INL/CON-23-70854-Revision-0

Mobile Hot Cell Digital Twin: End-of-life Management of Disused High Activity Radioactive Sources

March 2023

Rajiv Khadka, John A Koudelka, Kevin L Kenney, Steven E Egan, Konner M Casanova, Bryce C Hillman, Ted R Reed, Gary Alan Newman, Blesson Isaac

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Problem

Very few field tested mobile hot cells exist in the world, results in
  - Removal project delays
  - Dependency on third parties
  - Health and safety risks due to uncertain design
- Sealed radioactive sources are utilized for a wide range of applications.
- Recovery and consolidation of excess, unwanted or orphaned high activity sources is limited by hot cell availability and capability.
- Lack of robust, reliable, and autonomous systems to visualize and monitor the process of end-of-life management of spent radioactive sources

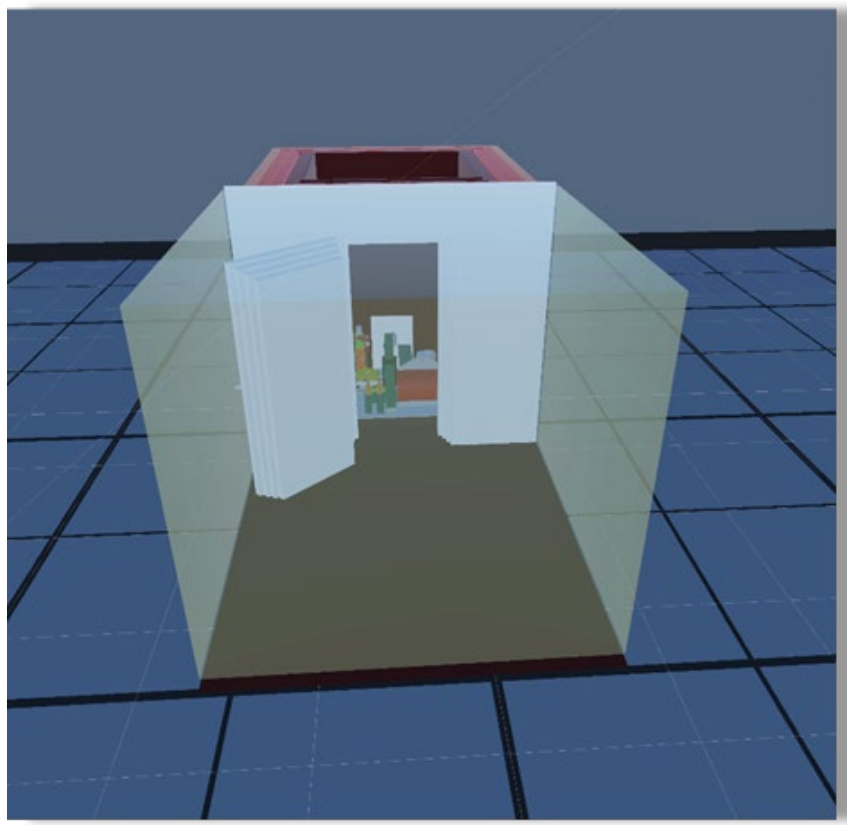
Importance

- Design a mobile hot cell that
  - Integrates “advanced” technologies
  - Increases safety and ease of deployment
  - Addresses lessons learned from current designs
- MHC construction is time intensive, taking up to two weeks for assembly and disassembly
- Manual hot cell operations increases dose, increases risk of error, and limits throughput and efficiency.
- Operator safety and comfort

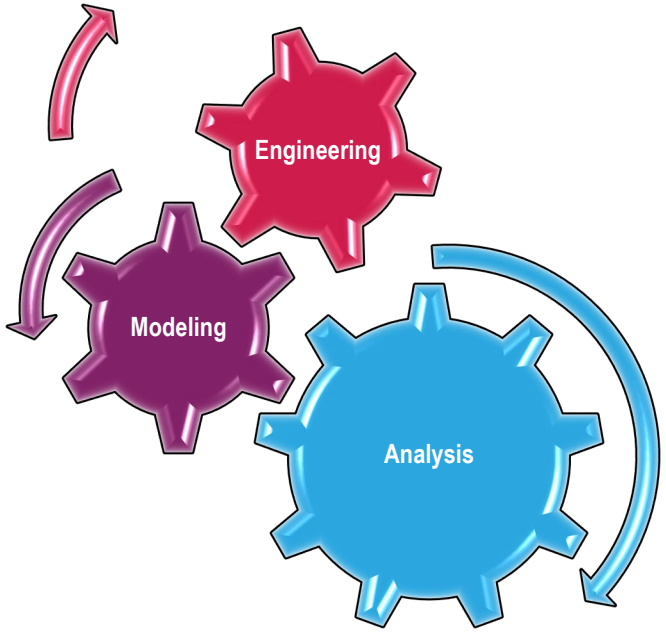
INIS Mobile Hot Cell
Source: Joint Investigation Report March 30, 2020

