Combining VR, AR, Simulation, and the IoT to Create a Digital Twin

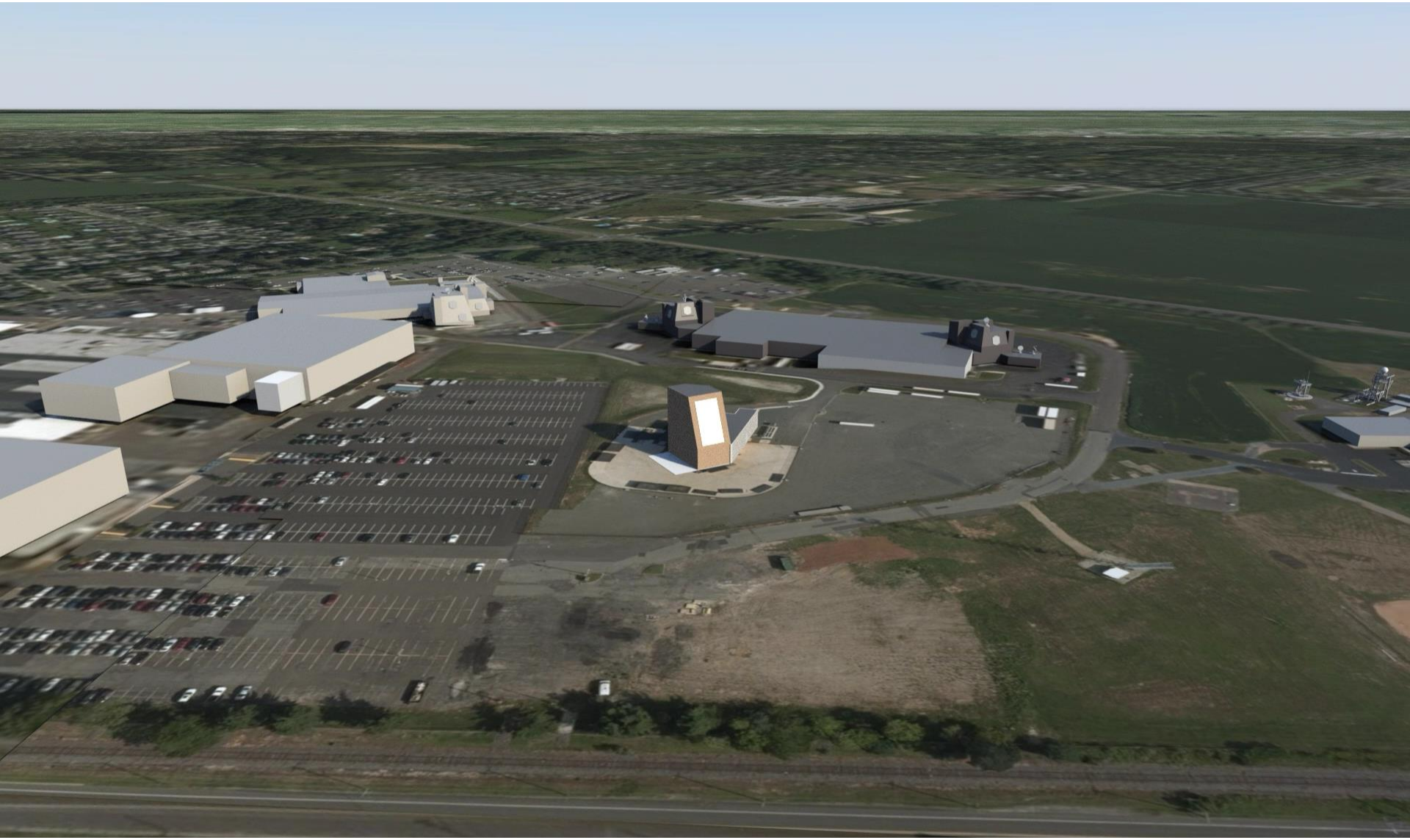
Rich Rabbitz
Chris Crouch

LOCKHEED MARTIN

Lockheed Martin Moorestown, New Jersey

- **Lockheed Martin Rotary and Mission Systems (RMS)**
  - Designs, manufactures, services and supports
    - Military and Civil Helicopters
    - Naval and Radar Systems
    - Provides World-Class Systems Integration Training and Logistics
  - **Lockheed Martin Moorestown, New Jersey**
    - Naval and Radar Systems
    - World-class Systems Integrator

Lockheed Martin Moorestown, New Jersey



Surface Navy Innovation Center (SNIC)

A research, development and demonstration lab dedicated to innovating affordable solutions across the maritime domain.

