Overview of NIST Modeling and Simulation Activities for Manufacturing and Homeland Security

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Overview of Presentation

• M&S for Manufacturing:
  – Core Manufacturing Simulation Data Model Standardization
  – Collaboration with Boeing and other organizations
  – Sustainability
  – Distributed Simulation using Web Services
  – Supply Chains

• M&S for Homeland Security:
  – Standards Support
  – M&S Taxonomy
  – Needs and Requirements Analysis
  – Identification of Best Practices
  – Strategic Planning
  – Technical Interest Groups
  – Wiki
M&S for Manufacturing

- Brief overview of CMSD and Sample Pilot Implementation Efforts

  • Volvo Cars paint Shop Operations
  • Volvo Truck Engine Assembly Lines
  • Boeing 777 Program collaboration
  • Chalmers University collaboration
  • University of Arizona collaboration
  • PDES, Inc Model-based Manufacturing collaboration
    - VSM process data to CMSD to simulation
CMSD Goals

The CMSD Information Model defines a data specification for efficient exchange of manufacturing data in a manufacturing simulation environment.

• Foster the development and use of simulations of manufacturing operations
• Facilitate data exchange between simulation and other manufacturing applications
• Enable better testing and evaluation of manufacturing software
• Increase application interoperability
Major Data Categories

- Organization
- Calendar
- Schedule
- Work
- Process plan
- Operation definition
- Resource
- Skill definition
- Setup definition

- Part
- Bill-of-Materials
- Inventory
- Maintenance plan
- Revision
- Probability distribution
- Reference
CMSD document review and collaborations

- Gregory Harward and Charles Harrell, Brigham Young University
  - Incorporated the input, recommendations, and suggestions in the CMSD document

- Collaboration with John Mauer, Geer Mountain Software
  - Incorporated recommendations on statistical distributed functions and attributes that could be supported in the document
CMSD document review and collaborations

- Collaborations with Siemens/UGS on incorporation SDX and plant layout data into CMSD specification
- NIST CMSD database and data editor pilot implementation
- NIST Virtual Manufacturing Enterprise (VME)
- Automotive assembly line
- Supply chain simulation
- Collaboration with Volvo Cars and Volvo Trucks
- Collaboration with The Boeing Company on tracking mobile assets for the 777/787 program
- Collaboration with Chalmers University, VTT and Visual Components
- Collaboration with University of Arizona on a job shop simulation
Volvo / NIST / Chalmers University Collaboration
Volvo Paint Shop Operation

Modeling and simulation using CMSD for interoperability
Manufacturing Resource Data

Organized in a set of tabs:

- Start
- Workstation capacity
- CT_Mean
- CT_Standard Deviation
- CT_Constant
- Disurbance
- Conveyors
- Lift Tables
- Elevators
Manufacturing Resource Data – Workstation Capacity

Each workstation is assigned 0-5 operators. For automated workstation, zero operator is assigned. For manual workstation, 1 to 5 operators are assigned. The number of operators assigned to the workstation differs in different shifts.
This table presents the mean cycle time for each resource. Normal distribution function is assumed for the cycle time. The cycle time to perform a process step at a resource is dependent on vehicle body style, number of operators assigned to the resource and the shift number.

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This table presents the standard deviation of cycle time for each workstation. The cycle time to perform a process step at a workstation is dependant on vehicle body style, number of operators assigned and the shift number. Normal distribution function is assumed for the cycle time.

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For each line, 3 AGVs move at the same time. The work duration at each station is called PACE. The PACE is currently preset to about 13 minutes. If one station is delayed, all other AGVs will wait.

Only 23 will operate concurrently. There are some zone restrictions.

CMSD Implementation for Truck Manufacturing,
By: John Marcus Johansson
Enterprise Dynamics and Plant Simulation Models

CMSD Implementation for Truck Manufacturing,
By: John Marcus Johansson
CMSD Implementation for Truck Manufacturing
CMSD document review and collaborations

- Collaboration with The Boeing Company on tracking mobile assets for the 777/787 programs
Implementation of Core Manufacturing Simulation Data in Aerospace Industry

Roberto F. Lu\textsuperscript{1}
Swee Leong\textsuperscript{2}
Nils Bengtsson\textsuperscript{2}
Björn Johansson\textsuperscript{2}
Frank Riddick\textsuperscript{2}
Tina Lee\textsuperscript{2}
Guodong Shao\textsuperscript{2}
Charles McLean\textsuperscript{2}
Al Salour\textsuperscript{1}
Laurance N. Hazlehurst\textsuperscript{1}
Sidney Ly\textsuperscript{1}

\textsuperscript{1}: Boeing \textsuperscript{2}: NIST
A CMSD Pilot Implementation

Tool Crib storage
MES storage
Gage Lab storage
Layout File storage
RFID Tracking System storage

Database extract documents
CMSD translator
CMSD instance document (XML)

Visualization Tools
- Adobe Flex (AIR)
- Silverlight
- JavaFX

CMSD interface
Simulation application A
Process model

CMSD interface
Simulation application B
Process model

Boeing test data set

Data source 1
CMSD instance document (XML)