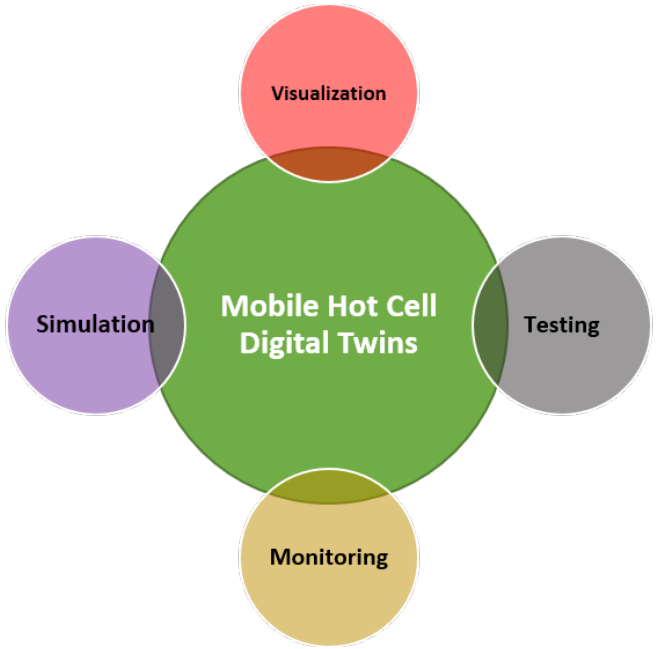
Proposed Idea

- **A Digital Twin Framework**
  - Visualize and monitor the process to inform the engineering and design of a new Mobile Hot Cell.
  - Reduces human error
  - Reduces equipment and construction cost
  - Support prototype demonstration



