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Nuclear Power Plant Decommissioning

Chornobyl – New Safe Confinement (NSC) Project

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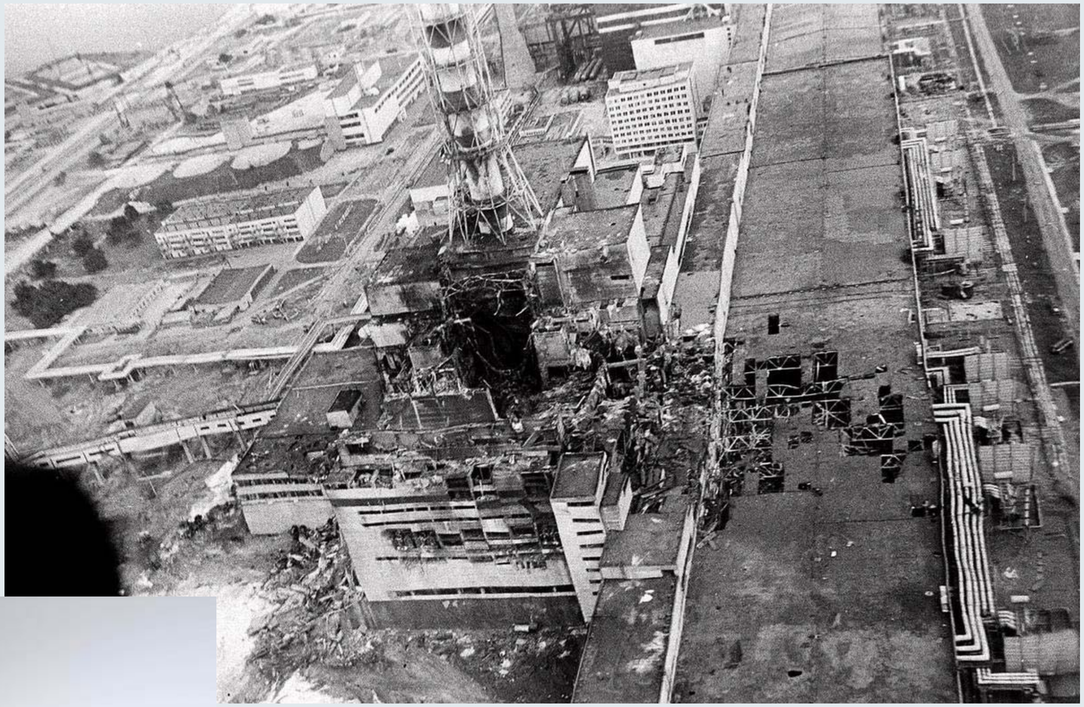
Topics

- The Big Picture
- What Happened?
- The Remediation Fix
- NSC Configuration
- Some key technical aspects – New Safe Confinement
  - Main Crane System
  - Sliding Mechanism
- Decommissioning

The Big Picture - 30 yrs later

1986



2016

Units 3 & 4

Beam
Support
Points

What Happened ?

The explosion at Unit 4 on April 26, 1986, was result of multiple failures that fall into 2 broad categories:

- System Design Weaknesses, such as -
  - Reactor design used by Soviet Union (RBMK) was inherently unstable at low power levels
    - Main contributor that lead to explosion
  - No containment structure
  - Control rod design
- Override of safety systems, such as -
  - Operating reactor outside of procedures

Soviets favored RBMK (**R**eactor **B**olshoy **M**oshchnosty **K**analny, or "high-powered channel reactor") because:

- Plutonium production
- Could be refueled while reactor was still running
  - Important to Soviet Union's national security

What Happened? (cont.)

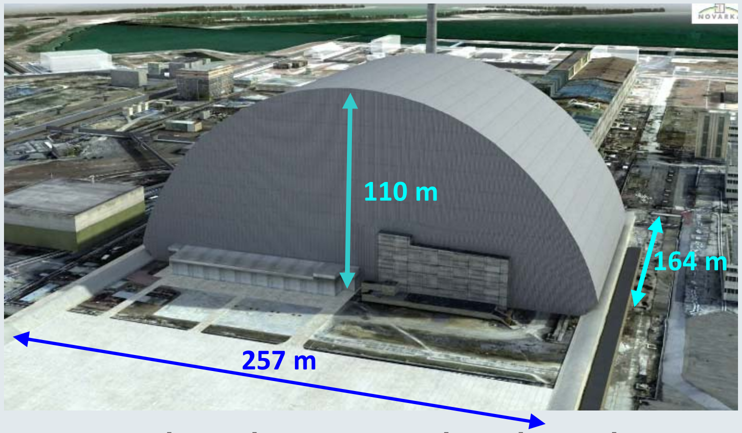
The experiment that lead to explosion:

- If loss of electrical power occurred, power provided by backup generators
- There was question on safety margin on time lag between reactor power loss and generator start-up
- As part of scheduled routine shutdown, decision made to test time lag
- Reactor's power level was lowered to see if turbine itself would have enough residual inertia to pump coolant through reactor core until backup generators started
- There was complex series of events, including multiple power surges, incorrect engagement of control rods, etc, which lead to reactor power rising far beyond design limits, with fuel pellet fracturing, rapid steam production, and explosion

The Remediation Fix

- Within 6 months after accident, a “sarcophagus” (now known as Object Shelter – OS) was built to enclose Unit 4 reactor to prevent water ingress & confine contamination releases
  - Within few years, recognized that OS had unacceptable risk of collapse, was allowing ingress of rain water, and radioactive dust was escaping
- A long-term strategy to provide adequate confinement of OS developed in 1997: the Shelter Implementation Plan (SIP)
  - SIP outlines step-by-step approach to:
    - Stabilize OS
    - Decrease risk to workers, general population, & environment
    - Transform Chornobyl into environmentally safe site
- Many projects on-going since 1998 to meet objectives of SIP, with NSC being the largest and most visible project
- Bechtel has the major role to implement the SIP, forming the Project Mngmt Unit
- EBRD administers funding provided by donor nations (over 40, including US)
- Design/build Contractor: NOVARKA – consortium of French companies –
  - Vinci Construction Grands Projets & Bouygues Travaux Publics

NSC Configuration



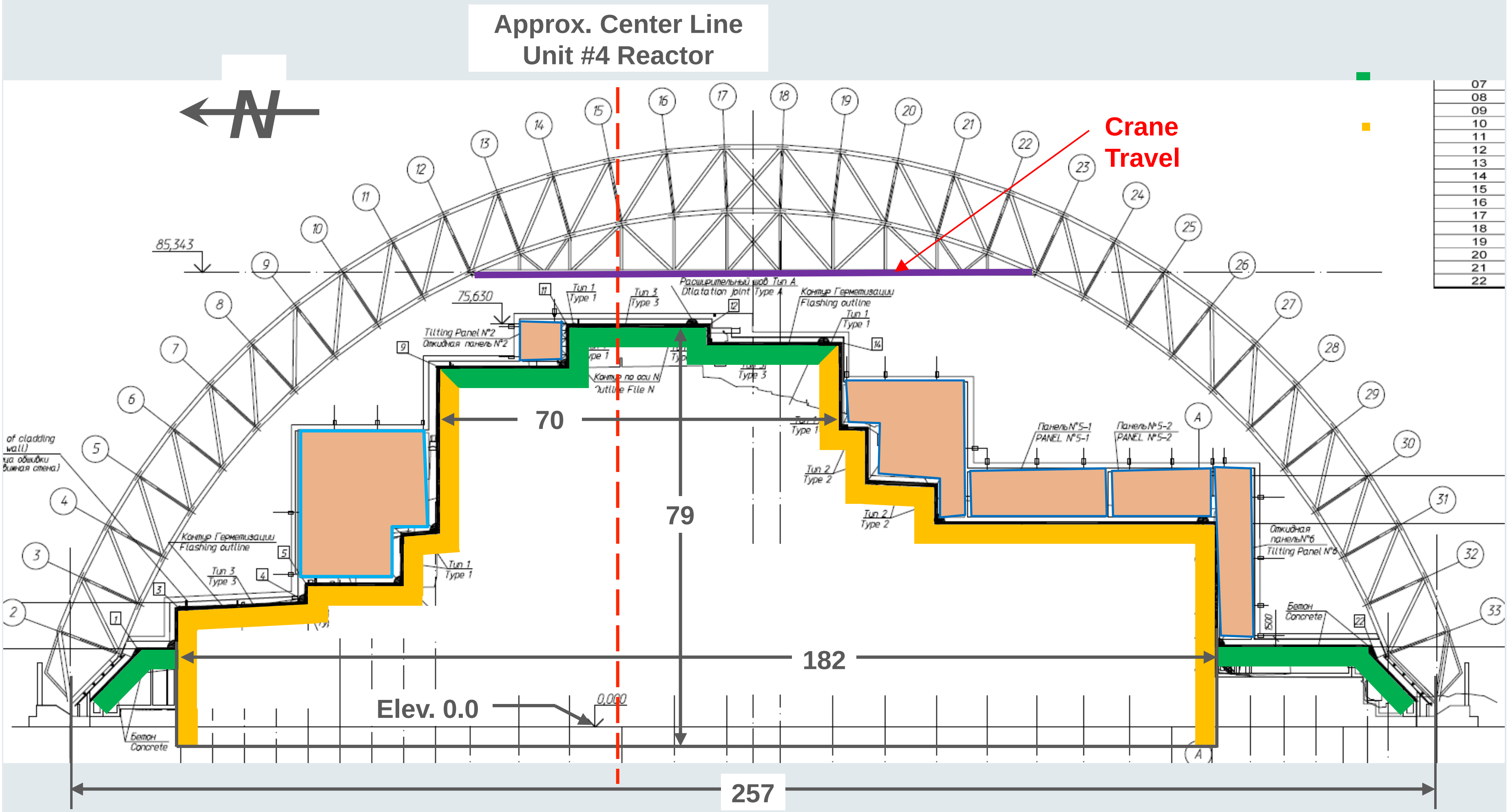
NSC structure:

- 16 arch-shaped trusses, 41-ft apart
- Each truss comprised of inner & tubular steel chords, 36-ft apart
- “Annular Space” comprises space between chords: contains bracing, HVAC system, and corrosion monitoring
- Cladding: SS skin both inner & outer surfaces
- NSC equipped with two, 50 mt capacity bridge cranes supported near the top of the structure
- End-walls at each end have “cut-outs” to accommodate existing Unit 4
- In addition, there are extensive foundations, support buildings, and complex sub-systems

Unique aspect: built 1100-ft from final position, then slid into place

NSC Configuration (cont.)

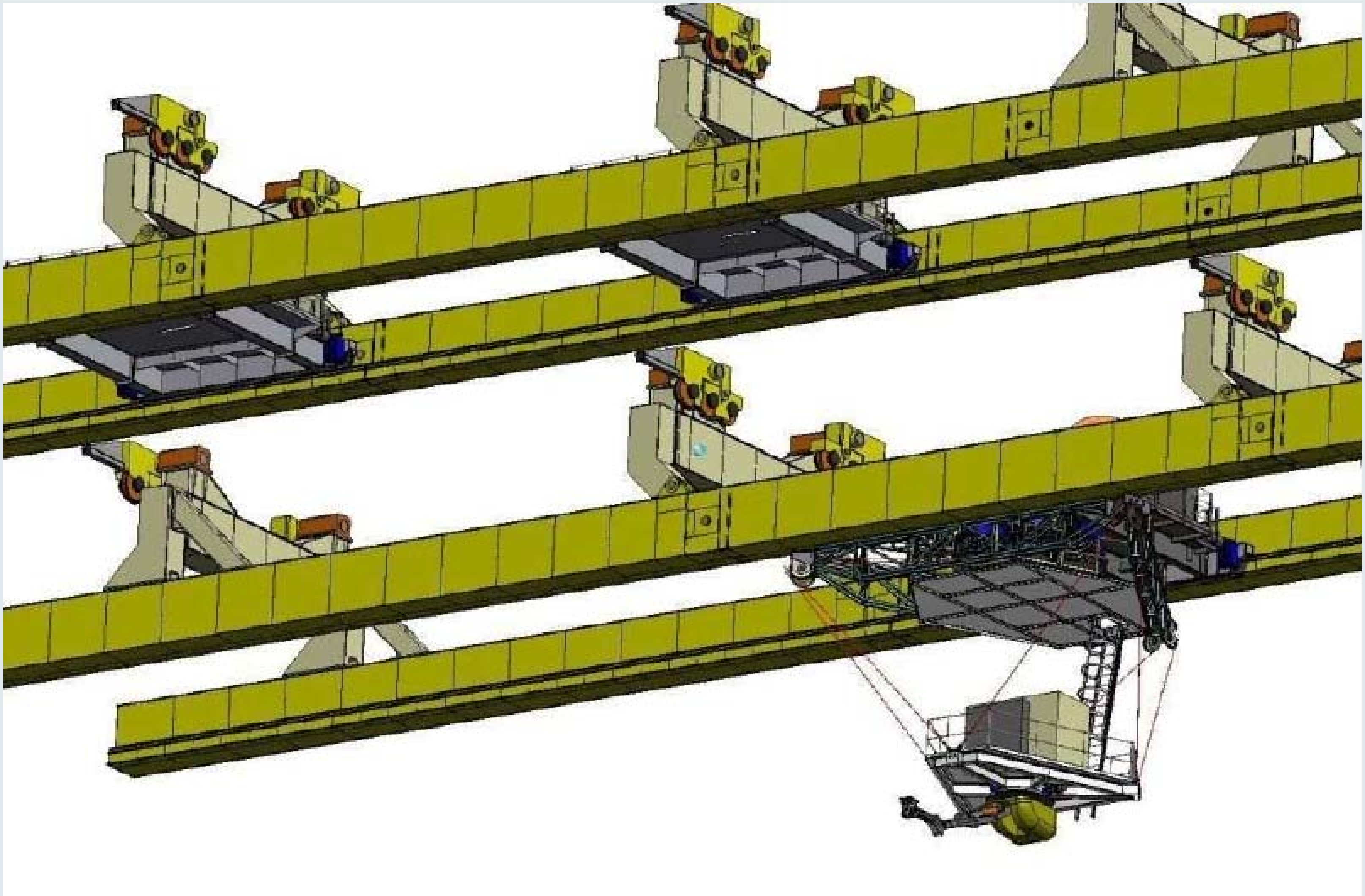
NSC Configuration (cont.)



