Orano’s Progress and Innovations for US NPP D&D

2023 RadWaste Summit

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Orano Decommissioning Services, LLC

June 8, 2023

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Contents

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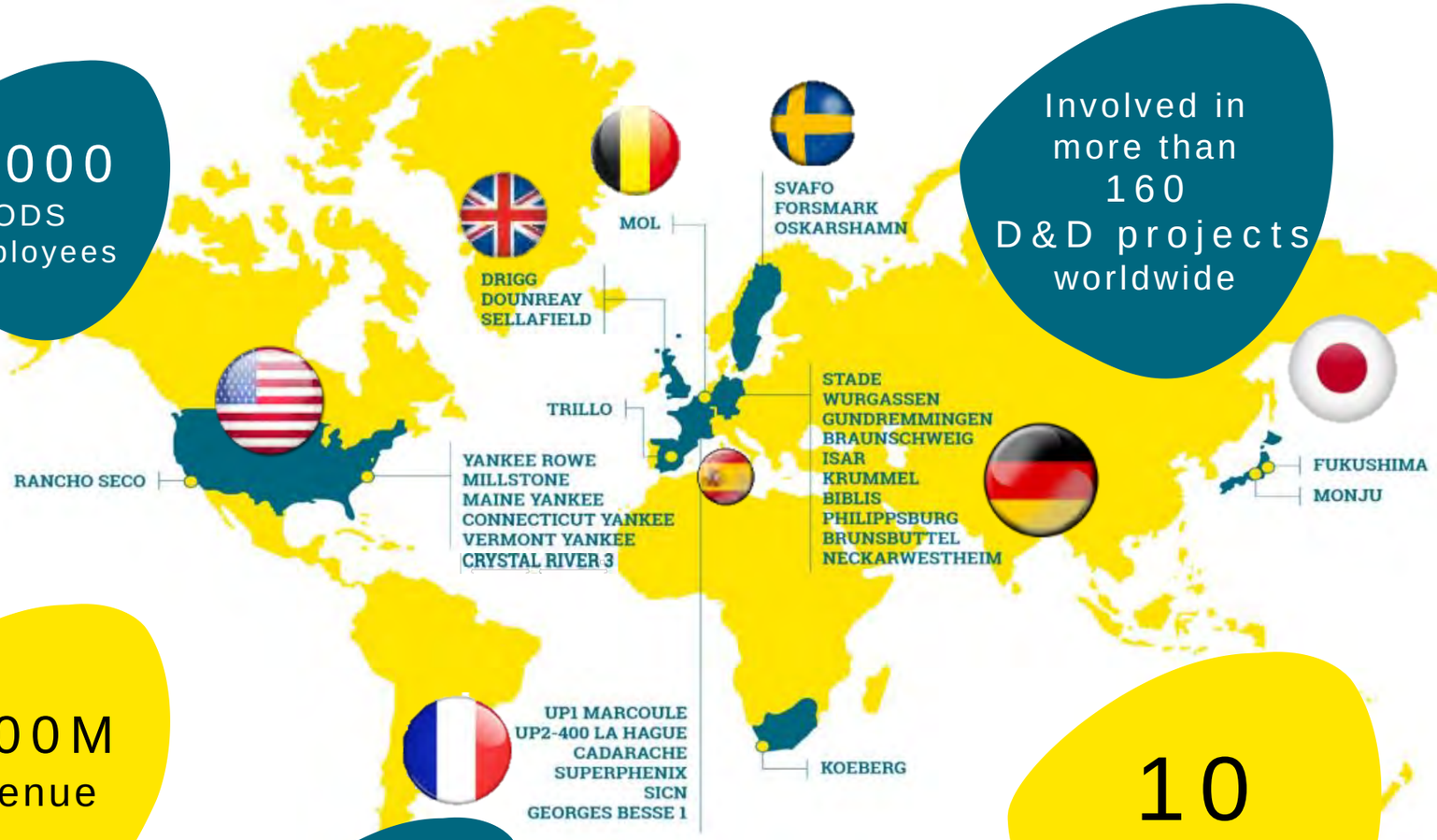
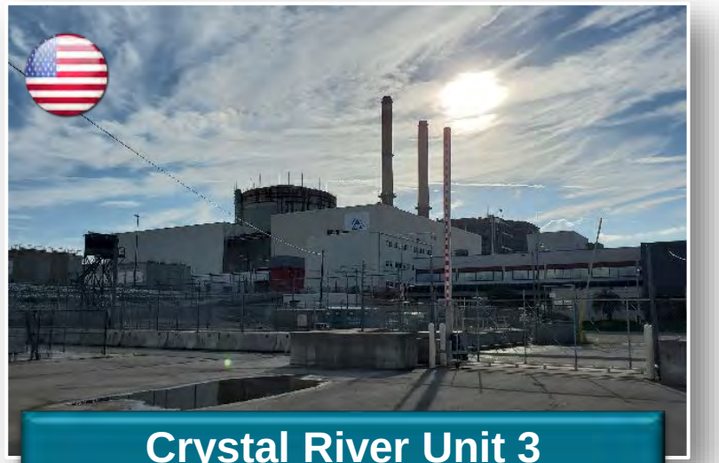
Worldwide presence and U.S. operations

