Reducing EWIS Manufacturing Cost and Risk via the Digital Thread

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Mentor, A Siemens Business

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2018

ELYSIUM Parker Aerospace NORTHROP GRUMMAN BOEING

Agenda

- **EWIS Manufacturing is Challenging**
- **The Digital Thread Can Help**
- **Specific EWIS Manufacturing Examples**

Electrical Domain: The Nervous System Connecting E/E Devices

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Integrates vehicle functions:

The **Electrical Wiring Interconnect System**

breathes life into an otherwise inanimate object

By its nature EWIS design demands intimacy with:

- ✓ 3D model
- ✓ Zone Environments
- ✓ Performance Constraints

Aerospace & Defense Platforms are Going ‘More Electrical’

Electrical complexity & implementation challenges exploding

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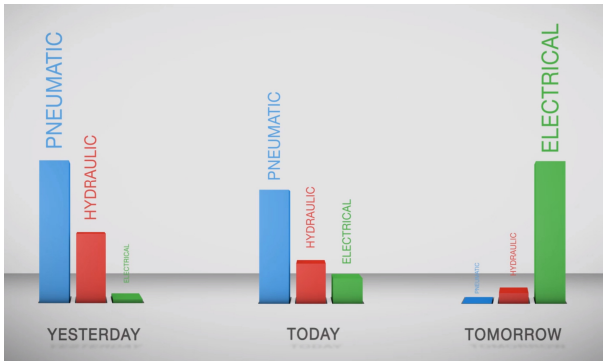


- ⊕ RELIABILITY
- ⊖ MAINTENANCE
- ⊕ AVAILABILITY
- ⊖ VOLUME
- ⊕ PAYLOAD
- ⊖ ENERGY
- ⊖ FUEL

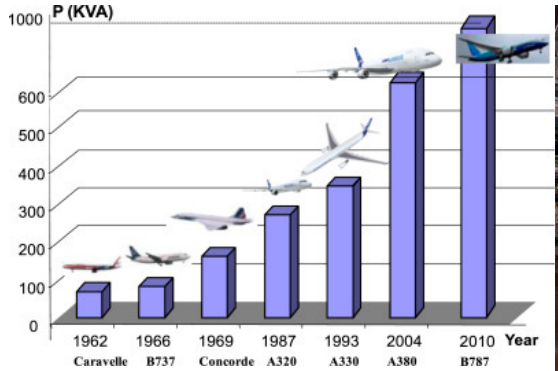
Magnitude of Impact:

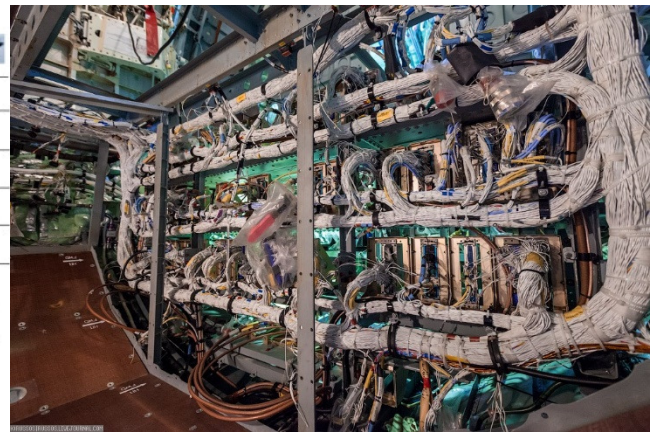
25% EE Content Growth Every 5 Years

10x Power Demand Over 50 years

EWIS now 3% of Aircraft Weight

EWIS Cost Grows Faster than Content





Aero EWIS: Miles of Wire & Hundreds of Harnesses

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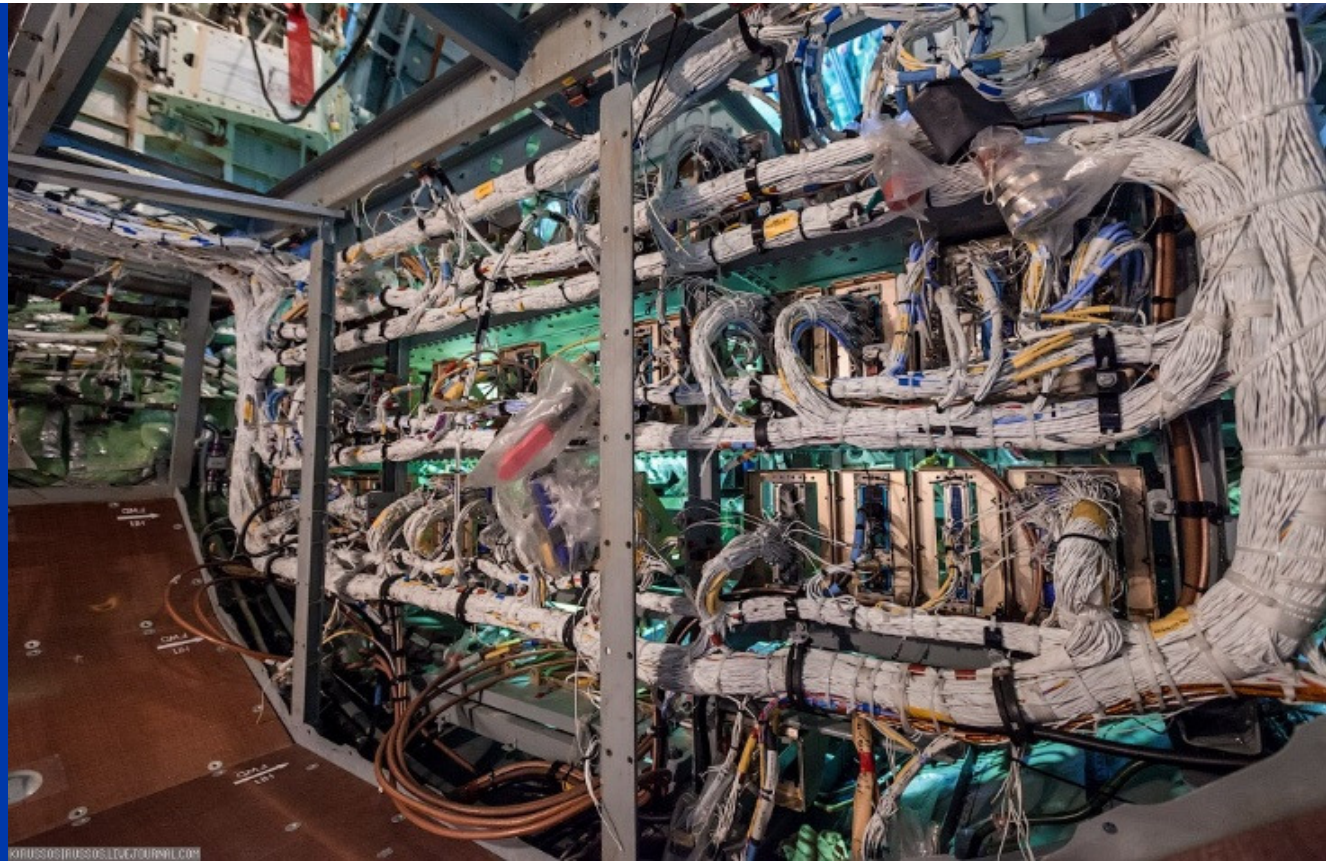
Military Cargo Aircraft:
- 40 miles of wire
- 160 harnesses

