

# EPRI Presentation

## NRC Public Meeting on Digital Twins

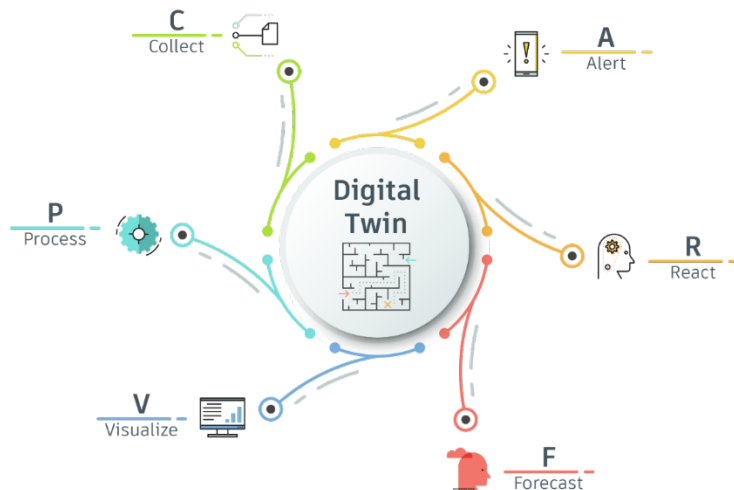
Hasan Charkas, PhD., PE.  
Principal Technical Leader

March 1<sup>st</sup>, 2022

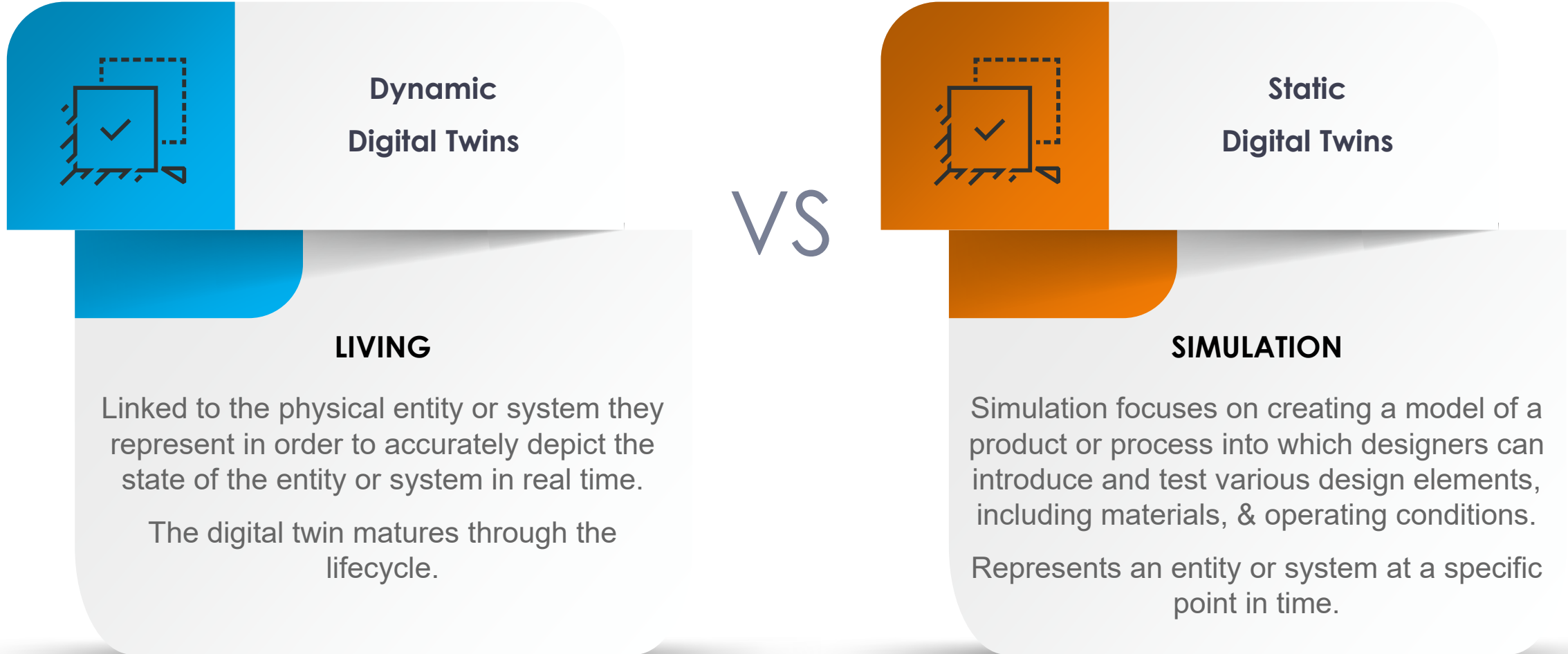


# EPRI Digital Twin Engineering Overview

- Working on developing DT guidance for proper implementation in the nuclear industry (2022)
- EPRI is leading the Digital Twin scope for the Nuclear Reactor Innovation Center (NRIC) demonstration project
  - Create a living digital twin for constructing a structure underground
  - Assess what-if scenarios
  - Inform design activities

