ANSI/ISA-95 (IEC/ISO 62264)

Industrial Systems Interoperability
Operations Management Overview

Integrated Manufacturing Systems in the Context of Industry 4.0
Agenda

- ISA-95 scope
- ISA-95 (inferred) ontology
- ISA-95 content
- ISA-95 usage examples
Supply Chain SCOR Model

Main SCM processes
Supply Chain information flows – ISA-95 scope

1. **PLAN**
   - Demand Aggregation
     - Demand
     - Forecasts
     - Sales
     - B2M CRM
   - Demand
     - B2M
     - B2B SRM
   - Planning & Scheduling
     - Forecast
     - Demand
   - Operations definition
     - Capability Capacity
     - Schedule Performance
     - Manufacturing
       - (Suppliers)
       - (Customers)

2. **SOURCE**
   - Purchases
     - (Suppliers)
     - B2B SRM

3. **MAKE**
   - (Suppliers)
   - Manufacturing
     - Operations definition
     - Capability Capacity
   - (Customers)

4. **DELIVER**
   - (Customers)
   - Sales
     - B2B CRM
     - B2M
     - B2B SRM
   - Purchases
     - (Suppliers)
ISA95 snapshot

- **B2M: Collaboration Business / Execution**
  - Communication between execution systems (MES/MOM, DCS, MMS, LIMS, WES, SCADA,…) and business systems (ERP, SCM)
  - Master data management

- **MES/MOM : Functional definition**

- **Data and Activity models**
  - Description of resources, capability, products, work order requests and reports
  - Definition of operation management activities (MES)

- **Applications:**
  - User requirements and functional specification of MES and B2M interfaces
  - Native B2M connectors - MES/ERP (B2MML)
  - Possible basis for developing MES applications and software…
Agenda

- ISA-95 scope
- ISA-95 (inferred) ontology
- ISA-95 content
- ISA-95 usage examples
Abstract system model

Behaviour (dynamics)

Structure (potential)

Action

Energy, Matter,

Information

Energy, Matter

Information
ISA-88/95 industrial system upper ontology

- **ISA-95**
  - Behaviour
  - Operation Process Management
  - Physical Process Management
  - Physical Process Control
  - Equipment Control

- **ISA-88**
  - Definitions, segments
  - Physical resources
  - Material resources
  - Human resources

**ISA-88**

**ISA-95**
IT systems involved (example)

- Operations Process Management
- Physical Process Management
- Physical Process Control
- Equipment Control

ERP

MES

DCS/PLC/SCADA
Industrial system general process map

- Market Demand
  - Requirements
  - Releases

- Customer Orders / Forecast
  - Orders
  - Processing knowledge
  - Capability

- Manufacturing
  - Processing requirements

- R&D

- Engineering, Sourcing, HR

Operations management
ISA-95 concepts for operations management

- Operations Segment
  - Operations Schedule
  - Operations Requests
  - Operations Capability
  - Operations Schedule

- Operations Definition
  - Operations Segments

- Process Segments
  - Process Segments
  - Resources
    - Personnel / Equipment / Material

- R&D
  - Product & process knowledge

- Engineering, Sourcing, HR
  - Equipment knowledge

Corresponds to:
- Reports usage
- Reports usage
- Reports usage
Agenda

- ISA-95 scope
- ISA-95 (inferred) ontology
- **ISA-95 content**
- ISA-95 usage examples
What is ISA-95?

**US & International standard “Enterprise - Control System Integration”**
- The ISA95 committee develops the ISA-95 US standard
- The ISO/IEC JWG5 develops the ISO/IEC62264 international standard

<table>
<thead>
<tr>
<th>US standard</th>
<th>INTL Standard</th>
<th>Sub Title</th>
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<tbody>
<tr>
<td>ANSI/ISA-95.00.01:2010</td>
<td>IEC62264-1:2013</td>
<td>Part 1: Models and Terminology</td>
</tr>
<tr>
<td>ANSI/ISA-95.00.02:2018</td>
<td>IEC62264-2:2015</td>
<td>Part 2: Object models attributes</td>
</tr>
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<td>ANSI/ISA-95.00.05:2018</td>
<td>IEC 62264-5:2016</td>
<td>Part 5: Business to Manufacturing Transactions</td>
</tr>
<tr>
<td>ANSI/ISA-95.00.06:2014</td>
<td>IEC PAS 62264-4:2016</td>
<td>Part 6: Messaging Service Model</td>
</tr>
<tr>
<td>ANSI/ISA-95.00.07:2017</td>
<td>-</td>
<td>Part 7: Alias Service Model</td>
</tr>
<tr>
<td>ANSI/ISA-95.00.08:2020</td>
<td>-</td>
<td>Part 8: Manufacturing Operations Management Information Exchange Profiles</td>
</tr>
<tr>
<td>ISA-TR88.95.01-2008</td>
<td></td>
<td>Using ISA-88 and ISA-95 Together</td>
</tr>
<tr>
<td>ISA-TR95.01-2018</td>
<td></td>
<td>Master Data Profile Template</td>
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*Grayed standards are studied in JVI4 course*
ISA-95 Scope overview

Level 4
- Business Planning & Logistics
  Plant Production Scheduling, Operational Management, etc

Level 3
- Manufacturing Operations & Control
  Dispatching Production, Detailed Production Scheduling, Reliability Assurance, ...

