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ENSA ENUN 32P Rail-Cask Transport Tests Start June 2017

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SNL; PNNL

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WHY ARE WE DOING THIS TEST?

To Validate our Hypothesis that Spent Fuel will Maintain Integrity During Normal Conditions of Transport.

- We don't have data for rail and during the transfer of the cask between transport modes
- We will be obtaining more realistic data for truck transport.

Transporting Spent Nuclear Fuel

- How do stresses on fuel during normal conditions of transport compare to failure limits?
- Could vibrations or shocks result in fatigue failure?
- Based on previous tests, the stresses fuel rods experience due to vibration and shock during normal transportation are far below yield and fatigue limits for cladding.
- But previous tests are only simulations of the configuration of ***actual*** SNF transport modes.

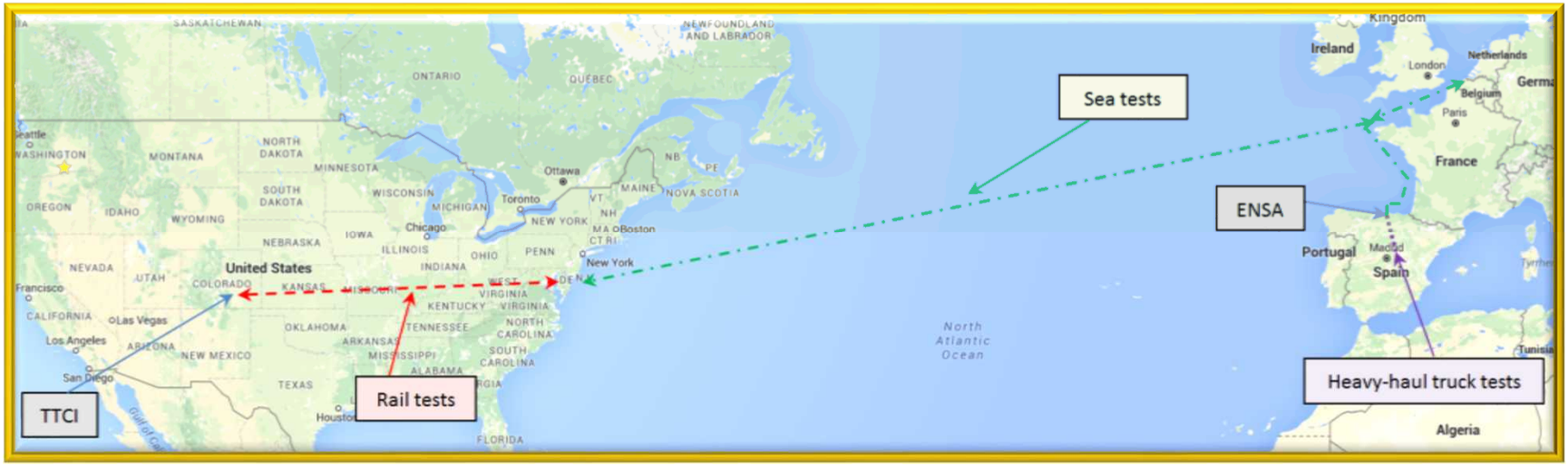
So, We Are Performing a More Realistic Test

- **Equipos Nucleares (ENSA) and Empresa Nacional de Residuos Radiactivos S.A. (ENRESA) provided an ENUN 32P rail cask, basket, and cradle for an international test program**
  - ENUN 32P is similar to existing NRC-licensed cask currently in use in USA
- **Testing to be conducted by DOE laboratories**
- **Tests are significantly different than previous tests**
  - Instrumented surrogate assemblies will be
    …within a rail-cask basket
    …within an actual rail cask on
    - *a heavy-haul truck*
    - *two different ships*
    - *a railcar*