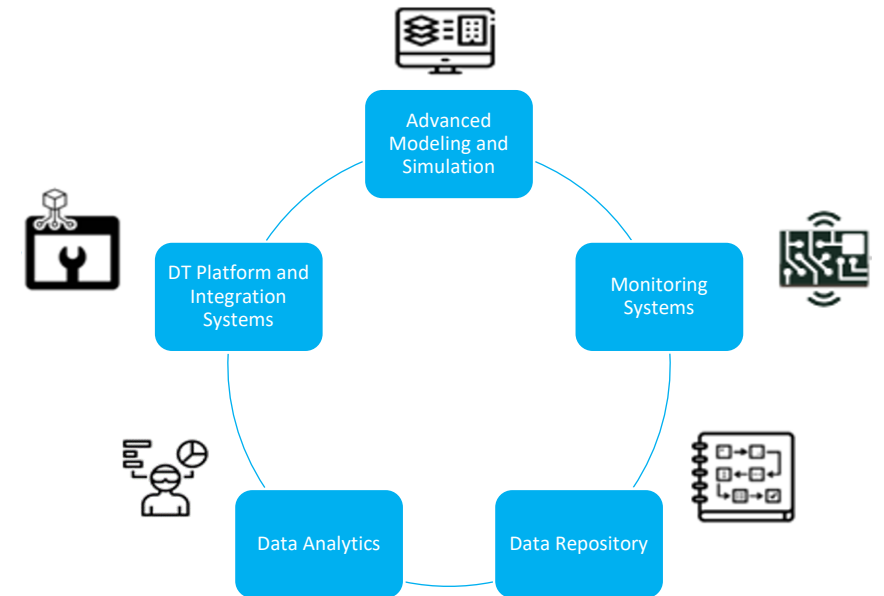
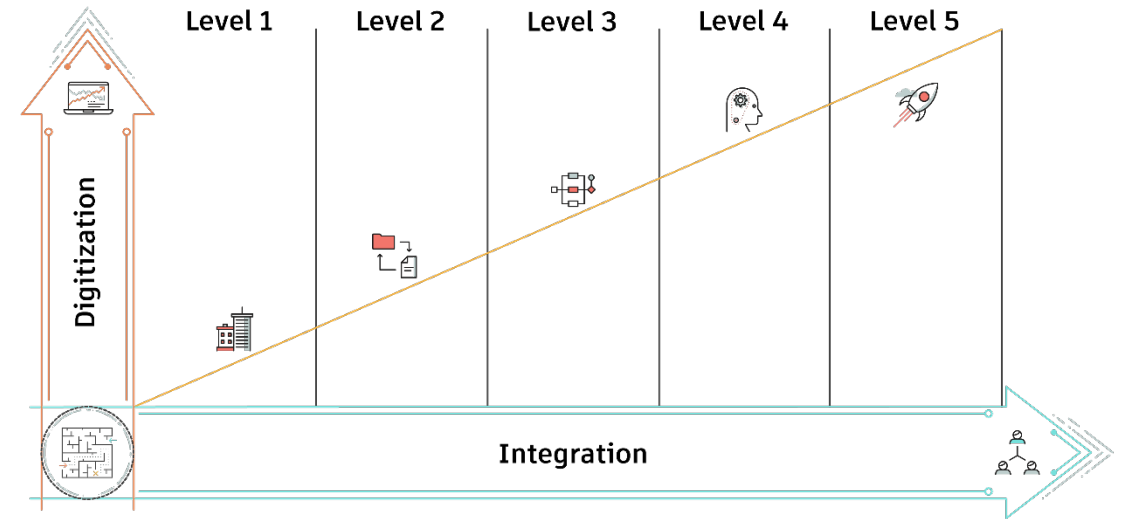


# Dynamic vs. Static Digital Twins



# Key Insights

- Start small and then scale up on digitization and integration to minimize risk
- Near-term use cases to focus on generating insights and assist in decision making
  - Subsequent development can move toward automation
- Plan for maintaining the DT and keeping it current
- Stakeholder steps to enable data V&V and reconciliation
  - Define reliability and performance metrics
  - Consensus on industry standards and common framework
    - Measures, tolerances, file formats, and safe data sharing protocols
  - Define responsibilities (NRC, utilities, contractors)
  - Collaborate within nuclear industry and other industries to share lessons learned and best practices.



**Elements of Digital Twins**



A blue-tinted photograph of four people standing in a row. From left to right: a woman with curly hair and glasses wearing a white lab coat with 'EPRI' on the pocket; a man with glasses wearing a white lab coat with 'EPRI' on the pocket; a woman wearing a white hard hat and a dark polo shirt with 'EPRI' on the pocket; and a man with glasses and a beard wearing a light blue button-down shirt. The text 'Together...Shaping the Future of Energy™' is overlaid in white in the center.

Together...Shaping the Future of Energy™

# Use of Digital Twins for Radiation Protection

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Principal Technical Leader  
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March 1, 2022

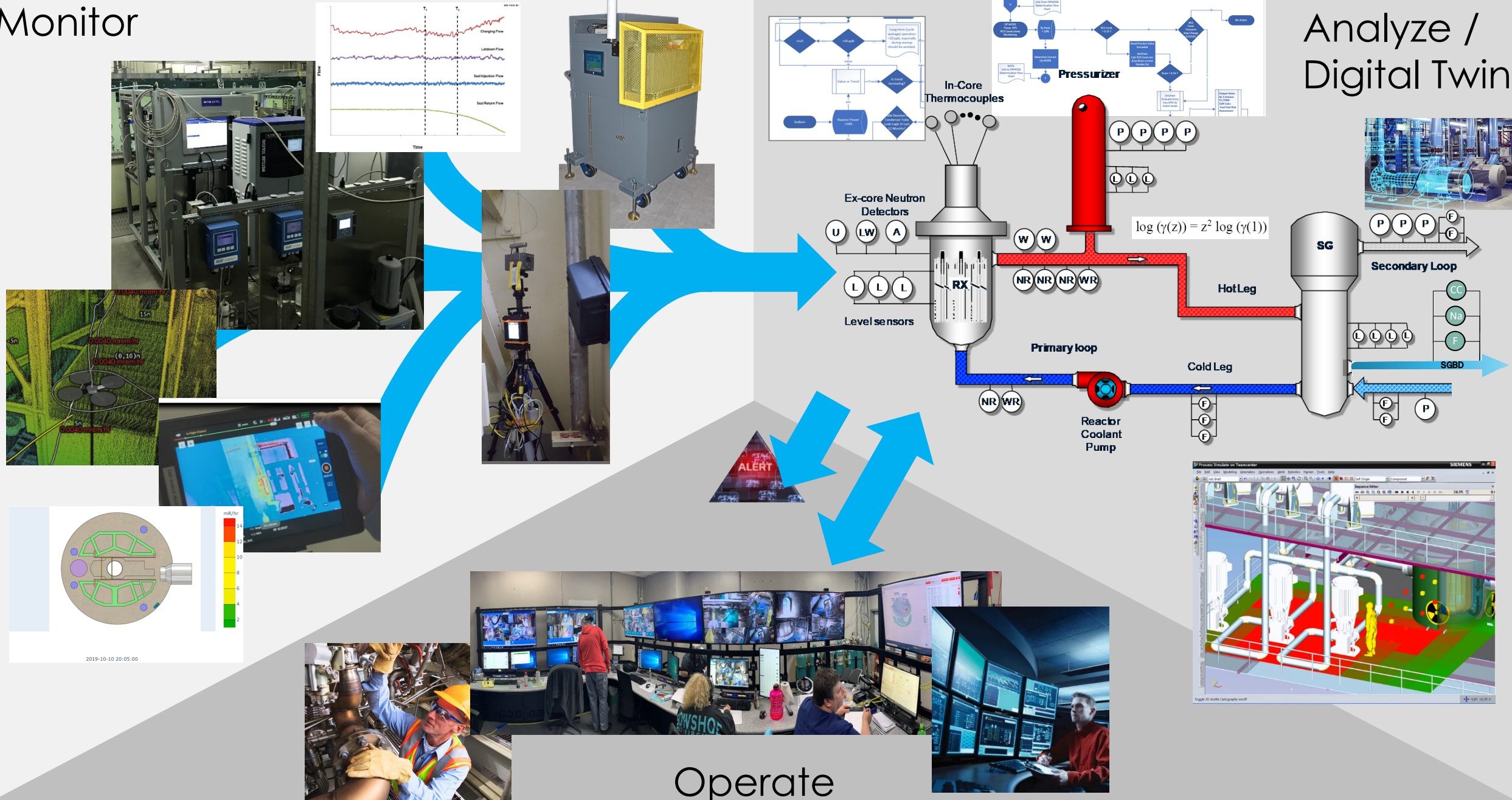
## NRC Workshop on Use of Digital Twins at Nuclear Reactors





