Digital Thread and Industry 4.0
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Agenda

- **The Digital Thread –**
  - **Phase 1 - The Beginning of the Digital Thread.**
  - **Phase 2 - Automation**
  - **Phase 3 - Taking it to the streets**
  - **Phase 4 - Tying the knot in the Digital Thread**
- **Phase 5 - Industry 4.0**

Lockheed Martin Corporation

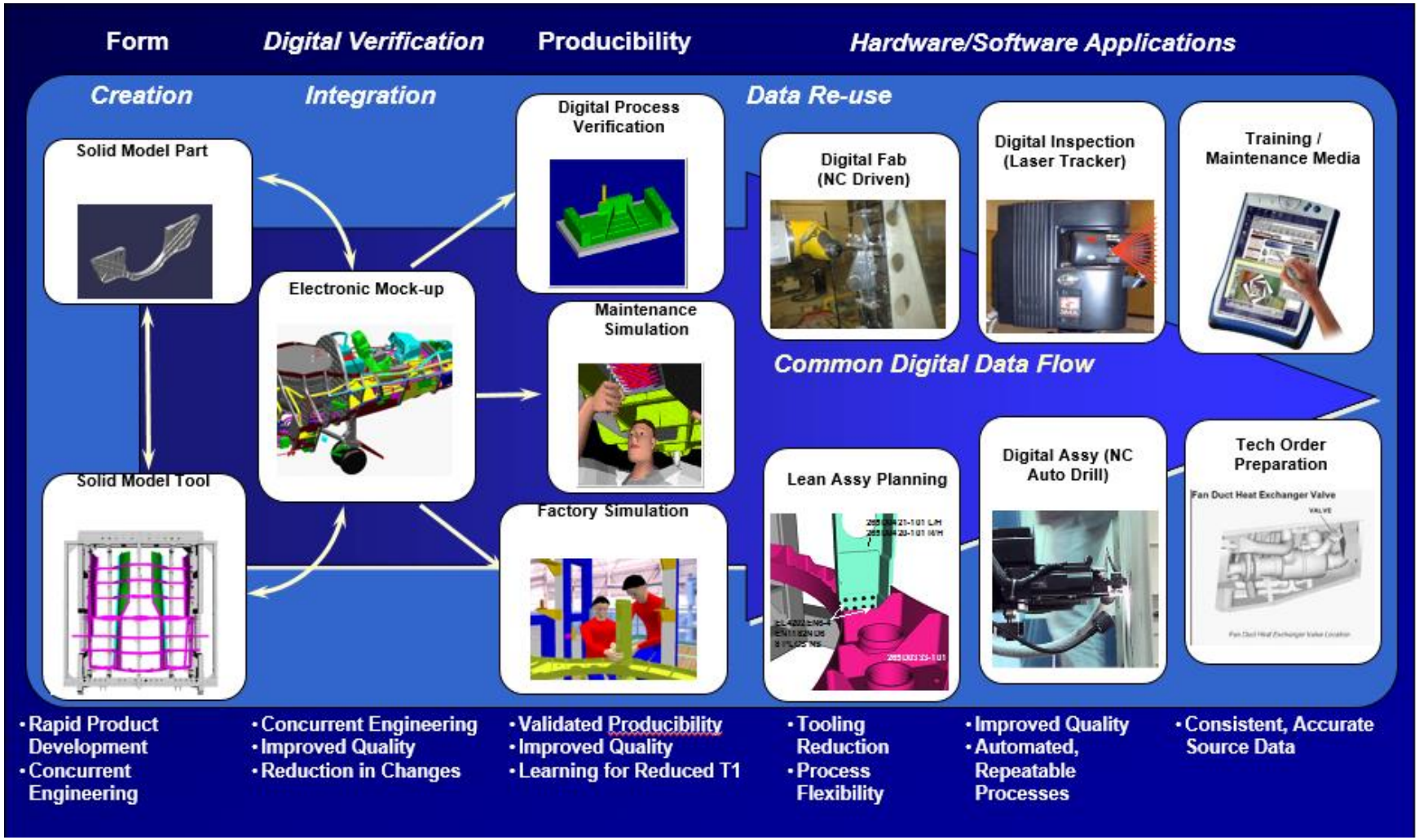
AERONAUTICS
- Tactical fighters
- Tactical and strategic airlift
- Advanced Development

ROTARY AND MISSION SYSTEMS
- Maritime Solutions
- Radar and Surveillance Systems
- Aviation Systems and Rotorcraft Platforms
- Training and Logistics Solution