ENUN 32P basket. Photo curtesy of ENSA

ENUN 32P Cask. Photo curtesy of ENSA

ENSA ENUN 32P Rail-Cask Transport Tests *Begin June 2017*

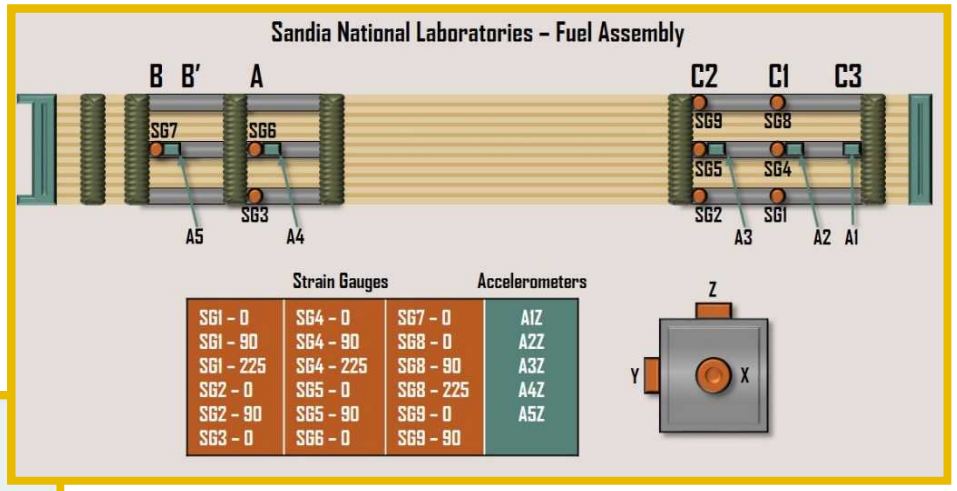


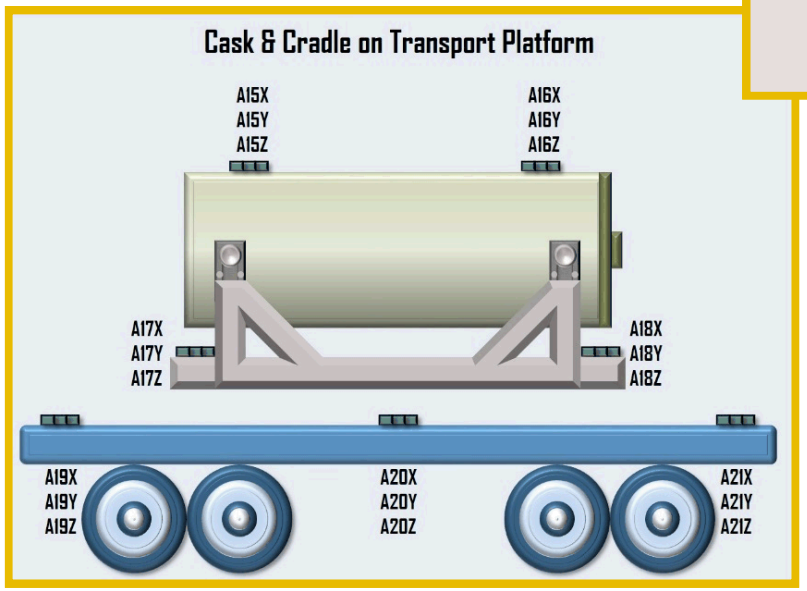
1. *Cask handling and heavy-haul truck from within SPAIN ~ 13 June 2017*
2. *Coastal sea shipment from Santander to Zeebrugge BELGIUM*
3. *Ocean transport from Zeebrugge to Port of Baltimore with arrival mid-July*
4. *Commercial rail shipment from Baltimore to Pueblo, Colorado*
5. *Testing at the Transportation Technology Center, Inc. mid-August*
6. *Return trip to ENSA will be the same*

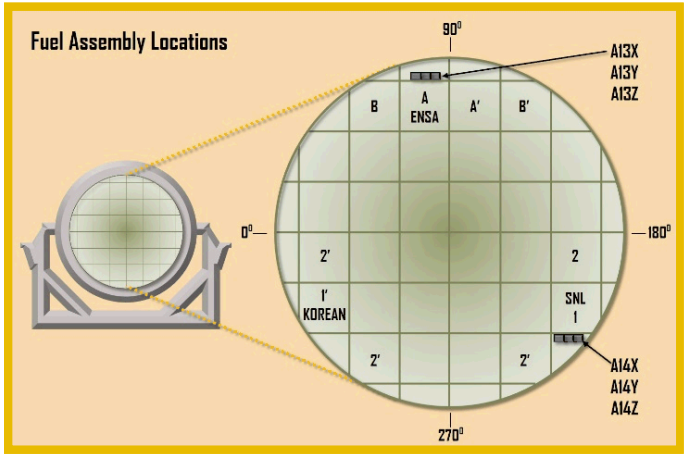
Data will be collected throughout all legs of the transport as well as the transfers between legs. Three PWR surrogate assemblies instrumented with strain gauges and accelerometers cask, basket, cradle, and transport platforms instrumented with accelerometers.