# Monitor

## Analyze / Digital Twin





# **EPRI NextGenRP Project**

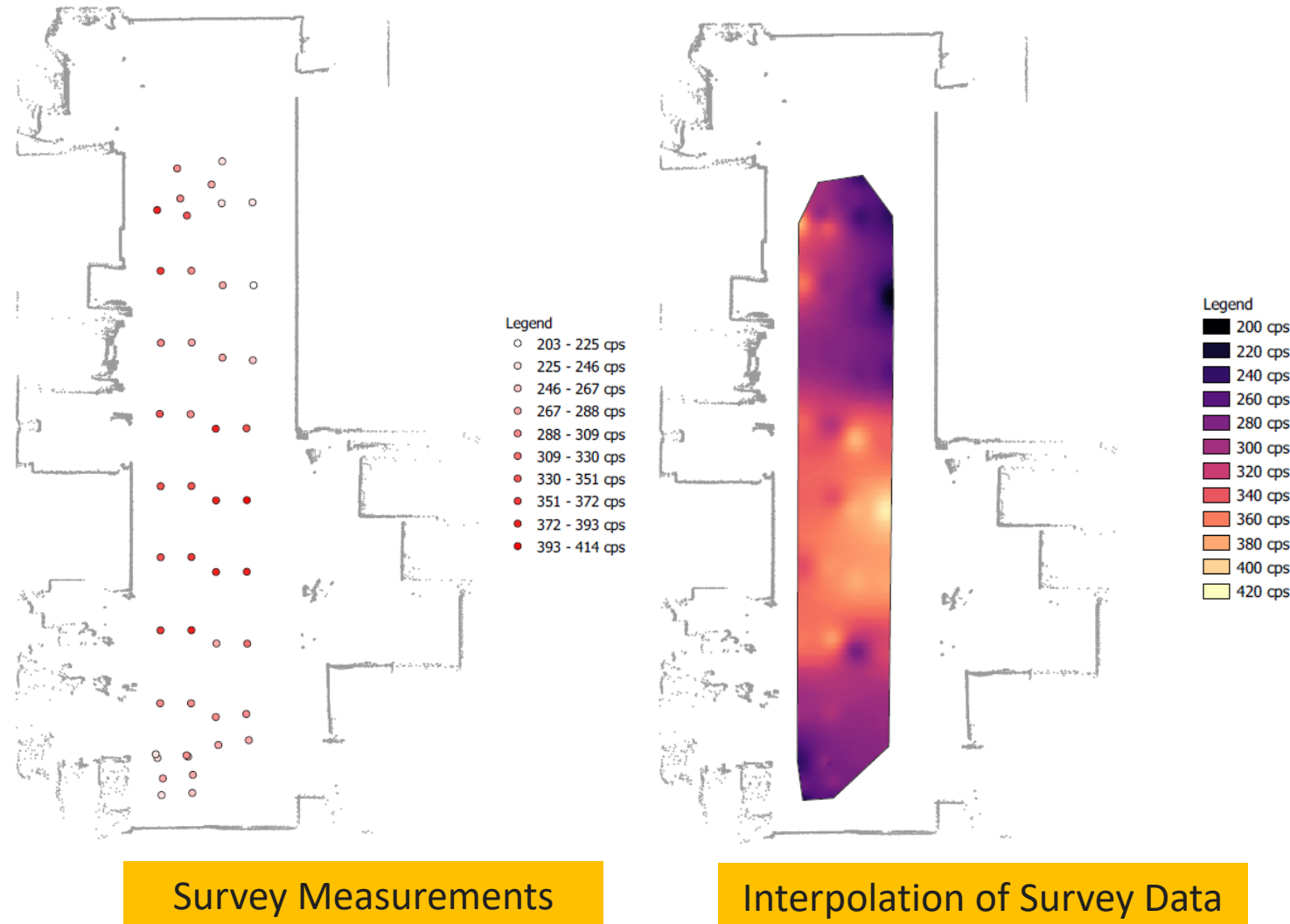
## **Development of a Digital Twin of a Real-time Radiation Monitoring Network**

# Development of a Geospatial Remote Live Streaming Radiation Monitoring Network

## Phase 1 - Demonstrate a Geophysical Application for Analyzing Radiological Survey Data

- Increased use of remote radiation monitoring technology is providing real-time radiological data.
- Measurement points are shown as single point sources with no values in between measurements.
- Geospatial technologies are available that can interpolate available remote detector readings to model the radiological conditions between measurement points.
- Digital Twin technologies represent a very rapidly growing industry with significant technological advances and applications in the recent past.

### Example of Actual Interpolation of Survey Data



# EPRI Project Objective and Potential Applications & Benefits

- **Objective:**

- To demonstrate software tools that leverages machine learning capabilities to create a radiation field digital twin by integrating real-time radiation fields with an accurate 3D map of the plant environment

- **Project Scope in 2021/Early 2022:**

- Available software applications evaluated - Createc, Inc (UK) technology chosen for demonstration
- Demonstration Results:
  - Program performed as expected
  - Integration into plant server or RP remote monitoring network yet to be demonstrated

- **Potential Applications and Benefits:**

- Acquire and project more accurate, comprehensive radiation field data that supports optimization of:
  - Radiological controls
  - Work planning including “What-If” scenarios
  - Pre-job briefings
  - Shielding analyses – visual impact related to addition or removal of shielding
  - Event analysis and reconstruction
  - Fixed radiation monitor positioning