MISSILES & FIRE CONTROL
- Air and missile defense
- Fire control and situational awareness
- Nuclear systems and solutions

SPACE SYSTEMS
- Surveillance and navigation
- Global communications
- Human space flight
- Strategic and defensive systems

Phase 1 - The Digital Thread Beginning



Solid Models for Engineering and Tooling Began the Digital Thread

Early Benefits and Lessons Learned

Benefits of the Digital Thread

- **Direct connection to suppliers and a common 3D digital design database**
- **Seamless Production and Sustainment access to all released engineering.**
- **Use of 3D models for integration and interfaces.**
- **Huge reductions in engineering and tooling drawing changes from 3D exact solids.**

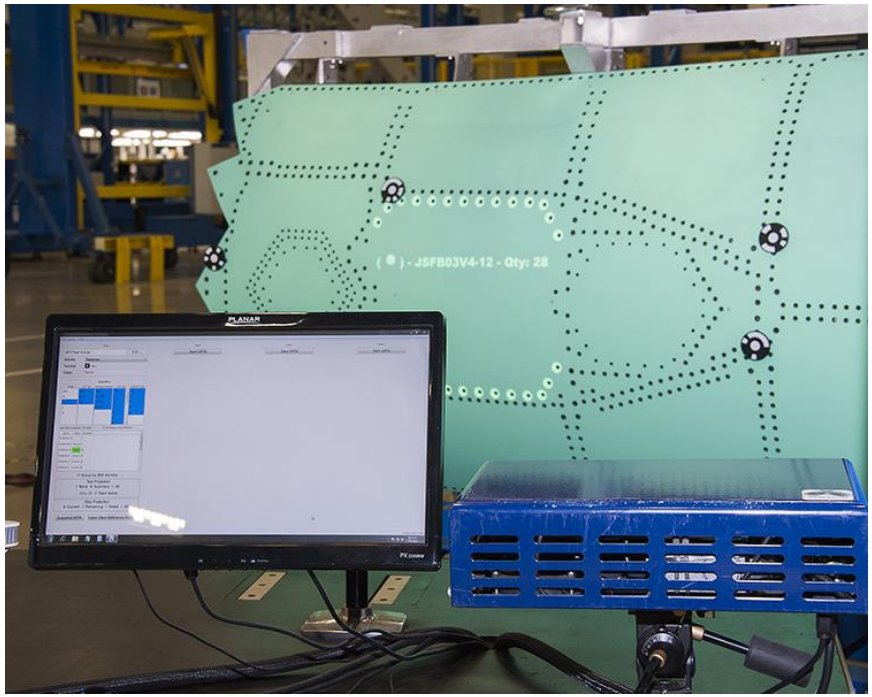
Lessons Learned

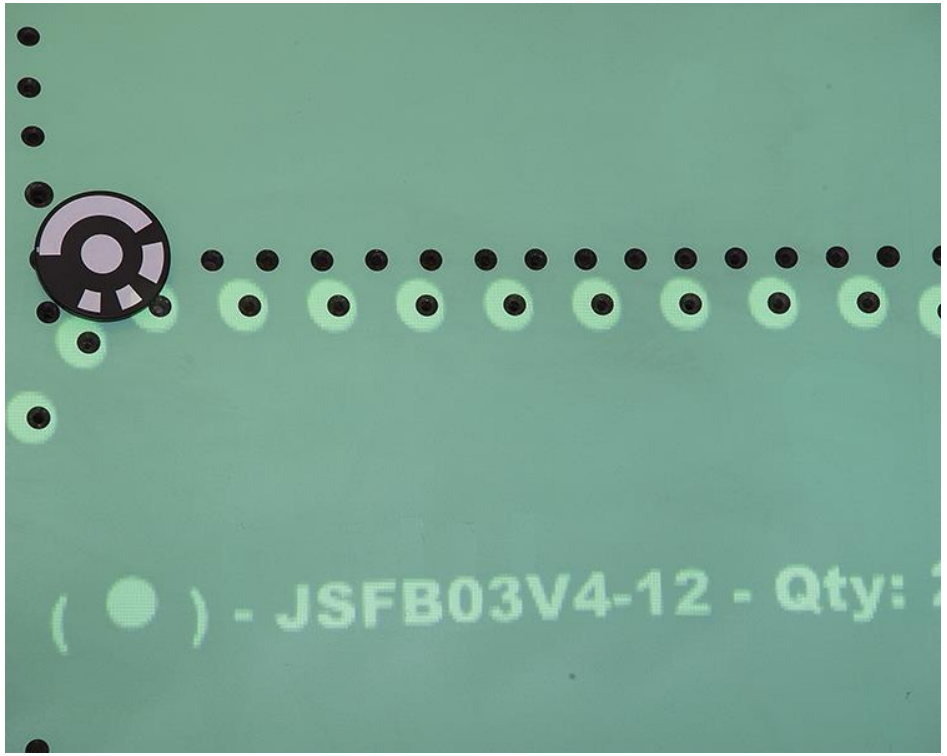
- **Standardization is important - Engineering, Planning, Tooling, Specifications, etc.**
- **Static graphics are expensive to maintain for developmental programs**
- **Mobile access to Engineering requirements is essential**
- **Data requirements (traceability, marking, etc) require an end to end enterprise data strategy.**