DOE Laboratories Team Instrumented Assemblies, Basket, Cask Body, Cradle, & Transport Platforms

- Sandia assembly instrumented February 2017 with strain gauges and uniaxial accelerometers.
- Triaxial accelerometers on cask, basket, cradle, and transport platforms.

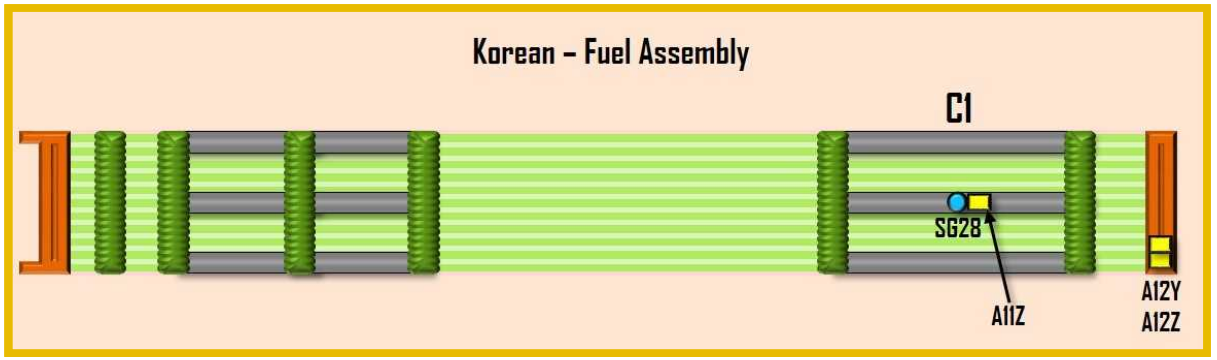