6,000
ODS
employees

Involved in
more than
160
D&D projects
worldwide



Vermont Yankee
Completed in 2022



Crystal River Unit 3
Completing in 2023

$600M
revenue

10
Reactor D&D
projects

50
Years of
experience

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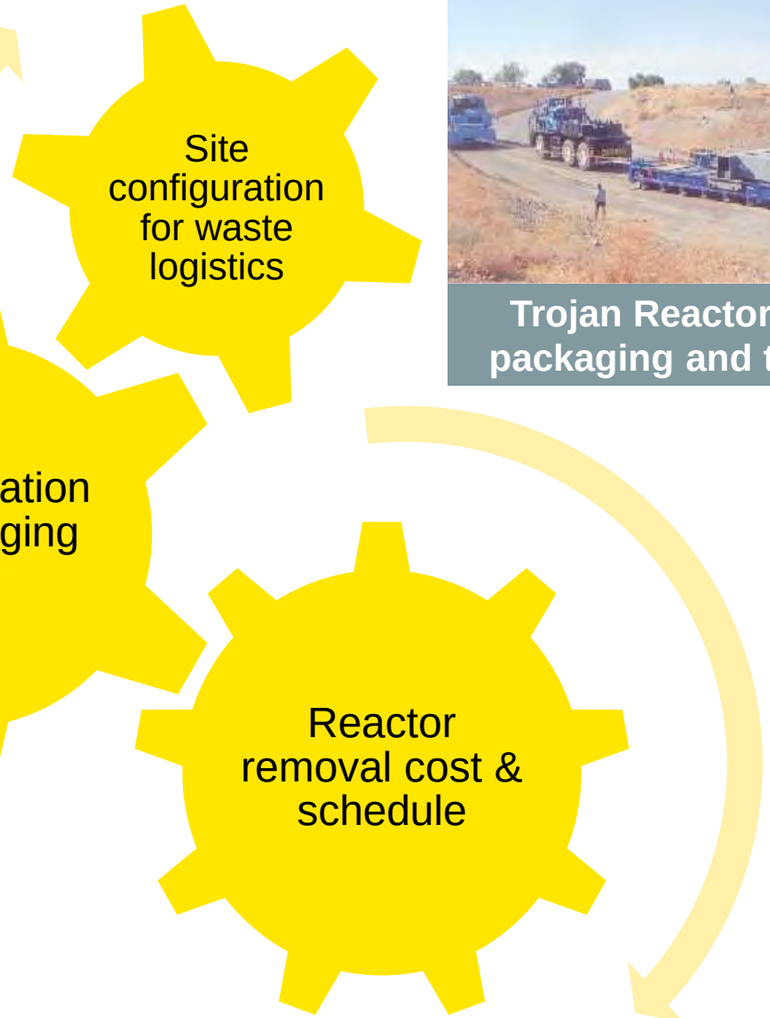
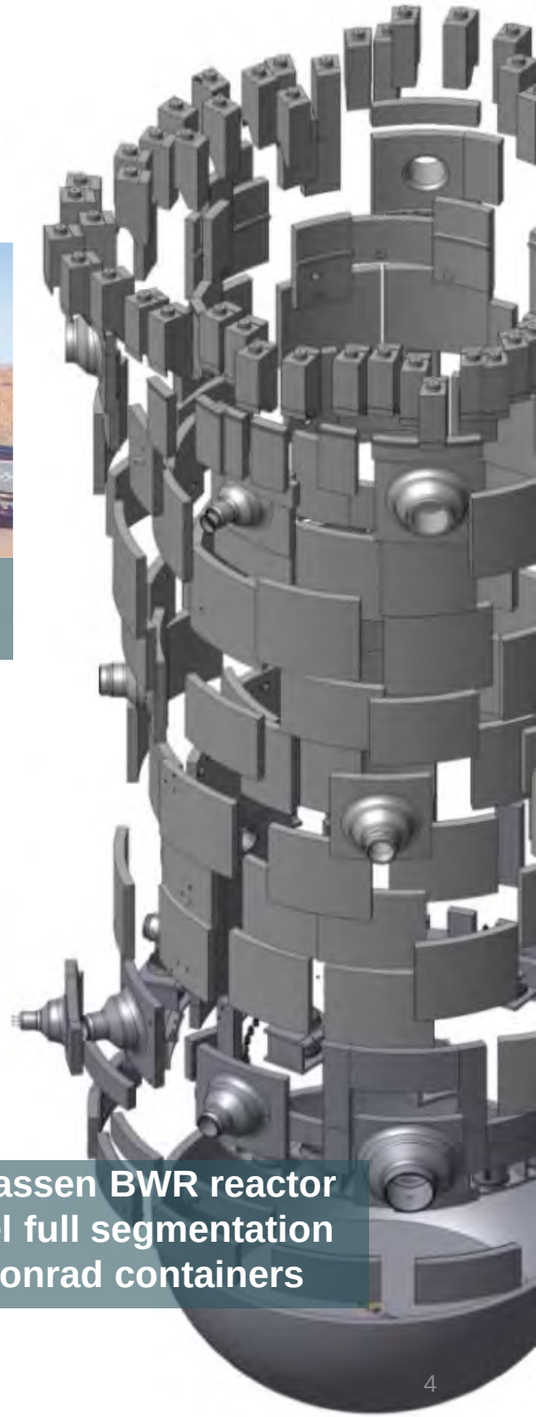
Main schedule and cost drivers to Reactor D&D

Vermont Yankee
Road and rail transportation

Crystal River
Road, rail, & barge transportation

Trojan Reactor “one-piece” packaging and transportation





Würgassen BWR reactor vessel full segmentation in Konrad containers

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Vermont Yankee BWR – First Accelerated Decommissioning

Project ID

Name: Vermont Yankee

Site: Vernon, Vermont

Reactor type: BWR (620 MW)