Tenets:

Put the Warfighter First – SNIC enables innovative concept exploration, rapid prototyping, and risk reduction activities for current and emerging Naval capabilities.

Accelerate Capability to the Warfighter – SNIC accelerates the push to adapt available technology and capabilities for maritime use.

Offer Flexible, Modular, Adaptable Solutions – SNIC utilizes an agile methodology and enabling architecture to respond quickly to new requirements and technologies.

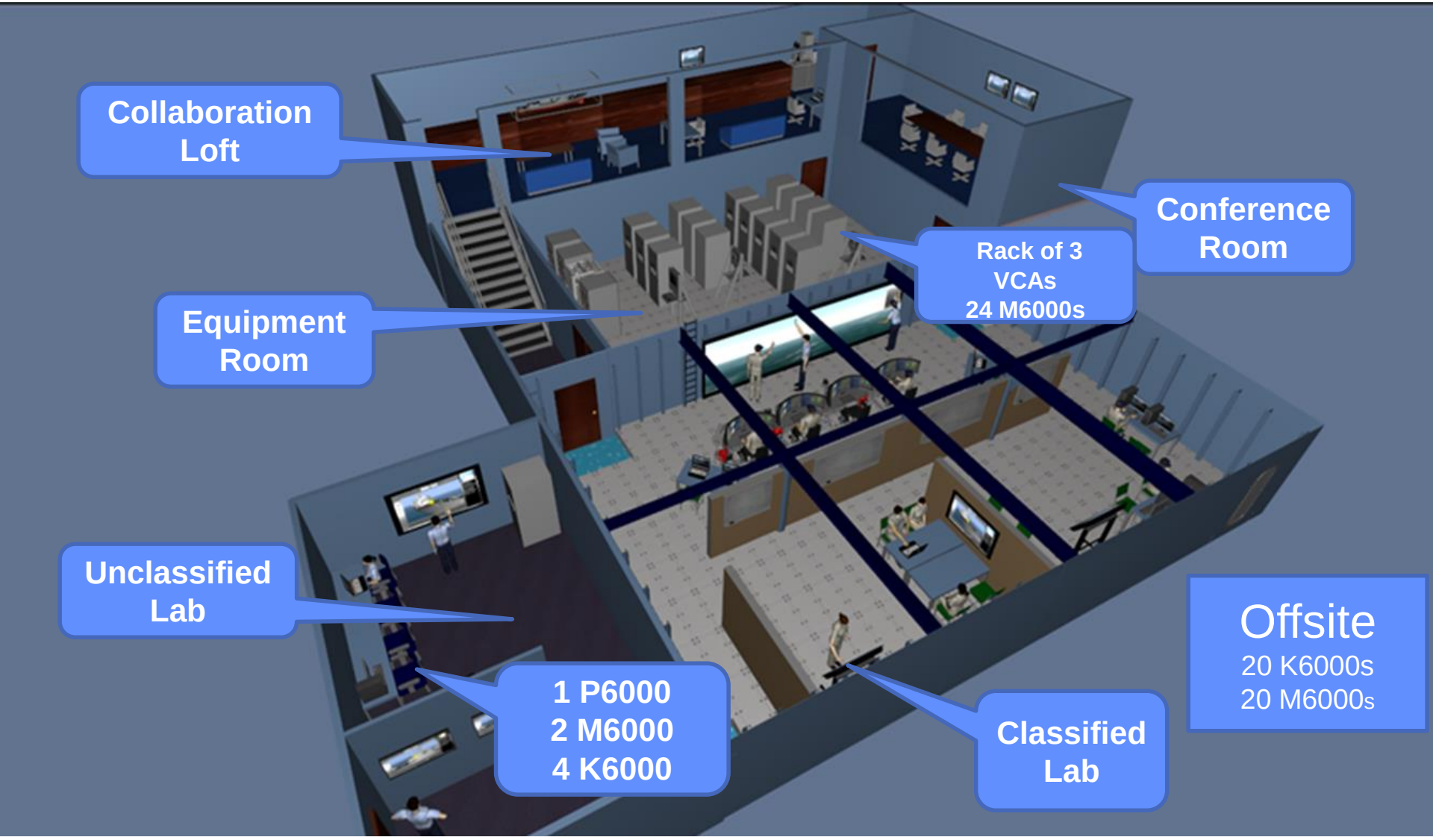
Set the Standard for Collaboration – SNIC establishes an open community space for government, industry, and academia.

