

UNIVERSITY OF
CAMBRIDGE
Institute for Manufacturing

Manufacturing Operations Management

Dennis Brandl
BR&L Consulting

Peter Owen
Eli Lilly & Co

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

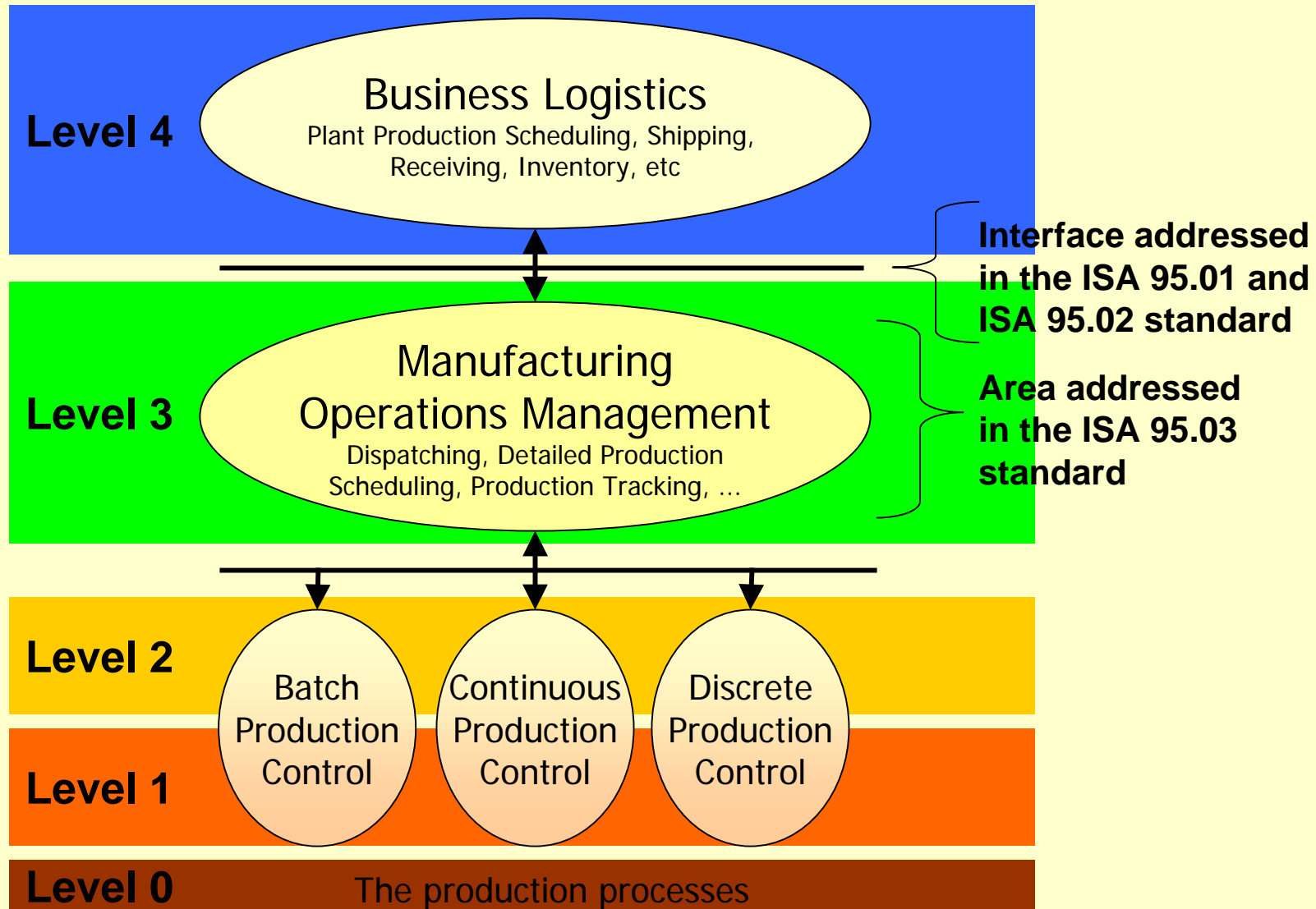
Philosophical Orientation

- 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



ISA 95 Control Hierarchy Levels

**Business Logistics
Management
(ERP)**

Interface addressed
in the ISA 95.01 and
ISA 95.02 standard

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

Area addressed
in ISA 95.03
standard

Level 2

Batch
Production
Control

Continuous
Production
Control

Discrete
Production
Control

Level 1

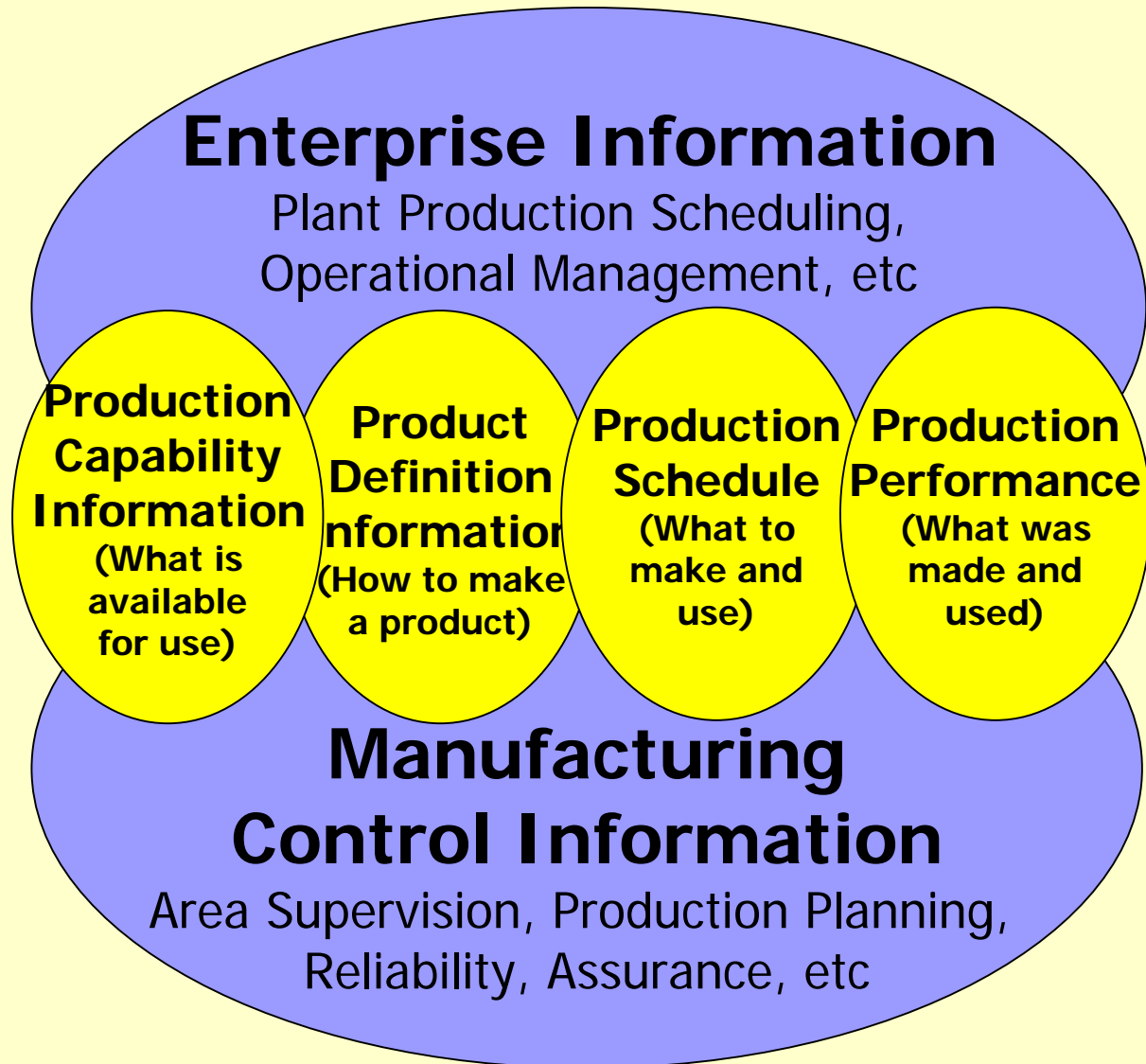
Level 0

