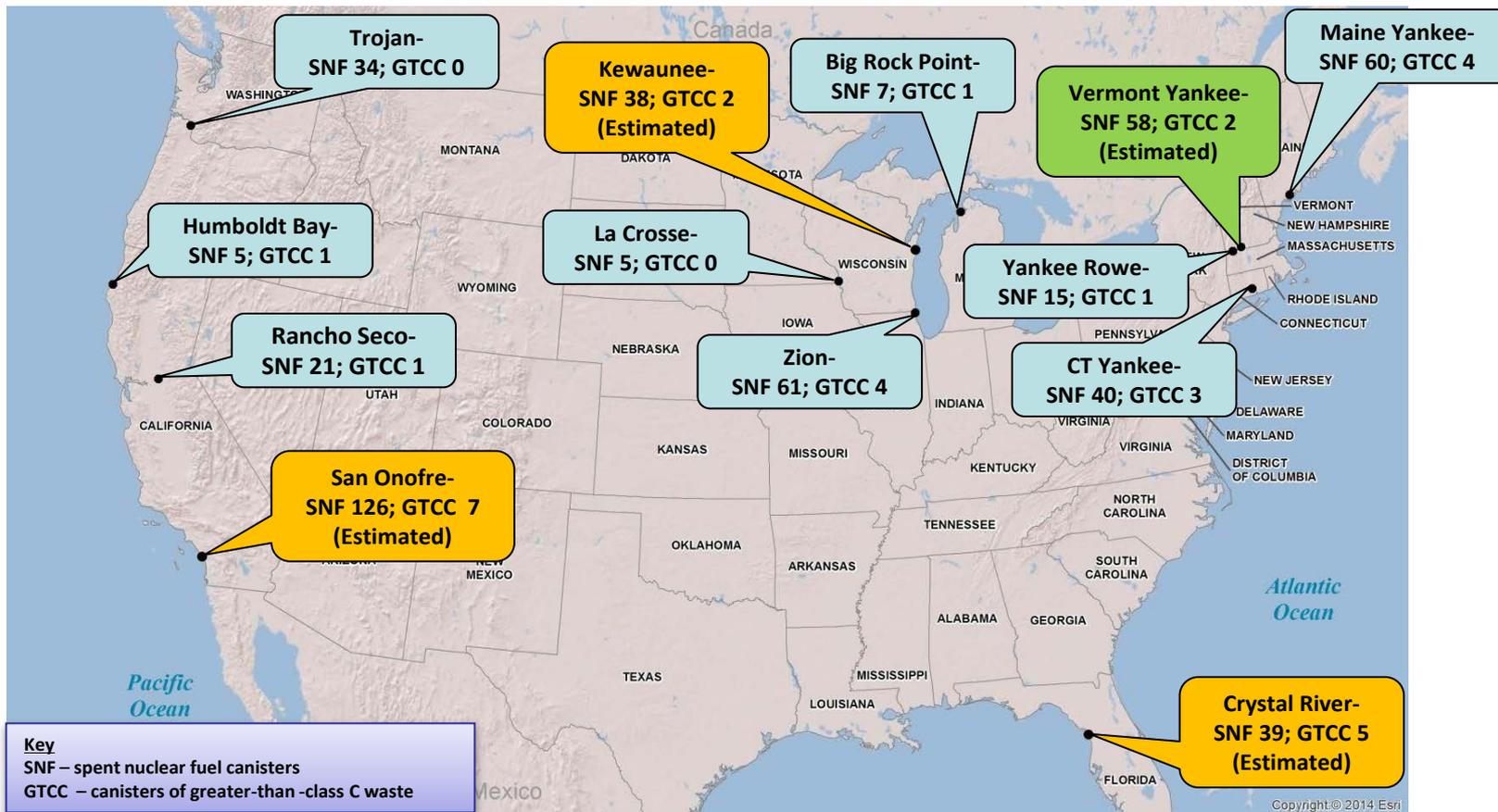
- The initial contract will cover the design, analysis and fabrication of the cask and buffer railcars for testing
- It is anticipated that this contract will be placed in the next 2 months
- No design work has yet been performed

■ NFST is evaluating options for acquiring compliant escort railcar





Locations of Shutdown Reactor Sites



Question ii. a.

