Manufacturing Operations Management

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Objectives

• Review the ISA 95 standards and how they are being used in companies like Eli Lilly & Company for shop floor to top floor integration
  – The standards provide a formal model for exchanged data between business systems and manufacturing systems
  – The models provide a definition of Manufacturing Operations Management, the activities on the shop floor that take production schedules and perform the actual work required to manufacture products and provide visibility of production

• The Manufacturing Operations Management models are currently being used in the development of multiple new manufacturing facilities
Manufacturing in the Supply Chain

• “Make” is a significant part of the supply chain and collaborative manufacturing, but is often the last element to be actually integrated
  – Collaboration in “Make” is usually not a “Low Hanging Fruit”
  – But can offer very high ROI for high volume, or high cost products

• However, Business IT and Manufacturing IT organizations are often at odds as they try to collaborate
  – They have different goals and different success criteria
  – They use the same terms for different elements and different terms for the same elements
Collaborative Manufacturing Help

• Fortunately there are multiple standards in place to help integrating business systems with manufacturing systems.
  – The ISA 95 Enterprise/Control System Integration standards, also an IEC/ISO standard
  – XML Schemas standards for collaborative manufacturing from the World Batch Forum

• Will show how they are being applied to the development of manufacturing systems roadmap
Different Points of View

- **Business Systems**
  - Time Horizons
    - Long-term view
  - Model detail
    - Linear route structures
  - Control emphasis
    - Product cost and overall profitability
  - Modeling criteria:
    - Accounting reference points
    - Has inventory value changed significantly? If not, don’t model separately
  - View from the boardroom

- **Manufacturing Systems**
  - Time Horizons
    - Real-time view
  - Model detail
    - Complex routes with rework paths
  - Control emphasis
    - Physical movement & accountability
  - Modeling criteria:
    - material movement reference points
    - Does product stop moving? If not, don’t model separately
  - View from the workcenter
Philosophical Orientation

• Enterprise Management systems:
  – How much is my stuff worth?
  – How much stuff do I have/need?

• Manufacturing Operations Systems:
  – How do I make my stuff?
  – Where is my stuff?
ISA 95 Provides Direction

• The ANSI/ISA 95.00.01 “Enterprise - Control System Integration - Part 1: Models and Terminology”
  – Also Draft International Standard ISO/IEC 62264-1

• ANSI/ISA 95.00.02 “Enterprise - Control System Integration - Part 2: Object Attributes”

• Draft ISA 95.00.03 “Enterprise - Control System Integration - Part 3: Activity Models of Manufacturing Operations Management”
ISA 95 Control Hierarchy Levels

Level 4
Business Logistics
Plant Production Scheduling, Shipping, Receiving, Inventory, etc.

Level 3
Manufacturing Operations Management
Dispatching, Detailed Production Scheduling, Production Tracking, ...

Level 2
Batch Production Control
Continuous Production Control
Discrete Production Control

Level 1

Level 0
The production processes

Interface addressed in the ISA 95.01 and ISA 95.02 standard
Area addressed in the ISA 95.03 standard
ISA 95 Control Hierarchy Levels

Business Logistics Management (ERP)

Manufacturing Operations Management (MES, LIMS, AM, ...)

Level 2
- Batch Production Control
- Continuous Production Control
- Discrete Production Control

Level 1
- The production processes

Level 0
- The production processes

Interface addressed in the ISA 95.01 and ISA 95.02 standard

Area addressed in the ISA 95.03 standard

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Exchanged Information

Information that crosses the boundary between business systems and manufacturing systems
Exchanged Information Categories

Enterprise Information
- Plant Production Scheduling
- Operational Management

Manufacturing Control Information
- Area Supervision
- Production Planning
- Reliability
- Assurance

Production Capability Information
- (What is available for use)

Product Definition Information
- (How to make a product)

Production Schedule
- (What to make and use)