The production processes

ISA 95 Part 1 and Part 2 Exchanged Information

Information that crosses the boundary between business systems and manufacturing systems

Exchanged Information Categories



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

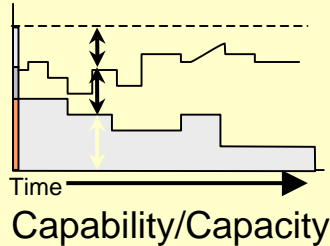
← Material resources managed for production



Process Segments

← Business view of production processes

Capability, Product, Schedule, and Performance Information



← What is available for use for production



Product
Definitions

← What is needed to make a product



Production
Schedule

← What to make and resources to use



Production
Performance

← What was made and resources actually used

Production Schedule



People



Equipment



Materials



Segments

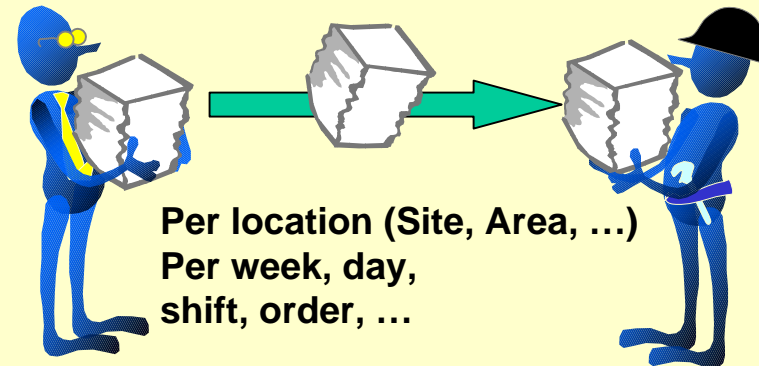
- Production Schedule
 - Production Request
 - Segment Request
 - Expected Produced Material
 - Expected Consumed Material
 - Expected Personnel
 - Expected Equipment
 - Production Parameters
 - ...



Production
Schedule

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,...)



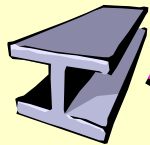
Production Performance



People



Equipment



Materials



Segments

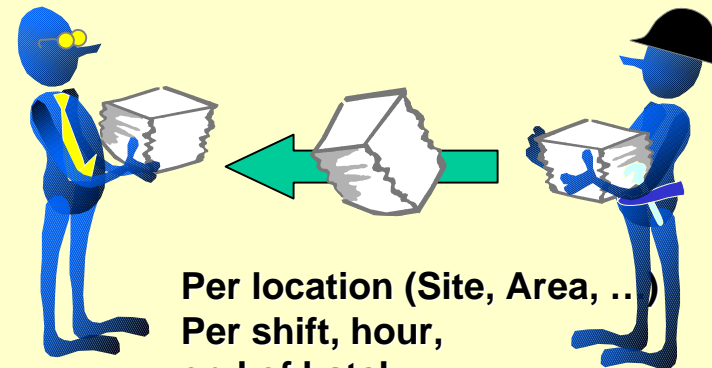
- Production Performance
 - Production Response
 - Segment Response
 - Produced Material Actual
 - Consumed Material Actual
 - Personnel Actual
 - Equipment Actual
 - Production Data
 - ...



