Digital Twin – Digital Thread in Aerospace

David Riemer
Siemens Focus is to Enable Excellent Performance on Every Program

Program Execution Excellence

Fully support a Model Based Enterprise, Digital Twin – Digital Thread to better meet cost, technical and schedule program goals.

Provide pre-configured technology to focus on the automation of specific A&D value streams to provide a potential competitive advantage.

Leverage the smart innovation Portfolio to enable product knowledge & definition to be shared to improve performance in production, support and future bids.
Industry 4.0 – What Is It?
The history of the industrial revolution

An industrial revolution was always driven by new enabling technologies
Industry 4.0
Defining the way forward in industry in the internet age

An initiative of the German industry sponsored by the German Government

Cornerstones of the initiative Industrie 4.0

• Horizontal integration of the value-add networks
• Seamless integration of the engineering of the entire value-add chain
• Vertical integration and networked production systems

Source: acatech, April 2013 “Umsetzungsempfehlung für das Zukunftsprojekt Industrie 4.0”

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Why Hasn’t the Digital Age Yielded the Benefits Expected?

What’s the difference?

No difference
Why Hasn’t the Digital Age Yielded the Benefits Expected?

Digital Twin Maturity

Digital Thread Maturity

Digitalization – Not only is the physical world virtually verified prior to design, process, tooling, etc. commitment – all the inputs, outputs and process used to create the information are completely traceable.

Where is Your Organization?

• Today the digital information we store is not connected to any of the inputs or requirements – making it difficult to fully understand a proposed change.

• A&D has unique product life spans that require full traceability.

Digitize

Digitize

Digitize

Digitize
Digital Thread – Creating the Digital Twin
# Program Execution Excellence

Value Stream Solutions Generate Competitive Advantage

## Program Execution Excellence

### Value Streams on the Smart Innovation Portfolio

<table>
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<tr>
<th>Systems Driven Product Development</th>
<th>Integrated Program Planning and Execution</th>
<th>Product Design</th>
<th>Supplier Source Selection and Management</th>
<th>Verification Management</th>
<th>Product Realization</th>
<th>Product Support Planning and Management</th>
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<tbody>
<tr>
<td><strong>OPTIMIZATION &amp; INNOVATION</strong></td>
<td><strong>MEETING COST, SCHEDULE AND TECHNICAL REQUIREMENTS</strong></td>
<td><strong>EFFICIENT FIRST TIME RIGHT</strong></td>
<td><strong>EFFECTIVE SUPPLIER MANAGEMENT</strong></td>
<td><strong>FASTER TIME TO CERTIFICATION</strong></td>
<td><strong>MEETING COST &amp; PRODUCTION GOALS</strong></td>
<td><strong>INTEGRATE SERVICE WITH THE FACTORY</strong></td>
</tr>
<tr>
<td>A systems driven product development approach to leveraging system and 3D models from idea thru support.</td>
<td>A systems approach to project planning a fully planned, resourced, budgeted and executed program management solution.</td>
<td>Design with advanced materials, integrated CAD/CAE, maximize reuse, advanced configuration management.</td>
<td>Enabling traceability from OEM requirements to suppliers. Proactive supplier management.</td>
<td>Enabling traceability from requirements thru virtual and physical test to ensure product verification.</td>
<td>“Shift left” manufacturing planning to ensure cost, schedule &amp; safety goals are achieved with fully integrated factory.</td>
<td>Design for support. Plan for support. Manage service planning. Closed loop support with manufacturing and design.</td>
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Optimizing the program execution process:

- **Optimization & Innovation**
  - Meeting Cost, Schedule and Technical Requirements
  - Efficient First Time Right
- **Verification Management**
  - Faster Time to Certification
- **Product Support Planning and Management**
  - Integrating Service with the Factory

**Enabling Traceability**

- From OEM Requirements to Suppliers
- Proactive Supplier Management

**A Systems Driven Product Development Approach**

- Leverages system and 3D models from idea thru support.

**Efficient First Time Right**

- Design with advanced materials, integrated CAD/CAE, maximize reuse, advanced configuration management.

**Effective Supplier Management**

- Enabling traceability from OEM requirements to suppliers.

**“Shift left” Manufacturing Planning**

- Ensures cost, schedule & safety goals are achieved with a fully integrated factory.

**Integrating Service with the Factory**

- Design for support. Plan for support. Manage service planning. Closed loop support with manufacturing and design.

