Smart Manufacturing: Hopes, Successes and Gaps

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Digital Thread for Smart Manufacturing

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Outline

- Hopes - NIST’s Smart Manufacturing Plans FY13-18
- Successes - What NIST projects have delivered in the past 4 years
- Gaps - What NIST will deliver in the next year and what our future plans could include
Hopes
aka NIST’s Smart Manufacturing Plans FY13-18
NIST helps drive innovation and reduce risks of adoption of Smart Manufacturing technology solutions

...by contributing to standards that provide a common language and test methods that technology suppliers and users can use to assess and communicate technical capabilities and performance.
Smart Manufacturing Operations Planning and Control Projects

Digital Thread for Smart Manufacturing
How can you use digital models based on open standards to support the product lifecycle, from design to production to service and sustainment?

Wireless Systems for Industrial Environments
How can you use wireless communications in industrial environments for more flexible manufacturing?

Prognostics, Health Management and Control
How can you use sensors, data, and computation to assess machine health, optimize maintenance, and avoid downtime?

Systems Analysis Integration for Smart Manufacturing Operations
How can you integrate different analysis tools to improve manufacturing operations?

Cybersecurity for Smart Manufacturing Systems
How do you secure the computers and networks that control manufacturing operations?
Lifecycle Information Framework and Technology

FROM INFORMATION SILOS...

Design  Analysis  Manufacturing  Quality Assurance  Customer & Product Support

## Lifecycle Information Framework and Technology

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<td>Customer &amp; Product Support</td>
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...TO LINKED DATA...

Lifecycle Information Framework and Technology

Product Lifecycle Data

Design | Analysis | Manufacturing | Quality Assurance | Customer & Product Support

Data Certification and Traceability
Root of Trust, Key Distribution, Cryptographic Services, Data Quality Services

...WITH BUILT IN TRUST AND TRACEABILITY...

Lifecycle Information Framework and Technology

...FOR DRIVING APPLICATIONS WITH DATA!

Product Lifecycle Data

Design | Analysis | Manufacturing | Quality Assurance | Customer & Product Support

Data Certification and Traceability
Root of Trust, Key Distribution, Cryptographic Services, Data Quality Services

Data-Driven Applications

Domain-Specific Knowledge | Decision Support | Requirements Management

Diagnosis, Prognosis, and Control

Successes

aka What NIST projects have delivered in the past 4 years
Major Products

Standards

• ISO 10303-242:2014 Managed Model-based 3D Engineering (STEP AP242)
• ANSI/DMSC Quality Information Framework 2.0:2014 and 2.1:2016 (QIF)
• MTConnect 1.3.1
• OMG Systems Modeling Language V1.4 ( SysML )

Events

• Annual MBE Summit, April 2-5, 2018

Software

• STEP File Analyzer
• Digital Manufacturing Certificate (DMC) toolkit

Data

• NIST Smart Manufacturing Systems Test Bed - Volatile Data Stream/QDR
• Technical Data Packages
  • CAD, STEP, MTConnect, QIF Results
PMI Validation and Conformance Testing

- Supporting PMI standards implementation in CAD
- Verified and validated representation of PMI concepts in CAD models
- [https://go.usa.gov/mGVm](https://go.usa.gov/mGVm)
- [NIST STEP File Analyzer](https://go.usa.gov/yccx)
Testing the Digital Thread

- Investigate model-based enterprise (MBE) cost-savings by comparing manufacturing and inspection via a 2D drawing vs. 3D model workflow

- Found on average ~75% reduction is cycle-time when using a model-based process in place of a drawing-based process

- [https://go.usa.gov/xnc3A](https://go.usa.gov/xnc3A)

- Full report available at: [http://dx.doi.org/10.1115/1.4032697](http://dx.doi.org/10.1115/1.4032697)
Design to Manufacturing and Inspection

• Proof-of-Concept demonstrator for standards-based transport of PMI downstream to manufacturing and First Article Inspections

• Reduced and/or eliminate recreation of part design data, reduce risk of error introduction downstream

• [https://go.usa.gov/xnc3v](https://go.usa.gov/xnc3v)

• Report: [https://go.usa.gov/xnc3f](https://go.usa.gov/xnc3f)
Tolerancing Standards and Modeling Challenge

• Utilize data interchange standards (QIF) for design and metrology information to capture metrology capability

• Metrology capability encoded in a standardized format and used to support design, manufacturing, and metrology activities

• QIF Resources, Rules, MBD

• Dr. Ed Morse presenting in QIF Symposium

• Report: ttps://go.usa.gov/xnc3t

http://qifstandards.org/
https://go.usa.gov/xncrr
Digital Manufacturing Certificate Toolkit

- Toolkit includes a User Interface and API for Reading, Writing, and Verifying digital signatures in models

- Supports G-Code (ISO 6983), QIF 2.0, PDF/PRC, and STEP P21 formats

- Toolkit and source code available at: https://github.com/usnistgov/DT4SM
NIST Smart Manufacturing Systems Test Bed

• Reference architecture and implementation

• Rich source of data for fundamental research

• Physical infrastructure for standards and technology development

• Demonstration test cases for education

• https://go.usa.gov/xnqJr

• Report: https://go.usa.gov/xncc3
Monitoring Manufacturing Systems

• Simulated cycle time for feature was 15 seconds, but measured cycle time was 80 seconds. Feed rate mismatch affects production schedule

• Determine root cause of feed mismatch and remedy production scheduling issues

• Integrate multiple data sources from systems across the product lifecycle to determine causation using data analytics

• Report: https://go.usa.gov/xnccB
NIST-MTC Collaboration

• The scenario is a contract design house (NIST) and OEM (MTC) relationship. The assembly was designed, manufactured, inspected by both parties. MTConect and QIF data was collected and analyzed.

• Data interoperability issues exist. Manual data manipulation was required. Persistent IDs are required to make all data traceable to the authority CAD model through all process steps.

• This is not easy!

• Dr. Toby Maw, MTC Keynote in QIF Symposium

• Paper on this collaboration is forthcoming
Gaps

aka What NIST will deliver in the next year and what our future plans could include
Announcing...

Manufacturing Handles: Spinning the Digital Thread of Connected Enterprises
Generating a Cyber-Physical Graph

https://hdl.mfg.io/20.500.11993/nist.abf
https://hdl.mfg.io/20.500.11993/nist.mmh
https://hdl.mfg.io/20.500.11993/nist.tdh1

physical.person

https://hdl.mfg.io/20.500.11993/lift

https://hdl.mfg.io/20.500.11993/d2mi.cam.827-9999-904.mcx-8
https://hdl.mfg.io/20.500.11993/d2mi.cad.827-9999-904.stp

Physical.machine


monitors

produces
cyber.data.stream

type of

cyber.data.model.manufacturing.plan

type of

realizes
cyber.data.document.scholarlyarticle

type of

*Append “?noredirect” to end of HTTPS-URI to see meta-data*
Stay tuned...

https://go.usa.gov/xnqwy
Publication Search: https://go.usa.gov/xnc2e

Disclaimer: Any mention of commercial products is for information only; it does not imply recommendation or endorsement by NIST.