Nuclear Energy

- **For shutdown nuclear power plant sites, have transportation issues or challenges been identified in the most recent site assessments that are different from the issues and challenges noted in earlier site assessments?**



Shutdown Sites: Issues and Challenges

■ FICAs, NSTIs, SPDs, and FIDS used as starting point in development of NFST shutdown sites report

FICA	Facility Interface Capability Assessment Project
NSTI	Near-Site Transportation Infrastructure Project
SPD	Services Planning Document
FIDS	Facility Interface Data Sheets

- Developed 1987 – 2005
- FICA and NSTI included site visits
 - Most recent visit was in 1991

■ NFST Program Shutdown Site Assessments

- 12 shutdown sites visited 2012-present
- Significant changes at some sites since previous studies



Shutdown Site Visits

- **Confirmed aspects of inventories at the sites, obtained detailed inventory data by canister, canister load maps, and canning of damaged and high burnup fuel**
- **Observed transportation infrastructure at and near sites**
- **Detailed photos taken at and near sites**
- **Leveraged technology during site visits**
 - Google Earth overhead satellite views
 - GPS and GIS (Stakeholder Tool for Assessing Radioactive Transportation, START)
 - Geo-coded dashboard camera photos for highway/rail routes
- **Information provided by the sites coupled with the opportunity to visit each site has been critical to DOE's understanding of the conditions at and near the shutdown sites**
- **Latest version of the shutdown sites report (SSR) posted on the DOE NE website on 05/28/2015**





Shutdown Sites – Transportation Issues and Challenges

■ Many transportation issues and challenges identified previously remain

- Weights and dimensions of railcars – will require route clearance for every shipment
- Condition of nearby rail, road, and barge infrastructure
 - General decay of transportation infrastructure
 - Abandonment of rail lines near sites - rail line to Humboldt Bay has been abandoned, resulting in a 160 to 260 mile heavy haul truck route
 - Highway infrastructure, roundabouts, overhead and lateral clearances
- Permitting, dredging, and bridge clearance for barge shipments
- Permitting for heavy-haul truck shipments
- Identifying potential transload locations
- Seasonal restrictions – winter and tourists



Onsite Rail at Crystal River

Shutdown Sites – Transportation Issues and Challenges

■ Some differences have been observed between previous assessments and current assessments of shutdown sites

- Rail is now the preferred transportation mode due to size and weight of spent fuel canisters
 - Heavy-haul truck (i.e., superloads) or barge shipments to transload locations are also included
- Additional route clearance issues from larger weights and dimensions
 - Several current casks have up to 12-foot diameter impact limiters, previous analyses based on 10'8"
 - Current casks weigh up to 156 tons for gross railcar weight of 250 tons; earlier assessments based on 100- to 125-ton rail transportation casks
 - Longer heavy haul truck lengths due to heavier casks needing more axles
- Local resistance to barging on Great Lakes and the California coast
- Loss of institutional knowledge of workforce and capabilities at shutdown sites



Shutdown Sites – Transportation Issues and Challenges

■ Additional differences between previous assessments and current assessments of shutdown sites

- Removal or disuse of onsite transportation infrastructure after decommissioning
- Potential upgrades of near-site roads, bridges, rail
- Rail industry changes – more short lines, more carrier interchanges, right-of-way ownership
 - Some short lines are publically owned and may have different issues and concerns than privately owned railroads

■ Increased consultative transportation planning process

- Site visits now involve State Regional Groups, states, Tribes, and Federal Railroad Administration
- Because of Federal Railroad Administration involvement, we have had direct access to railroad facilities



Question ii. b.