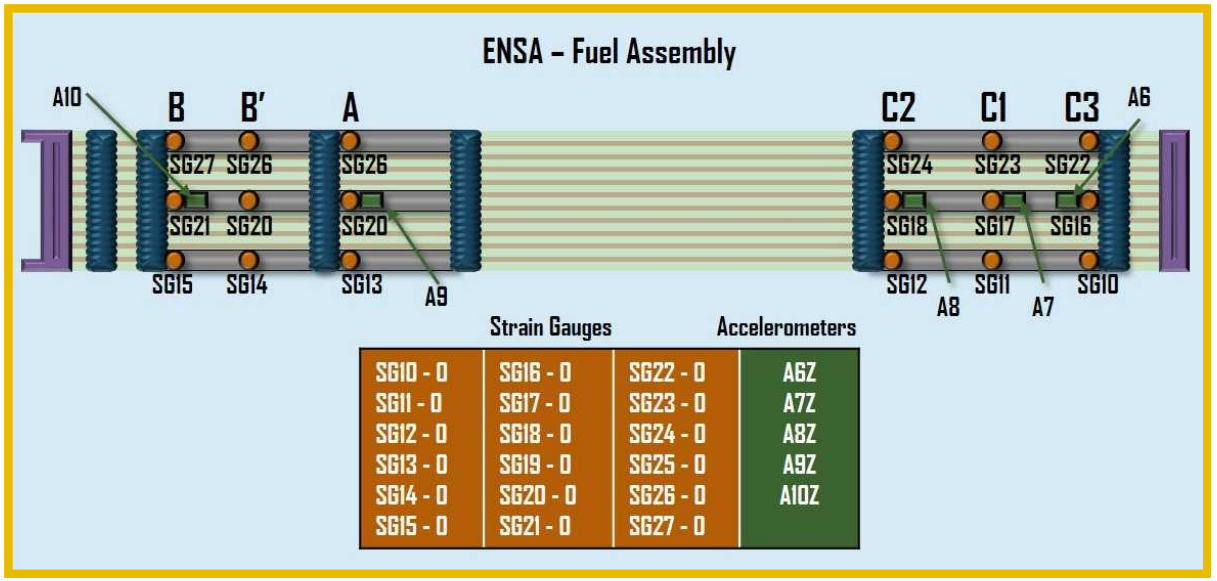


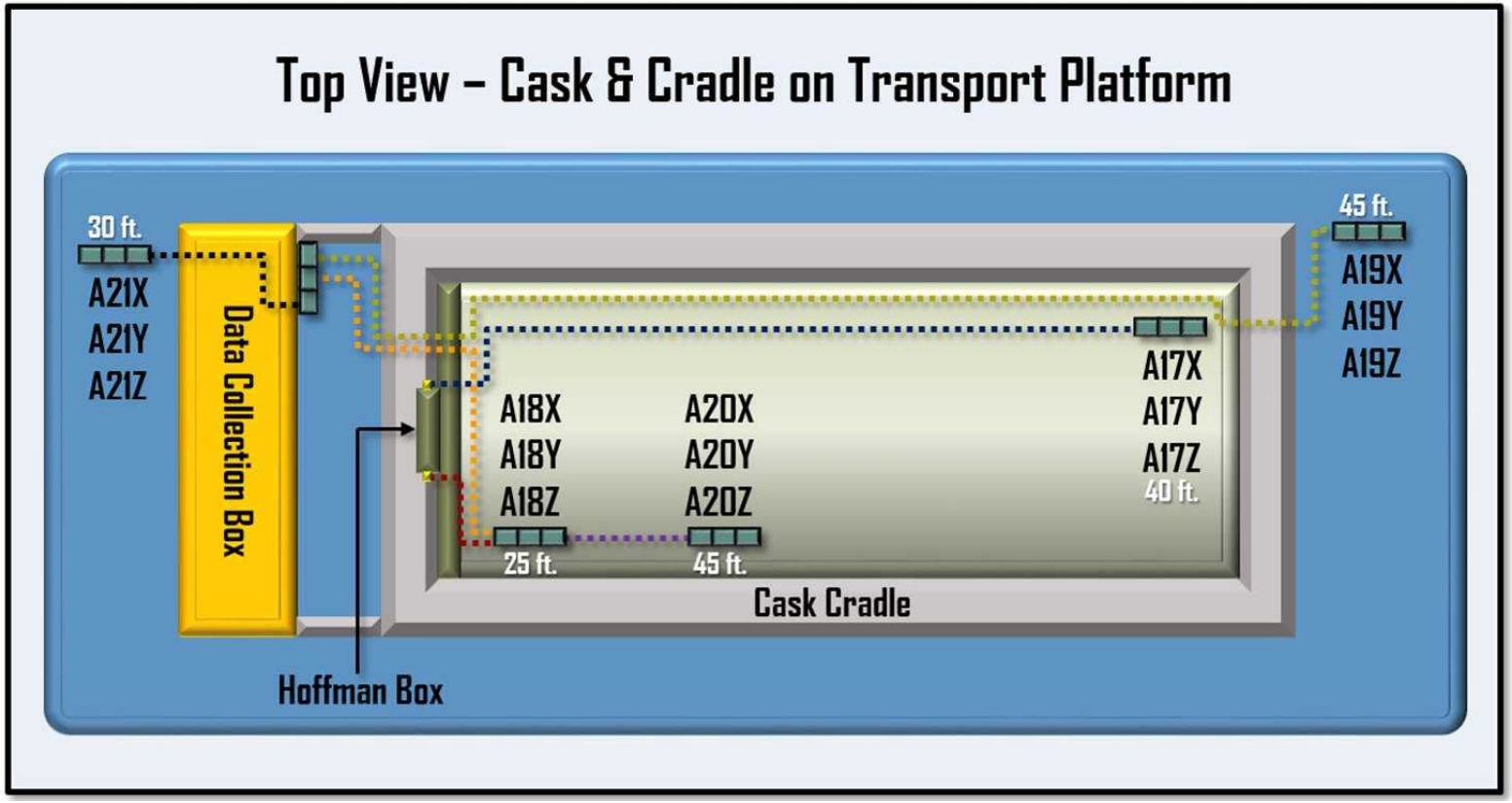


DOE Laboratories Team Instrumented Two Assemblies in Spain

- Team traveled to ENSA facilities March 2017 to instrument the Spanish assembly (ENUSA, ENRESA, ENSA) and the Korean assembly (KORAD, KAERI, KNFC) with strain gauges and accelerometers






