Digital Transformation - Verify and Validate Production System

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Weapons Production Engineering
The Boeing Company

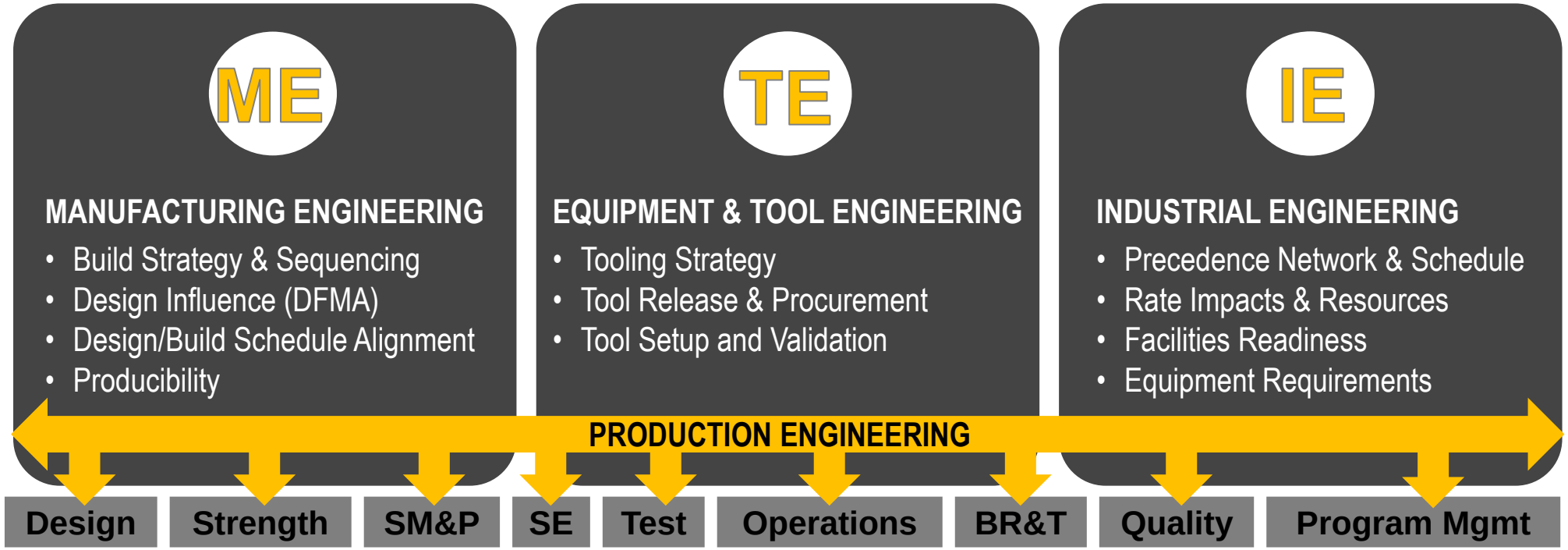
Presenters Bio

- **From St. Louis, MO area and worked from STL entire career**
- **33 Years with McDonnell Douglas and Boeing**
- **Boeing Designated Expert in Advanced Technologies and Visualization**
- **Direct support of C-17, F/A18, F-15, JSF, 787, 777x, V-22, MQ-25 and Weapons**
- **20 Years in Advanced Technologies focused around Manufacturing Engineering & Operations**
- **15 Years as leader of Boeing XR Community of Excellence and yearly conference**
- **Current assignment: Technical Lead Engineer to Implement Digital Transformation for the Boeing Weapons Production System**

Who we are…

The role of ***PRODUCTION ENGINEERING*** is to:

- Develop and activate the ***PRODUCTION SYSTEM***
- ***INFLUENCE*** the Product design to align with the build strategy
- Prepare the Production System to enable ***FLAWLESS EXECUTION***



- ***The voice of Engineering and the advocate of Operations***

Why are we here?