Production Performance
- (What was made and used)
4x4 Object Models

• **Four** categories of resources
  – Personnel
  – Equipment
  – Material (and Energy)
  – Process Segments

• **Four** Process, Product, & Production Models
  – Capability & Capacity Definition
  – Product Definition
  – Production Schedule
  – Production Performance
Four Resource Object Models

- **People**
  - Personnel resources managed for production

- **Equipment**
  - Equipment resources managed for production

- **Materials**
  - Material resources managed for production

- **Process Segments**
  - Business view of production processes
Capability, Product, Schedule, and Performance Information

What is available for use for production

What is needed to make a product

What to make and resources to use

What was made and resources actually used
Production Schedule

- Production Schedule
- Production Request
- Segment Request
  - Expected Produced Material
  - Expected Consumed Material
  - Expected Personnel
  - Expected Equipment
  - Production Parameters
  - ...

What to make
- Priority and/or dates
- What materials to use
- What equipment to use
- What personnel to use
- Production parameters (e.g. Color, Options, ...)

Per location (Site, Area, ...)
Per week, day, shift, order, ...

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Production Performance

- Production Performance
  - Production Response
  - Segment Response
    - Produced Material Actual
    - Consumed Material Actual
    - Personnel Actual
    - Equipment Actual
    - Production Data
    - ...

What was made
- What material was actually produced
- What materials were actually consumed
- Equipment used
- Personnel used
- Production data (e.g. Purity, density, ...)

Per location (Site, Area, ...)
Per shift, hour, end of batch, ...
XML Standard for B2M Exchanges

• The World Batch Forum has developed XML Schemas that map to the ANSI/ISA-95 models
• Defines how to represent the ISA-95 information in XML
  – Business To Manufacturing Markup Language
  – B2MML V2.0
• One schema for each object model
• Formal way to exchange information
  – www.wbf.org
An XML Example – Material Lot

```
<Material
  <MaterialLot>
    <ID> W89 </ID>
    <Description> A lot of material </Description>
    <MaterialDefinitionID> WXE908 </MaterialDefinitionID>
    <Location> Tank 1 </Location>
    <Quantity
      UnitOfMeasure = "KL" > 4500
    </Quantity>
    <MaterialLotProperty>
      <ID> dateTimeProduction </ID>
      <Value> 2001-01-06T00:14:23+11:30 </Value>
    </MaterialLotProperty>
    <MaterialLotProperty>
      <ID> Quality Status </ID>
      <Value> Good </Value>
    </MaterialLotProperty>
  </MaterialLot>
</Material>
```
ISA95 Part 3
Activity Models of Manufacturing Operations

In Development
Expected Release 2004
Other Enterprise Activities in Manufacturing Operations

- Production, Maintenance, Inventory, Quality
- Management of information, compliance, security, documentation, and configurations
Implementations

• Nestle
  – Project to use the XML schemas for schedule exchange

• Arla Foods
  – Project to use XML for standard interfaces to multiple ERP systems and MES systems

• Empersas Polar
  – Project to use XML schemas for schedule exchange

• Eli Lilly
  – Projects to use ISA 95 models for manufacturing operations management architecture
Building Collaborative Manufacturing Systems

• Process Used to Develop Solution Architectures
  – Conceptual Topology
  – Functional Areas
  – Standards and Guidelines
  – Standard Applications
  – Logical Architecture Design
  – Physical Architecture Design
ISA 95 Control Hierarchy Levels

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ISA – IEC/ISO Interface Standards
ISA Functional Model
IEC, OPC, & OMAC Interface Standards
Conceptual Topology – IT View

- IT View of the ISA-95 Levels and relationship to systems and networks
- Levels 1-2
  - Control the process and provide visibility to the process
  - Electronic records are not embedded in the control layers (Level 1-2)
  - Usually some specialized hardware and possibly networks
- Level 3
  - Maintenance of production information is centralized to provide greater control and availability of the records
  - Electronic records are managed and controlled through Level 3 systems with audit trail, access control, backup, and ERP connectivity
  - Usually standard hardware and networks
Conceptual Topology – IT View