Phase 2 - Automation is Enabled by the Digital Thread

Data is Constructed to Enable Automation

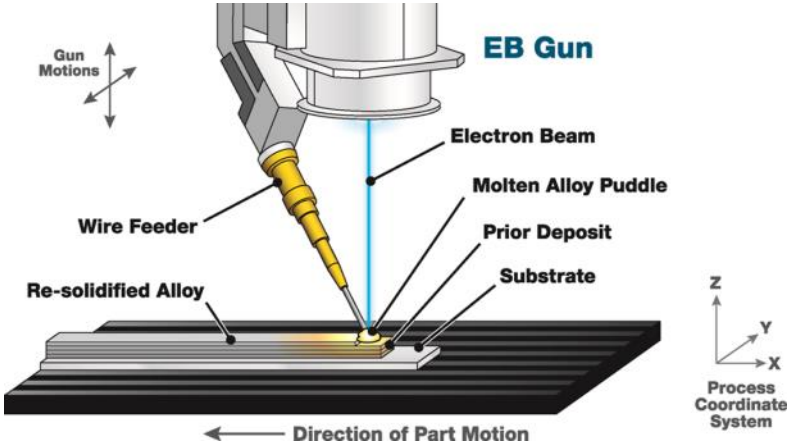
Phase 3 - Taking it to the Streets

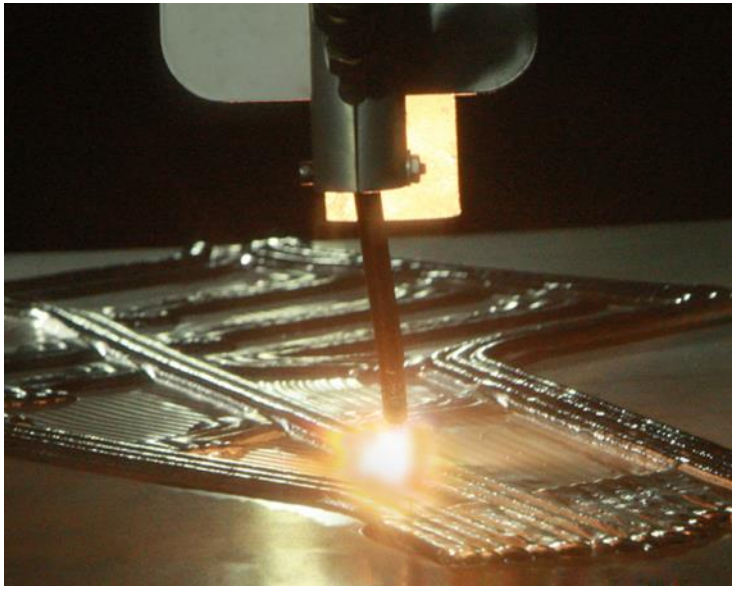




Engineering Data is Projected onto the Work Surfaces

Additive Manufacturing Development

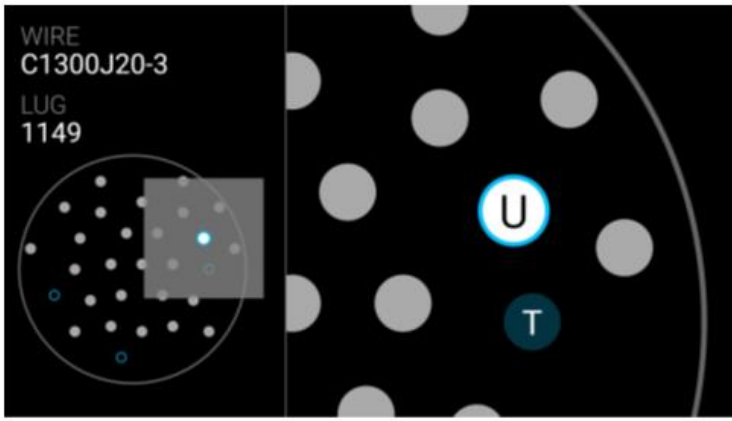




Augmented Reality

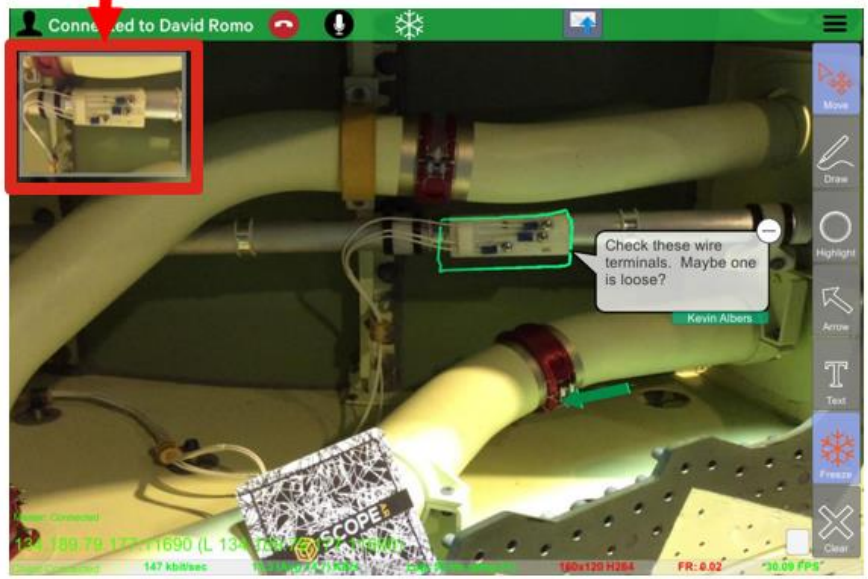