- **Tesla CEO Elon Musk said:**

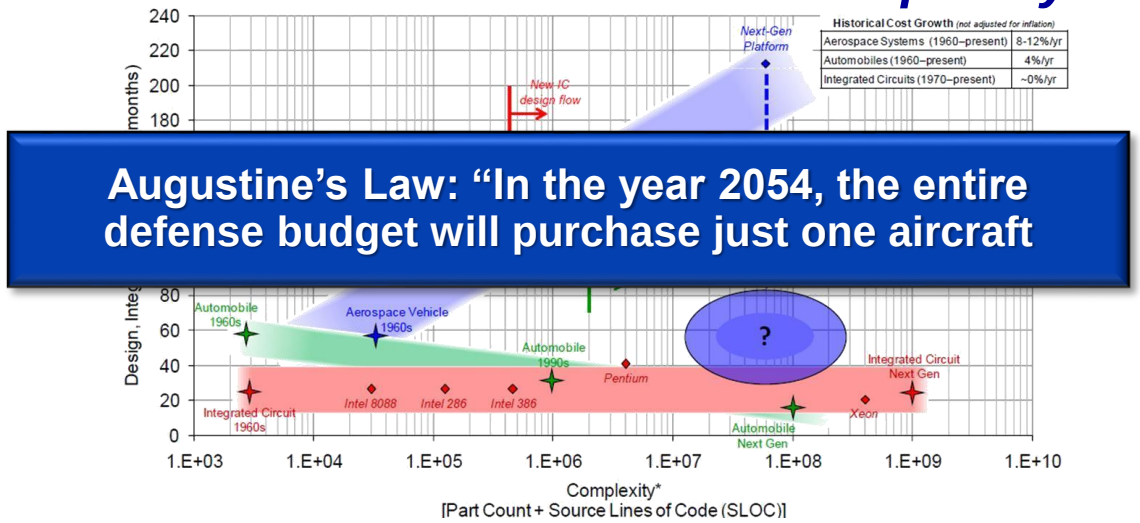
  "The difficulty and value of manufacturing is underappreciated," he told the Wall Street analysts, "The issue is not about coming up with a good design — it's absolutely about the production system," Musk said. "You want to have a good product to build, but that's basically the easy part. The factory is the hard part. Its 10-100 times more effort to design the Manufacturing System than the product."

The Challenge

Our Build Lifecycle Today

- **Product complexity**
- **It takes too long!**
- **It cost too much!**
- **Mistakes discovered too late**
- **Slow cultural change**
- **Little cross-functional collaboration**
- **Still largely paper and document-based**

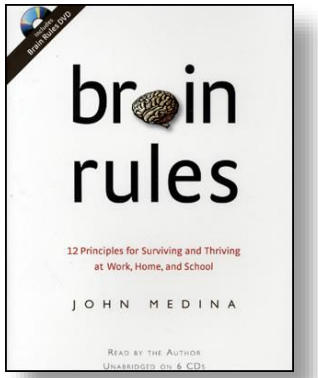
Historical Schedule Trends With Complexity



Augustine's Law: "In the year 2054, the entire defense budget will purchase just one aircraft

We want to help us fail safe, fail sooner, and succeed quicker to create unmatched producibility

Why Visualization?



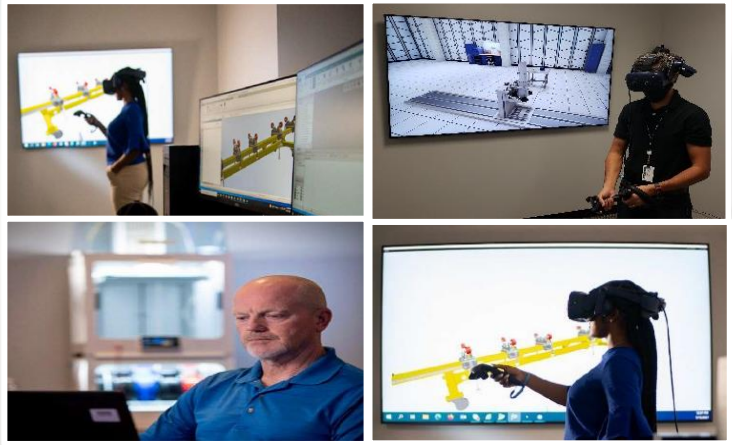
- **Your brain is "wired" to be visual**
- **50% of your brain is dedicated to processing visual information**
- **80% of the information that you take in is visual**

Weapons Visualization Center (WVC)

The WVC is an extension of the Production Engineering team incorporating Digital Transformation tools to visualize, interact and analyze the virtual product

