NIST Smart Manufacturing Systems Test Bed

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Systems Integration Division
Disclaimer

• Identification of commercial systems does not imply recommendation or endorsement by NIST

• Identified commercial systems are not necessarily the best available for the purpose
Design and implement reference solutions to collect rich data to support technology development and transfer

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

Domain-Specific Knowledge
Decision Support
Requirements Management

Diagnosis, Prognosis, and Control

Product Lifecycle Data
Design
Analysis
Manufacturing
Quality Assurance
Customer & Product Support

Lifecycle Information Framework
Current Challenges

- **PLM solutions:**
  - CAx: CAD, CAE, CAM, etc.
  - PDM
  - V&V

- **Operations solutions:**
  - Devices, SCADA, PLC
  - MES, MOM
  - ERP

Primarily IT;
Engineering focused;
Relatively expensive

Mixture of IT and OT;
Lack of integration across control levels

Integration of heterogeneous solutions across the product lifecycle for SMEs and larger organizations
NIST Smart Mfg. Systems Test Bed

Goals:
- Reference architecture and implementation
- Rich source of data for research community
- Physical infrastructure for standards and technology development
- Demonstration test cases
- Improvements in Fabrication Technology operations

Prototype complete
Full deployment May 1st
Data Collection and Aggregation

Design → Fabrication → Inspection

CAD → CAM → MTConnect → QIF

ECR

As Designed → As Planned → As Executed → As Measured

Monitoring + Diagnosis + Prognosis
Shop-Floor Implementation

Multi-Sensor System

- Equipment Controller
- External Sensors

IO Bus #1

IO Bus #2

IO Bus #3

Data Aggregator

Time Buffer

Firewall

Public Web Service

Private Web Service

Pulls data from IO Buses, synthesizes and contextualizes data, and stores data

REN
**MTConnect: Key Mfg. Standard**

![Diagram of MTConnect architecture]

- **Add-on Sensors**
  - Powermeter
  - Accelerometers
  - Thermocouples
  - Torquemeter
  - Etc.

- **Controller**

- **Server**

- **MTC Adapter**

- **MTC Agent**

- **MTC Adapter**

- **Wireless TCP/IP Network**

- **Wired (Ethernet, USB, etc.) or Wireless**

- **Collects, arranges, stores data to transmit**

**Key Components**:
- Machine Tool #1
- Machine Tool #2
- Machine Tool #3
- Machine Tool N
- Inspect Tool #1
- Inspect Tool #2
- Inspect Tool #3
- Inspect Tool M

**Additional Details**
- Translates data output to MTC data definition

**Dates**:
- 12 APR 2016
- 2016 MBE Summit
Public and Private Web Services

- Public web service
  - Volatile data streams of manufacturing data from processes and equipment
  - Query-able database repository
  - Data packages for testing, verification, and validation

- Private web service
  - Similar to public web service except includes data and information shared internally that is not ready for public release
Volatile Data Stream

Smart Manufacturing Systems Test Bed

Volatile Data Stream

You are viewing the Volatile Data Stream (VDS) component of the NIST Smart Manufacturing Systems (SMS) Test Bed located in Gaithersburg MD USA. Please visit the SMS Test Bed Information Page for more information.

- creationTime: 2016-04-05T14:48:52Z
- sender: mulder
- instanceId: 1459827175
- version: 1.3.0.16
- bufferSize: 131072
- nextSequence: 214354
- firstSequence: 83282
- lastSequence: 214353

Device: NIST-SMS-TestBed-5Axis; UUID: nist_testbed_GF_Agie_1_3a0e8a

Rotary: A

Samples

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Device: NIST-SMS-TestBed-5Axis

Events

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Virtual Factory Data

- Test bed can serve as virtual factory since data is presented for each process or equipment on shop floor
- Data does not need to be validated against a real system
- Data is presented in “raw” form including any deficiencies expected from industrial environments
- Data enables fabrication-focused research, including:
  - Data preprocessing, validation, robustness, and quality
  - Condition monitoring, diagnosis, and prognosis
  - Process monitoring and data analytics
Standards and Technology Development

- Test and validate enhancements to standards
- Integrate domain standards to connect information across design and manufacturing
- Develop optimized data packages for technology verification and validation
Demonstration: Feed Analysis

- Feed influences:
  - Quality of finished machined surface
  - Time required to complete operation
- Acceleration of feed drives causes discrepancy between actual and commanded feed

Important to identify where and when discrepancy occurs

Vijayaraghavan et al. (2008)
Demonstration: Feed Analysis
Applying Info to Improve Processes

- **[Design]** Can we redesign geometry to avoid the need for toolpaths with high feed discrepancies?
- **[Planning]** Can we redesign toolpath to minimize impact of machine dynamics?
- **[Machining]** Can we enable operator to make informed decisions?
- **[Inspection]** Can we use information to identify areas for more detailed measurement?
Summary

- **May 1\textsuperscript{st} target for full deployment**

- Reference implementation documents – guides, recommendations, specifications, methods – to be released

- Please stay tuned for more info!

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