Nuclear Energy

- **For shutdown nuclear power plant sites, what are DOE's priorities related to removing SNF from the sites and how do they correspond to the scope of the integrated waste management activities planned for fiscal year 2016?**

Priorities for Removing SNF from Sites

- **DOE' s current priorities are long lead-time, destination-independent aspects of the transportation system, including:**
 - Development, design and testing of specialty rail cars to meet AAR S-2043
 - Continued development of the Transportation Planning Framework and standardized routing methodologies
 - Activities to establish relationships with other federal agencies, states, and Tribes to develop policies and agreements on transportation system operations and responsibilities
 - Work required to develop a deeper understanding of the tasks and interfaces necessary for the complete de-inventory of the shutdown sites.

- **All work falls within the scope of the integrated waste management activities currently planned for fiscal year 2016**

Question ii. c.

Nuclear Energy

- **How does the new Transportation Planning Framework document differ from the National Transportation Plan that was issued in April 2014, from a technical perspective?**

Draft Transportation Planning Framework

- **The draft Transportation Planning Framework (TPF) and the draft National Transportation Plan are the same document**
 - The full name of the document is now *Transportation Planning Framework for Removal of Commercial Spent Fuel from Shutdown Reactors*
 - The name was changed to more accurately reflect the scope of the document
 - No major technical changes were made when the document's name was changed
 - Revisions made were based in part on input from state and tribal representatives
 - Updates included adding data from additional site visits to shutdown reactors
 - Cask certificate information was also updated to reflect recent renewals

- **The TPF outlines DOE's plans and activities needed for large scale SNF transportation campaigns and recognizes the role of stakeholders in system development**

Question ii. d.

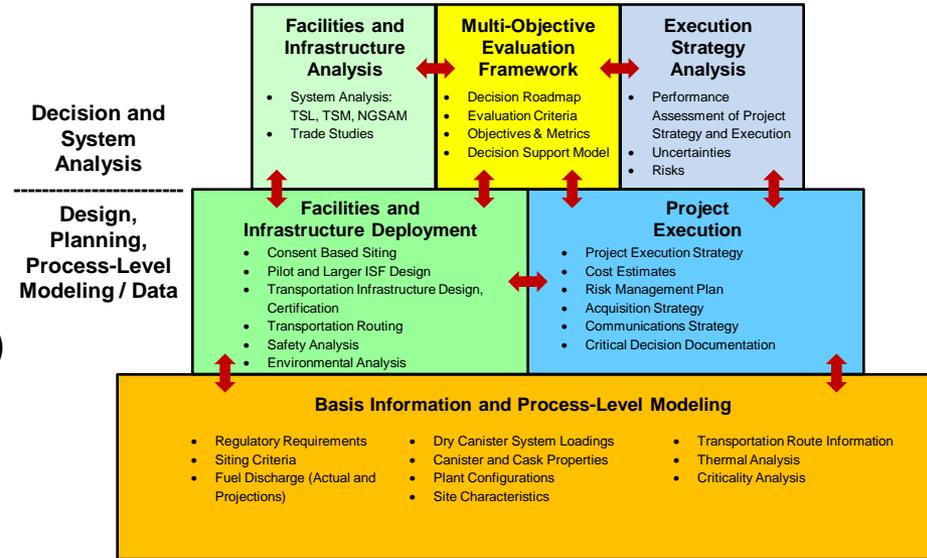
- **To support the planning for transportation of SNF from the shutdown sites, what progress and improvements have been made in the development of systems oriented tools using advanced information technology to aid with decision-making and stakeholder engagement?**



Systems Oriented Tools

■ NFST is developing a number of tools to support decision-making and stakeholder engagement

- Multi-Objective Evaluation Framework (MOEF)
- Facilities and Infrastructure Analyses
 - Advanced Integrated Architecture Analysis Tool (NGSAM)
- Execution Strategy Analysis (ESA)
- Unified Database and UNF-ST&DARDS
- Stakeholder Tool for Assessing Radioactive Transportation (START)