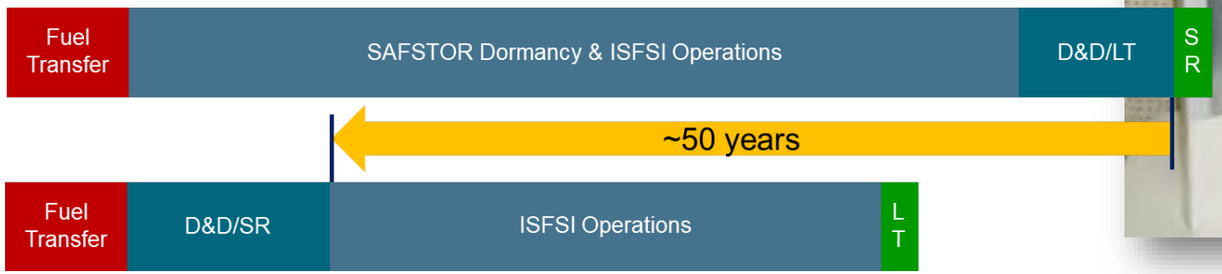
Scope of work: RPV – RPV Internals segmentation

Work progress:

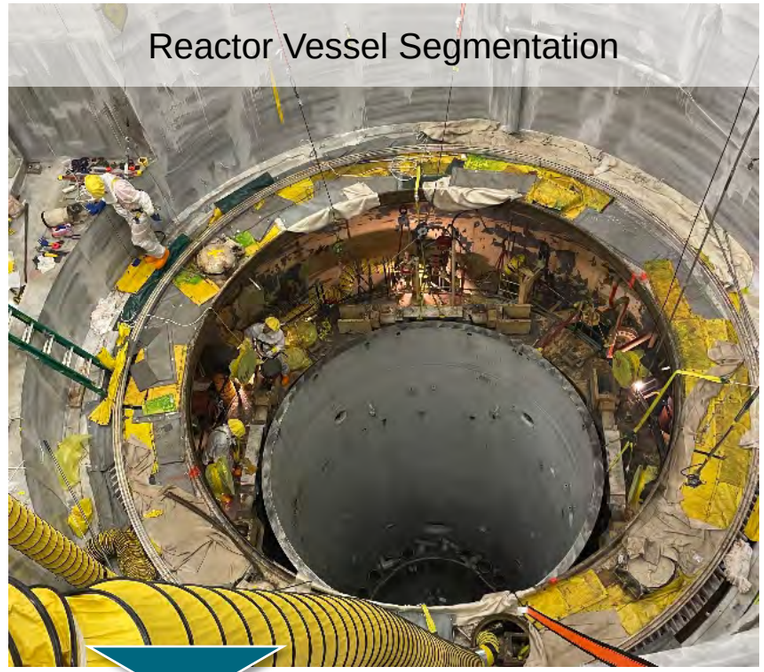
- ☑ Project Kick-Off – July 2017
- ☑ Site mobilization – March 2019
- ☑ RVI complete – Aug 2021
- ☑ RV complete – Aug 2022

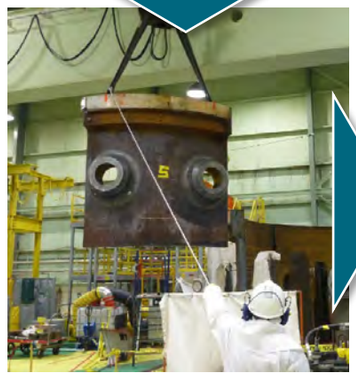
100%

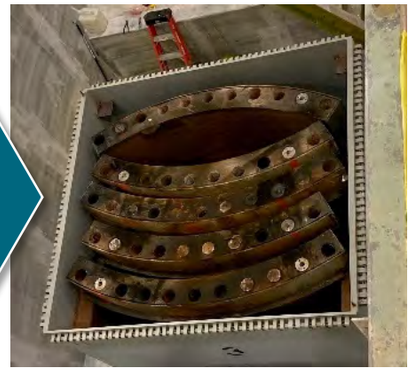
270,000 hours of safe work without a Lost Time Accident



Reactor removal **completed** - On track for Plant Accelerated Decommissioning in **< 10 years**







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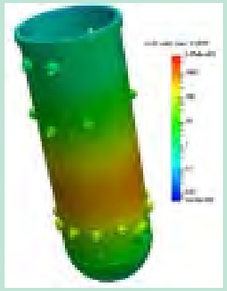
Vermont Yankee BWR – Waste Synopsis

RV / RVI Components

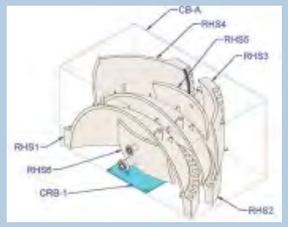
> 1,000 segments

Waste Classification

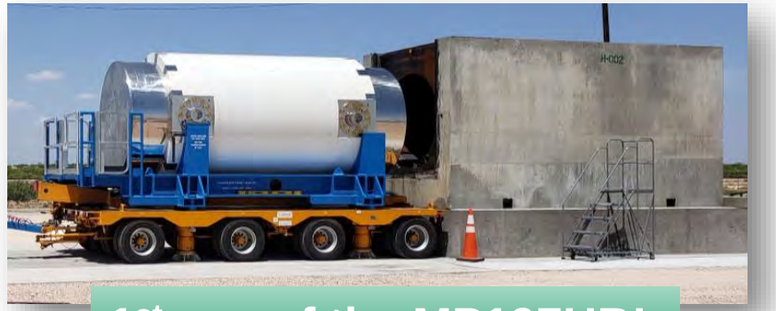


- GTCC
- LLRW Class B & C
- LLRW Class A

Waste Packaging



- 1 HI-SAFE
- 7 RWC
- 17 Custom Boxes
  13 x 160-Liners



1st use of the MP197HB!