Top View – Cask & Cradle on Transport Platform
30 ft.
A21X
A21Y
A21Z
Data Collection Box
Hoffman Box
A18X
A18Y
A18Z
25 ft.
A20X
A20Y
A20Z
45 ft.
Cask Cradle
A17X
A17Y
A17Z
40 ft.
45 ft.
A19X
A19Y
A19Z

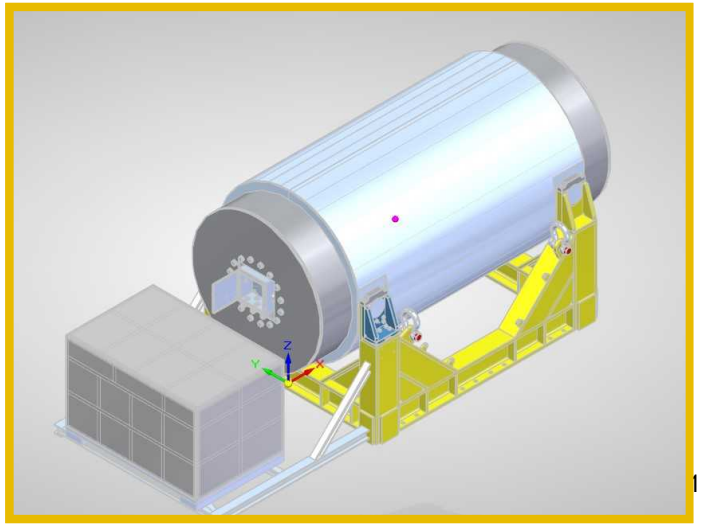
Data Collected via Battery-Powered Instrumentation Box Attached to Cradle

- Instrumentation box has two 40-channel Siemens data acquisition units

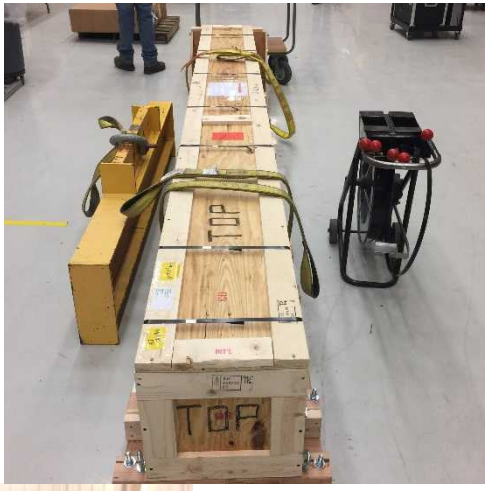
Location	Instruments	Data Channels
Sandia assembly	18 strain gauges 5 uniaxial accelerometers	23
Spanish assembly	18 strain gauges 5 uniaxial accelerometers	23
Korean assembly	1 strain gauge, 2 uniaxial and 1 biaxial accelerometers	4
Basket	2 triaxial accelerometers	6
Cask Body	2 triaxial accelerometers	6
Cradle	2 triaxial accelerometers	6
Transport Platforms	3 triaxial accelerometers	9

Instrumentation/Battery Box

Two 40-channel data acquisition systems, 20 batteries, 6160 feet (1¼ miles) of cable



Six crates packed & shipped to Spain 15 May 9727 pounds



DOE Team to Be in Spain & Belgium

Early June through Early July

First tests
(12 June)

1) Cask handling tests with cask in vertical position simulating placing a storage cask onto an ISFSI pad, followed by
2) Placement of cask onto cradle