# Example of Digital Twin Technology – Createc, Inc.

## Step 1:

Data Collection using a range of instruments or robotics & sensor configurations

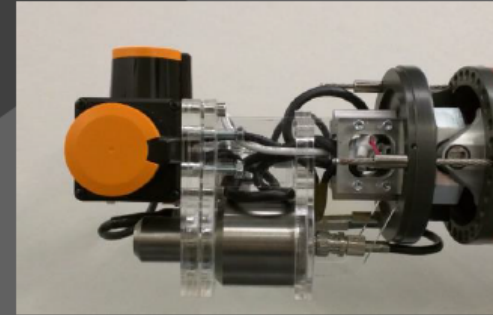


N-Visage® Scanner

N-Visage® Recon



N-Visage® sensors mounted on robotics

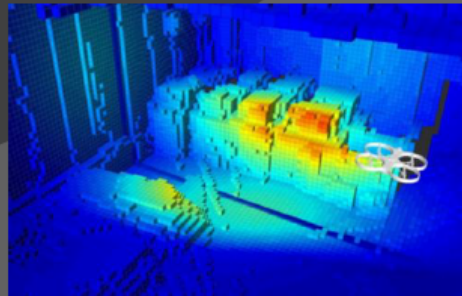


N-Visage® UAV sensor payload

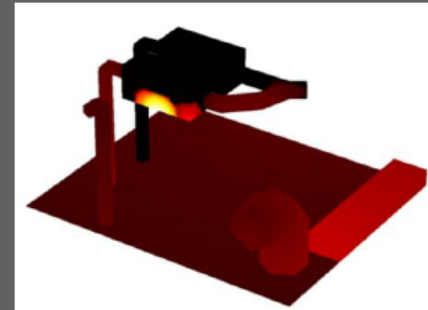


## Step 2:

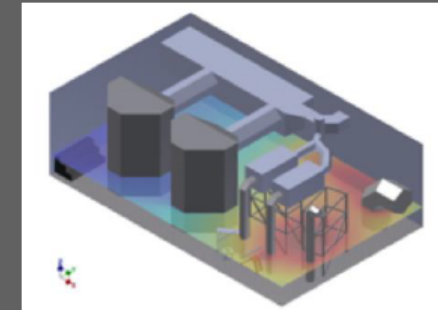
Data Analysis to produce a 3D map for radiation source distribution with N-Visage® Fusion



Realtime 3D heat map of sources



N-Visage® Fusion activity map



N-Visage® Fusion Dose Planes

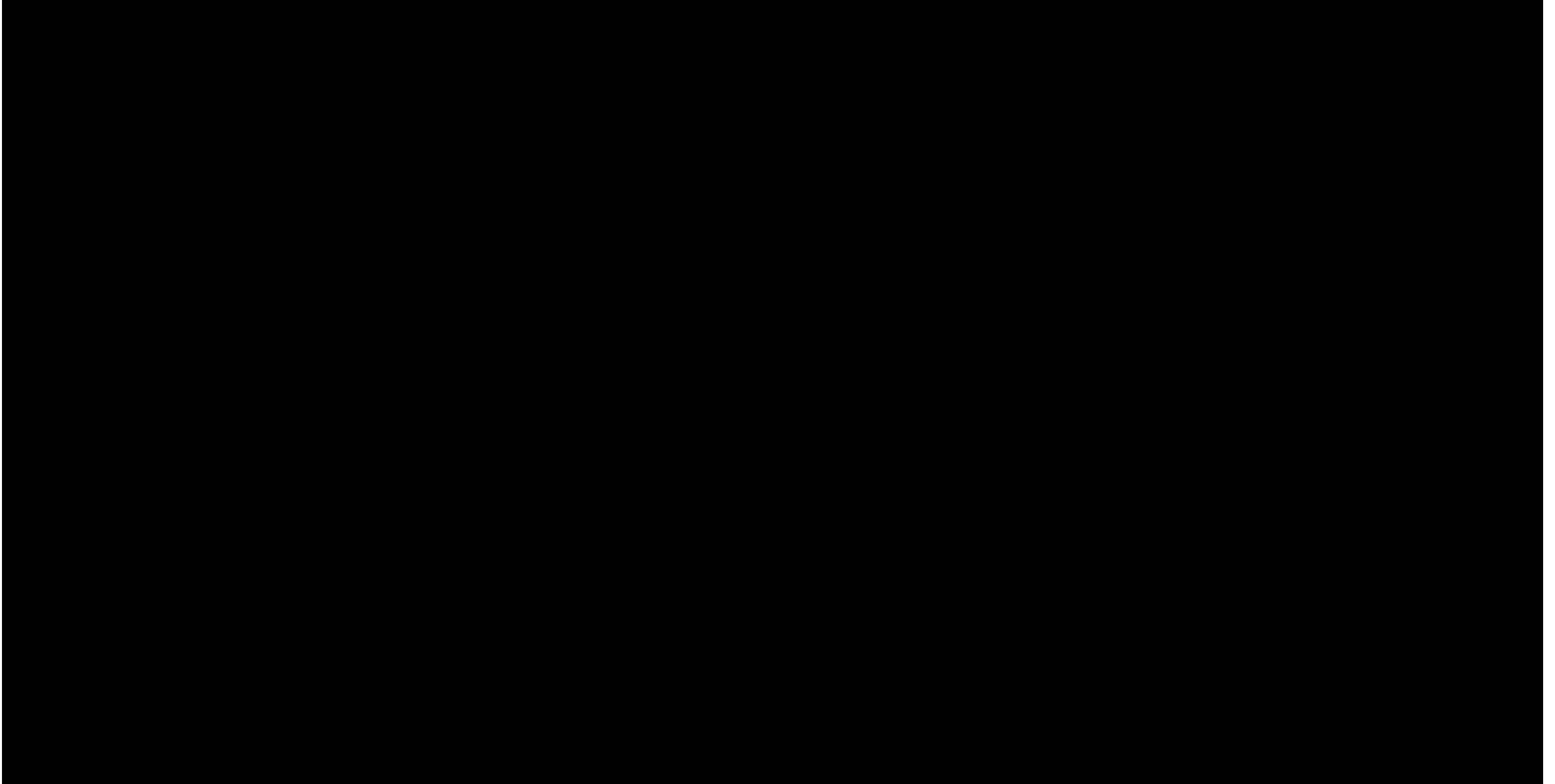
Data from transmitting Electron Personal Dosimeters (EPDs) can be integrated into data analysis