Technical Domain Focus:

- Training
- Cybersecurity/IA
- Big Data Analytics
- Models and Simulation
- Additive Manufacturing
- Mobile/Remote Workforce
- Advanced HMI/GUI Displays
- Advanced Display Technologies
- Augmented / Virtual Reality
- Situational Awareness
- Lifecycle Engineering
- Architecture/Design
- Cloud Computing
- Mission Planning

Driving Innovation, Affordability, and Capability

Surface Navy Innovation Center (SNIC)



Digital Twin

Data

Information

Physical Space

" In 2003 I introduced the term Digital Twin in *Virtually Perfect: Driving Innovative and Lean Products through Product Lifecycle Management (pg. 133). I attributed it to John Vickers of NASA whom I work with. We have subsequently used this term in current projects.*"

Dr. Michael Grieves
Florida Institute of Technology

Virtual Space

Digital Twin has Numerous Definitions

From IBM's internet of Things blog

- **"The digital twin is the virtual representation of a physical object or system across its life-cycle. It uses real-time data and other sources to enable learning, reasoning, and dynamically recalibrating for improved decision making."**

- **" In plain English, this just means creating a highly complex virtual model that is the exact counterpart (or twin) of a physical thing. The 'thing' could be a car, a tunnel, a bridge, or even a jet engine. Connected sensors on the physical asset collect data that can be mapped onto the virtual model. Anyone looking at the digital twin can now see crucial information about how the physical thing is doing out there in the real world."**

Digital Twin

- A digital twin is a virtual model of a real physical product
- Basic components required to build a digital twin

  - Simulation
    - All the physics models that define product
    - Simulate operations
    - Reconfigure system and test using digital twin

  - Internet of Things (IoT)
    - Monitor the systems of the physical product via physical data probes
    - Pressure conditions, temperatures, component stress
    - Use algorithms to make reasonable projections about the future

  - Visualization
    - Dashboard
    - Virtual Reality
    - Augmented Reality

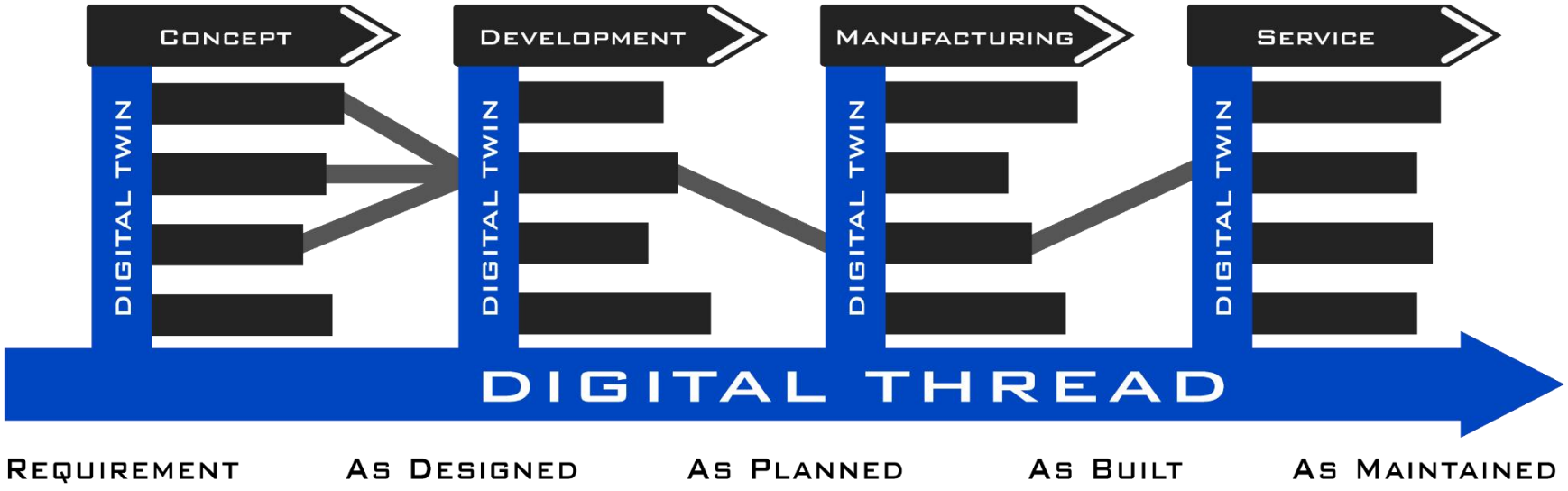
Digital Twin Evolution

- What has changed since 2003?
  - Moore's Law
  - More powerful GPUs
  - Deep Learning
  - High fidelity 3D geometric models
  - Advances in VR
  - Consumer AR becomes a reality