Guided Work Instructions with Voice Controls (After)

Operator's view in glasses



Remote Augmented Reality

“Technician” view on Tablet

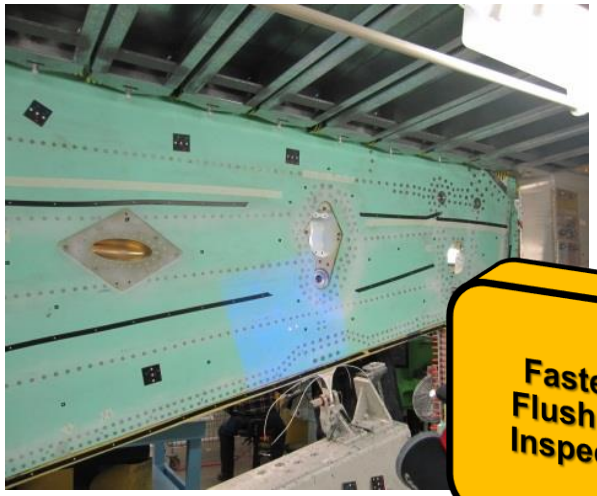


“Expert” view at Desktop Computer

“Technician” view on Tablet

“Expert” view at Desktop Computer

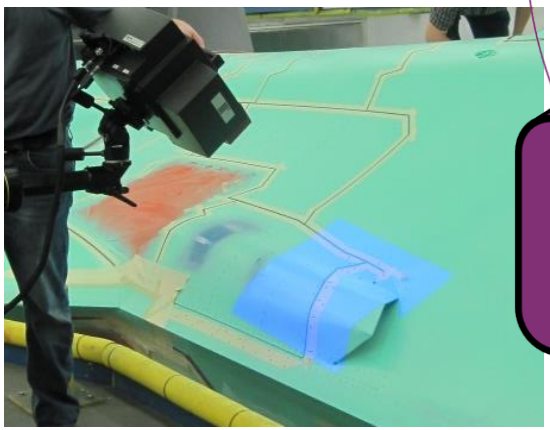
Phase 4 – Tying the Knot in the Digital Thread
Non-Contact Metrology Applications Development