Modern Business Aircraft:
- 50 miles of wire
- 345 harnesses

Modern Commercial Aircraft:
- 70 – 100 miles of wire
- 500 – 1400 harnesses



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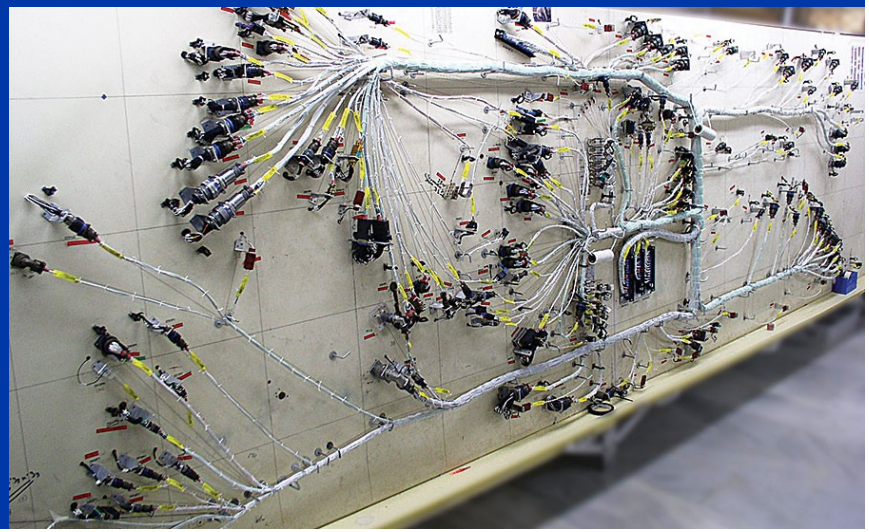
EWIS Manufacturing Must Satisfy Key Business Drivers

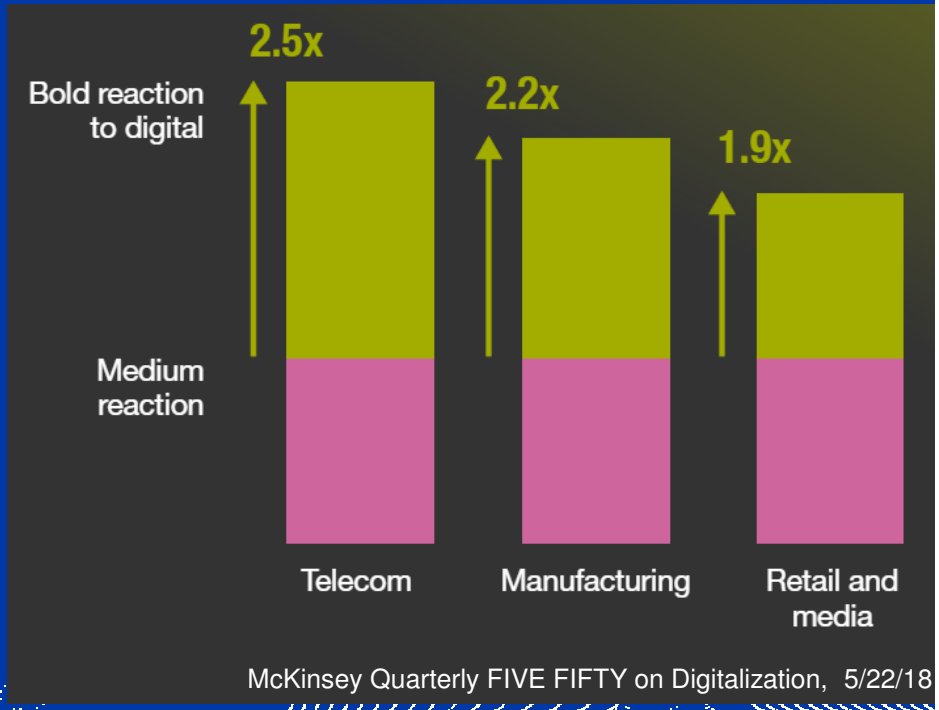
- **Profitability – Margin Pressure**
- **Revenue Ramp**
- **Production Ramp**
- **Cost Control**
- **Just-in-Time, Quality Deliveries**
- **Supply Chain Collaboration**

Profitably Manufacturing an EWIS Is Challenging

- Assembly is largely a manual process
- Requires skilled assemblers
- Design data often re-entered manually
- Large component variation, increasing carried inventory
- Incomplete MBOMs drive excess inventory
- Varied assembly specifics, forcing process research
- Difficult to create complete work instructions
- Building work instructions on-the-fly
- Assembly errors found in test, driving scrap & rework
- Tooling often incorrect
- Manufacturability changes not synced to design docs
- Delays can result in $M of unexpected freight costs
- Tribal knowledge, expertise, leaving the company



Digitalization changes everything



McKinsey Quarterly FIVE FIFTY on Digitalization, 5/22/18

Digitalization: The use of digital technologies to change a business model

Digital Enterprise Value Streams

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Digital Enterprise		
Ideation	**Realization**	**Utilization**
Systems Driven Product Development	Manages increased product complexity by providing accelerated product development via linked, shared, traced, and managed digital definitions achieving optimized designs with model-based systems engineering	
Integrated Program Planning and Execution	Provides a systems approach to project planning that integrates cost, schedule, risk and technical requirements in a fully planned, resourced and budgeted program management solution	
Product Engineering and Design	A best in class interdisciplinary development platform enabling design to evaluate mechanical and electrical component designs jointly prior to prototype and physical test	
Supplier Source Selection and Management	A digital thread approach to managing interactions with suppliers which coordinates processes and manages information, both internal and external, across all stages of the product lifecycle.	
Verification Management	Provides the ability to achieve certification faster through synchronizing requirements from design, analysis and test to ensure that analysis and simulation models are synchronized across all lifecycle information achieving conformance.	
Product Realization	Leverage a comprehensive digital thread and digital twin by deploying a common system to orchestrate production processes and bring relevant production data to every aspect of program development	
Product Support Planning & Management	Enables manufacturers, owners and service organizations to support complex products with a configuration driven service management environment.	