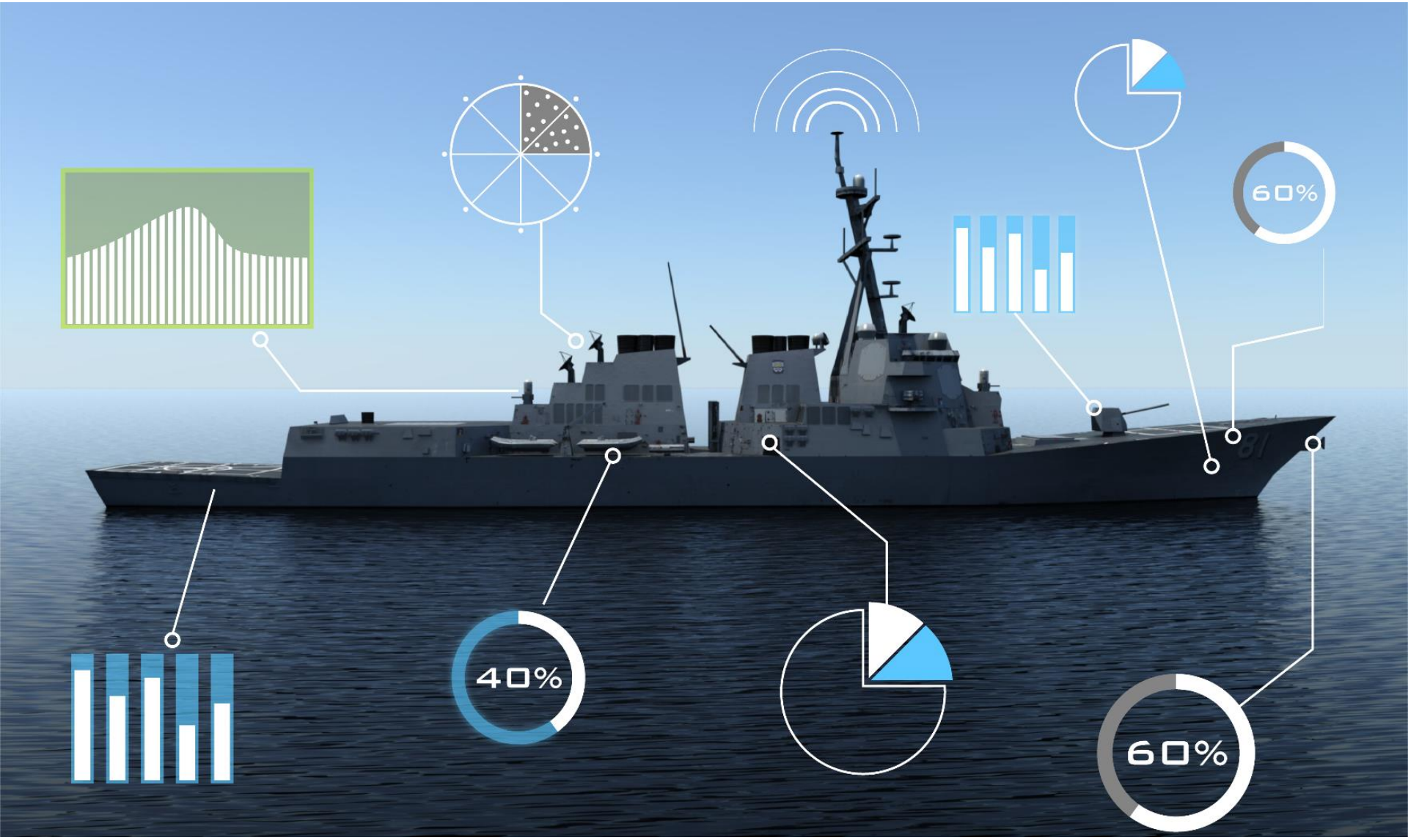
- Modeling and Simulation
  - Geometry, much more better represented (richer)
  - Behavior

- Linking the data via a Digital Thread
    - Data from Physical Space
    - Information from Virtual