Dimensions in Meters

Key Technical Aspects

MCS – Main Crane System



Key Technical Aspects – cont.

MCS – Mobile Tool Platform

3 Carriage Configurations:

- Mobile Tool Platform:

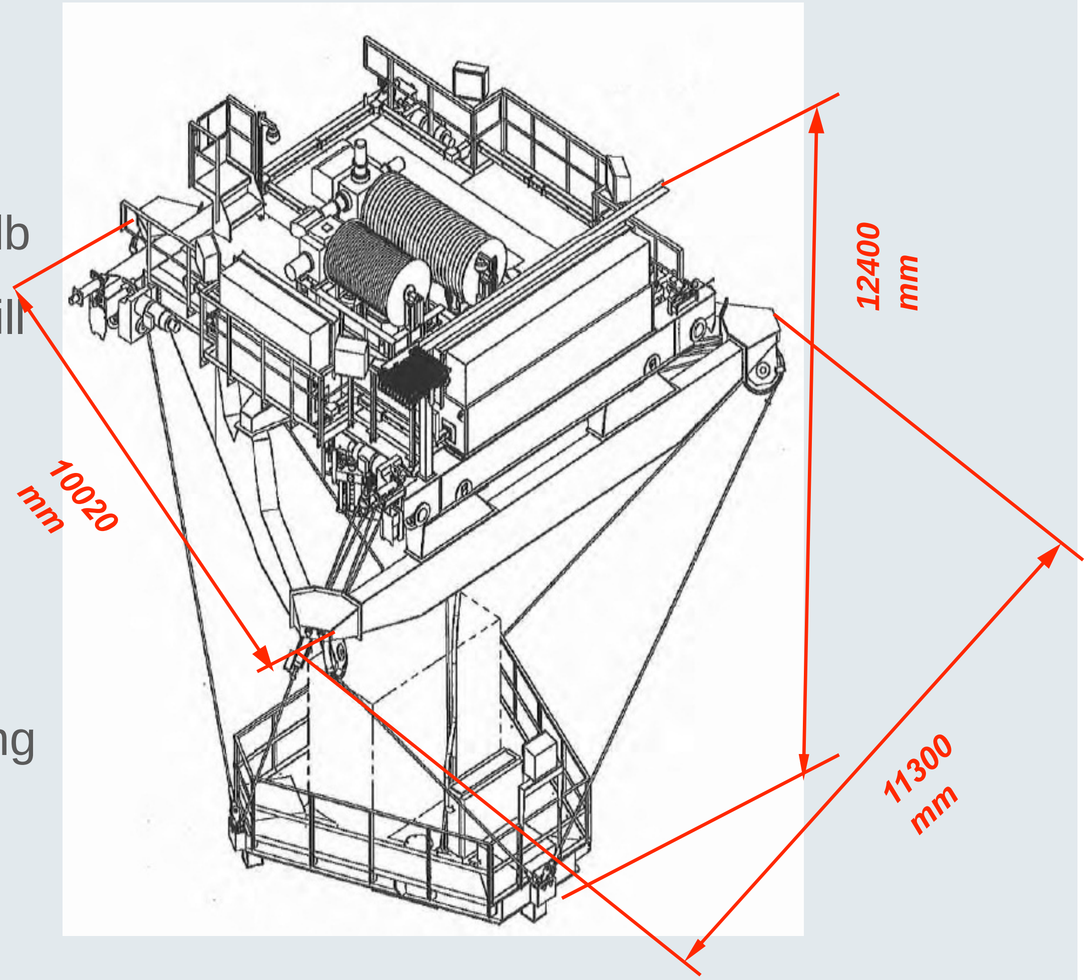
  "Tensile Truss" reacts 700 lb lateral load for concrete drill and jaw crusher