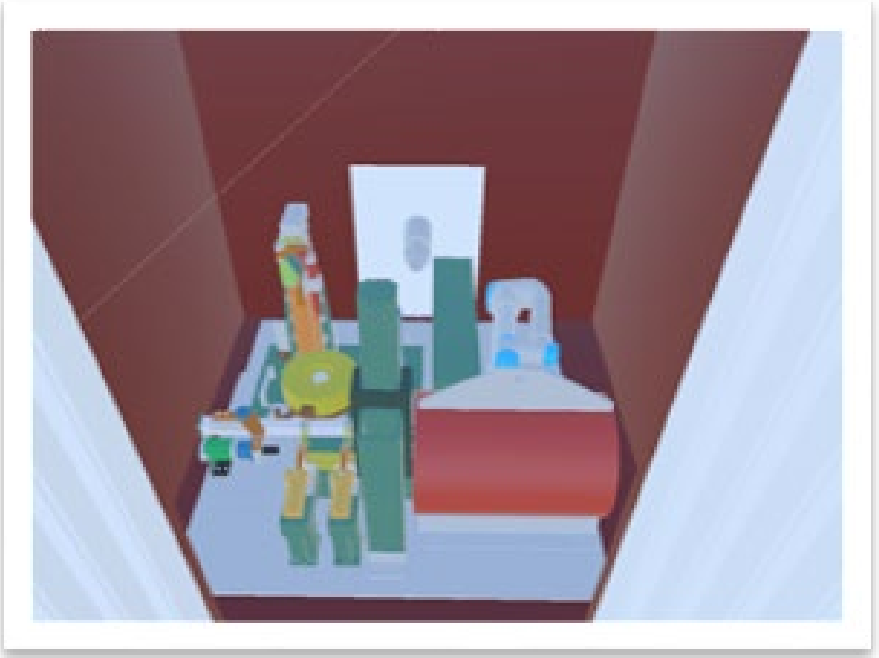
Mobile Hot Cell: Digital Twin





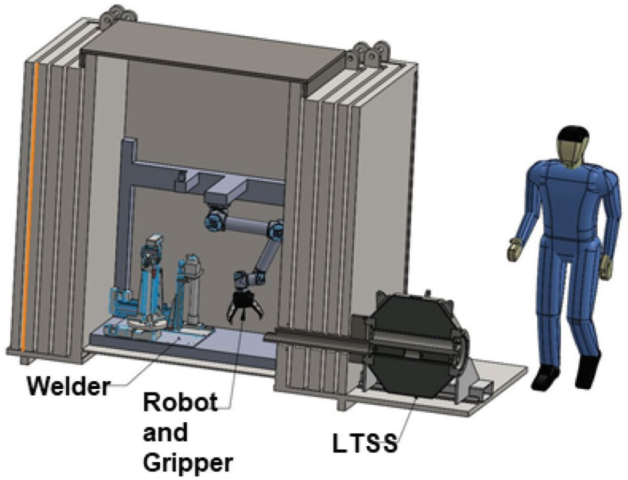
Mobile Hot Cell: Digital Twin Operation

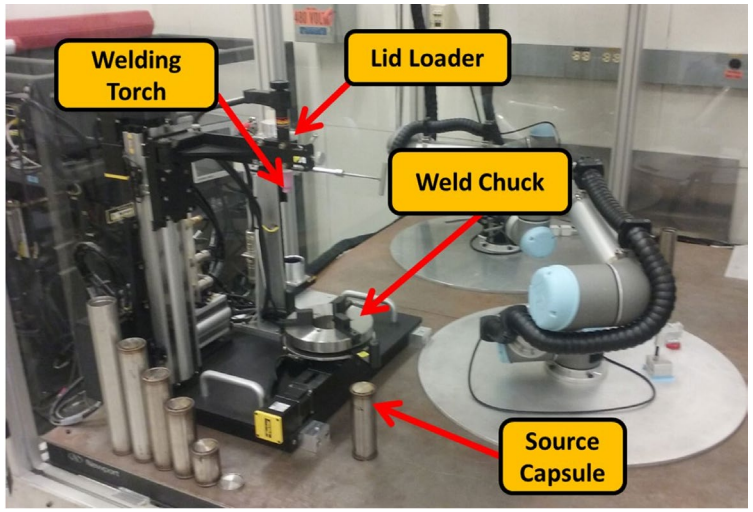
- Replica of the physical models and assets
- Data connection
- Validation of the radiation dose rate accumulation and component functions
- Continuous development, optimization, and iteration

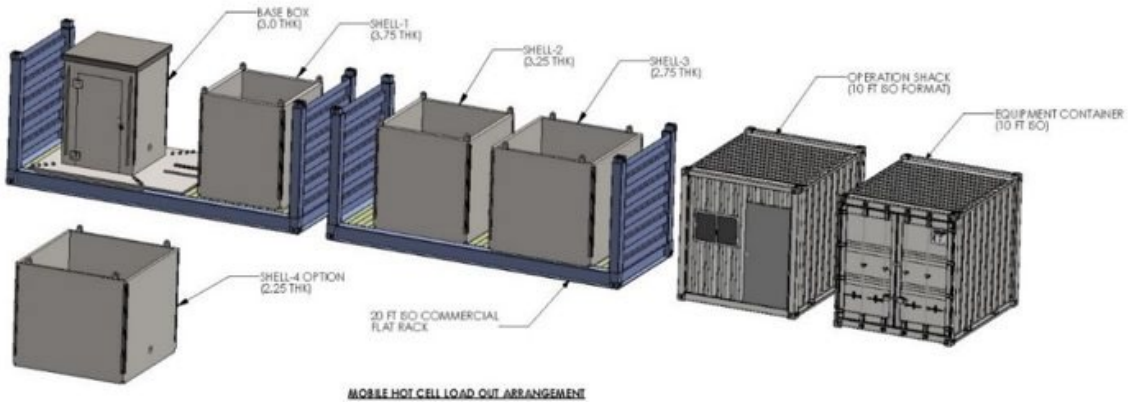


Mobile Hot Cell: Real-World Physical Object

- Handle and manage used sealed sources of highly radioactive materials by isolating the radioactive materials using a shielded enclosure called a hot cell.
- Assist operators in performing operations without exceeding the allowable dose rate