IBM's Digital Thread Concept



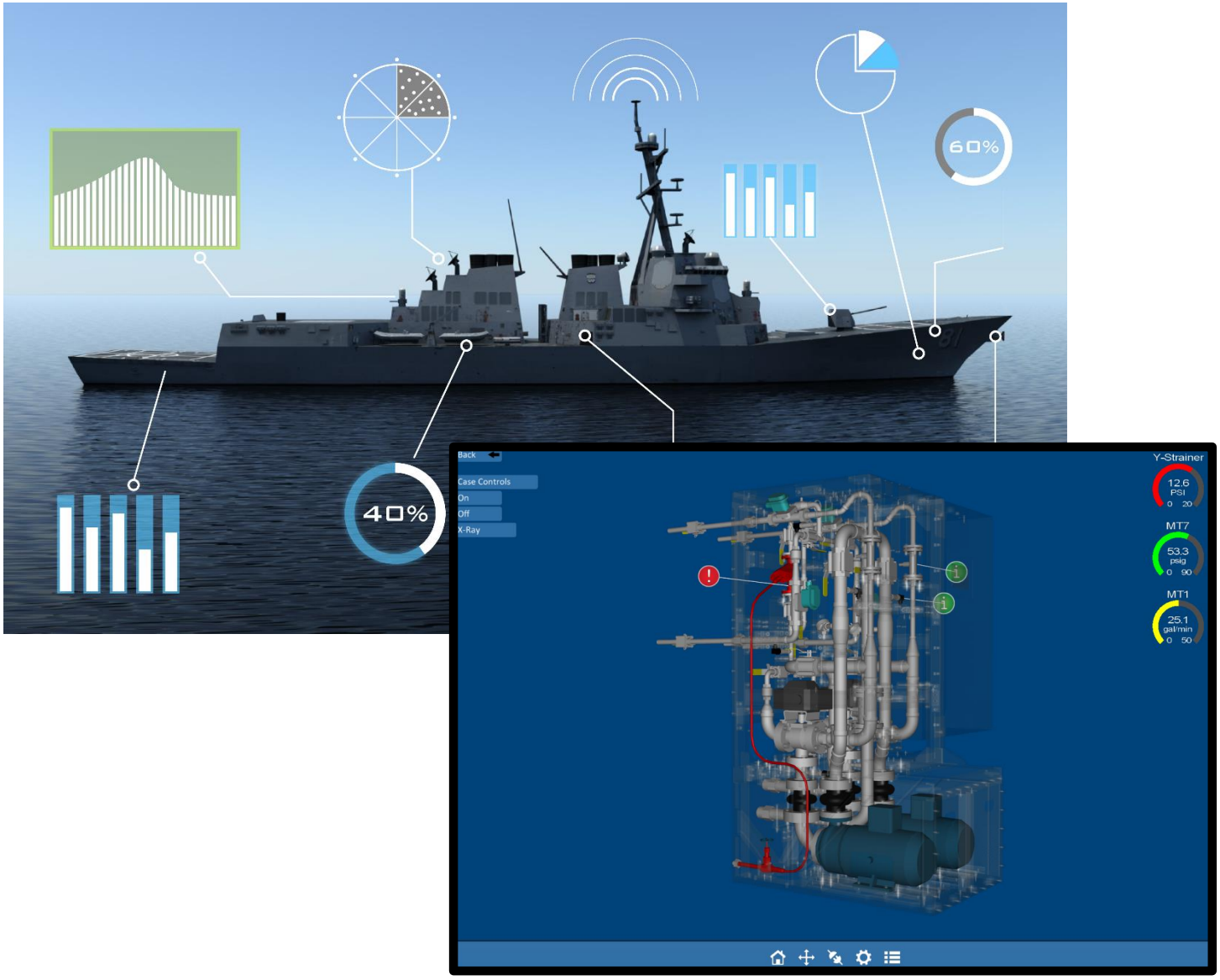
Digital Twin of a Naval Vessel



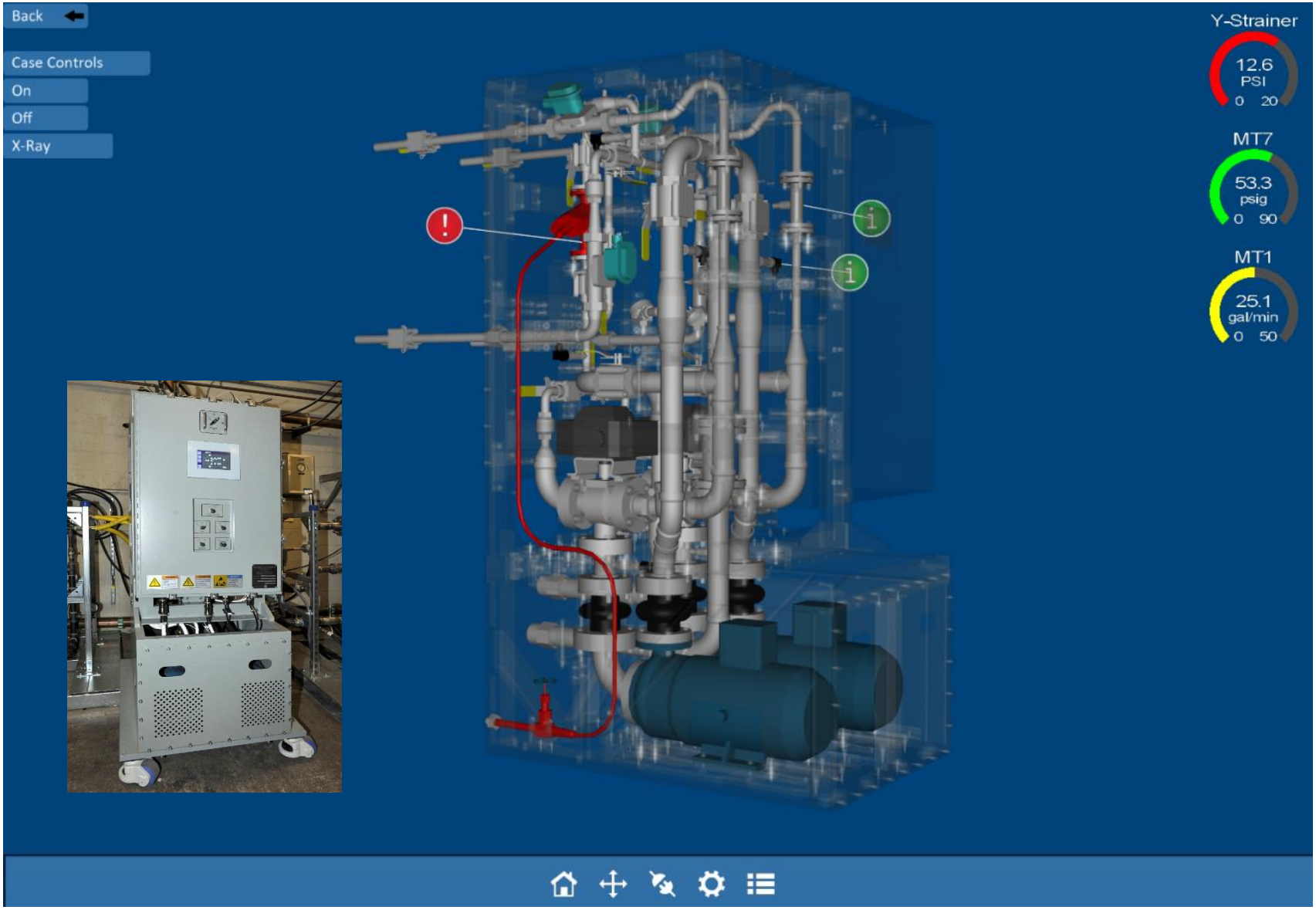
Challenges

- Challenges of creating a digital twin
  - Cybersecurity for IoT
    - Naval ships
    - Naval planes
    - Naval helicopters
    - Ground based facilities
  - High fidelity Simulations
    - Electrical Simulations
    - Mechanical Simulations
  - Machine Learning
    - Predictive Maintenance
  - Visualization of the Digital Twin
    - Dashboard
    - Virtual Reality (VR)
    - Augmented Reality (AR)