OVERVIEW

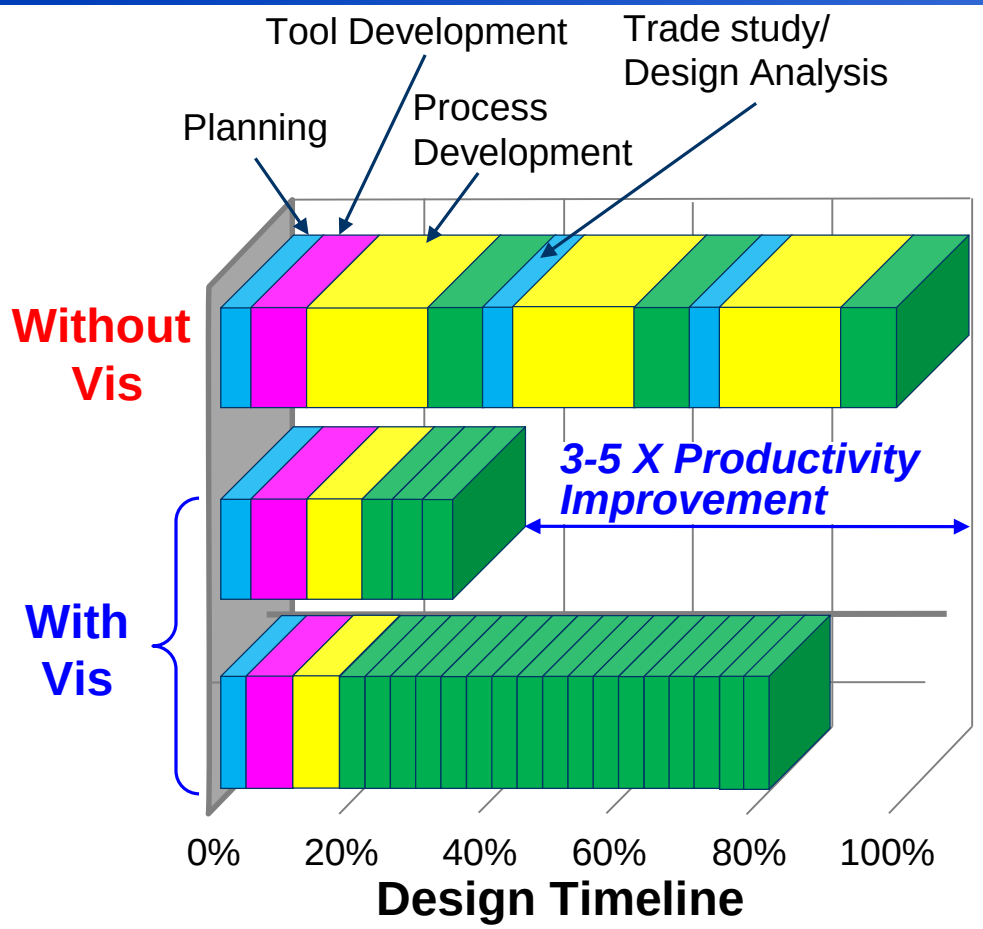
- - Located in St. Charles, MO
- - Weapons Program resource
- - High computing and Graphics for Immersive
- - Virtual Reality and Augmented Reality applications



- **Integrate VR/AR training modes for Weapons Programs**
- **Utilize simulation to verify build processes and engineering designs**
- **Optimize CMS production system for high rate using Ergonomics and Simulation**
- **Problem solve and replicate Operations issues using VR/AR**
- **Develop Use Case ideas for future capability enhancements for the WVC**

IMMERSE ***INTERACT*** ***INNOVATE***

Immersive Visualization to Shorten Design Cycle



Virtual Build Validation

Few design iterations result in sub-optimal design, leading to engineering escapes and increased costs

3-5X productivity improvement (for same number of design iterations), or

Many design iterations result in optimized design and significant cost savings over the program lifecycle

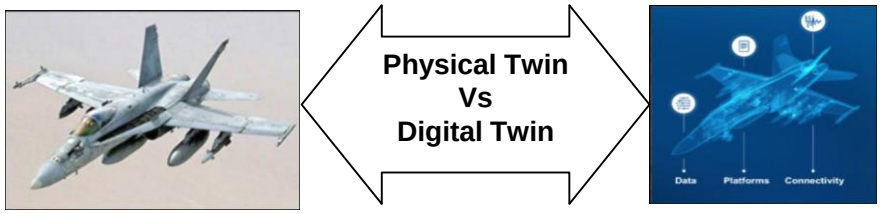
Lack of discipline to iterate the build process is one of the leading causes of engineering escapes leading to program failures

Model-Based Production System

- **Digital Twin**

A virtual representation of the properties and behaviors of a specific instance of a physical system or process that enables prediction and optimization of performance and maintains synchronization with that physical system or process through its operational life.