Detail Part Validation

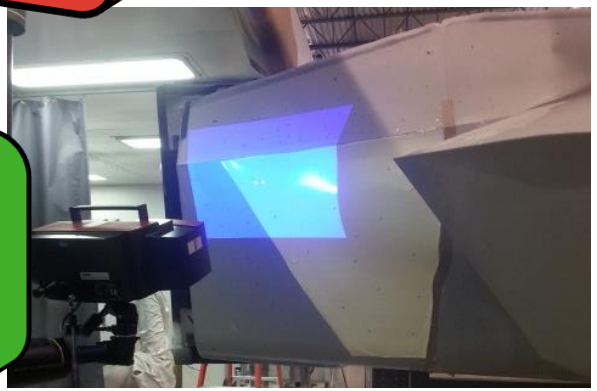
Fastener Flushness Inspection

Virtual Opening Verification



Seam Validation

Coating Thickness Inspection

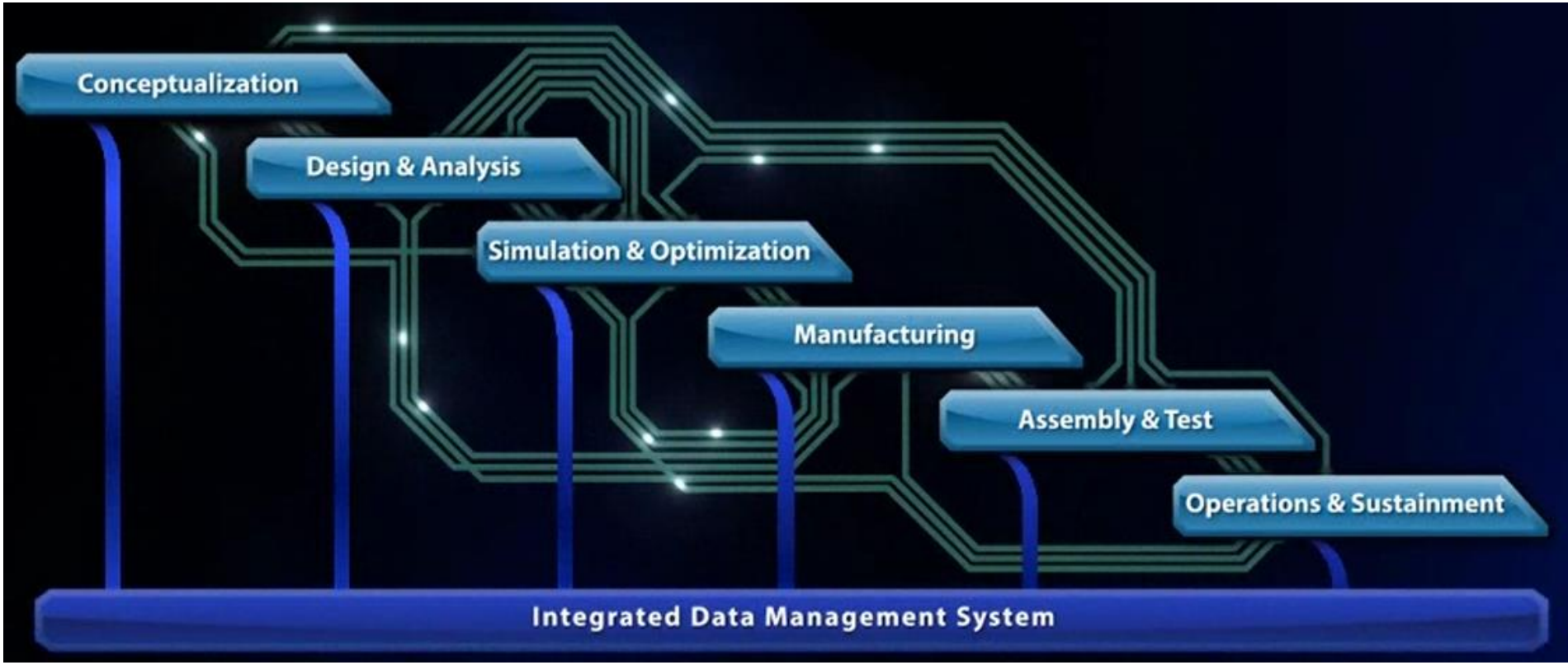


Digital Thread Phases 1-4 Summary

- **Significant savings from the use of 3D solid models for BTP (build to package(models, drawings, tooling, work instructions) development.**
- **Consumption of 3D data (drawings?) by production still problematic. Optical/laser projection and AR technologies continue to develop.**
  - **What will or should Engineering look like in the future?**
- **Engineering focus needs to be on Enterprise requirements and on recurring downstream consumption.**
- **Additive manufacturing for temporary tooling is proven. AM for support equipment and non critical applications maturing. Primary structure applications perhaps a decade away.**
- **Automation opportunities depend on the volume of production, technology, and economic ground rules. Rise of the robots?**
- **Validation of as-designed to as-built configuration is now possible and will soon be standard practice for at least first article parts, tools, and assemblies if not for real time monitoring of Production and Sustainment.**