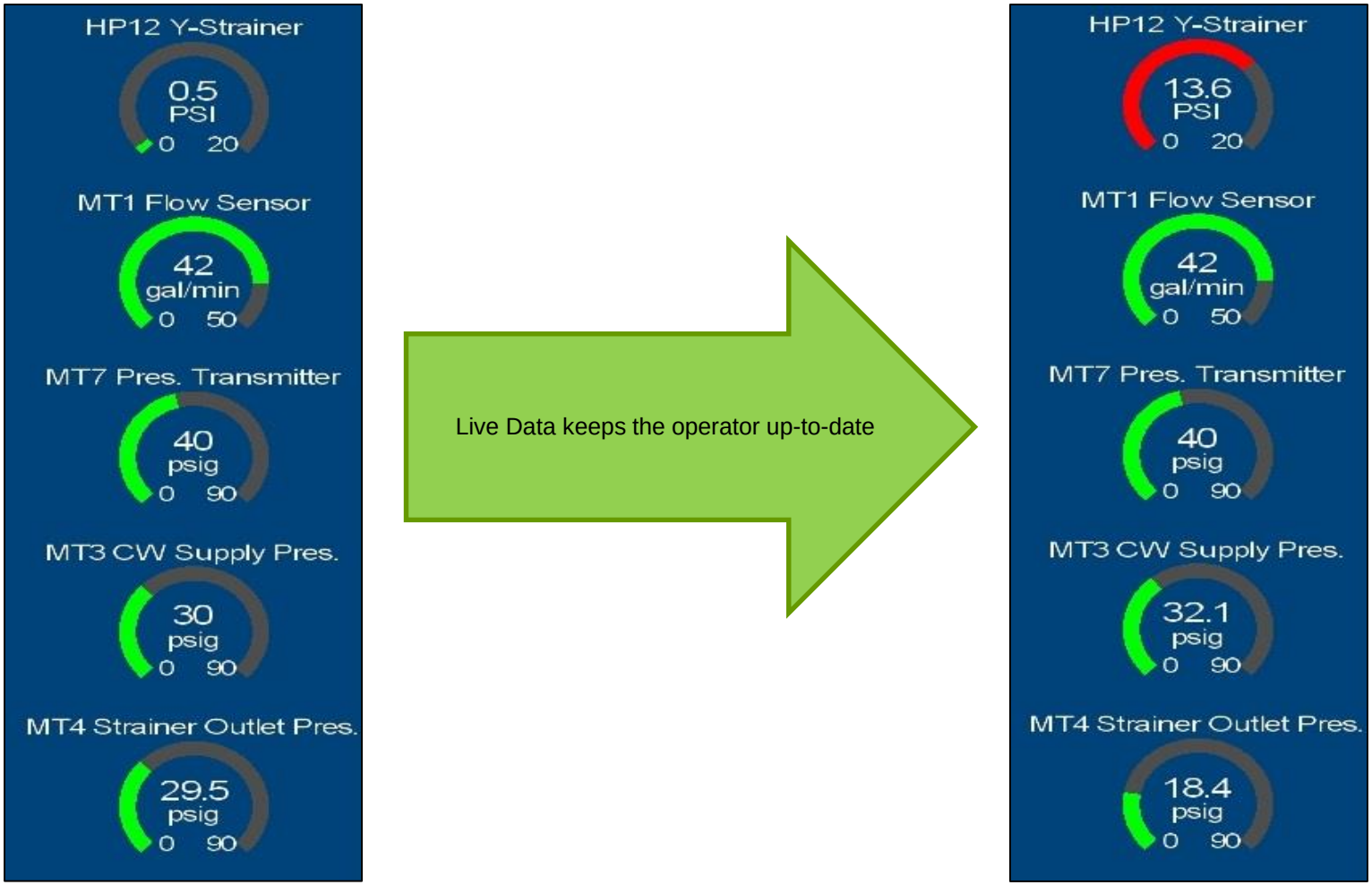
Digital Twin Data Drilling



Digital Twin Data Drilling



Visualizing Data from the IoT



COMITS-AR

- Microsoft HoloLens®
  - Can display models up to ~80,000 polygons while running on 60 FPS
  - Larger models lag in the display
- How do we overcome this limitation?
- Image generation
  - Constant image size per frame
  - One image required for left and right eye per frame
  - 720p or 1268x720 per eye
- Use GPU to generate left and right eye images
  - Send these two images to HoloLens® device via Wi-Fi