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**ENABLING TRACEABILITY FROM REQUIREMENTS THRU VIRTUAL AND PHYSICAL TEST TO ENSURE PRODUCT VERIFICATION.**

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**Design for support. Plan for support. Manage service planning. Closed loop support with manufacturing and design.**

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**Systems Driven Product Development**

- A systems driven product development approach to leveraging system and 3D models from idea thru support.
Program Execution Excellence
Using world class capabilities to generate business value

Digital Enterprise Foundation

**Smart Ideation**
- As-designed BOM Management
- Requirements Management
- Advanced Aerostucture Design
- MBOM and Bill of Process
- Automated Design & Engineering
- Reliability and System Safety
- Automation Design & Engineering
- Document Management (CDRL/SDRL)
- 3D Electronic Work Instructions
- Part Manufacturing
- 3D Massive Model Visualization
- MBOM and Bill of Process

**Smart Realization**
- CAM / Tooling / Fixtures
- End-item Delivery (DD250 or Airworthiness)
- Manufacturing Execution Management
- Manufacturing Operations Management
- Manufacturing Execution Management
- MBOM and Bill of Process

**Smart Utilization**
- Plant Design & Optimization
- Assembly Manufacturing Engineering
- Quality Management
- ERP Integration
- Technical Publications (S1000D)
- Maintenance Planning
- Failure Reporting & Corrective Action
- Logistics Support Analysis
- As-Maintained BOM
- GSE/EGSE Design
- Spares Definition and Condition of Supply
- Maintenance Simulation
- Service Bulletins
- Software Maintenance
- Maintenance Ergonomic Analysis
- Field Experience Feedback
- Obsolete Management
- Manufacturing Optimization
- MRO Integration

**Industry Value Streams**
- **Smart Innovation Portfolio**
- **Capabilities**
- **Smart Ideation**
- **Smart Realization**
- **Smart Utilization**
- **Product Design**
- Supplier Source Selection and Management
- Verification Management
- Product Realization
- Product Support Planning and Management
- Systems Driven Product Development
- Integrated Program Planning and Execution
- Manufacturing Operations Management
- ERP Integration
- Technical Publications (S1000D)
- Plant Design & Optimization
- Quality Management
- 3D Massive Model Visualization
- ASME PTC 19.3 Compliant and Customizable
# Program Execution Excellence

**Systems Driven Product Development**

## Digital Enterprise Foundation

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- Configuration and Change Mgt

### Smart Realization
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## Industry Value Streams

**Systems Driven Product Development**

- **Integrated Program Planning and Execution**
- **Product Design**
- **Supplier Source Selection and Management**
- **Verification Management**
- **Product Realization**
- **Product Support Planning and Management**

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Benefit:
Ability to completely trace a requirement through the design to the shop floor
Provide the knowledge base to manage the product throughout its extended life (~>40 years)
Complete and thorough change management – Absolutely know ALL the impacts of a proposed change
MADe – how it supports the “V”

End-item Requirements | System Requirements | Component Requirements | Design | Component Verification | System Verification | End-item Verification

Failure Hazard Analysis | Failure Hazard Analysis | Preliminary Fault Tree Analysis | Preliminary Fault Tree Analysis | Update Fault Tree Analysis | Update Fault Tree Analysis | Update Fault Tree Analysis

Fault Tree Analysis | Common Cause Analysis* | Common Cause Analysis* | Common Cause Analysis* | Common Cause Analysis* | Common Cause Analysis* | Common Cause Analysis*

Common Cause Analysis* | Logical Architecture | Physical Hardware Software | Failure Mode & Effects Analysis | Failure Mode & Effects Summary | Failure Mode & Effects Summary | Failure Mode & Effects Summary

Also includes:
- Teamcenter Integration
- RAM tools
- Prognostics & Health Management tools
WHY ALM + PLM

- Each domain has unique needs
- Each solution provides unique benefits
- Design dependencies cross domains
- Customers require engineering synergy
- Domain expertise needs to be seamlessly integrated

PLM & ALM must work in unison to address product development demands
**Systems Driven Product Development**

**Integrated ALM + PLM**

- **Product Line**
  - Multi-Domain Lifecycle Management
  - Domain Traceability and Configuration Management
  - Systems Architecture and Modeling

- **Domain Realization**
  - Requirement Decomposition

- **Physical Lifecycle**
  - Traceability of physical requirements to the BOM
  - Intelligently assess the impact of requirements or design changes
  - Ensure requirements are met from design through manufacturing & service