Creating a Holistic Digital Twin (a.k.a. The Model!)

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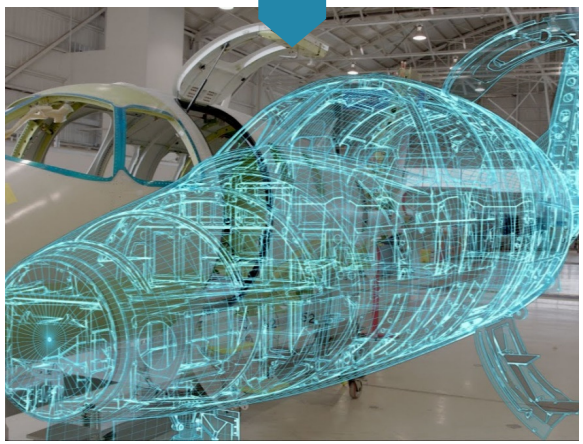
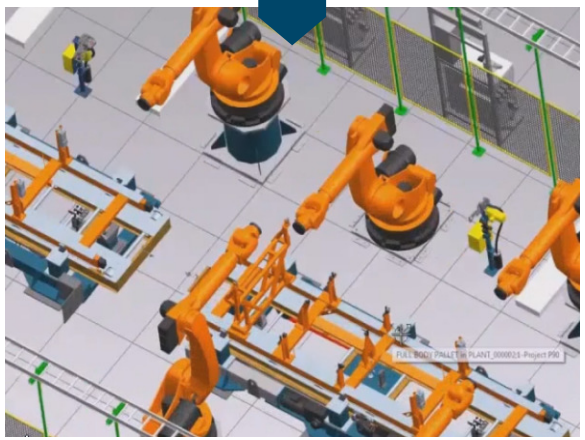
Cloud

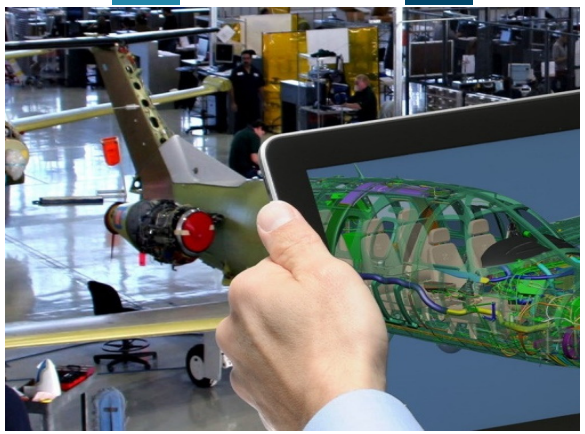
feed back insights to continuously optimize product and production



Digital Twin of the product



Digital Twin of the production



Digital Twin of the performance

Three Key Tenets of a Model Based Enterprise

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DIGITALIZATION

Digital models become the authoritative information source driving all downstream implementation steps.

AUTOMATION

Transformation into subsequent forms is significantly automated to create **correct-by-construction outcomes.**

DATA REUSE

Data created once is reused to the greatest extent possible by all downstream consumers.

Automation for Electrical Systems

Executable Transformations Between Abstractions

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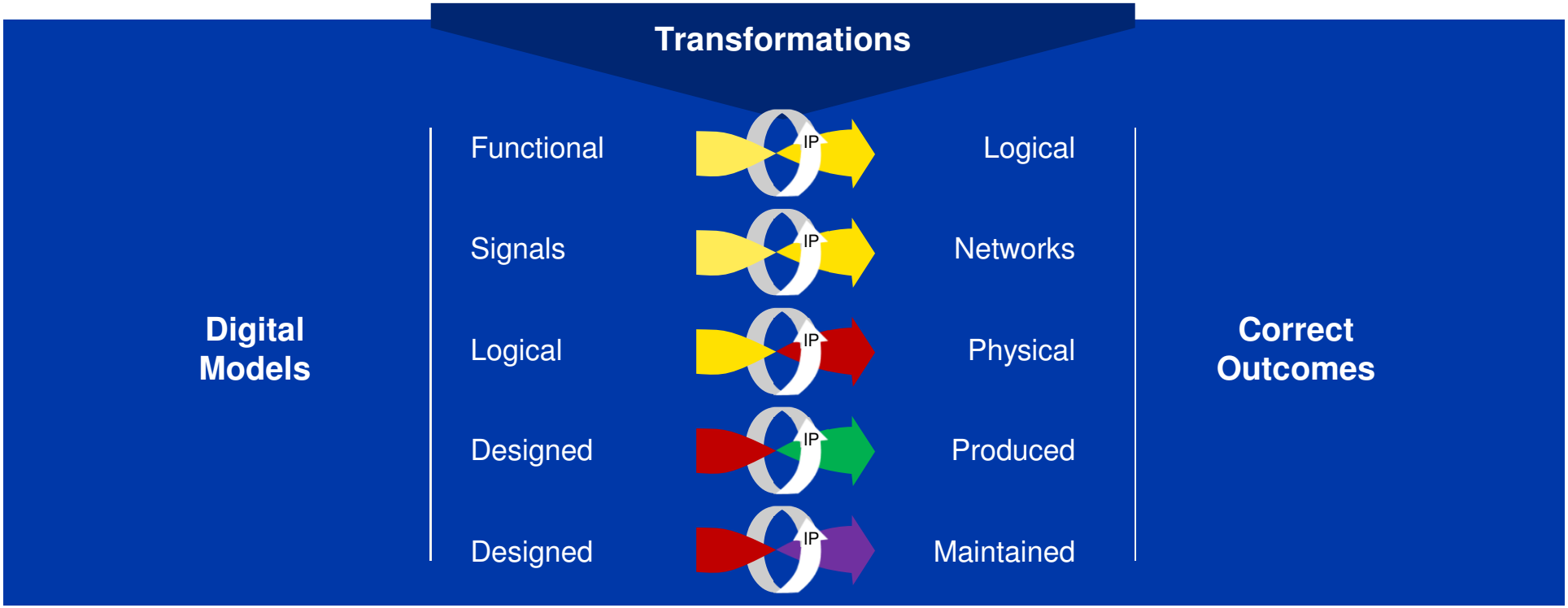