RV + RVI

Full Segmentation and Packaging

in **38 Containers**

VY Reactor Head Custom Box

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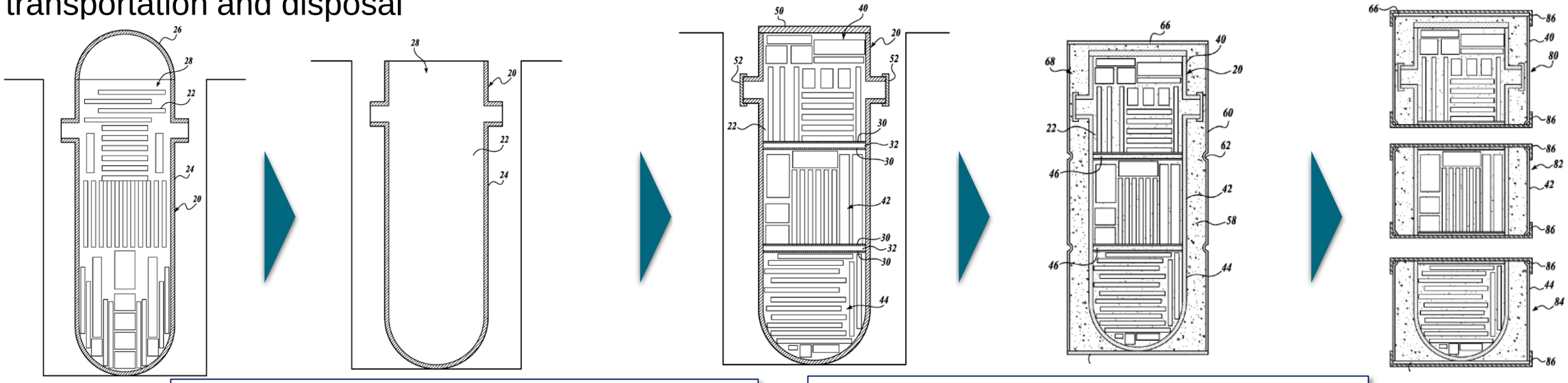
Innovating with the ‘Optimized Segmentation’ solution

- US 9,728,287 and US 9,984,780 patents
- The Reactor Vessel receives segments of the Reactor Vessel Internal Structures from which the GTCC components have been extracted
- The non-GTCC internals components are consolidated and encapsulated within the Reactor Vessel
- The resulting monolith is segmented, and each piece is conditioned in individual packages for off-site transportation and disposal



(12) **United States Patent**
Lessard et al.

(10) Patent No.: US 9,728,287 B2
(45) Date of Patent: Aug. 8, 2017

(54) PACKAGING FOR DECOMMISSIONED AND DISMANTLED NUCLEAR REACTORS AND REACTOR COMPONENTS

(12) **United States Patent**
Lessard et al.

(10) Patent No.: US 9,984,780 B2
(45) Date of Patent: May 29, 2018

(54) PACKAGING FOR DECOMMISSIONED AND DISMANTLED NUCLEAR REACTORS AND REACTOR COMPONENTS

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The Crystal River 3 Segmentation and Packaging Plan