Levels 2, 1, 0
- Batch Control
- Continuous Control
- Discrete Control

Parts:
- Part 1
- Part 2
- Part 3
- Part 4
- Part 5/6/7/8
Part 1: Models and Terminology

- An introduction to the standard
- Explains its background from PRM (Purdue Reference Model)
- Only one normative item: physical hierarchy
Part 1: planning vs execution processes

Manufacturing Planning

- Make to Order
- Make To Stock
- Design To Order
- Configured / Assembled To Order

ISA95

Hybrid Manufacturing
Continuous Manufacturing
Batch Manufacturing
Discrete Manufacturing
My So Specific Manufacturing typology

Manufacturing Execution
Part 1: information categories

Manufacturing planing

(Operation) definition information
(What must be defined to make The job)

(Operation) capability information
(What resources are available)

(Operation) schedule information
(What actual job will be executed)

(Operation) performance information
(What actual job was achieved)

Manufacturing Execution
Part 1: ISA95 extended physical model

Role based equipment hierarchy

- Enterprise
  - Site
    - Area
      - Work Center
        - Process Cell
          - Unit
            - Equipment Module
              - Control Module

- Batch Process (ISA88)
  - Production Unit

- Continuous Process
  - Production Line

- Discrete Process
  - Work Cell

- Warehouse
  - Storage Zone
  - Storage Unit
Part 2: Object models attributes

- This standard describes the information models for exchanging information between business and control systems
Part 2: Scope

Level 4

Business Planning & Logistics
- Plant Production Scheduling,
  Operational Management, etc

Level 3

Manufacturing Operations & Control
- Dispatching Production,
  Detailed Production Scheduling,
  Reliability Assurance, ...

Levels 2, 1, 0

- Batch Control
- Continuous Control
- Discrete Control
Part 2: Example - Operations schedule model
Part 3: Activity Models of Manufacturing Operations Management

This part of ISA-95 defines activity models of manufacturing operations management that enable enterprise system to control system integration. It includes:

- A model of the activities associated with manufacturing operations management, Level 3 functions;
- An identification of some of the data exchanged between Level 3 activities
  - Note that the data flows in this part are unusable
  - They are incomplete and inconsistent with part 2/4 information models

This part of the standard provides a documentation structure for:

- Business requirement
- Functional specifications
- Software solution marketing
Part 3: Scope

Level 4

Business Planning & Logistics
Plant Production Scheduling,
Operational Management, etc

Level 3

Manufacturing
Operations & Control
Dispatching Production, Detailed Production
Scheduling, Reliability Assurance, ...

Levels 2, 1, 0

Batch Control
Continuous Control
Discrete Control
(3) Timing focus MES Main Functional areas

Reference data

Resource Management

Definition Management

Pre-Work

Detailed Scheduling

Dispatching

Post-Work

Tracking

Performance Analysis

Actual Work

Data collection

Execution Management
Part 3: A Tri-dimension functional framework

Manufacturing Operation Category
- Production
- Maintenance
- Quality Tests
- Inventory
- …

Supporting activities
- Management of security
- Management of information
- Management of configurations
- Management of documents
- Management of regulatory compliance
- Management of incidents and deviations

Manufacturing Operation Core Functions
- (Operation) Detailed Scheduling
- (Operation) Dispatching
- (Operation) Execution management
- (Operation) Data Collection
- (Operation) Tracking
- (Operation) Analyzis
- (Operation) Definition Management
- (Operation) Resources Management

Operation Processes

Planning Functional Requirements
Agenda

- ISA-95 scope
- ISA-95 (inferred) ontology
- ISA-95 content
- ISA-95 usage examples

- Case 1: Large company (>100 plants)
- Case 2: medium company (3 plants)
- Case 3: small company (single facility)
Context and challenge

- Central ERP system + hundreds of factories worldwide
- 3 selected control/MES vendors
- Difficult decision taken between
  - Let vendors taking care of integration
  - Adopt a company wide interoperability language: vendor neutral / company responsible ISA-95 interface
- Designed in Europe, developed in India, implemented and used everywhere
### Interface scope: 20 messages (phase 1)

<table>
<thead>
<tr>
<th></th>
<th>ERP-&gt;MES</th>
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<tbody>
<tr>
<td><strong>Production</strong></td>
<td>• Production Orders</td>
<td>• PO reports: material produced, consumed, down times</td>
</tr>
<tr>
<td>transaction</td>
<td>• PO status change</td>
<td>• PO status change</td>
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<tr>
<td></td>
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<tr>
<td><strong>Logistics</strong></td>
<td>• Transfer Orders – in and inter plants</td>
<td>• TO reports and cancellation</td>
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<tr>
<td>transactions</td>
<td></td>
<td>• “Spontaneous” transfer</td>
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<td></td>
<td></td>
<td>• Raw material reception</td>
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<tr>
<td><strong>Inventory</strong></td>
<td>• Material status change</td>
<td>• Material status change</td>
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<tr>
<td>transactions</td>
<td>• Inventory response</td>
<td>• Inventory query</td>
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</tbody>
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Work methodology