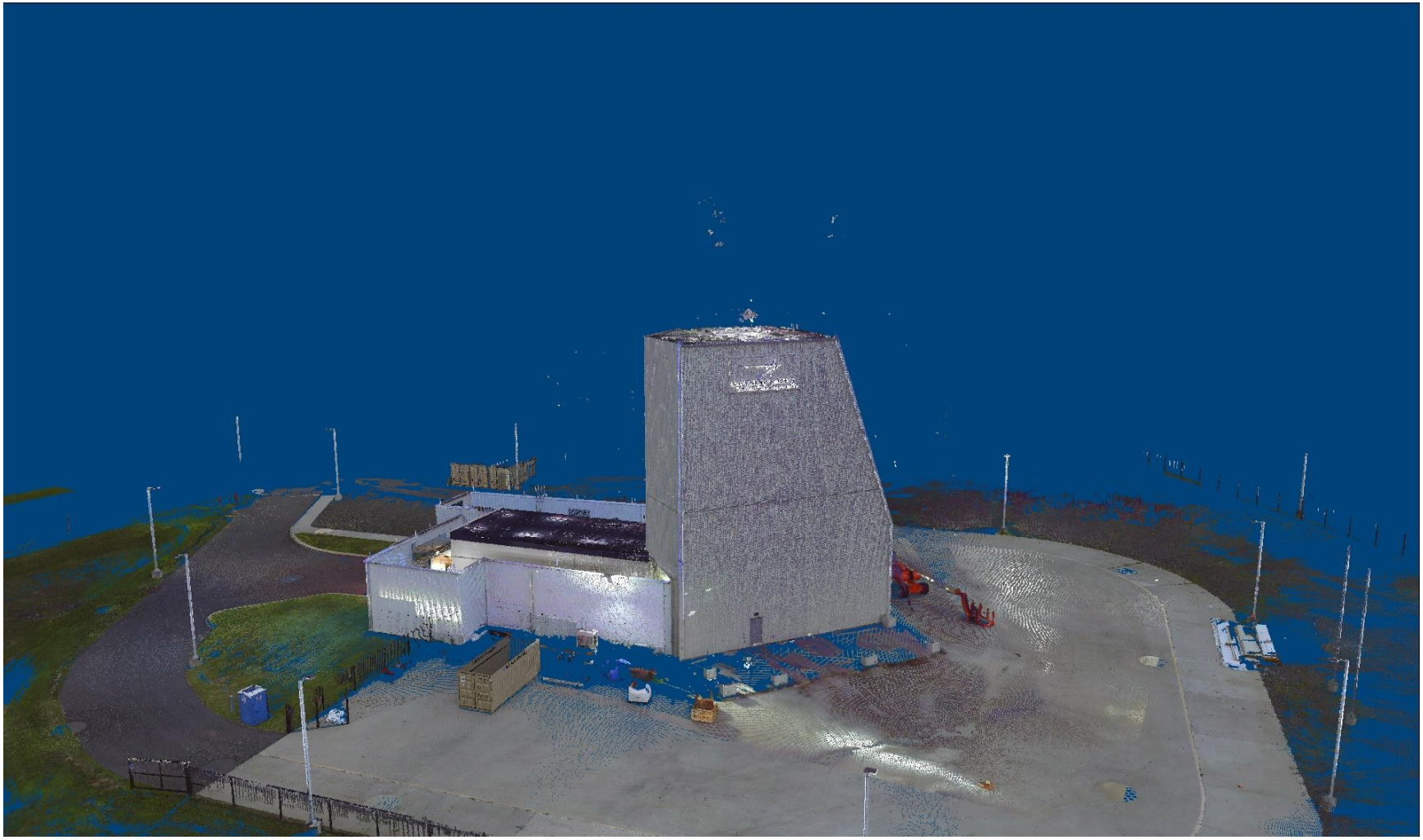
GPU-AR

- Install the Microsoft® Remoting Player app
- Establishes a connection with the HoloLens and server with one or more GPUs
- The connection is made using standard Wi-Fi
- Receives a data stream with input from a HoloLens
- Renders content in a virtual holographic view
- Streams content frames back to the HoloLens in real-time
- This two-way connection allows the HoloLens to send sensory and control information to the server
  - Gestures
  - Voice commands
  - Spatial mapping
- Server processes this information, updates the state of the application, and sends images and sound back to the HoloLens® in a constant stream
- 64 bit application vs 32 bit
  - More accuracy

GPU-AR

Model Registration for AR

- Utilize laser scanning technology
- Real-time Point-Cloud Rendering (utilizing P6000)
- A billion points rendered



Model Registration for AR

- Use key points from the point cloud that will be matched with the real-world product

Digital Twin Benefits and Use Cases

- Smart connected products
- Virtual Prototyping
- Continuous data-driven optimization
- Real-world usage/conditions data
- Predictive models
- Reduce downtime and maintenance costs
- Design driven by customer

References

Tobe, Frank. "Challenges for the Digital Twin Concept." *Design World*, July 25, 2016, www.designworldonline.com/challenges-digital-twin-concept/

Mikell, Matthew, and Clark, "Cheat sheet: What is Digital Twin." *Internet of Things blog*, January 4, 2018, www.ibm.com/blogs/internet-of-things/iot-cheat-sheet-digital-twin/

“How a digital thread makes a better digital twin.“ IBM Watson Internet of Things, October 31, 2017, https://www.youtube.com/watch?v=nvAM2zLjVMQ

Rich Rabbitz
Lockheed Martin RMS
Principal Member of Engineering Staff (PMES)
Ship Integration and Test
Email: richard.j.rabbitz@lmco.com