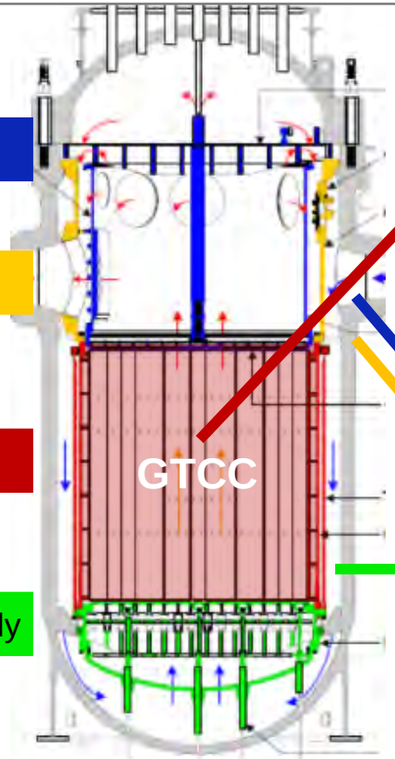
Head Removal and Packaging

Plenum Assembly

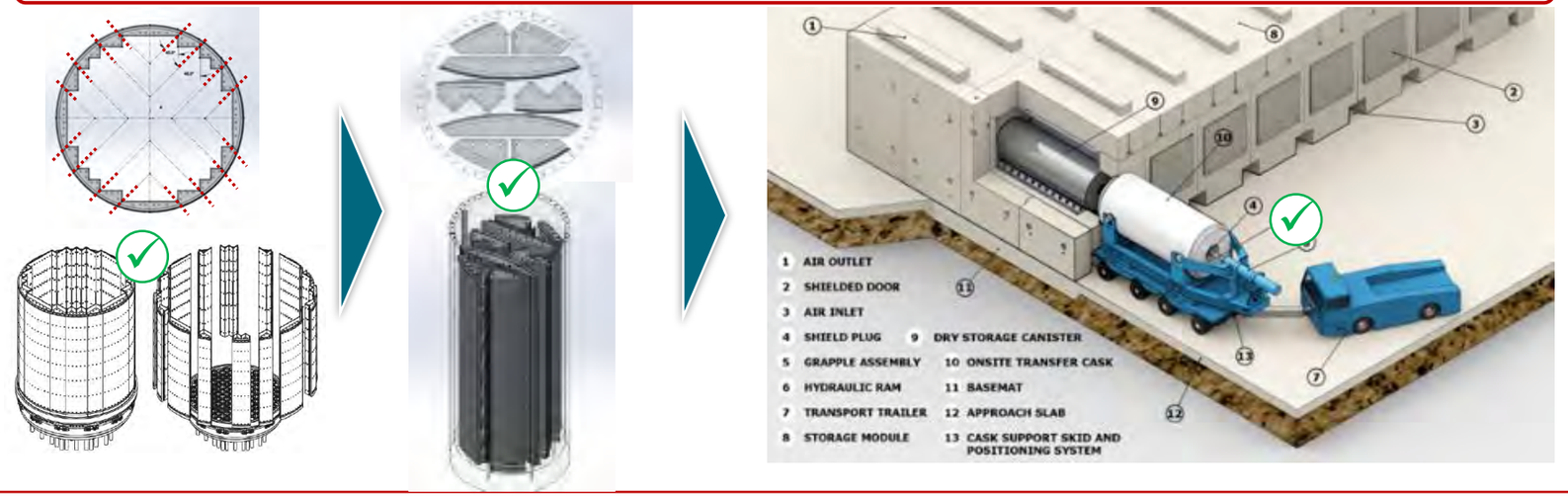
Core Support Shield

Core Barrel Assembly

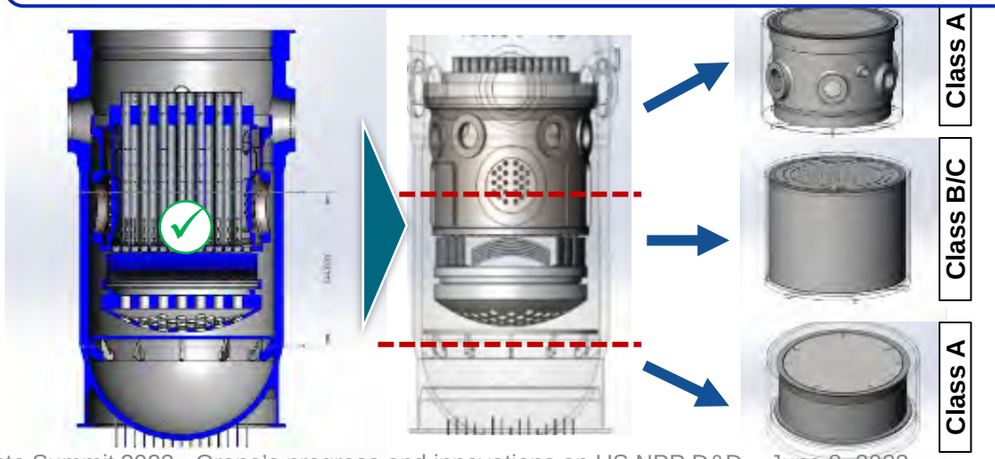
Lower Internals Assembly



GTCC reactor components packaged in 2 RadWaste Canisters for onsite ISFSI storage



Balance of reactor components repositioned inside the vessel and grouted
Vessel is segmented and packaged in 3 custom shipping containers for off-site disposal



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CR3 Reactor D&D progress status – Project start

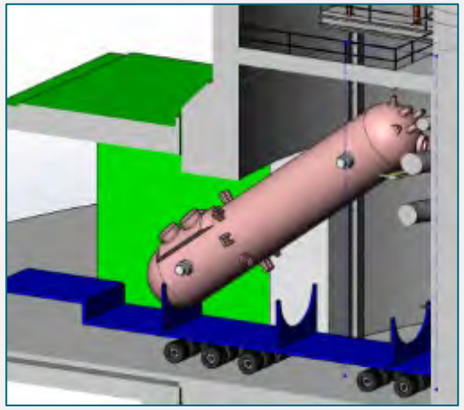
2020 | **2021** | 2022 | 2023

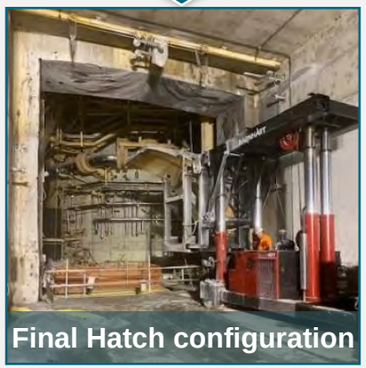
★ 10/2020 – Contract Closure & Project Kick-Off

Site Modifications & Infrastructure Upgrade

Equipment Hatch Enlarged:

- Facilitate equipment transfer, reactor components, and waste containers in and out of the containment building





GTCC Waste Storage:

- Added 2 NUHOMS® modules to upgrade the CR3 ISFSI for storage of the reactor GTCC waste

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CR3 Reactor D&D progress status – Reactor Coolant System

2020 | **2021** | 2022 | 2023

Reactor Coolant System Removal

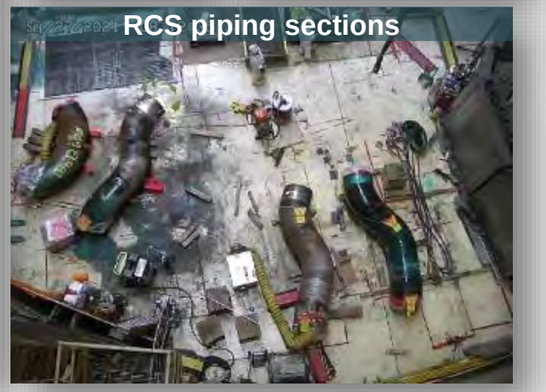
Removal, Packaging, Transportation and Disposal of:

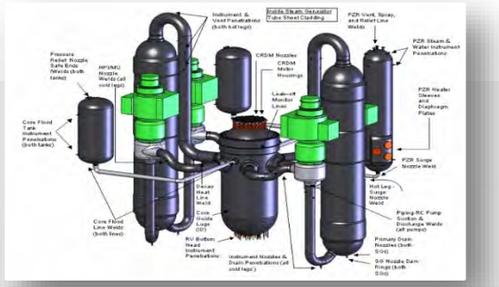
- 4 Pumps
- 4 Motors
- 1 Pressurizer
- Reactor Coolant Piping
- Ancillary Structures