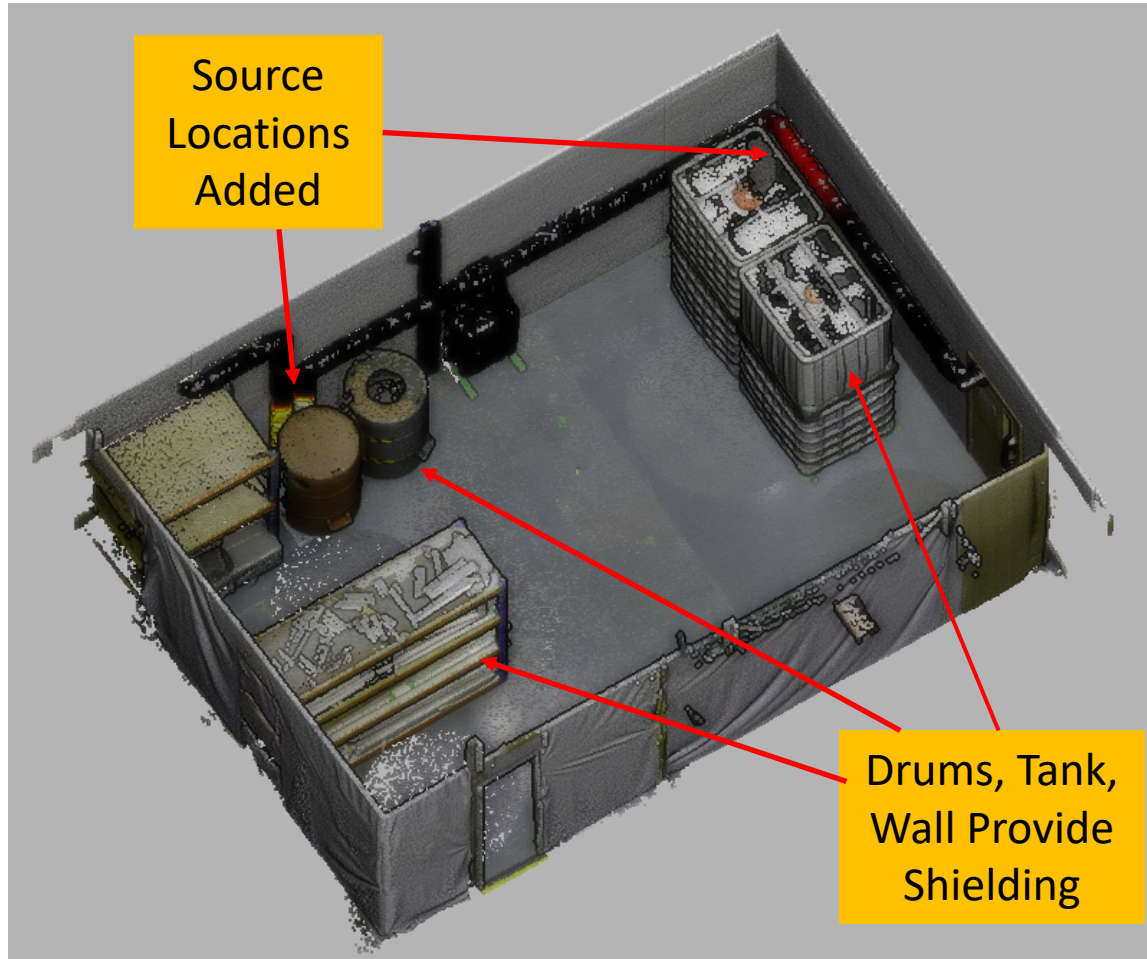
# **EPRI Demonstration Results: Existing Digital Twin Technology**