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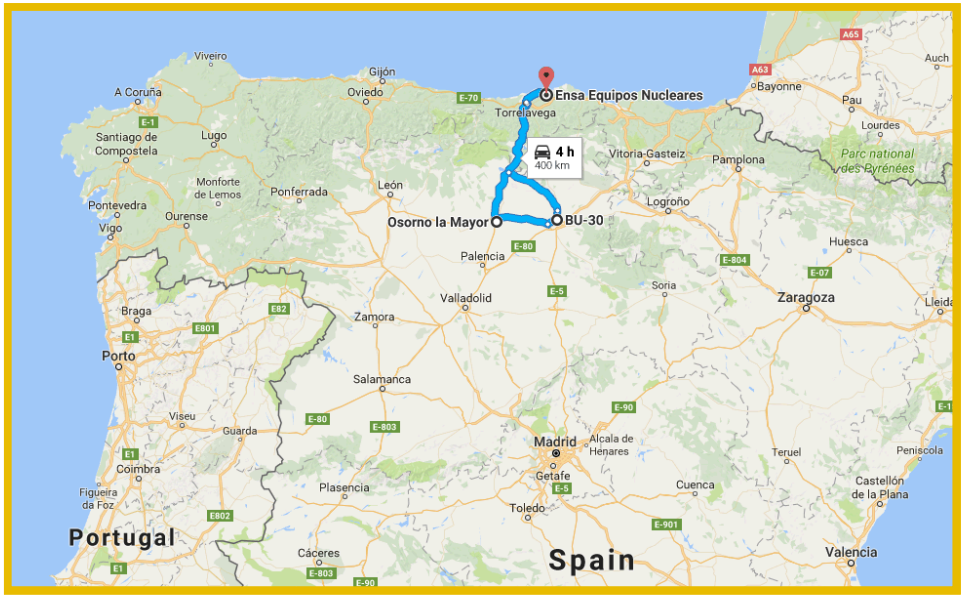
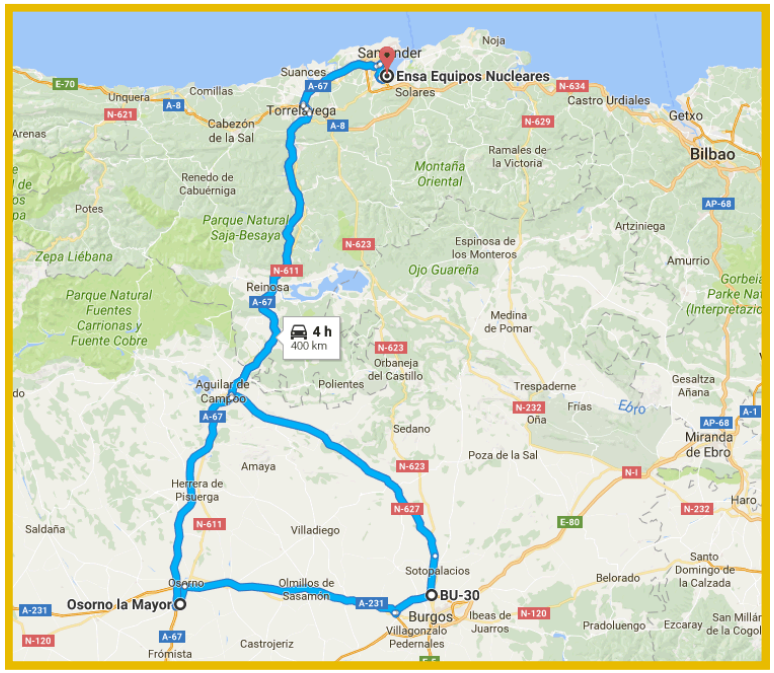
Heavy-Haul Truck Tests

Begin 16 June

- 3 days, 400 km, departing from and returning to ENSA facility near Santander SPAIN
- Truck tests will be preceded by a cask handling test to collect data as cask/cradle/instrumentation box is loaded onto truck trailer
- Data will be collected continuously during truck transport
- 3-day test will generate 353 GB ASCII data