Realizing the Electrical Model Based Enterprise

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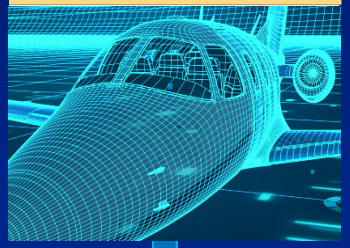
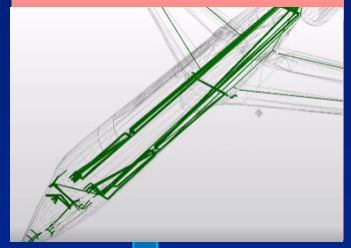
IDEATION		Models	REALIZATION	UTILIZATION
DEFINE	**DESIGN**	**MANAGE**	**PRODUCE**	**MAINTAIN**
Optimize Architectures Functional, Logical, SW	Create / Verify the EWIS and NW Communication	Manage Processes, Assets & Integration	Engineer, Cost & Produce Harnesses	Create Publications & Enhance Diagnostics



Product Life Cycle Management – Collaboration and Innovation

The PRODUCE Domain

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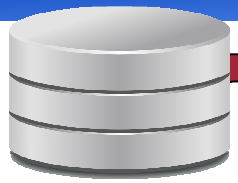
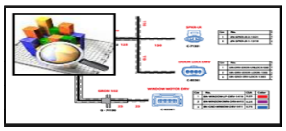


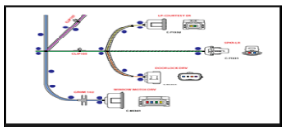
Digital Thread

Harness Design & Engineering



- Release Design / ECO
- Complete Product Eng. for Mfg.

Formboard (Tooling) Design



- Design the Main Formboard
- Design PM Formboards

Modular Product Engineering

- Design Production Modules

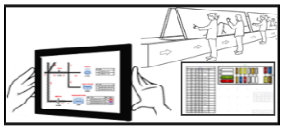
Process Design & Optimization

- Generate the SBOM
- Line Balancing

Harness Costing

- Cost Harness
- Cost the MBOM

Manufacturing Documentation



- Create Work Instructions

Business and Manufacturing Systems

- QA Electrical Test Machine Feeds
- Forecasts Harness P/N Order Planning
- ERP (BOM – MRP)
- Manufacturing Execution System
- Finance Actual Costing Pricing
- Manufacturing

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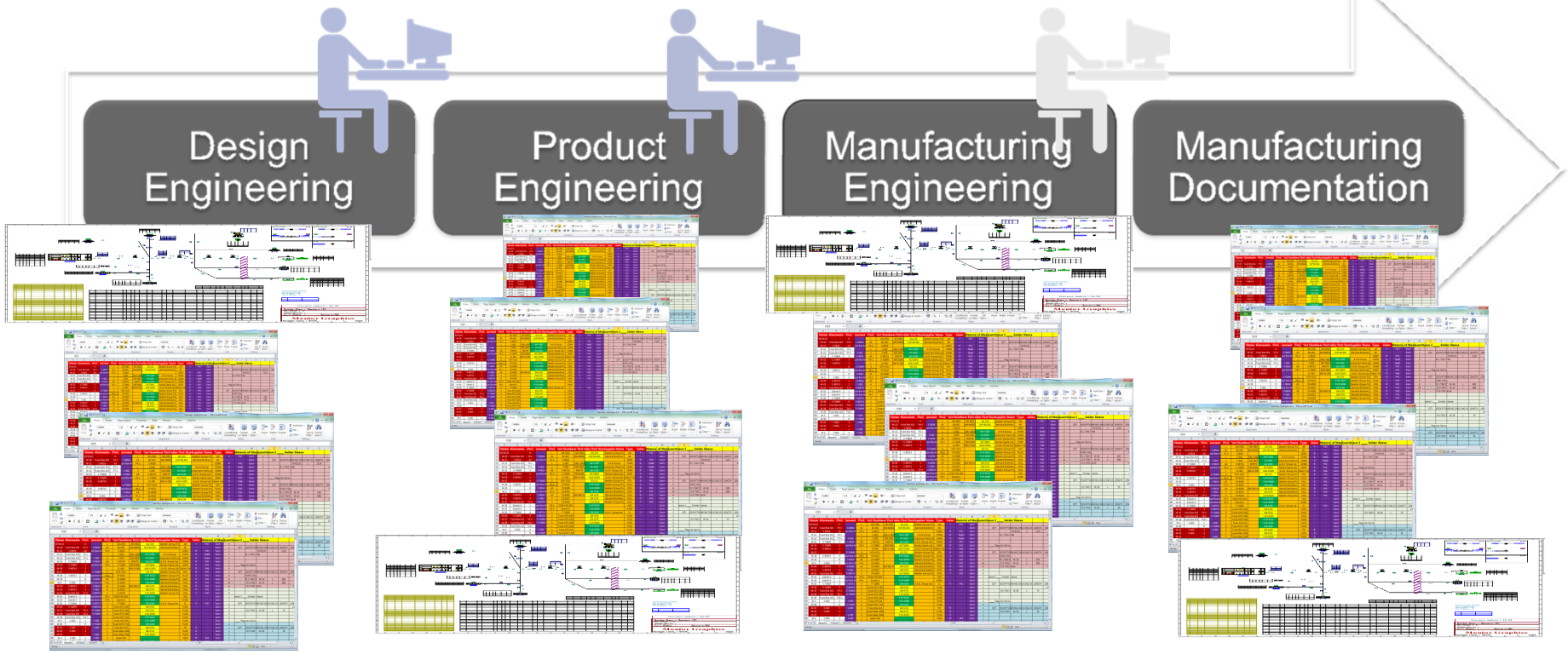
Current Engineering Practices: Manual Data Re-Entry

- Cycle times of months
- Manual mistakes cost money
- No time to optimize process

Methods are no longer adequate



But… the Entire Value Chain Can Use the Same Model!