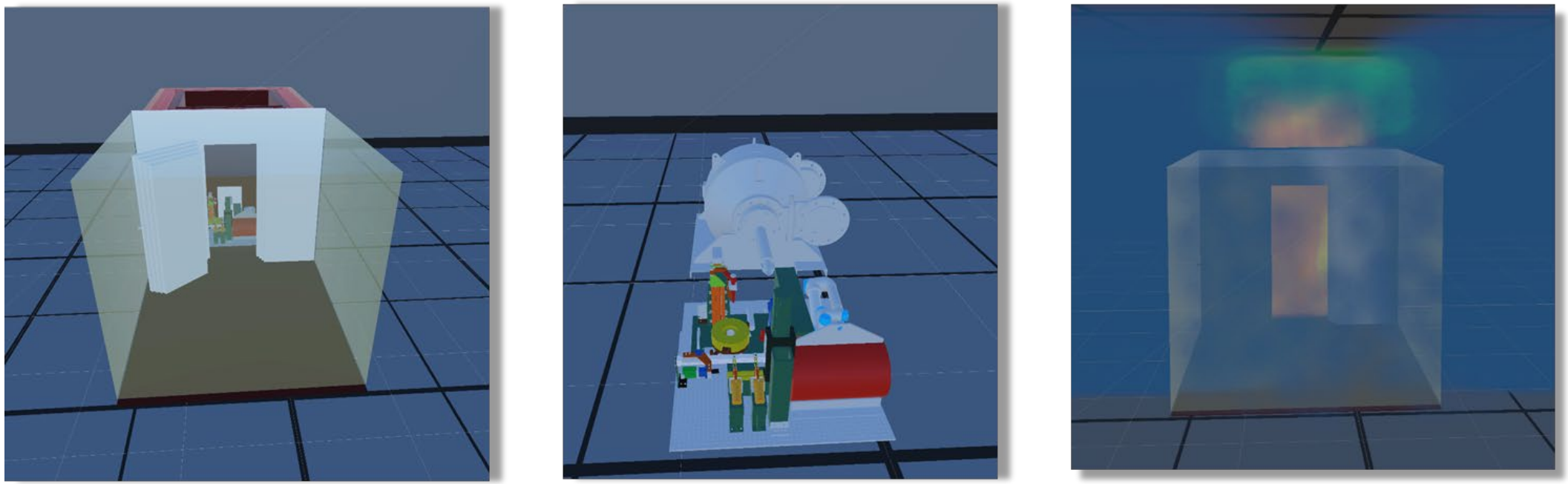






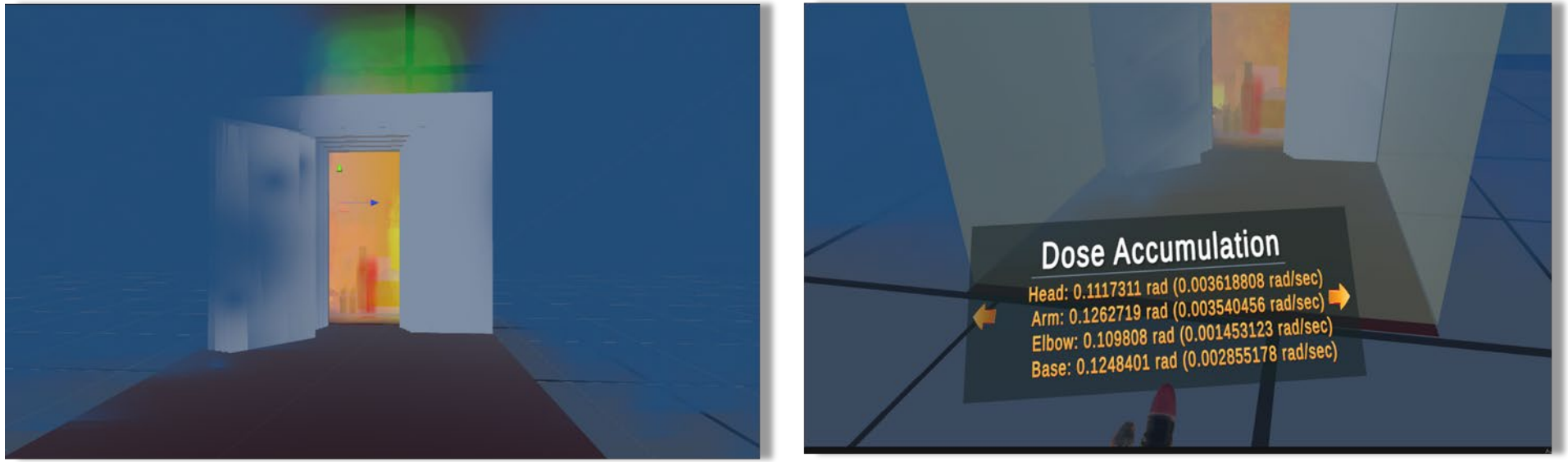
MOBILE HOT CELL LOAD OUT ARRANGEMENT

Mobile Hot Cell: Digital Object



Virtual Prototype of Mobile Hot Cell (left), radiation modeling of the environment (middle) and inner components (right)

Mobile Hot Cell: Radiation Modeling



Radiation Modeling and Visualization (left) and radiation dose rate accumulation information using MCNP data during the source recovery operation (right)