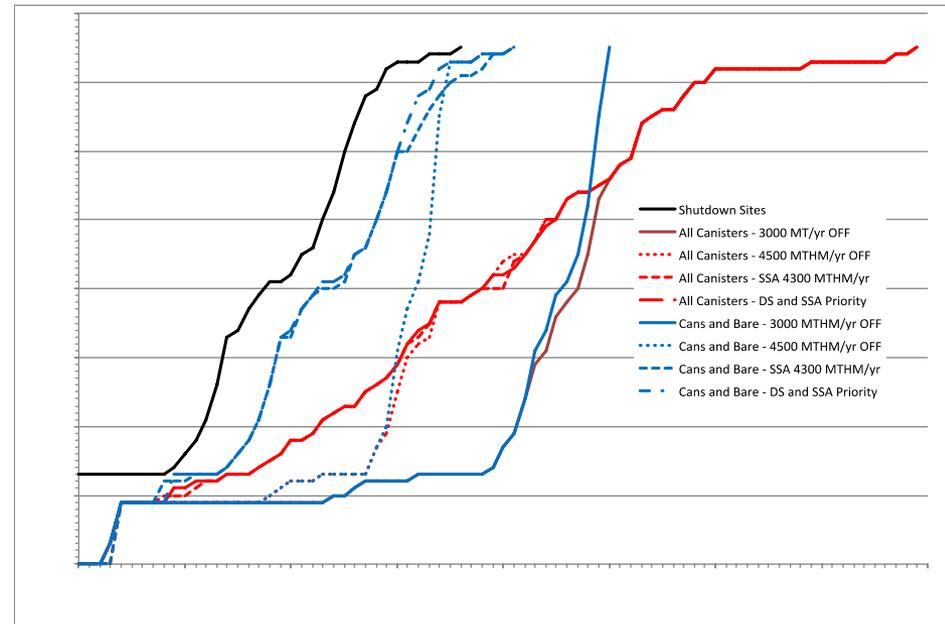




Systems Oriented Tools to Aid with Decision Making

■ Integrated Waste Management System Architecture Analyses support the future deployment of a comprehensive system for managing SNF, GTCC low-level radioactive waste, and DOE-managed SNF and HLW

- Emphasis on providing flexibility
- Evaluating system impact of continued waste management practices
 - Loading large dual-purpose dry storage casks
- Identifying and evaluating alternative strategies and approaches for managing SNF to determine potential benefits
 - including those pertaining to cost and flexibility

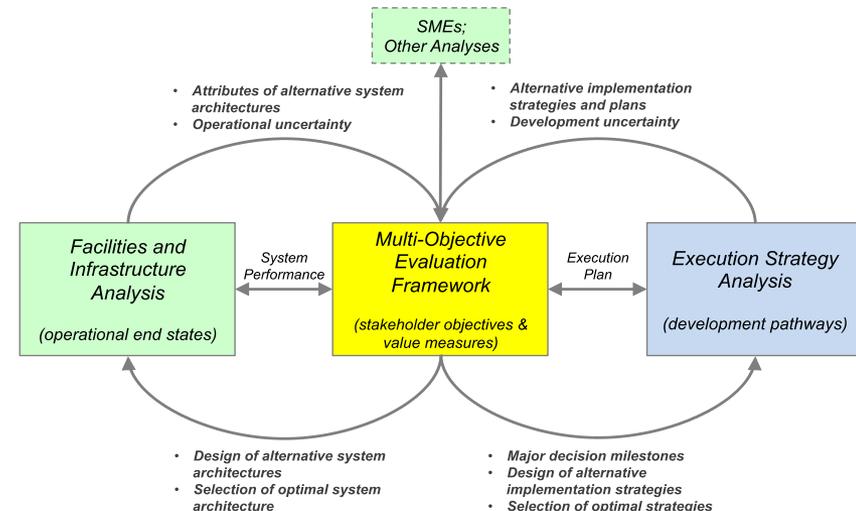




Systems Oriented Tools to Aid with Decision Making

■ Multi-Objective Evaluation Framework – Develop and apply capabilities, methods, tools, and processes to evaluate, select, and document preferred alternatives from among multiple options.