Production Performance

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

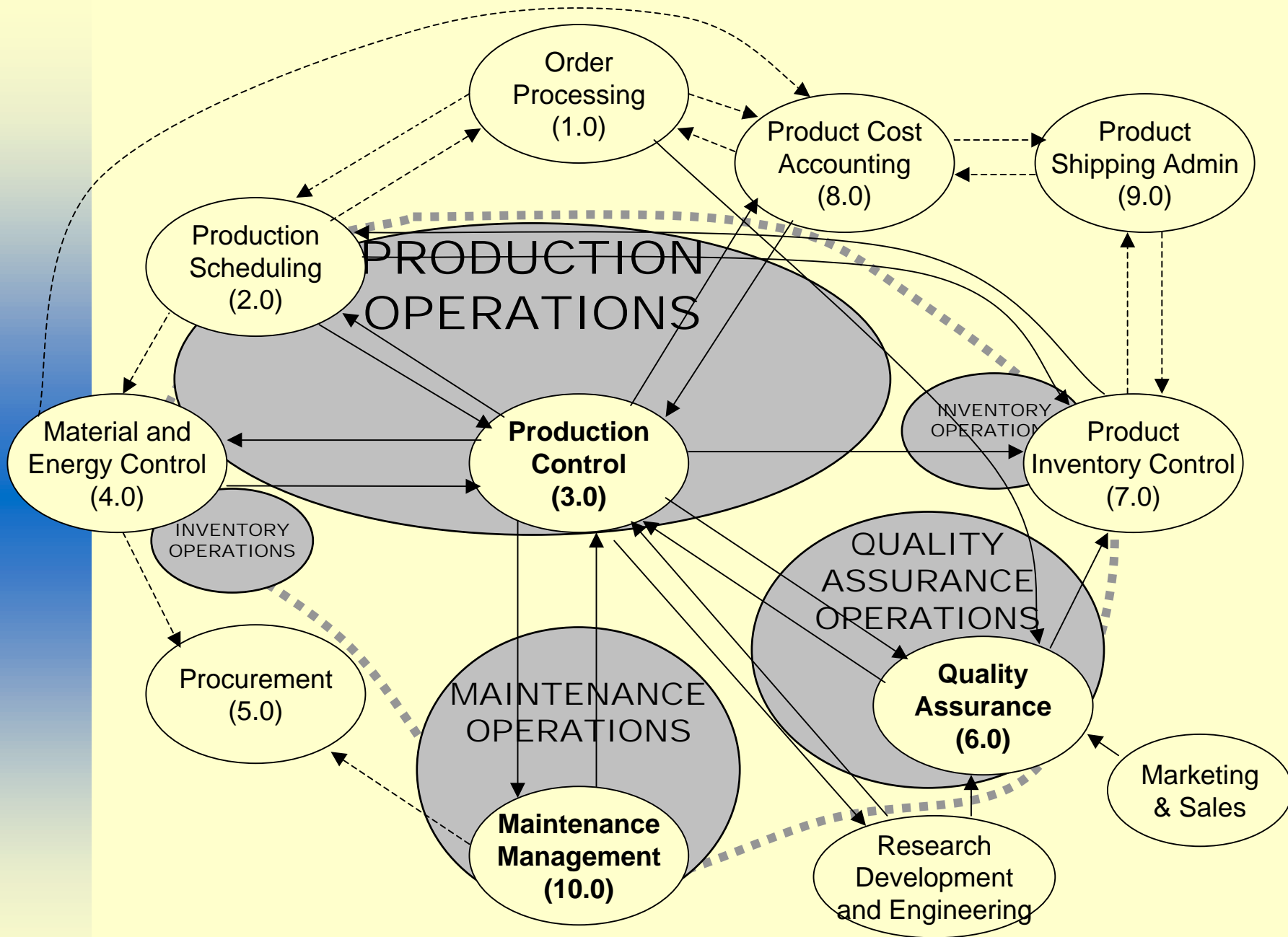
An XML Example – Material Lot

```
<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>
```