Digital Thread

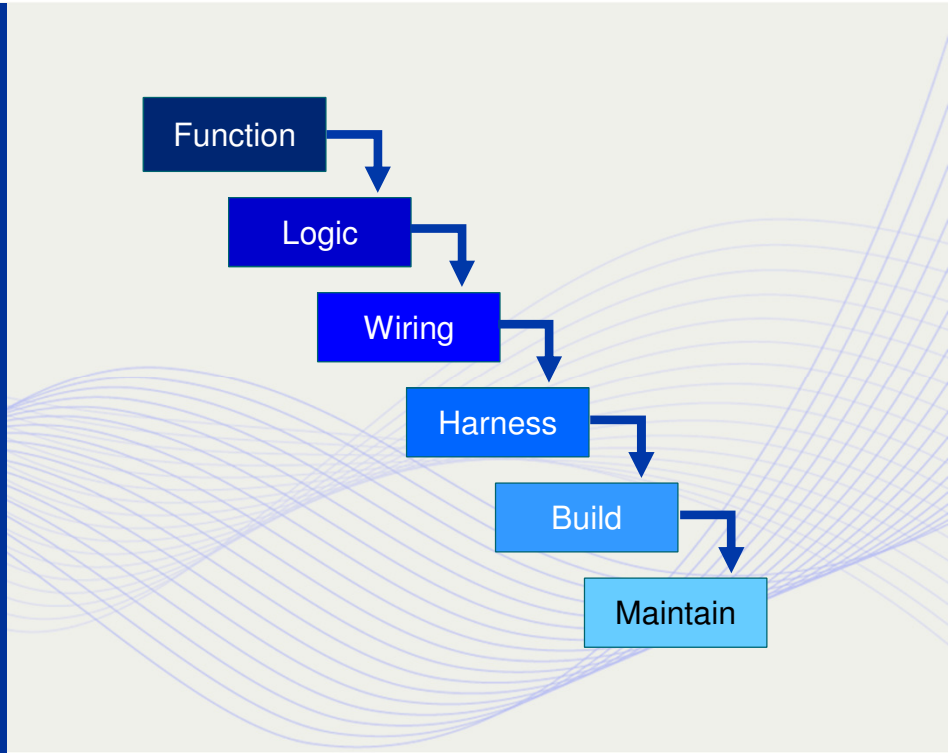
Assess to cross-domain decisions

Faster **design cycles** – more iteration

"Configuration aware" design environment

Address issues early when costs are lower

Reduce rework, **minimize** NRE costs



Transformations via the Digital Thread

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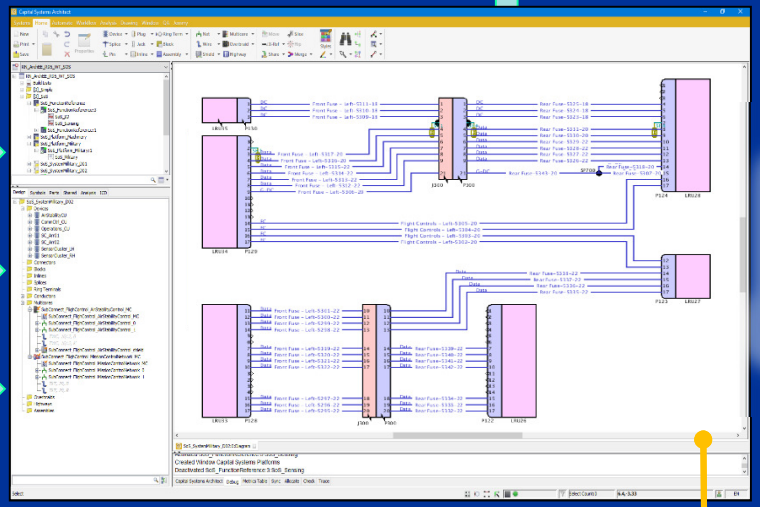
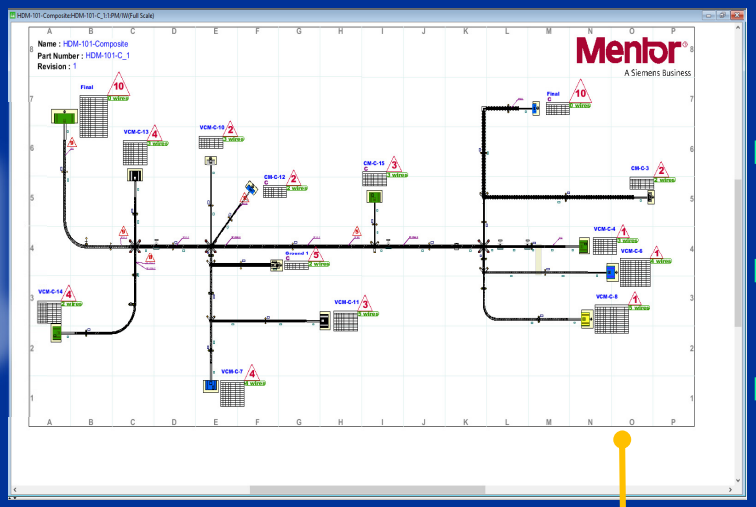
Model Transition & Transformation



Digital Thread



Logical Design

Buildable Design

Capital Harness Manufacturing Engineering

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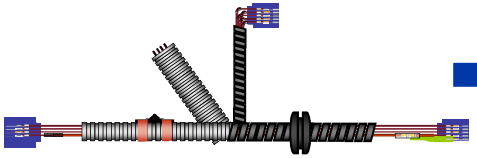
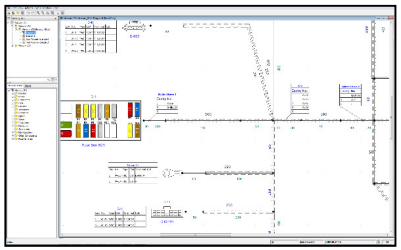
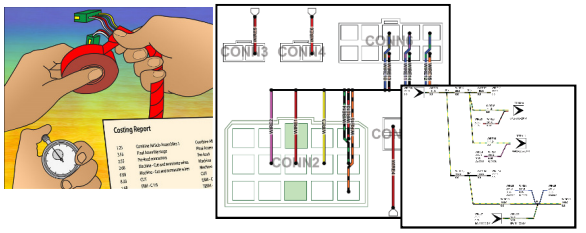
Integrated process design, costing & documentation

Harness Model

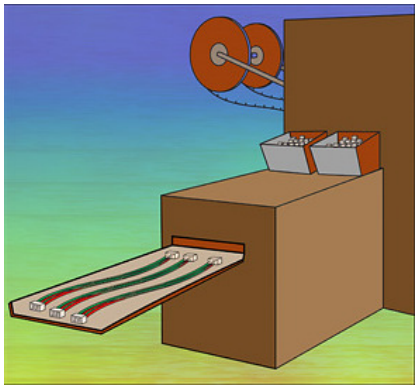




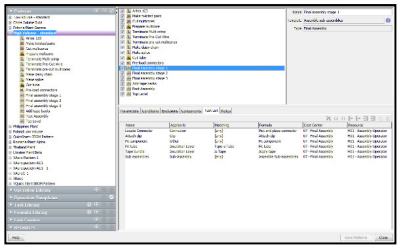
Process & Cost Calculations, Documentation