Data source 2

Transplant

CMSD

ARENA
A 777 Hypothetical Case

Logistics

Asset /Vehicle / Equipment Management

Production System Data

Sample Automatic Identification Technologies (AIT)

- Linear Barcode
- 2D Barcode
- Memory Buttons
- RFID Passive
- RFID Active
A Hypothetical Case Simulation

777 Part Tracking Model

Thursday  June 26, 2008  08:39:56

Current - No RFID

- Number of Locations Checked: 4
- Last Search Time: 55.3 minutes
- Average Search Time: 57.6 minutes
- Max Search Time: 305.5 minutes
- Min Search Time: 7.0 minutes
- Total Search Time: 2372.9 minutes

Scenario - RFID

- Number of Locations Checked: 2
- Last Search Time: 37.7 minutes
- Average Search Time: 27.5 minutes
- Max Search Time: 262.5 minutes
- Min Search Time: 7.0 minutes
- Total Search Time: 11337.8 minutes

NOTE: All Times Recorded in Minutes
Test Data Set

- The data that is mapped into the Core Manufacturing Simulation Data (CMSD) structure
Sample CMSD UML Diagram
How we mapped the test data to the CMSD data structures
Sample CMSD XML file

- The first row of the Excel file
Sample CMSD interface to Arena

- Sample VBA script in Arena
- Using the XML DOM standard to read in the CMSD XML file
- Use Arena SIMAN code to set the variables in Arena model
Sample CMSD information in Arena

- Show the CMSD information in Arena model variable textbox
- This variable is set in the VBA code and this is only for displaying the information
CMSD document review and collaborations

- Collaboration with Chalmers University, VTT Finland and Visual Components simulation
  - Simter project
SIMTER SubTools
Made by Chalmers, VTT (Finland) & NIST (USA)

Björn Johansson
NIST, MEL, Gaithersburg, MD, USA
&
Department of Product and Production Development
Chalmers University of Technology
Sweden, Gothenburg
Analyze the impact of Level of Automation (LoA) on environment, ergonomics, and energy consumption and cost
Define system level inputs (material and energy)
Define system level outputs
View summary results

“Update values” gets latest saved results from LoA, Ergo and Env-addons.

Note: there are 3 boolean layout properties, when any value is set to “True”, SimterMain updates automatically after a short countdown.

SimterENV and simtERGO both
sinterLoA
sinterENV value set to true after click on Analyze-button
sinterOSKU value set to true after click on Write2Layout-button

“Setup” currently opens a definition file with Notepad.

There are definitions from which layout property each value is fetched.

E.g.
- textboxname propertyname
- txtCO2#1 CO2_product
- txtCO2#0 CO2_day
- txtCapacity unloader|capacity

propertyname can also point to a component property when separated with “|”-character, e.g.
- txtCapacity unloader|capacity
CMSD document review and collaborations

– Collaboration with Young-Jun Son, University of Arizona
  • Collaborated in a CMSD pilot with integrated Lekin job shop scheduler (freeware), Wildcat order and inventory system (custom developed as part of this project), and Arena simulation package.
Inter-operability of Manufacturing Applications via CMSD:
Data Structure in CMSD vs. Data Representations in Scheduler, Order & Inventory System, Discrete Event Simulator)

Esfand Mazhari and Young-Jun Son
Systems and Industrial Engineering
The University of Arizona
Overview of Interoperability Demo

- Demo on interoperability of manufacturing applications using CMSD, involving
  - Lekin Job Scheduling Software (freeware)
  - Wildcat Order and Inventory System (custom developed freeware)
  - Arena simulator
- Job shop information: Work, resource, setup, part status, and corresponding information (products, orders, process plans)
- Two screen capture movies (one for "Development (Initialization) Stage" and the other for "Operation Stage") can be found in the following web site
  - [http://www.sie.arizona.edu/faculty/son/NIST3.html](http://www.sie.arizona.edu/faculty/son/NIST3.html)
Representation of Orders in Arena simulation software

- Each entity represents an order item and as being processed based on process plan
Simulation Standards Consortium

**Government**
- Defense Modeling Simulation Office
- NIST (Coordinator)
- Air Force Research Lab
- Jet Propulsion Lab

**Industry**
- Aegis Technologies
- The Boeing Company
- CostVision
- DSN Innovations (Doyle Center)
- Ford Motor Company
- General Motors
- John Deere
- Lockheed Martin
- Raytheon
- Rockwell Collins
- Volvo Car Company
- Volvo Trucks
- VTT - Finland

**Software Vendors**
- Brooks Automation - AutoSimulation
- Delmia Company
- InControl Enterprise Dynamics
- Geer Mountain Software
- Flexsim
- ImagineThat
- Knowledge Based Systems Inc.
- MicroAnalysis and Design
- ProModel Corporation
- Rockwell Software – Systems Modeling
- Simul8
- Virtools
- Siemens/UGS
- Visual Components
- Witness
- Wolverine Software

**Academia**
- Brunel University
- Carnegie Mellon University
- Chalmers University
- Florida International University
- George Washington University
- University of Arizona