- **Software Lifecycle**
  - Traceability of software requirements to test cases, work packages and code
  - Intelligently assess the impact of requirements or design changes
  - Ensure requirements are met from design through coding, testing build & release

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**Teamcenter**

**ALM Connector for Teamcenter**

**ALM (Ex: Polarion)**
Program Execution Excellence
Integrated Program Planning and Execution

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Capabilities
- Smart Innovation Portfolio
- As-designed BOM Management
- Reporting and Analytics
- Model Based Systems Engineering
- Software Management
- Configuration and Change Mgmt
- Requirements Management
- 1D / 3D Simulation and Test Management
- Mechanical Design Model Based Definition
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Integrated Program Planning and Execution
Only Integrated Solution – Program Digital Thread

• Process uses a “Common WBS” to organize all bid/program information
• Bases on set of criteria applied to the “Common WBS” a Program WBS is created
• Work Package includes requirements, processes, inputs, deliverables, logical, functional and physical architectures
• Complete support for Integrated Master Plan, Integrated Master Schedule and third party EVMS systems
• Complete configuration management of all program artifacts

IPP&E Process diagram
Organize Common and Program Around WBS
Totally Integrated and Traceable
Program Execution Excellence
Supplier Source Selection and Management

Digital Enterprise Foundation

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Software Management
- Electrical and Electronics Design
- Supply Chain Collaboration
- Part Manufacturing
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Supplier Source Selection and Management

Solution Description

• Change source selection from document manual process to electronic requirements based
• Provide traceability to contract or company requirements
• Change supplier management from re-active ad-hoc to proactive process based
• Integrate supplier schedules with program schedule

Since the Executive Council Meeting

• Initial process diagram complete
• Big Block diagram in work
• Ready for customer vetting
# Digital Enterprise Foundation

## Smart Innovation Portfolio

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### Smart Realization
- 1D / 3D Simulation and Test Management
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Current Verification Documentation is Segmented and Disconnected between Virtual and Physical Environments

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Solution Description
- Integrated requirements verification management process
- Complete traceability of all artifacts
- Tie production eBOM to test article eBOM for rapid change impact awareness
- Manage test article configurations
- Ensure analysis models are based on latest design model

Status
- Process diagram complete
- Big Block diagram complete
- Customer vetting complete
- V1.0 Catalyst deployed – customer installed
- V1.1 Catalyst development – Release in April
- Enhanced verification by analysis
- Supports A&D template – doc centric
## Verification Management

### Closed Loop Requirements to Compliance – Qualification Digital Thread

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Solution Description

- Full end to end process
- Focus on driving manufacturing requirements into Concept to Build
- Concurrent maturing of manufacturing processes, tooling, plant layout with design maturity
- Simple effective as-engineered to as-built for delivery assurance
- Closed loop process ensures continuous improvement
- Design reviews are not just of product but also manufacturing processes, tooling, planning – drive concurrent development

Since the Executive Council Meeting

- Process diagram complete
- Big Block diagram complete
- Initial customer vetting complete
Digital Thread in Product Support Planning and Execution

Design and Development

- Testability
- Reliability
- Maintainability
- Supportability

Logistics Support Analysis

- Customer Requirements
- Environment & Operational Requirements

Support Concept

- Supply Support
- Technical Data
- Training and Training Equipment
- Personnel Requirements

Support Equipment

- Infrastructure
- Maintenance Plan
The Digital Enterprise
Connecting Manufacturing to Engineering

Digitalization Cornerstones

- A Digital Enterprise uses transformative technologies to drive significant improvements in efficiency and agility
- The Siemens Digital Enterprise Suite is built on class-leading PLM, MOM & Automation portfolios
- The Teamcenter Collaboration platform underpins the Digital Enterprise and:
  - Drives inter-departmental collaboration
  - Synchronizes Suppliers and Customers
  - Coordinates the network of production facilities
- The rock-solid, bulletproof automation technology for Speed, Reliability, Safety, Security and Sustainability
Digital Enterprise Software Suite -
The Siemens answer to Industry 4.0 requirements
Summary

• Digital Twin provides virtual verification of the product and process
• Digital Thread ties critical information to its inputs, processes and outputs
• Siemens provides a unique solution set for Industrie 4.0 and the digital-thread / digital-twin
• Siemens is a hardware manufacturing company using our solutions to deliver customer value