# EPRI Demonstration Results: Digital Twin of Radiation Environment

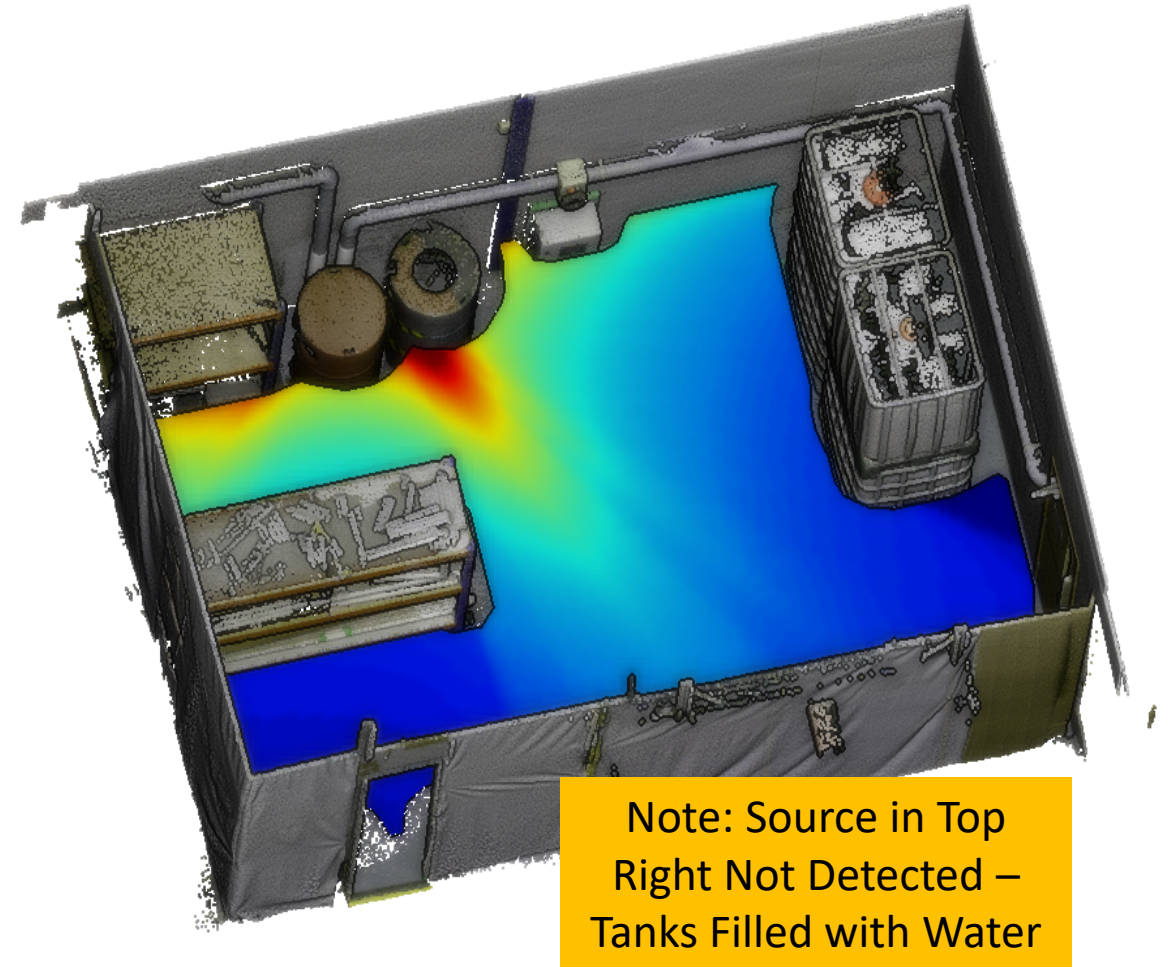


# EPRI Digital Twin Demonstration Results (1/3)

## 3D Image of Room Created with Mapping Technology



## Createc N-Visage Scan Creates Waist-High Radiation Field Heat Map

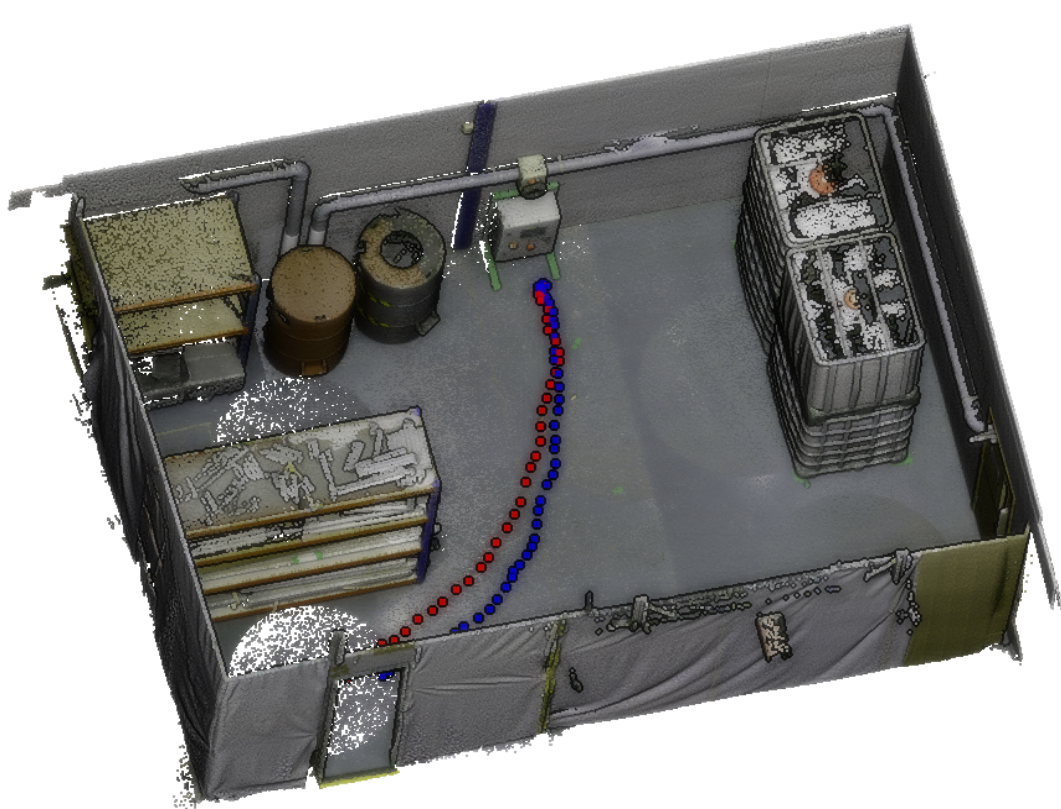




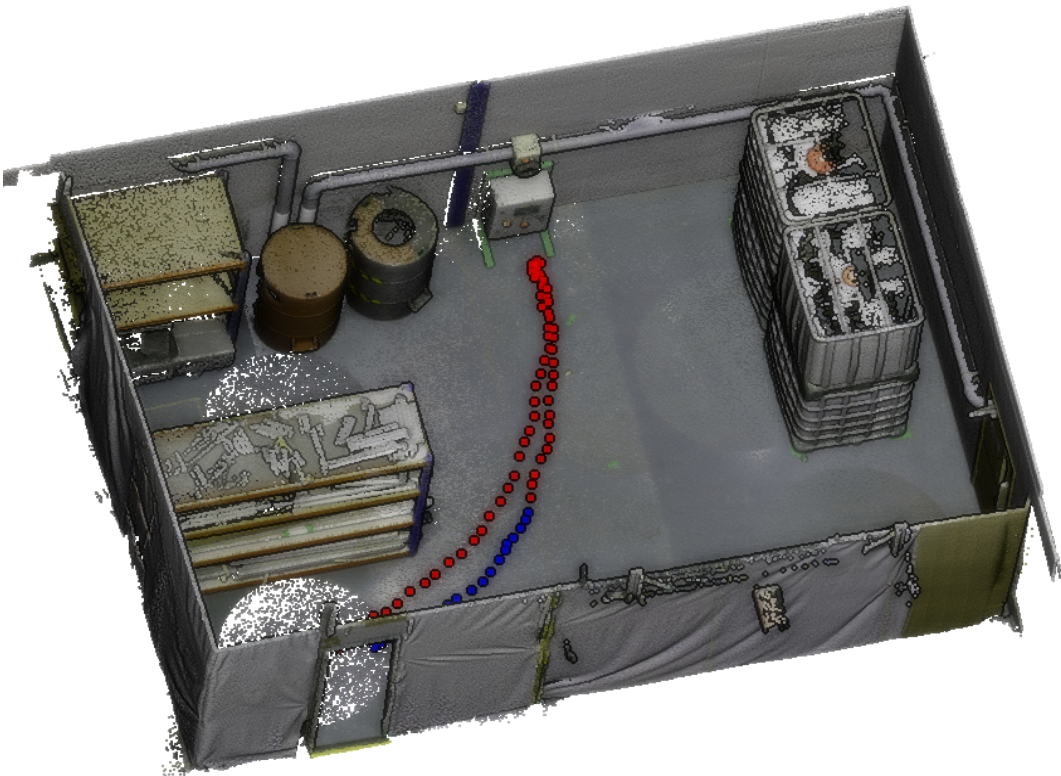
# EPRI Digital Twin Demonstration Results (2/3)

Worker Path Assessed for Projected Cumulative Radiation Exposure (CRE)