- Capabilities
 - Knowledge, skills, and experience of analysts, modelers, and SMEs
- Methods
 - Proven decision analytic approaches
 - Flexibility to address emergent decision situations
 - Adaptable and responsive to project needs
- Tools
 - Commercial software
 - Custom analytic techniques
- Processes
 - Well suited to breaking down complex and difficult decision situations into manageable and insightful components
 - Transparent, defensible, and auditable record of decision making

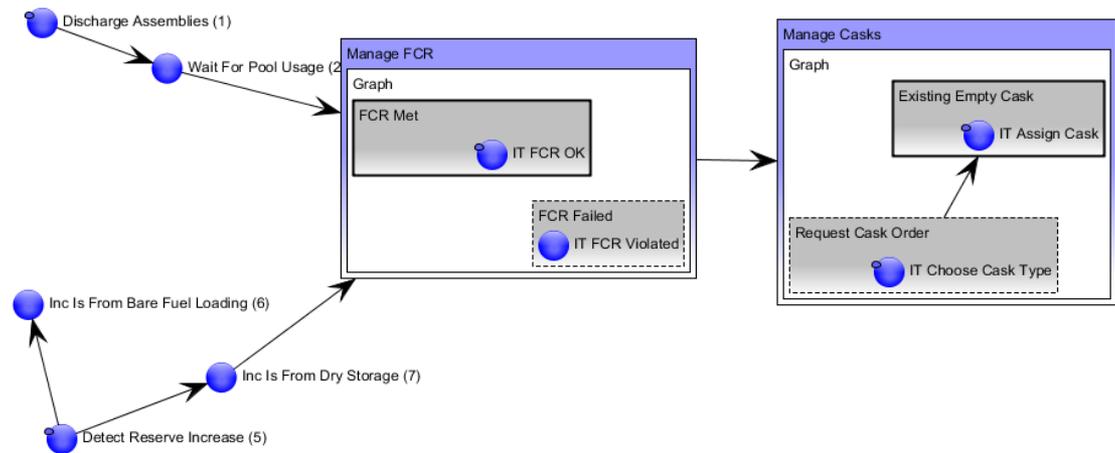




Systems Oriented Tools to Aid with Decision Making

■ Next Generation System Analysis Model (NGSAM) – An advanced integrated waste management system simulation tool that is more capable than legacy tools

- Readily sustainable and maintainable in the future (open source, Java based)
- Intended for a broad set of users (web based)
- Better represent actual constraints
- Advanced simulation techniques, such as agent-based simulation
- Leverage existing logistics and transportation simulation models developed for other applications
- Links with the UNF-ST&DARDS

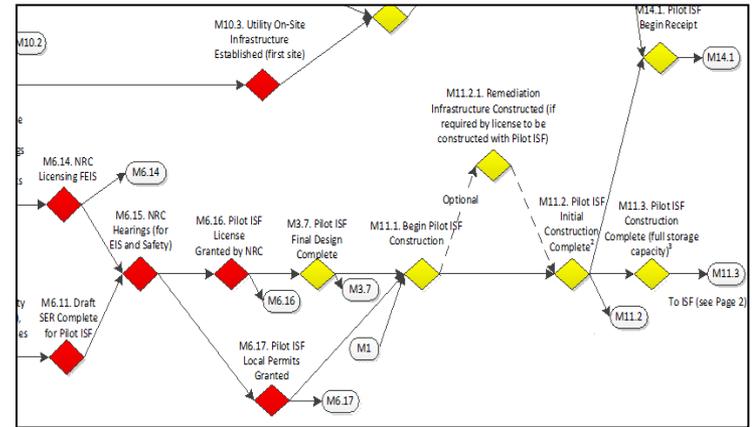




Systems Oriented Tools to Aid with Decision Making

■ Execution Strategy Analysis – A dynamic simulation modeling capability for use in the analysis of alternative implementation strategies and plans