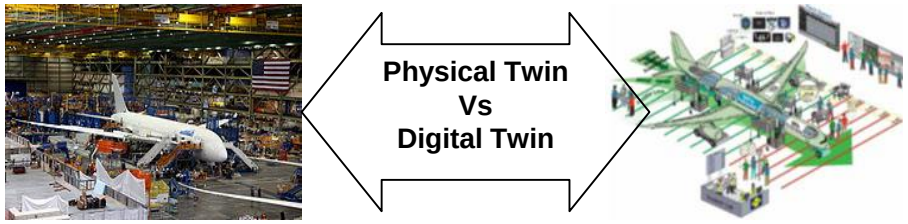
Product Digital Twin



- **Production System (PS)**

The global enterprise of people, processes, and assets used to transform raw materials and ideas into products and services that satisfy customer, industry, government, and Boeing requirements throughout the Boeing Product Lifecycle.

Production System Digital Twin



- **Production System Digital Twin (PSDT)**

A Production System Digital Twin is a virtual representation of the properties and behaviors of a specific instance of a physical production system or process that enables prediction and optimization of performance and maintains synchronization with that physical system or process through its operational life.

Interactive VR Design Review

Objectives:

- **Allows you to see and interact with the model at full scale**
- **Clearly and accurately convey an idea of design's components and implications.**
- **Builds common ground for understanding issues during the design & development processes.**
- **Analyzing data with closer scrutiny**
- **Better for reviewing path planning, interferences, or stay out zones**

Leverage Modeling & Simulation in a collaborative environment will improve safety, quality, and productivity

Factory Layout Analysis

Objectives:

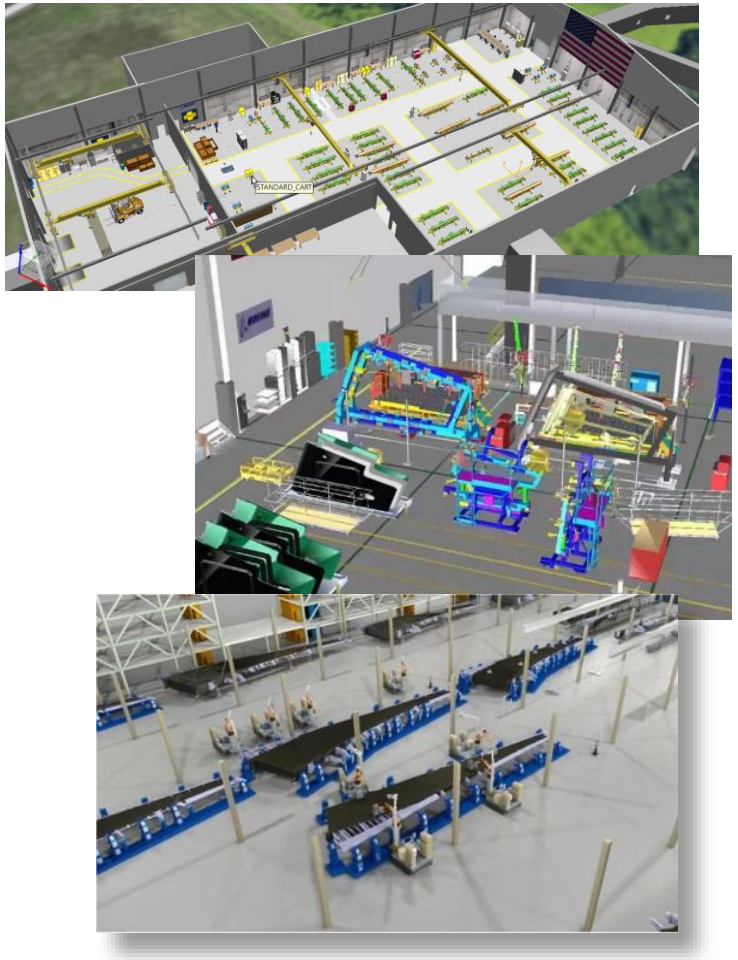
- **Provides a window into the activities of the factory**
- **Determine square foot requirements for new facility**
- **Assess the impact of building design changes**
- **Determine if production layout can be fit into existing footprint**
- **Look at lifting requirements (Cranes, Alum-a-lift, Personal Lift)**
- **Define transportation/pedestrian isles**
- **Simulate material flows**