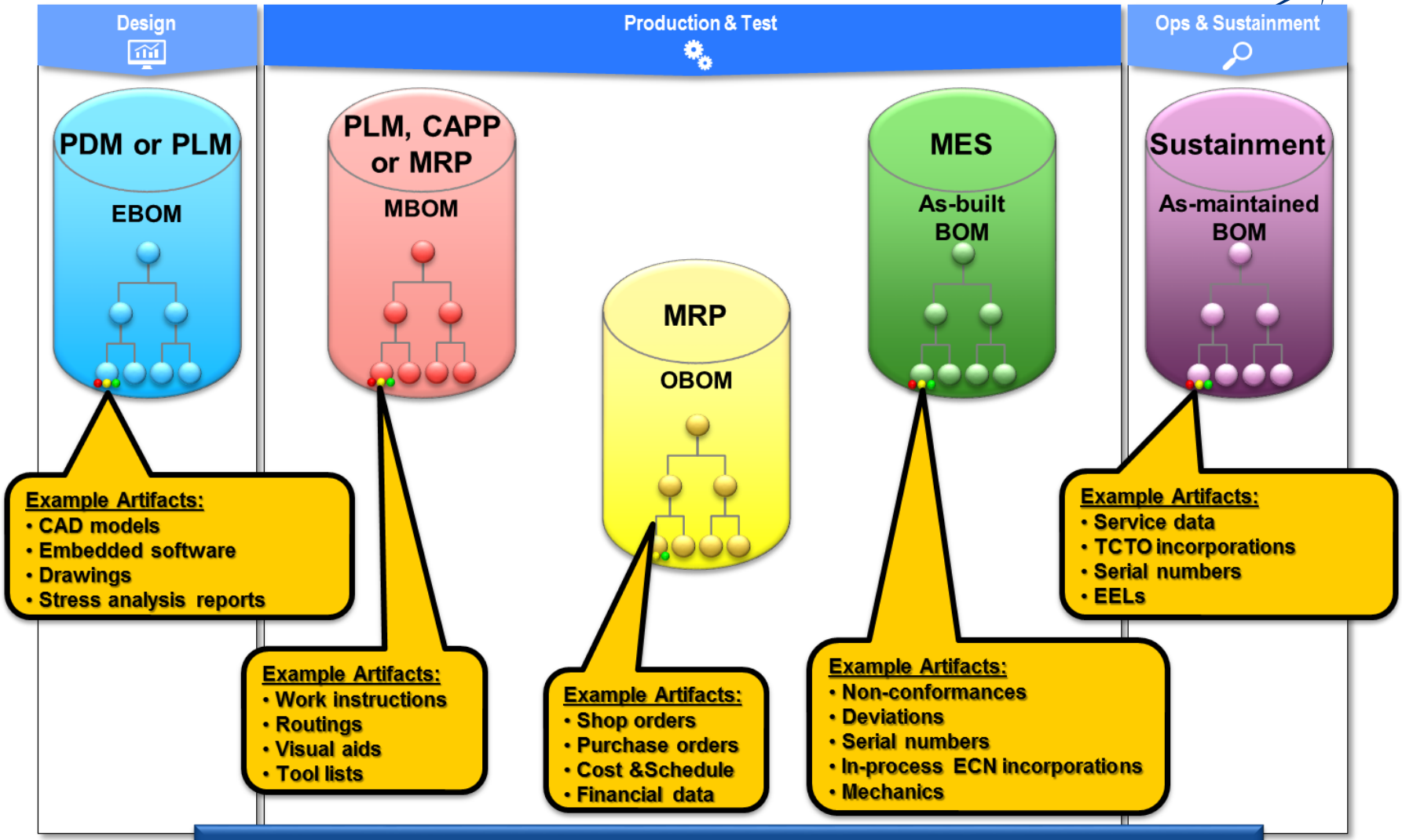
Phase 5 – Industry 4.0
The Revolution of Data