Reactor Coolant System in the 2 “D-Ring” spaces


Motor


Pumps


RCS piping sections




Pressurizer


Pressurizer packaging


Pumps in shipment


Pumps in disposal

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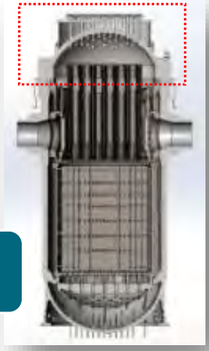
CR3 Reactor D&D progress status – Reactor Head



2020 | 2021 | 2022 | 2023

Reactor Head Removal

Removal, Packaging, Transportation and Disposal of:

- All Control Rod Drive Mechanisms
- Service Structure
- Reactor Head packaged and ready for shipment

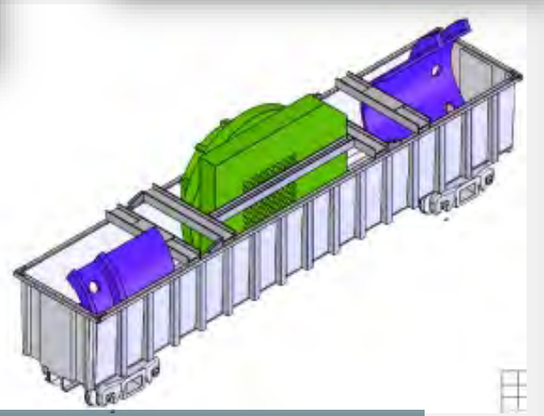
Control Rod Drive Mechanisms removal and packaging

1

Reactor Head lifted from the Reactor Vessel

2

Service Structure segmented and packaged for shipment



3

Reactor Head ready for packaging

Reactor Head packaged and transferred out of containment

Reactor Head packaged and ready for shipment

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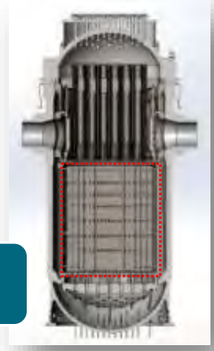
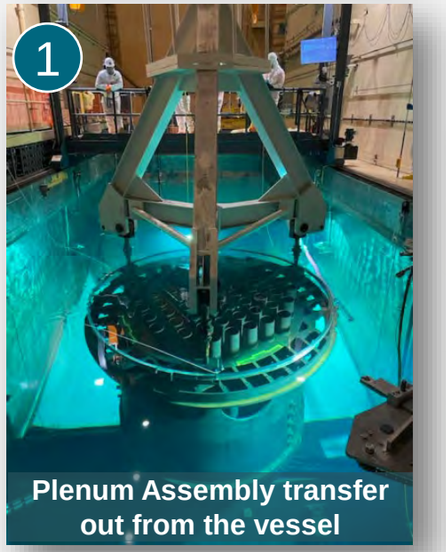
CR3 Reactor D&D progress status – GTCC Removal

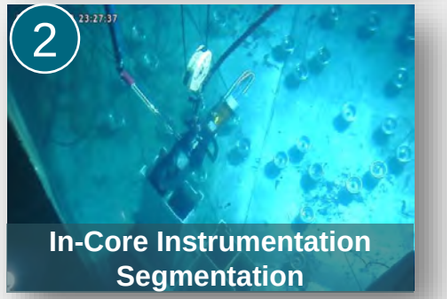


2020 | 2021 | 2022 | 2023

GTCC Removal



Plenum Assembly transfer out from the vessel



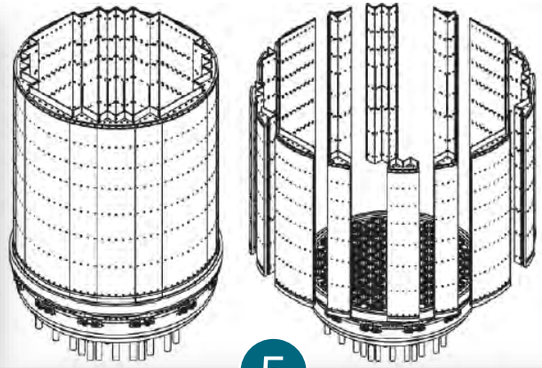
In-Core Instrumentation Segmentation

Reactor Vessel Internals Segmentation:

- Segregation of GTCC portion
- GTCC Packaged in RadWaste Canisters

Core Support Shield separated from the Lower Core Support Assembly

Thermal shield cut-out and loaded in a rack



GTCC segments of the Core Barrel assembly packaged in one RWC

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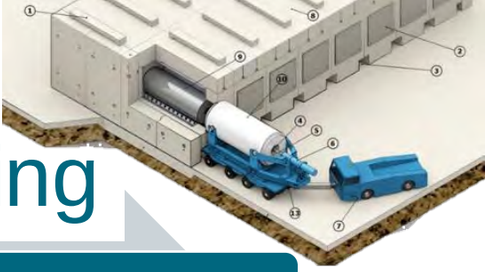
CR3 Reactor D&D progress status – GTCC Packaging



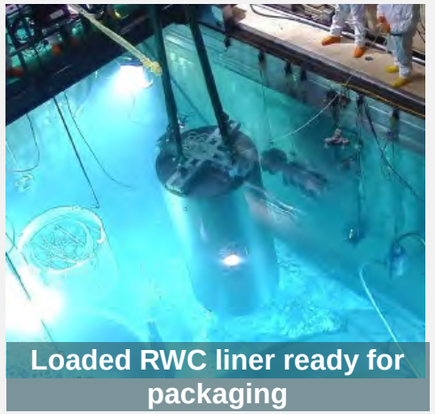
2020 | 2021 | 2022 | 2023

GTCC Packaging

Packaging, Processing and Transfer to the ISFSI of:

- GTCC portion of the Reactor Vessel Internals,
- CR3 site legacy GTCC waste

Legacy CR3 site GTCC waste consolidated with the reactor GTCC segments in a RWC Liner



Loaded RWC liner ready for packaging

RWC liner loading in the transfer cask and RWC shell

Transfer cask lifted to the handling station for RWC vacuum drying and welding

RWC undergoing weld closure in the transfer cask handling station

Transfer cask ready to deliver the GTCC RWC to the ISFSI

Transfer cask on transfer trailer conveying a GTCC RWC to the ISFSI for dry storage

Transfer of a GTCC RWC into its assigned NUHOMS dry storage module in the CR3 ISFSI

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CR3 progress status – Vessel Removal

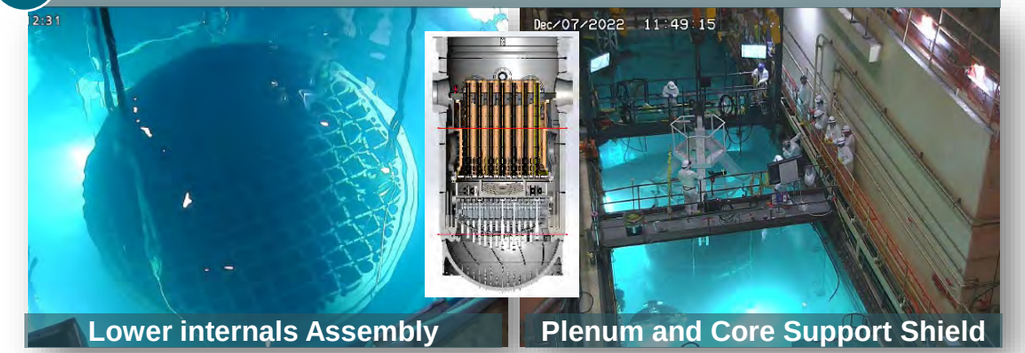
2020 | **2021** | **2022** | **2023**

Reactor Vessel Removal

Reactor Vessel Removal:

1. Internals repackaging inside the Vessel
2. Fuel transfer canal cleanup and drain down
3. Reactor vessel grouting and segmentation
4. Reactor vessel segmentation

1 Non-GTCC internal components were repositioned inside the vessel

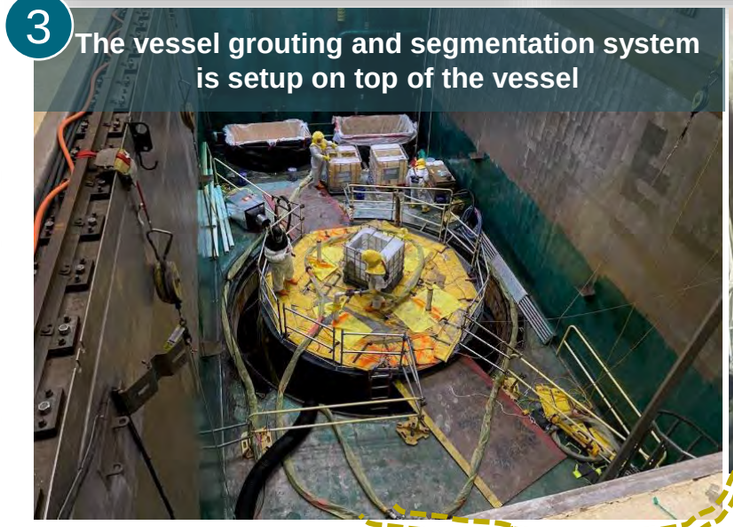


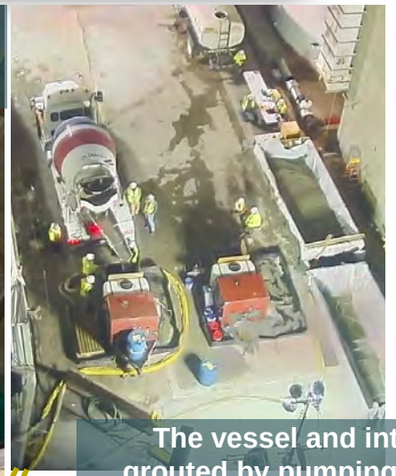
Lower internals Assembly

Plenum and Core Support Shield

2 All RVI underwater activities were completed and the Fuel Transfer Canal was cleaned-up and drained down to prepare for RV dry segmentation work

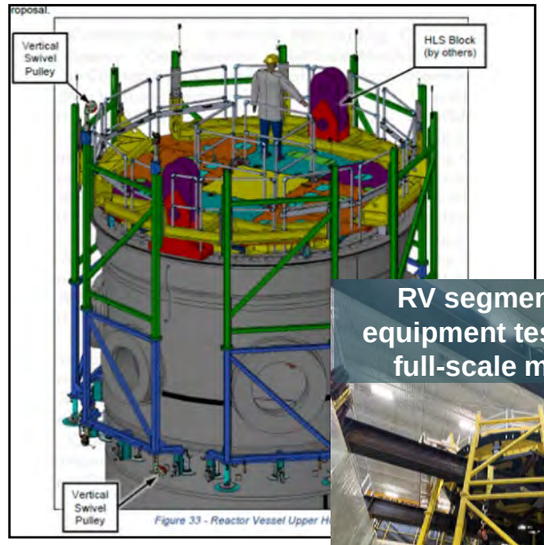
3 The vessel grouting and segmentation system is setup on top of the vessel





The vessel and internals were grouted by pumping a low-density cellular concrete inside the vessel