Level 4
- ERP, APO, Logistics Systems

Level 3
- MES, LIMS, WMS, CMM Systems

Level 2
- HMI, SCADA, Batch Systems
- PLC, DCS, Packaged Systems

Level 1
- I/O, Devices, Sensors
Functional Areas

• Use the ISA 95 and ISA 88 models of functions
• Map the functions to system areas and networks
• Use the ISA 95 rules for determining what is in Level 3 (vs Level 4)
  – The function is critical to plant safety
  – The function is critical to product quality
  – The function is critical to plant reliability
  – The function is critical to maintaining regulatory compliance.
    • Includes such factors as safety, cGMP, and environmental compliance
    • Maintaining FDA, EPA, USDA, OSHA, TÜV, EU, EMEA, and other agency compliance
Functional Areas – From ISA 95 & 88

**Level 1**
- Sense Events
- Manipulate Equipment
- Sense Process
- Manipulate Process

**Level 2**
- Alarm Management
- Operator Visibility
- Equipment Information Collection
- Operator Control
- Continuous Control
- Programmed Control
- On/Off Control
- Interlock & Safety Control
- Phase Control
- Recipe Control
- Supervisory Control

**Level 3**
- Detailed Scheduling
- Product Definition Management
- Production Execution
- Resource Management
- Configuration Management
- Production Dispatching
- Production Analysis
- Production Tracking

**Business Process Information Network**

**Operations Information Networks**

**Automation Networks**

**Discrete & Process Device Communication Networks**
Logical Architecture

- Maps functional areas and data locations
  - Independent of technology
- Defines the different layers of the architecture in terms of data and control
  - These are mapped to physical networks, servers, and applications in the physical architecture
- Defines what functions are to be performed at each level, and what data is to be maintained at each level
  - To result in maintainable and robust systems
  - To provide a way to manage the life cycle of the production systems
  - Provides the structure required to grow and modify the system without compromising any of the previous advantages
Logical Architecture – IT View

Level 3
- Reporting HMI (Investigations, Trends, …)
- Engineering Tools (Diagnostics, analysis, …)
- MES
- ERP Connection

Level 2
- Supervisory HMI
- Recipe Execution
- Data Acquisition
- Automation Network
- Controllers
- Packaged Equipment
- Device Connection & Networks

Level 1
- Sensors/Actuators
- Process/Equipment
- Site Data Storage
- Area Data Storage
- Operations Information Network

Centralized Servers
- Fault tolerant
- Permanent Database
- Operations Control

Production Areas
- Operator Control
- Batch Execution
- Real-time Data and Buffering
- Real-time Control and Data Collection

Desktop
- Reports and Analysis
A Physical Architecture

- Defines the IT infrastructure and applications
  - Defines networks and network connections
  - Defines locations of applications
  - Defines locations of servers
  - Defines the mapping of applications to servers

- Physical architecture depends on the solution set used:
  - Vendor capabilities
  - Networks
  - Security and network management
  - …
Conclusions

• Linked execution systems deliver results!
  – Reduced direct costs; increased productivity
  – Improved traceability; reduced “witch hunt” expense
  – Near-theoretical cycle times: customer responsiveness, reduced WIP inventory
  – Greater agility: smaller lot sizes, more premium products in the mix, happier customers, happier shareholders!

• S95 defines the currency for manufacturing object and information exchange
  – Faster project implementation cycles
  – Flexibility to integrate and realign as corporate structures change
Status

• ISA95.00.01 & ISA.95.00.02 available
• IEC/ISO 62264-1 available from IEC & ISO
• ISA 95.00.03 in draft
  – Still under development in the committee
• World Batch Forum
  – Developed XML Schemas for the exchanged information
• Vendors
  – Many currently using ISA-95 models in development and current products
• Users
  – Specifying ISA-95 in their RFPs