Actual Entry – Worker EPD (Blue) Reaches Alarm Setpoint Earlier Than Expected



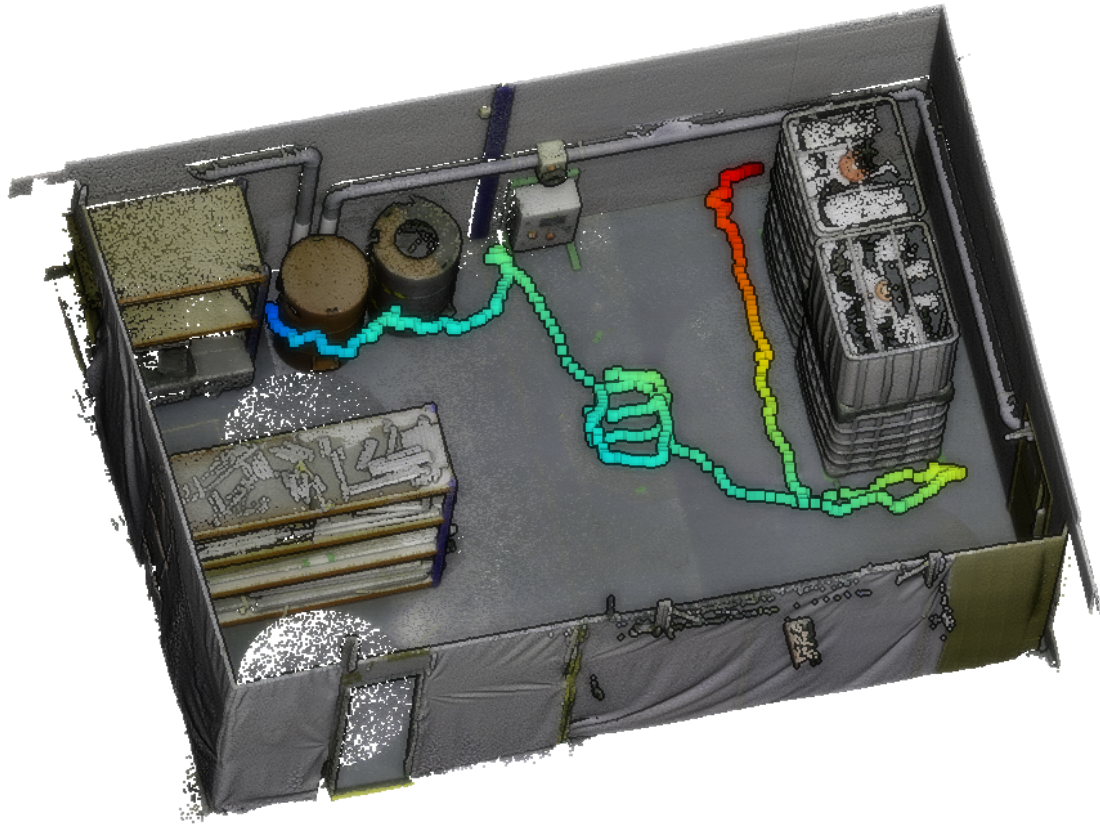
Red = Planned Pathway - CRE  
Blue = Expected Worker EPD CRE



EPD Alarm at Blue to Red interface  
Worker Leaves Area

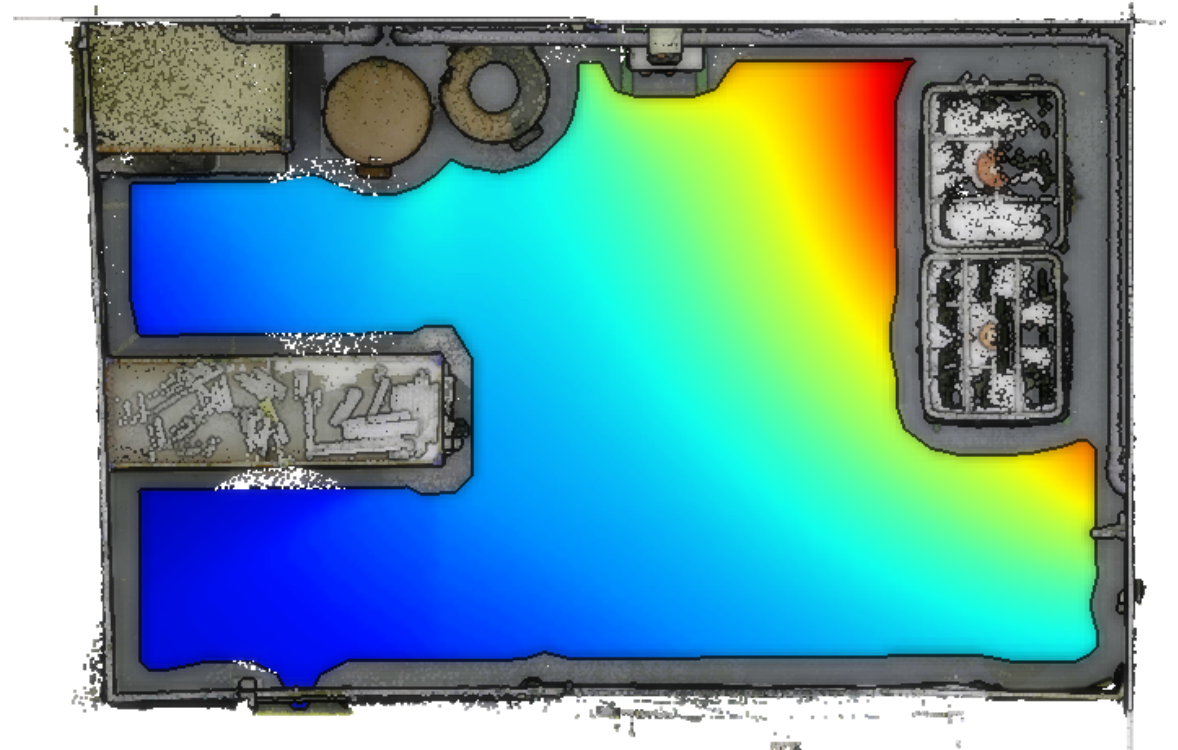
# EPRI Digital Twin Demonstration Results (3/3)