Digital Thread – Future Vision



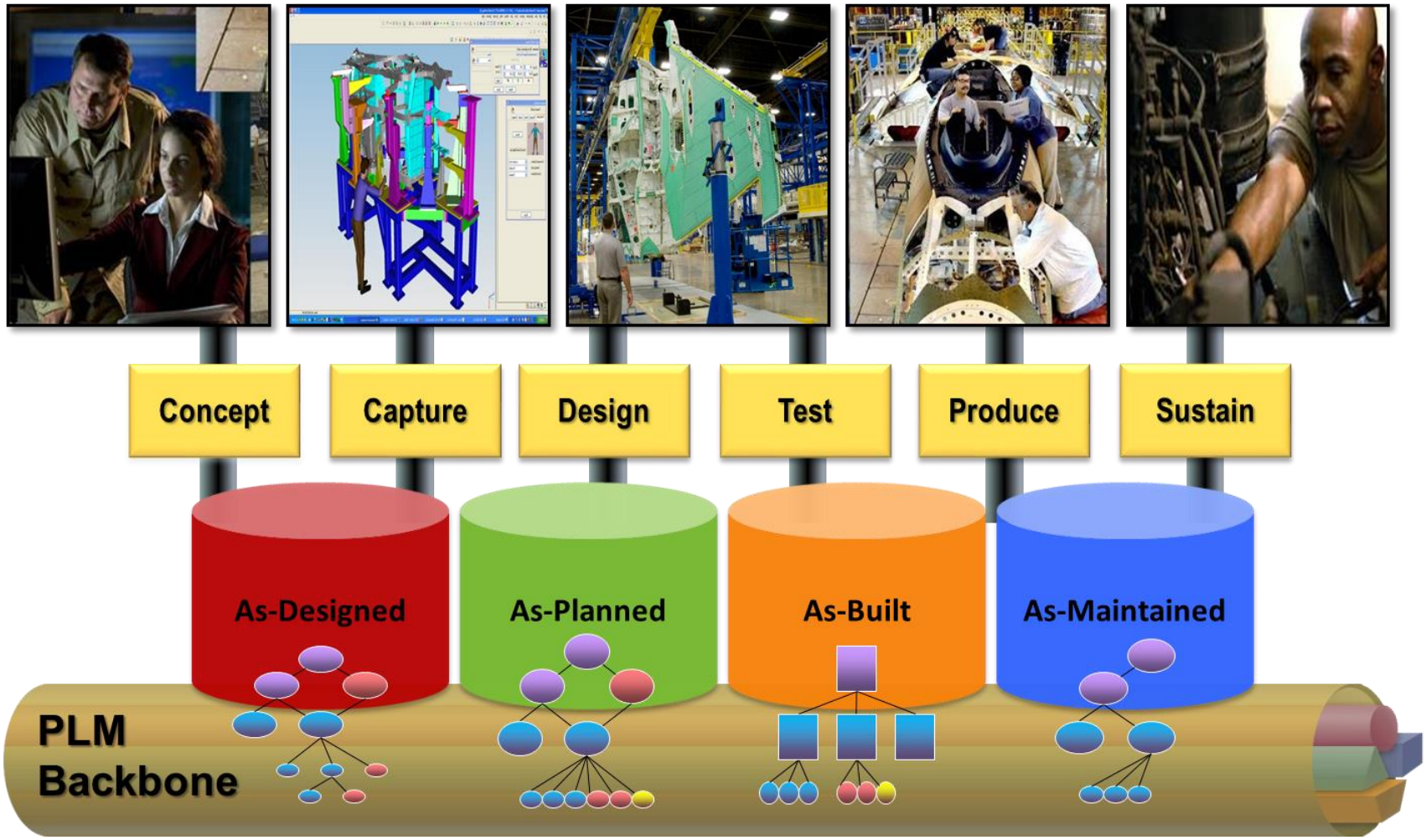
Information seamlessly available from all parts of the lifecycle to all parts of the lifecycle