The manufacturing digital twin provides the virtual representation of the Site, Buildings, Tooling and Resources needed to support the product

Factory Flow Support

Objectives:

- **Simulate equipment and position optimization**
- **Define layout of assembly lines and individual stations**
- **Define ship side support requirements and footprint**
- **Digitally prototype the product and the plant in context**
- **Validate use of robots, tools AGV's. special equipment**
- **Early discovery of layout and flow issues**
- **Determine potential safety issues for workers**

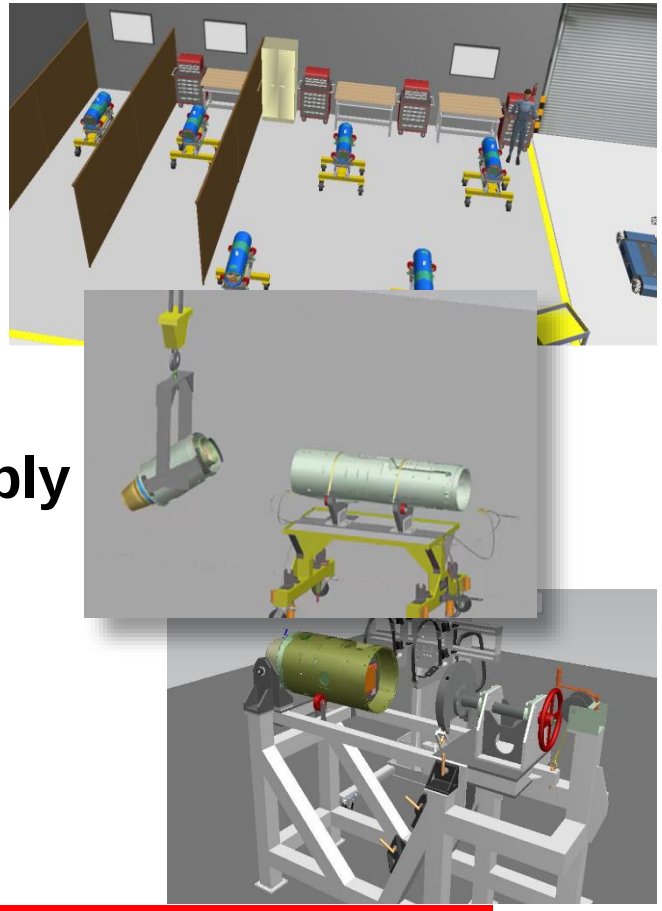


Create Digital Twin Facilities model and simulate the real world production lines.

Assembly Simulation Analysis

Objectives:

- **Assists in the definition assembly precedence**
- **Determine part sequencing into tooling**
- **Verify collision free assembly**
- **Verify ergonomic and safe assembly processes**
- **Determine removal and move process for finished assembly**
- **Determine work area requirements to support assembly**