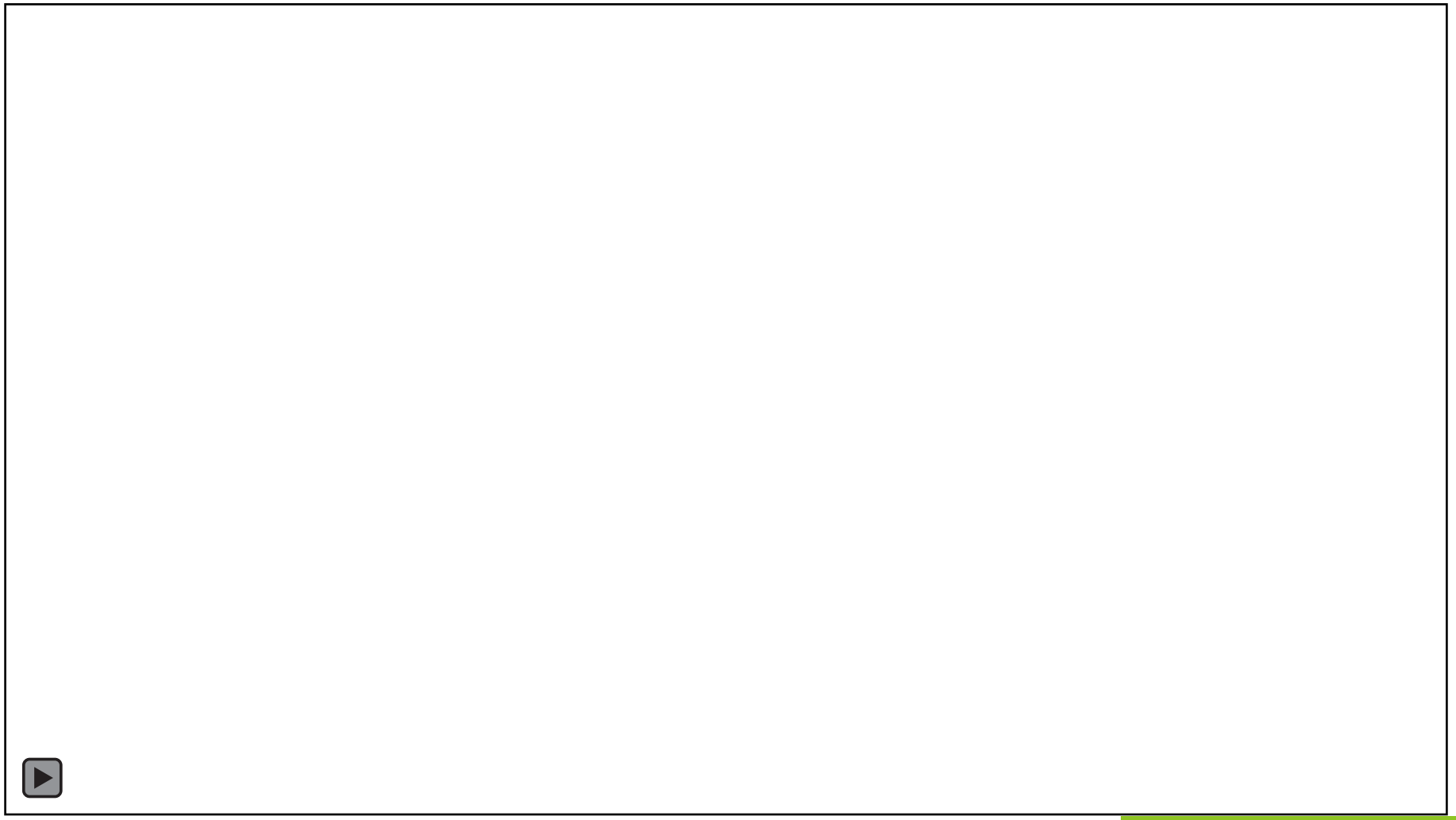
Mobile Hot Cell: Visualization

Mobile Hot Cell: Software & Hardware

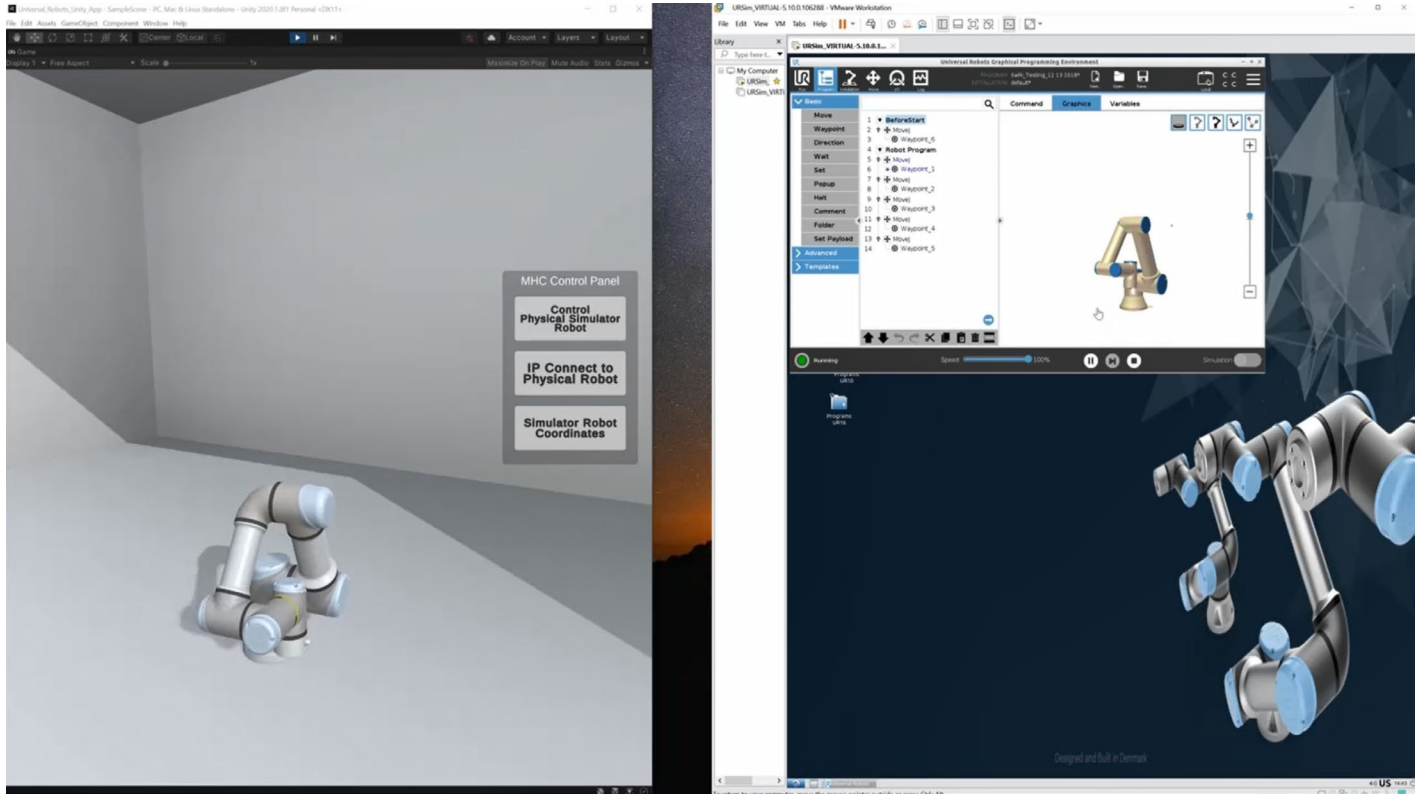
unity

MCNP

Demonstration



What next?


MHC Control Panel
Control Physical Simulator Robot
IP Connect to Physical Robot
Simulator Robot Coordinates

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