- Provides performance assessment of evolving project direction that takes into account
 - Strategic assumptions
 - Risks and uncertainties
 - Linkages between program/project elements
- Capability helps
 - Identify alternative implementation strategies
 - Understand consequences of changing resources and priorities
 - Understand impacts of project risks



Example Draft Linkages for Execution Strategy Analysis



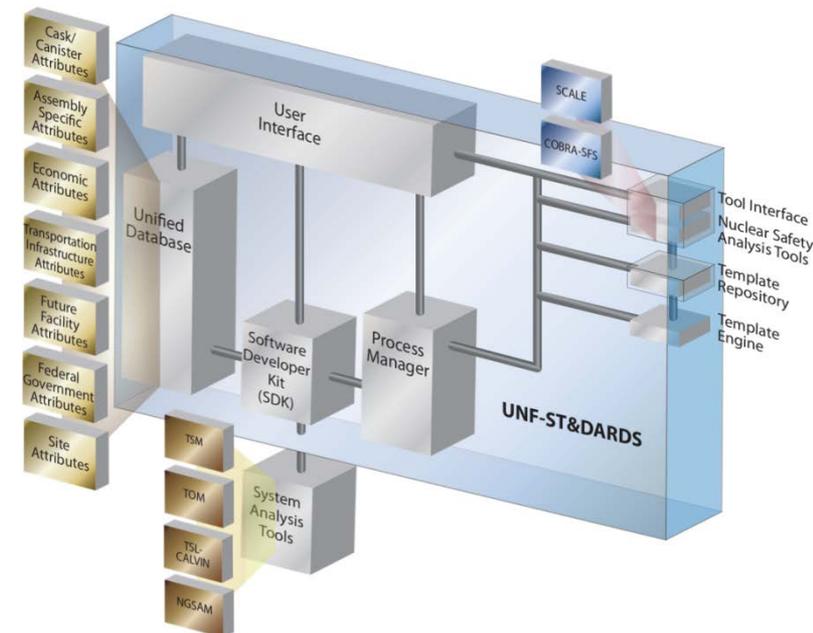
Systems Oriented Tools to Aid with Decision Making

■ Establishing a Unified, Comprehensive SNF Database and Integrated Analysis System (UNF-ST&DARDS) to:

- Characterize the input to the waste management system
- Provide a credible, controlled data source
- Support safety confidence
- Provide a foundational data and analysis capability

■ UNF-ST&DARDS currently includes:

- Fuel assembly discharge information
- Fuel assembly design data
- Reactor-specific operation data
- Cask design and loading data
- Infrastructure and logistics-related data to support systems analyses





Systems Oriented Tools to Aid with Decision Making

Web-GIS spent fuel routing tool

- Routing information for use by DOE and key stakeholders
- Emergency response infrastructure to support Section 180(c) training needs assessments
- Incorporates site-specific infrastructure information and photographs

START
Stakeholder Tool for Assessing Radioactive Transportation (START), version 1.1

Active Route: OR 180c...

Rail route from Trojan across Oregon selected for Section 180(c) Exercise

Avoid Portland

Trojan Site

Your Selections:

Origin	TROJAN
Destination	A user defined point
Transport Mode	Rail
Criteria	Minimum Distance
Buffer Distance	0.5 miles

Summary Attribute Results:

Avg. Accident Frequency	0.0214 avg. crashes per mile per year
Avg. Population Density	524.2 persons per square mile
Child Care	51
Dams	3
Minimum Distance	615 miles
Fire	32
Hospitals	3
Tribal Lands	35.6 square miles
Malls	0
Nursing Homes	8
Parks	134
Police	45
Population	322,385 persons
Risk	18,231.4
Schools	175
Sensitive Environmental Areas	88.3 square miles