- Messages identification and content provided by ERP functional consultants
  - Factories IT, MES vendors / integrators were never invited!
  - Opportunistic design, no high level guidance

- Mapping of message through workshops involving
  - ERP consultants, ISA-95 expert

- Extension and adaptation of ISA-95, B2MML
  - Company specific B2MML and ISA-95 extensions to overcome their limitations at this time (2004) – a major input for the next releases
    - ISA-95: Handling of inventory (and other) operations types
    - B2MML: Custom extensions
Example

Central ERP api

ERP connector

Enterprise bus ISA-95 messages

MES connectors

Distributed MES api

Production orders

Production order status

ProductionSchedule

Production order status

Production order parameters

Production Response

Material Consummed

Material Produced

ProductionPerformance

Any/Unknown MES / control systems

SAP PP-PI

SAP WM

ERP connector

Central ERP api

Enterprise bus ISA-95 messages

Any/Unknown MES / control systems

Production orders

Production order status

ProductionSchedule

Production order status

Production order parameters

Production Response

Material Consummed

Material Produced

ProductionPerformance

Any/Unknown MES / control systems
**Outcome**

- **Outcome**
  - Design of ERP/MES through ISA-95 like enterprise language
    - only needs to be considered from ERP – can ignore MES
    - No need for ERP / MES meetings
  - Interface deployed worldwide
  - « Perfect delivery »
    - the initial spec/schemas are still in use - no update after 8 years
  - Subsequent extension for Quality

- **ISA-95 support : 40 days / 1 year**
  - Detailed message definition, Functional specification writing
  - Many meetings…
Agenda

■ ISA-95 scope
■ ISA-95 (inferred) ontology
■ ISA-95 content
■ ISA-95 usage examples
  ➢ Case 1: Large company (>100 plants)
  ➢ Case 2: medium company (3 plants)
  ➢ Case 3: small company (single facility)
Context and challenge

- Central ERP system + 3 factories in Europe
- ESB Messaging framework available but deemed too expensive / complex => abandoned

Objective:
- Enterprise controlled interfaces
- Integration implemented by MES vendor using native systems interfaces
### Interface scope: 14 messages

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<td>Inventory transactions</td>
<td>• PO reports : material produced, consumed,</td>
</tr>
<tr>
<td></td>
<td>• Sync material lots</td>
</tr>
<tr>
<td>Master data transactions</td>
<td>• Sync material definitions</td>
</tr>
<tr>
<td></td>
<td>• Sync Equipment definitions</td>
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</tbody>
</table>
Work methodology

■ Messages identification and content provided by company’s business consultants
■ Build a taxonomy of the enterprise language
■ Provide a mapping
  ➢ based on business terms
  ➢ Providing translation in ERP and MES terminology
■ Only 3 meetings to gather requirements and wrap up the whole detailed mapping specification
Outcome

- **Outcome**
  - A handy spec detailing all messages in 3 languages: ERP, MES and Business
    - understandable by all stakeholders
  - Only a specification
    - No messaging involved,
    - Direct peer to peer connexion between MES and ERP under vendor’s responsibility

- **ISA-95 support: 15 days / 1 month**
  - Detailed message definition
Agenda

- ISA-95 scope
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- ISA-95 usage examples
  - Case 1: Large company (>100 plants)
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Context and challenge

- **A complex interface project involving 7 different systems**
  - The most complex among these 3 use cases
- **Strictly limited budget for external support**
  - 2 days workshop planned for knowledge transfer
  - Design to realized internally
## Interface scope: 20 messages

<table>
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<th>ERP/MDM/LIMS/SCADA -&gt; MES</th>
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</table>
| **Production transaction** | • PO reports  
• Temperature reports | • deviation reports and ack  
• Production orders |
| **Logistics transactions** |                          | • Material movements |
| **Quality transactions** | • Quality report         | Quality order       |
| **Inventory transactions** | • Material reception  
• Material quality       | • Weight control order |
| **Master data transactions** | • Sync material definitions |                     |
Work methodology

Only 2 days budget:

■ 1st day:
  - Teach ISA-95+B2MML: High speed knowledge transfer
  - Team’s brain overload
  - Manager’s desperation: “Find another way by tomorrow”

■ 2nd day
  - All 20 messages identified and drafted
  - Definition of an XML enforced company language +ISA-95 spirit
    ▪ Using an ISA-95 (really simple) meta-model

■ 3rd day (over-budget)
  - Review of the internal team work
Outcome

- **Outcome**
  - Full autonomy achieved in 3 days
  - Smart design
  - Low cost

- **ISA-95 support : 3 days / 1 week**
  - Get the team thinking the ISA-95 way
Thank You !