4 The RV/RVI monolith will be separated from the RCS piping and segmented using Diamond Wire Sawing



RV segmentation equipment tested on a full-scale mockup

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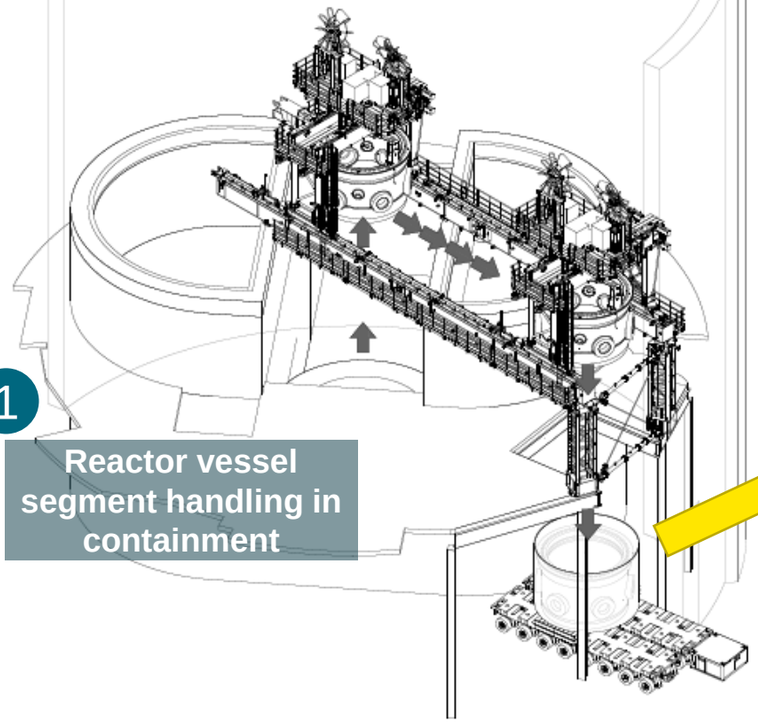
CR3 progress status – Packaging and shipment for disposal

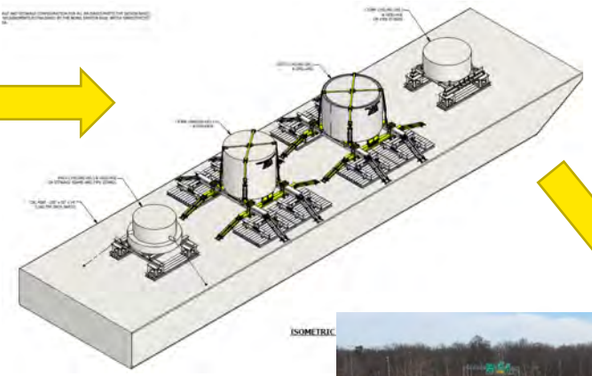
2020 | **2021** | **2022** | **2023**



1

Reactor vessel segment handling in containment

RV type B package ready to receive the “middle” RV+RVI segment

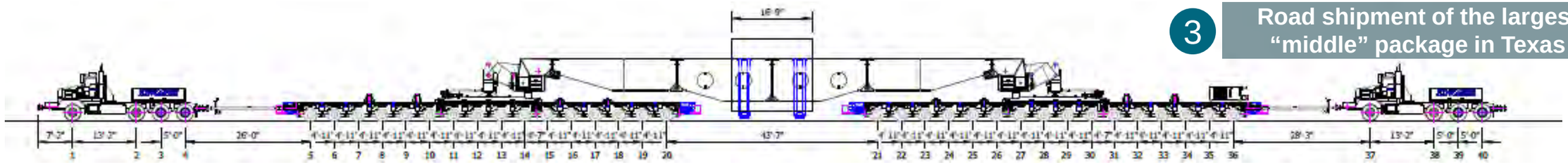


2

Barge shipment from Florida to Texas

3

Road shipment of the largest “middle” package in Texas



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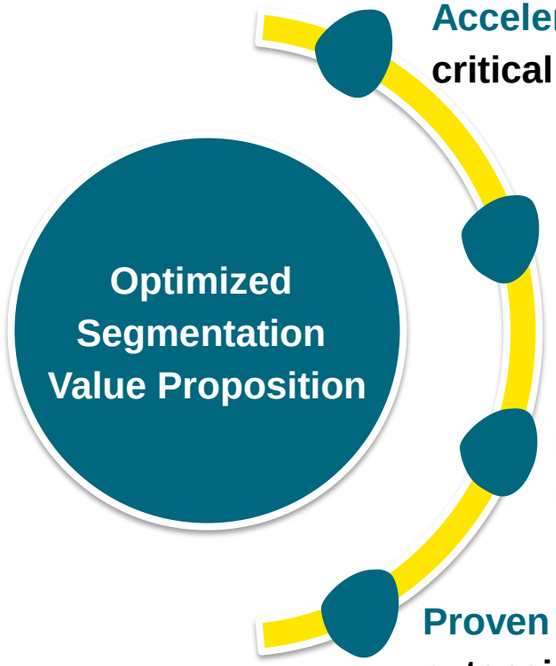
Conclusion – Innovating for more safety and efficiency

Orano has expanded its toolbox and options offered to the industry with access to larger packaging systems and minimized segmentation work

At Crystal River Unit 3, Orano is delivering the first implementation of the Optimized Segmentation **break-through** strategy



Accelerated site operations on the program critical path reactor removal work

Minimized segmentation and packaging operations that reduces duration, risk, and overall dose to the workers

Minimized transportation frequency, and risk to the public

Proven technologies from experience & extensive lessons learned

Number of LLW Packages / Shipments for the Reactor Components	
Typical BWR / PWR Full Segmentation	~ 50 - 80
Vermont Yankee BWR Full Segmentation	38
CR3 PWR Optimized Segmentation	6

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