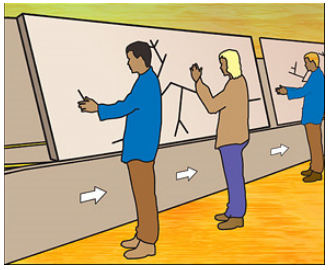
Factory Model

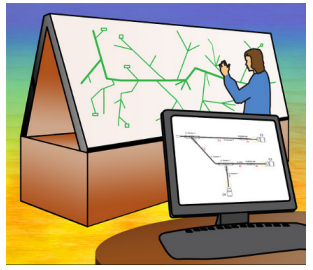


Electronic Descriptions



Manufacturing





Tribal Knowledge Exiting Organizations

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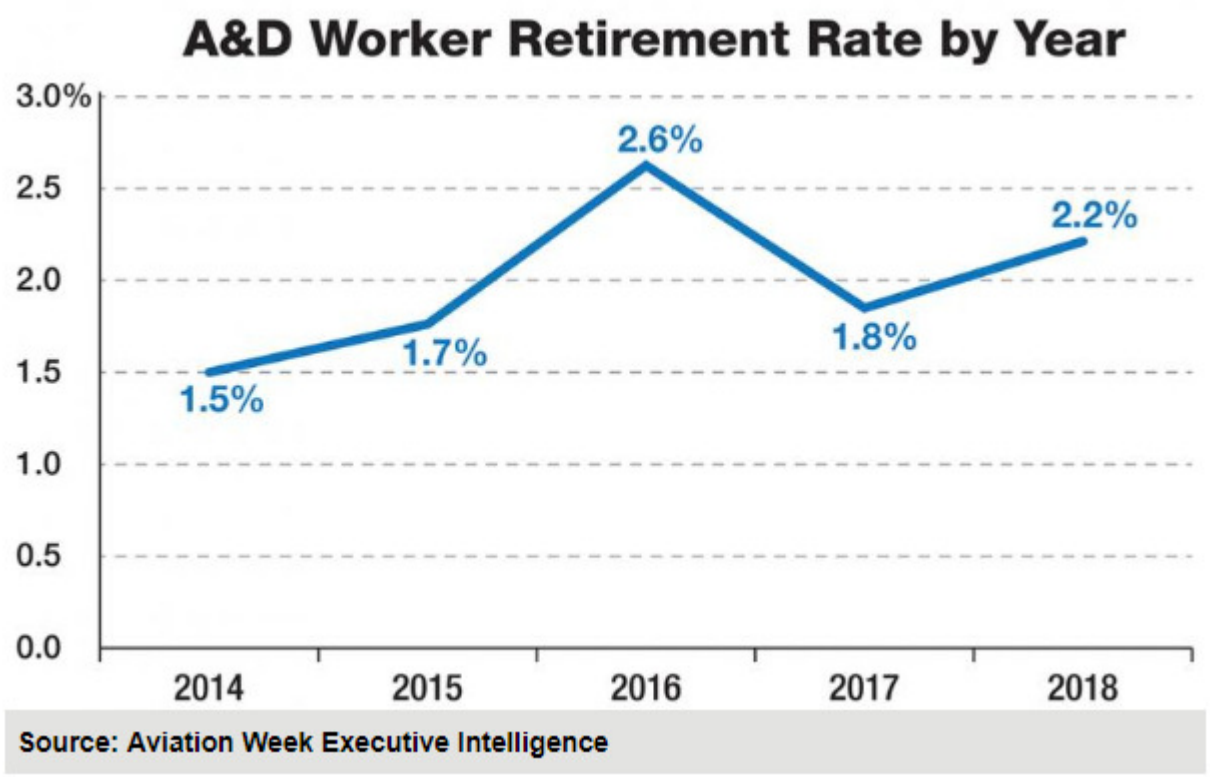


Relevant Areas of Impact:

Systems Engineering
Design
Manufacturing
Service

How do managers:

Maintain production rates?
Maintain productivity?
Retain expertise?
Reduce program risk?

"A potential tidal wave of baby-boomer exits from the aerospace and defense sector is increasingly weighing on the minds of industry leaders."

Aviation Week, 8/29/18

How to Capture & Reuse Expertise?

Capture Tribal Knowledge in **Rules & Constraints**

Example rules

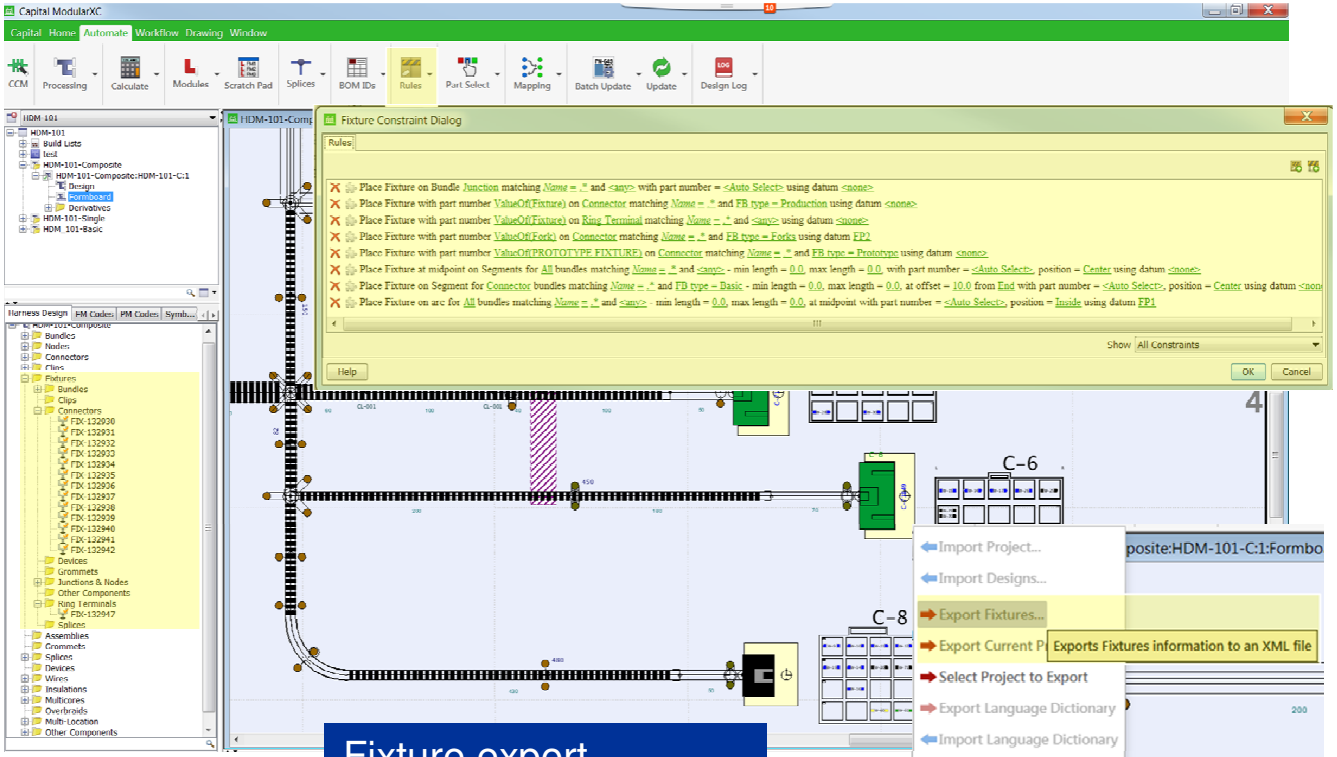
1. Create modules for ‘networks’ of spliced connectivity
   - Single splice, spliced daisy chains and multi-crimped ring terminals
   - If the splices are attached to multicores via shield terminations then the multicores are included
2. Sort and creates single connector modules
   - Firstly looking at connector where all of the remaining wiring has no variance (e.g. same spec)
   - Work up from the smallest by remaining wire count
3. Creates single connector modules for remaining wires
4. If a module contains all of the wires in any bundle then it will include any insulations or fixings on those bundles