- Classic Carriage:

  50 t capacity, 244-ft lift

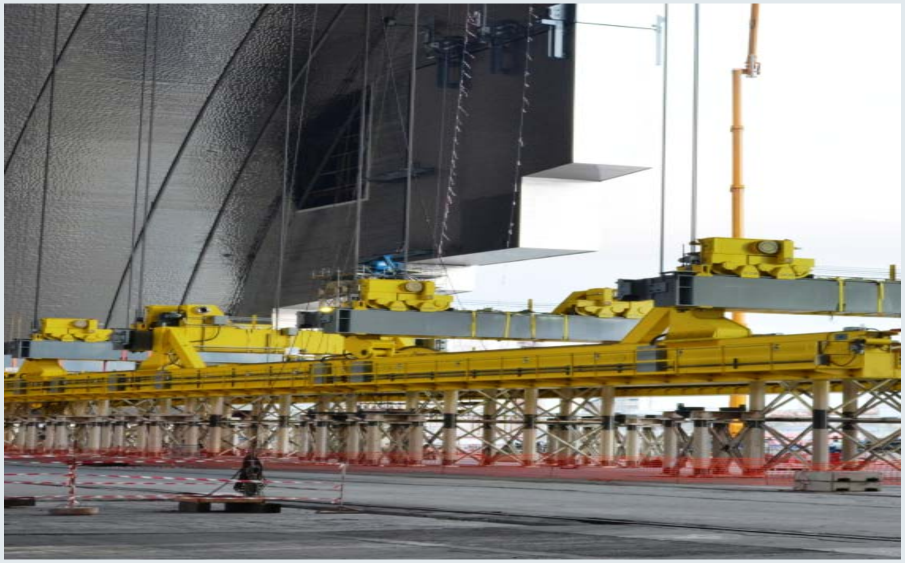
- Secure Carriage:

  Shielded box for transporting personnel.



Key Technical Aspects – cont.

MCS



Key Technical Aspects

Sliding Mechanism

- The 1986 accident blew the roof off the reactor's concrete containment building, and severely damaged the upper portions of the walls
- Some of the post-accident remediation tasks provided roof structures to reduce rain/snow infiltration and contain dust releases
  - These steel roof structures (part of the "sarcophagus") provide minimal radiation protection
- Radiation shine upwards results in necessity to construct NSC away from Unit 4 to protect workers
- NSC built 1100-ft away, and will be slid to final positon

Key Technical Aspects – cont.

Sliding Mechanism

4 push-pull units at 28 locations = 112 units to control

Key Technical Aspects – cont.

Sliding Mechanism

"Skidshoe" system

- Located where each main truss connects to foundation – "foot"
  - 32 skidshoe systems, 16 each on north & south sides
- Operation
  - 4 vertical jacks lift each arch approx. 2-in., transferring load from foot to skidshoe
  - 4 horizontal jacks (clamped to the foundation) push/pull approx. 24-in.
    - Sliding surface is Teflon-coated stainless steel
  - Vertical jacks transfer load from skidshoes to foot
  - Clamps are released and repositioned with horizontal jacks
  - Clamps are engaged, and the next cycle starts
- Complex computerized control systems, cameras, etc
- Sliding: started 11/15/16, completed 11/27

Decommissioning

- Decommissioning centers around deconstruction of Unit 4 sarcophagus and damaged reactor structure
- Deconstruction performed with 3 types of MCS carriages: classic carriages, mobile tool platform, and secure carriage
  - All MCS operations performed remotely
- First, the sarcophagus erected after accident will be deconstructed
  - Steel structures: massive beams, trusses, large diameter pipes, etc
  - It is necessary to use the 2 classis carriages to lift & rotate 90 deg the largest elements, to place in laydown area
- Second, the Unit 4 structures, primarily reinforced concrete, will be deconstructed
  - Mobile tool platform primarily used to cut rebar & drill/crush concrete
- After members removed by cranes and placed in laydown area, elements decontaminated to maximum extent possible

Decommissioning (cont.)

- Once decontaminated, elements further fragmented for packaging and disposal
- Laydown area (located adjacent to west end-wall) at ground level, protected by existing concrete walls, allowing access by personnel with PPE
  - Extensive decon, fragmentation, and packaging structures & systems
- Removal of contaminated material will not be undertaken until long-term repository is available
  - Ukraine responsible for removing & storing radioactive material
  - Activities are outside scope of the SIP
    - No plan is in place for design & construction of long-term repository
    - It could be many years before deconstruction begins