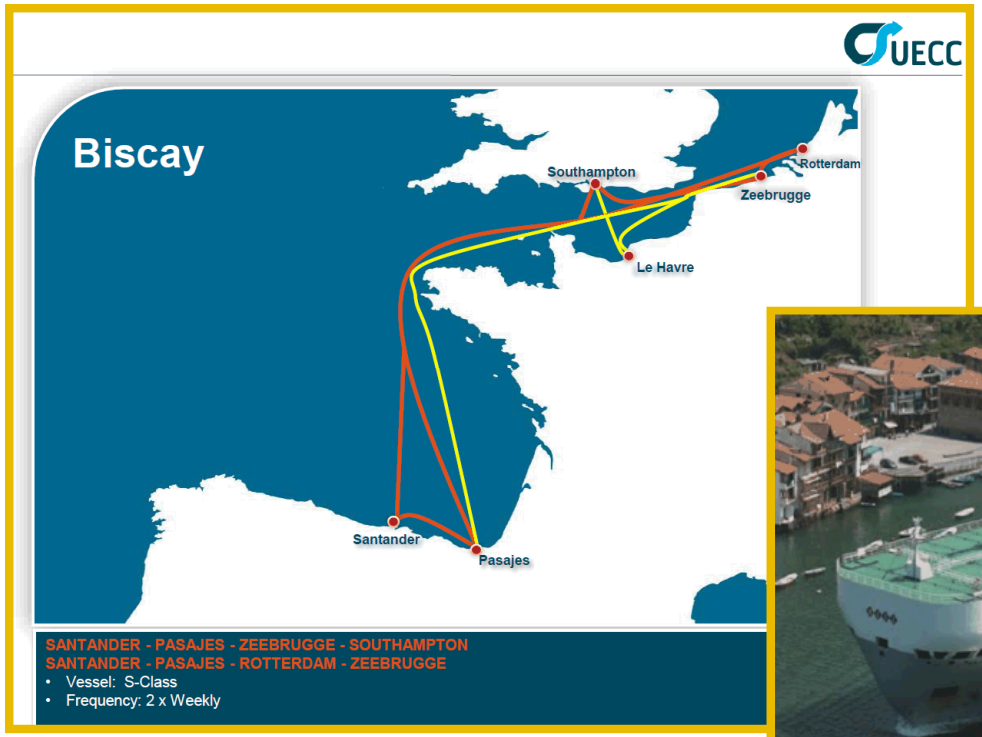




Cask Transported to Zeebrugge, BELGIUM *After Heavy-Haul Truck Tests*

22 June

- Data will be collected continuously during 4-day transport on a RORO ship from Santander to Zeebrugge



- Cask handling test data will be collected during transfer of cask from truck trailer to ship transport platform (MAFI™)
- 471 GB of ASCII data