N-Visage Recon Investigation Survey  
Performed by RP Technician



Red Highlights Elevated Dose Rates  
Top Right

Water Shield Found to be Drained -  
Updated Heat Map Generated

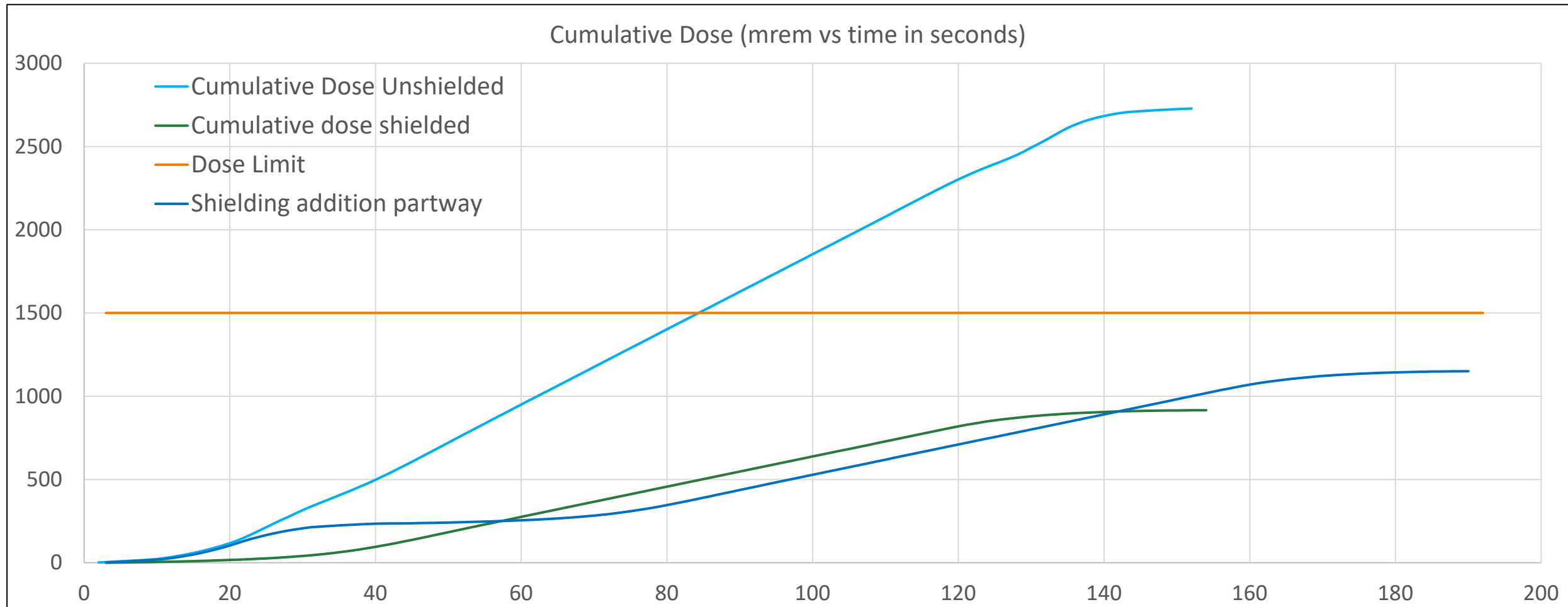


Drums in Upper Left Remain Shielded



# Exposure Scenarios can be Evaluated

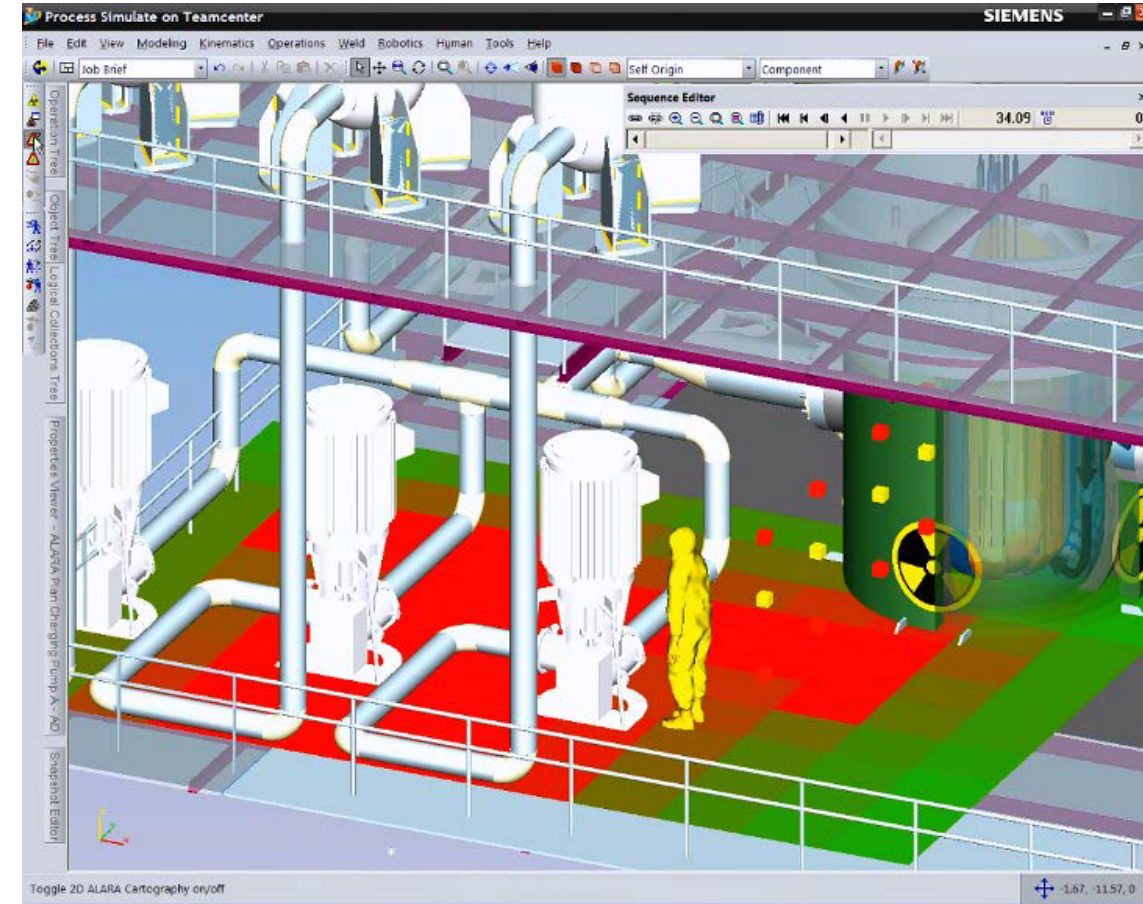
- Scenario on last slide analyzed – Light blue line shows detection of higher than expected dose rates
- Effect of shielding – Green line shows dose after water tanks refilled and shielding installed in front of tanks
- Dark blue line – Total dose for work including dose from aborted entry



# Development of a Geospatial Remote Live Streaming Radiation Monitoring Network

## Phase 2 - Apply Machine Learning to Geophysical Radiological Survey Application

- Machine learning can be coupled with the geospatial algorithm to refine the radiation field estimates as measurements are updated
- The digital twin could be used to allow for:
  - Ongoing monitoring, trending, and alerts and
  - Alternative maintenance and dose/cost optimization scenarios to be investigated in cyberspace before the work is performed
- Simulation results could be visualized by the worker during job preparations, job briefings, and in the work environment using augmented reality techniques.
- Project scope for 2022:
  - Evaluate software tool(s) for use in machine learning of survey data
  - Power plant demonstration to see if tool accurately predicts future radiation dose rate trends from survey data analyzed



Example of ALARA Planning Tool for Potential Further Development



A blue-tinted photograph of four people standing in a row. From left to right: a woman with curly hair and glasses wearing a white lab coat with 'EPRI' on the pocket; a man with glasses wearing a white lab coat with 'EPRI' on the pocket; a woman wearing a white hard hat and a dark polo shirt with 'EPRI' on the pocket; and a man with glasses and a beard wearing a light blue button-down shirt. The text 'Together...Shaping the Future of Energy™' is overlaid in white in the center.

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