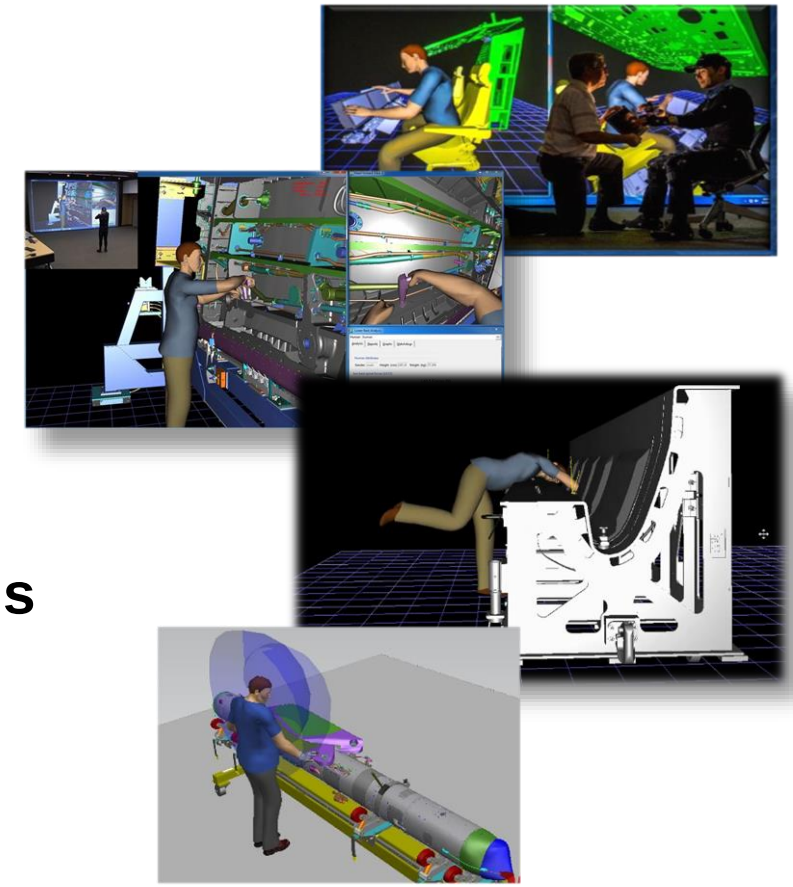


Assembly assessments provides a 3D visualization of the assembly process that includes engineering parts, tooling, hand tools, human models and other resources.

Ergonomic Assessments

Objectives:

- **Determine posture, reach, position of human**
- **Determine repetitive motion**
- **Determine lifting requirements and weights**
- **Determine forces**
- **Determine walking distances**
- **Determine work stand usage for 5 to 99% populations**
- **Determine vision requirements**



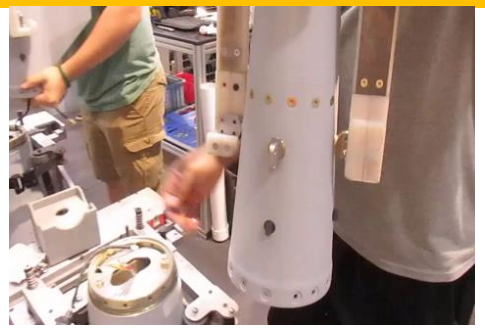
Maximize productivity by reducing operator fatigue and discomfort. Then performing an analysis to ensure that the human can perform tasks effectively, efficiently, and safely.

Virtual Reality Training

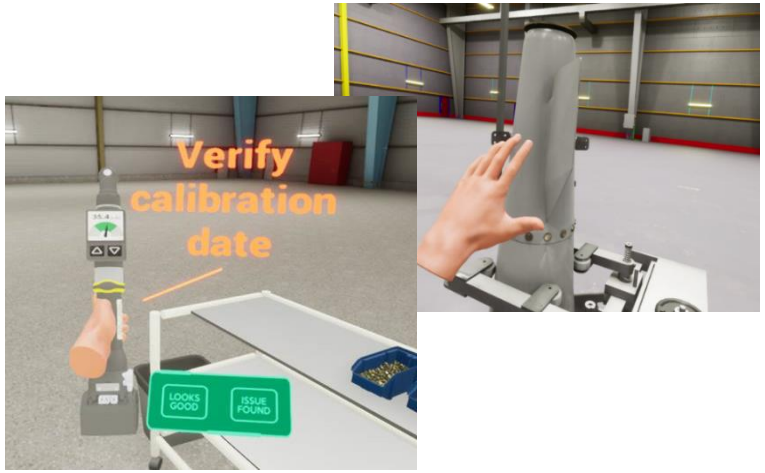
Objectives:

- **Safe learning environment**
- **Practice makes perfect**
- **Accelerated learning**
- **Multiple levels of training**
- **Multiple employees trained at same time**
- **Valuable feedback metrics**
- **Train employees anywhere in the world**
- **VR increases confidence, efficiency, and skills**

'YouTube' style videos for Production Line



Mechanic Onboard VR Training



Provide virtual product specific applications to enhance operators skills

Thank You

Questions