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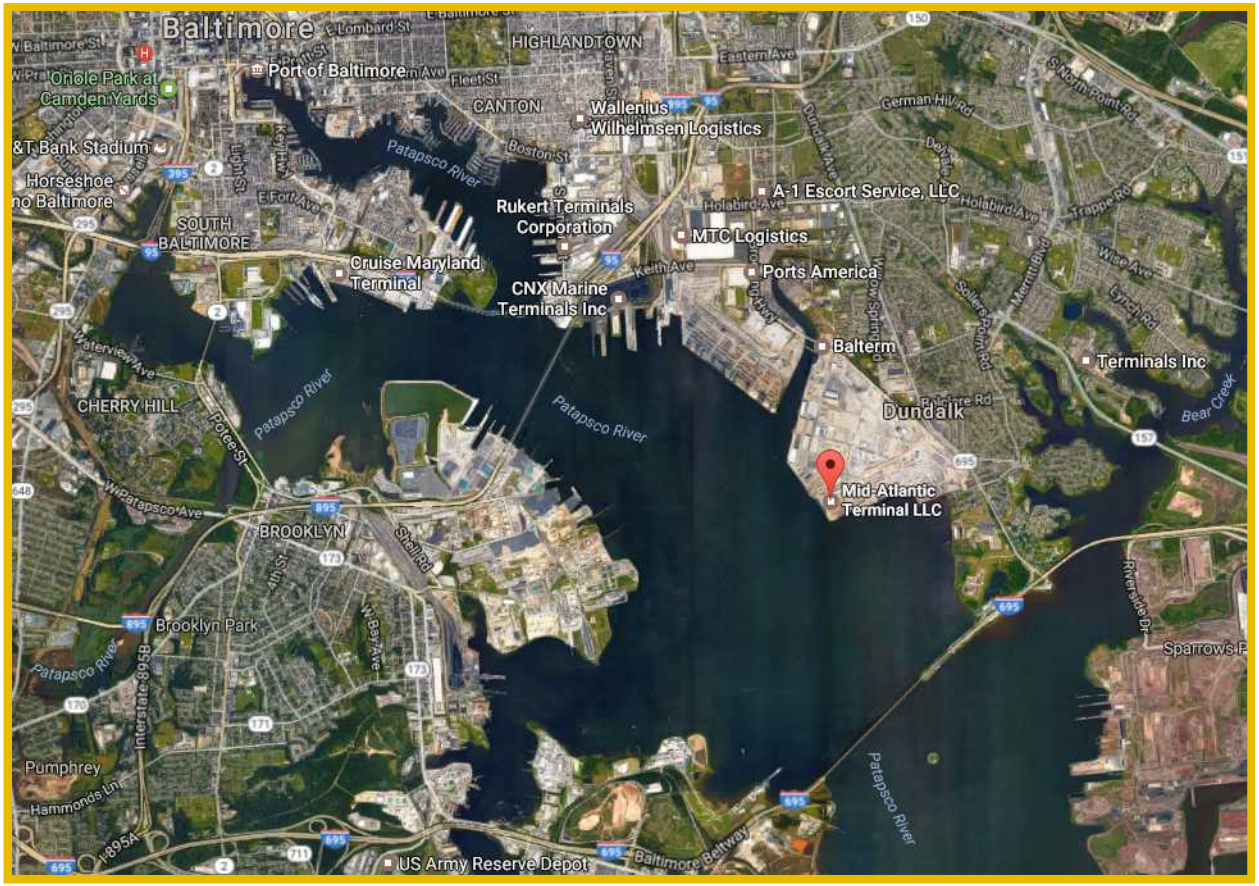
Cask to Transfer to Ocean Ship in Zeebrugge Heading to Port of Baltimore

1 July

Data to Be Continuously Collected During 12-day Trip to Baltimore Mid-Atlantic Terminal

Arriving 13 July

- Ship will be met by DOE Laboratories Team to retrieve data (1.3 TB) and charge batteries (30 hours)



Cask to Transfer to Flat-deck 12-Axle Rail Car in Baltimore Heading to Colorado

Transportation Technology Center, Inc. (TTCI)

- Exact route TBD but will likely pass through Kansas City on Norfolk Southern Railway for transfer to BNSF Railway to Avondale, Colorado, near Pueblo and TTCI.
- Cask will arrive at TTCI around mid-August for up to 3 weeks of testing.
- Exact number of days of rail transport to TTCI is TBD but likely more than the 14 days of battery life. So, the data collection system will power off after 14 days.
- The total ASCII file size will be 1.65 TB for the 14 days of rail travel.

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Rail Tests to Be Conducted at TTCI

mid- to late-August

1) Crossing Diamond Tests – These tests are intended to subject the vehicle to typical vertical impacts resulting from the wheels traversing gaps in the rails where tracks intersect.
2) Twist & Roll Test – This test is conducted to determine the car's ability to negotiate oscillatory cross-level perturbations.
3) Pitch & Bounce Test – This test is conducted to determine the car's ability to negotiate parallel vertical rail perturbations.
4) Dynamic Curving Test – This test is conducted to determine the cars ability to negotiate curving over jointed track with a combination of lateral misalignment at the outer rail joints and cross-level due to low joints on the staggered rails.
5) Tests at Pueblo Chemical Depot – These tests include runs over FRA Class-2 railroad track and tests through No. 8 turnout and No. 8 crossovers.
6) Coupling Impact Test – This test is conducted to provide longitudinal inputs from coupling at higher than normal speeds.
7) Loaded Hunting Test – This test is conducted to determine the vehicle's lateral stability at higher speeds.
8) Single Bump Test – This test is intended to represent a grade crossing. The test zone consists of a 1" bump on tangent track. The bump is a flat topped ramp that rises up over 7', has a steady elevation over 20', and drops back down over 7'. Test speeds are 40-75 mph in 5 mph increments. Railroad industry experience is that vertical dynamic response at grade crossings is a significant source of large vertical accelerations and shock and vibration in freight cars.