Case Study: Formboard Design & Engineering

Formboard Fixtures

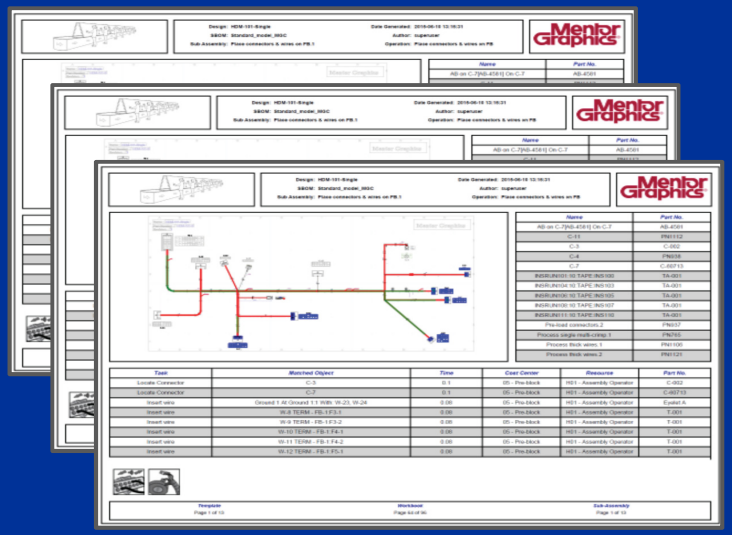
- Powerful automation
- Configurable fixture selection
- Rules-based fixture placement
- Exportable fixture BOM & drill coordinates

Jig/fixtures/drill-points are automatically placed based on applied rules



Fixture export
Drilling report export

Problems Caused by Incomplete/Late Work Instructions



Causes

- Upstream schedule delays **reduce time** to manually generate work instructions
- Data is buried in **process specifications**

Ramifications

- **Kits aren't released** until work instructions are complete
- Assembler spends time **looking for data**
- **Key program delivery milestone aren't met**

Capital Harness Manufacturing Engineering

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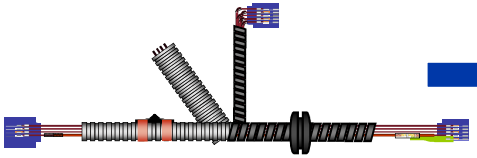
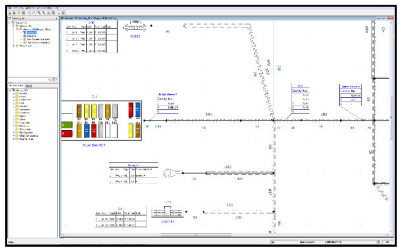
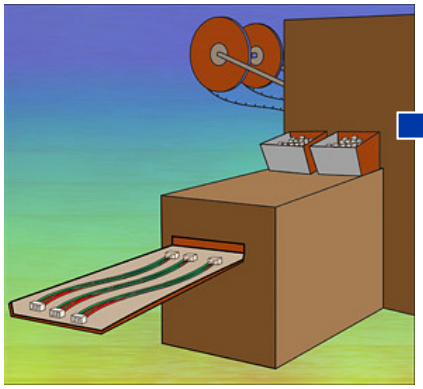
Integrated process design, costing & documentation

Harness Model





Factory Model



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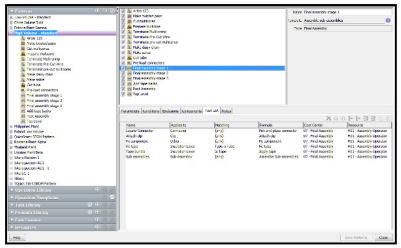
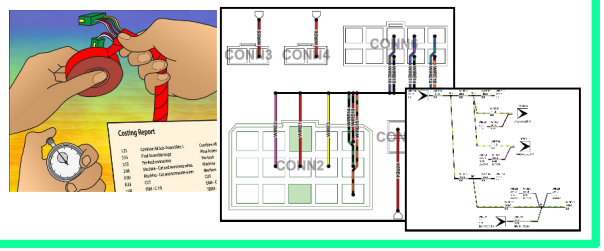
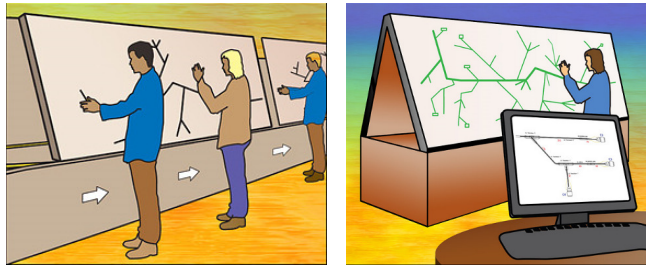