Enterprise Data Systems

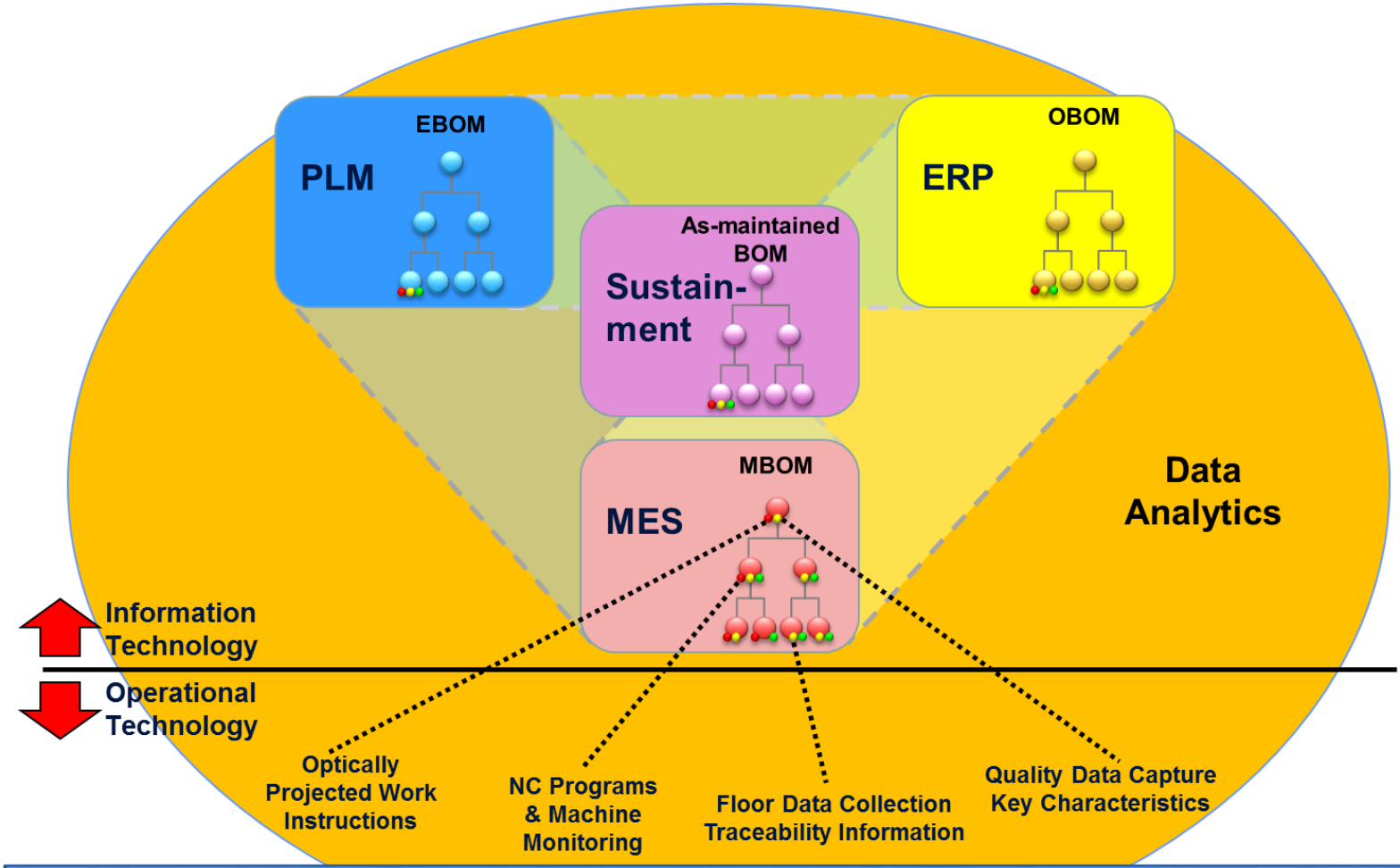


Data is Often Functionally Silo'd and Not Well Integrated for Enterprise Accessibility and Analysis

The BOM is the Golden Thread



The Connected Enterprise – Industry 4.0



The Connected Enterprise Enables Automated Metrics, Financial Reporting, Data Analytics, Integration with Factory Equipment, and Real Time Management Visibility

The Future of the Digital Thread

- **Advance the Digital Thread for Product Development, Manufacturing, and Sustainment –**
  - **Focus on increasing quality and decreasing span time for development**
  - **Digital Twin, Automated Analysis, Robotics, Simulation, Augmented Reality, etc.**
- **Apply systems engineering data strategy to integrate tools and seamlessly connect the enterprise systems (PLM, MES, SAP, Sustainment) – BOM is the Golden Thread**
- **Embrace Industry 4.0 –**
  - **Descriptive Analytics - Desktop access to task level/program level performance that crosses functional boundaries and early warning alarm systems for future problems.**
  - **Predictive Analytics and Machine Learning – Analysis of future performance based on current performance and predicted future disruptions.**

How Will We Design, Build, Sustain, and Manage the Starship Enterprise?