Create Work Instructions from Design & Factory Data



Manufacturing

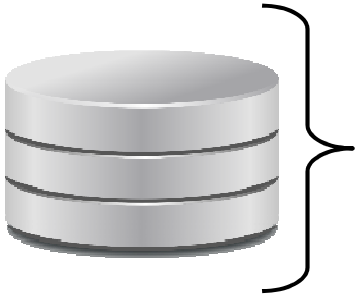


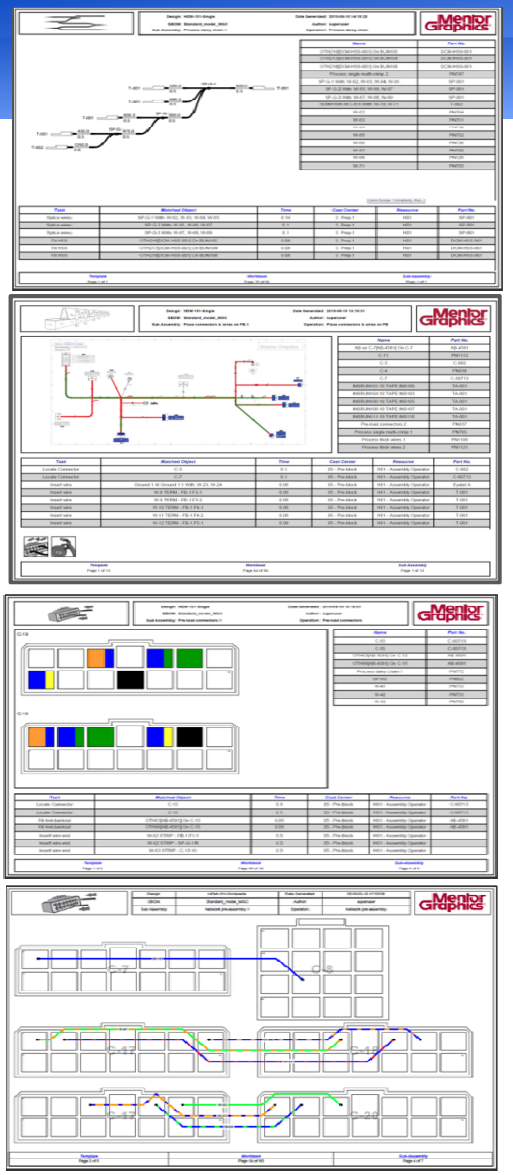
Automatically Create Work Instructions

Design Data
- Digital Twin

Factory Data
- Digital Twin

Corporate Assets
- Fixture libraries
- Language dictionaries
- Process specification details





Quantitative Proof Point Examples

Significant Benefits Achieved Across Several Industries

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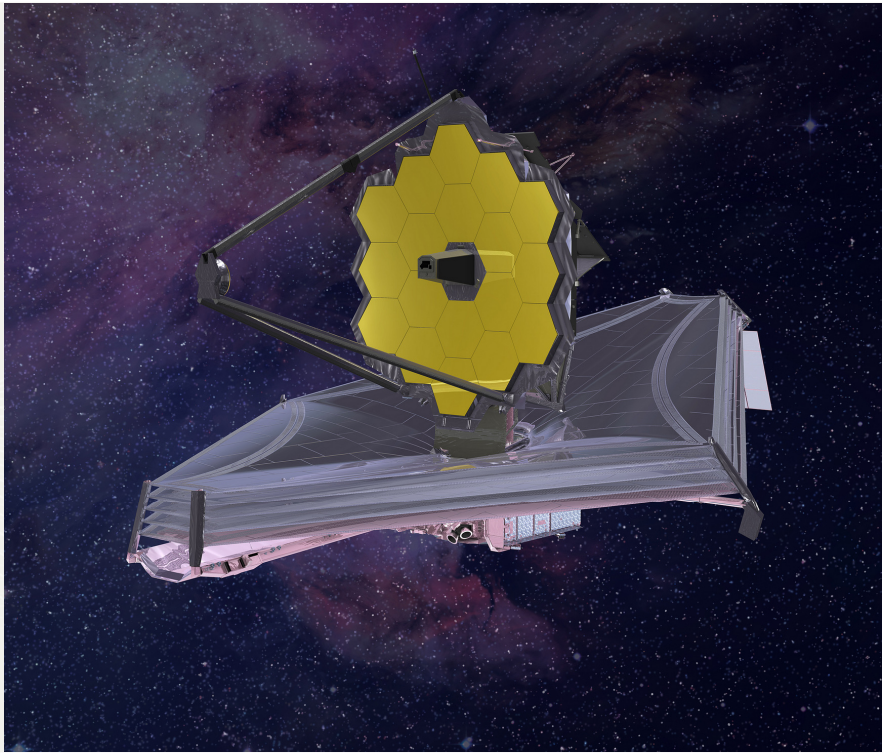
90% manufacturing ECO reduction	Flight simulators
50% electrical design time reduction	Satellites
30% electrical design time reduction	Missile systems
85% formboard design time reduction	Business jets
Weeks → hours test pattern generation time reduction	Helicopters
Zero scrapped wire harnesses (first time ever)	Helicopters
6.5kg per car weight reduction	Cars
Months → weeks EE architecture design time reduction	Cars
50% electrical design time reduction	Trucks
30% quote-to-production cycle time reduction	Harnesses
80% electrical documentation time reduction	Cars
40% electrical fault diagnosis time reduction	Cars

US integrated electrical solutions: Northrop Grumman

NORTHROP GRUMMAN

"We have consistently realized between **50-55% efficiency improvement** over all previous methods.

Our workload has increased by 30%during the design process **without additional man power.**



Digital Thread Reduces EWIS Manufacturing Cost and Risk

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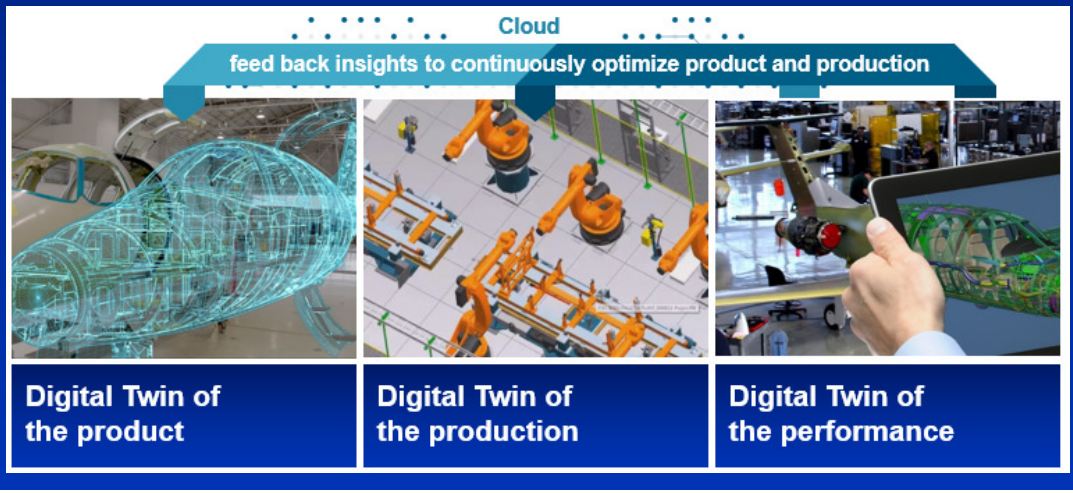
- Functional Designs
- Logical Designs
- Physical Designs
- Harness Designs
- Formboard Designs
- Work Instructions
- Technical Publications



Thank you

Feel free to contact us with questions:

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