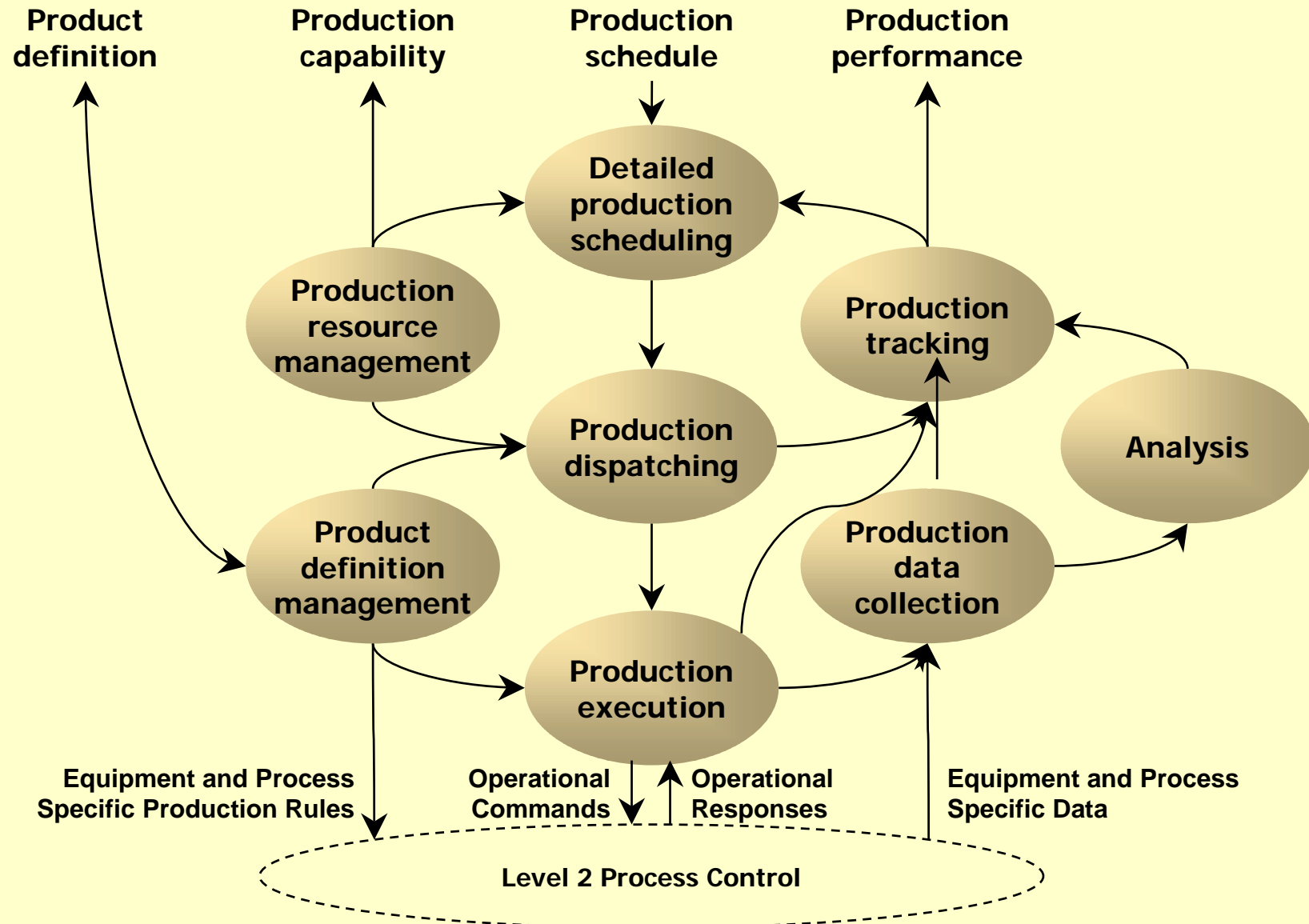
ISA95 Part 3

Activity Models of Manufacturing Operations

In Development
Expected Release 2004

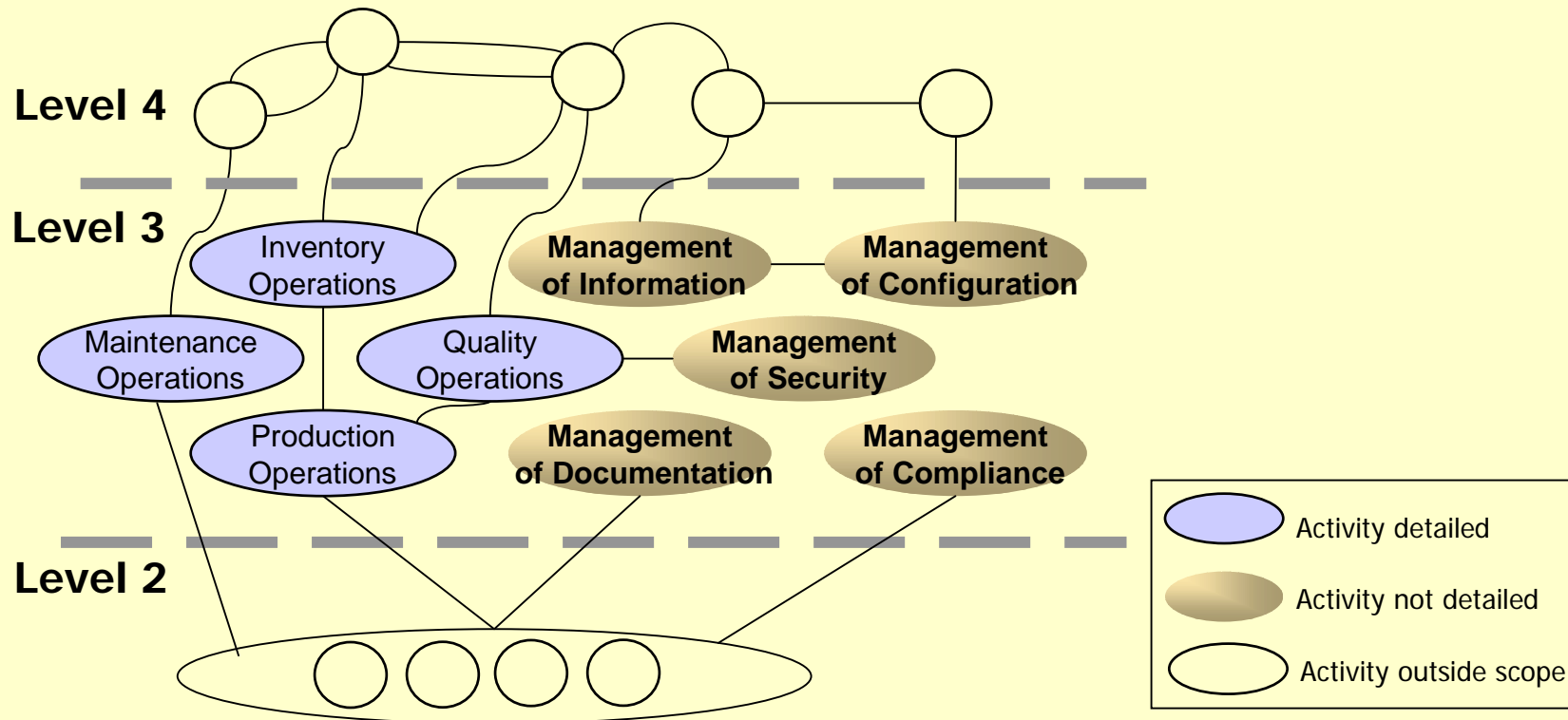


ISA 95.03 Manufacturing Operations Functions



Other Enterprise Activities in Manufacturing Operations

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



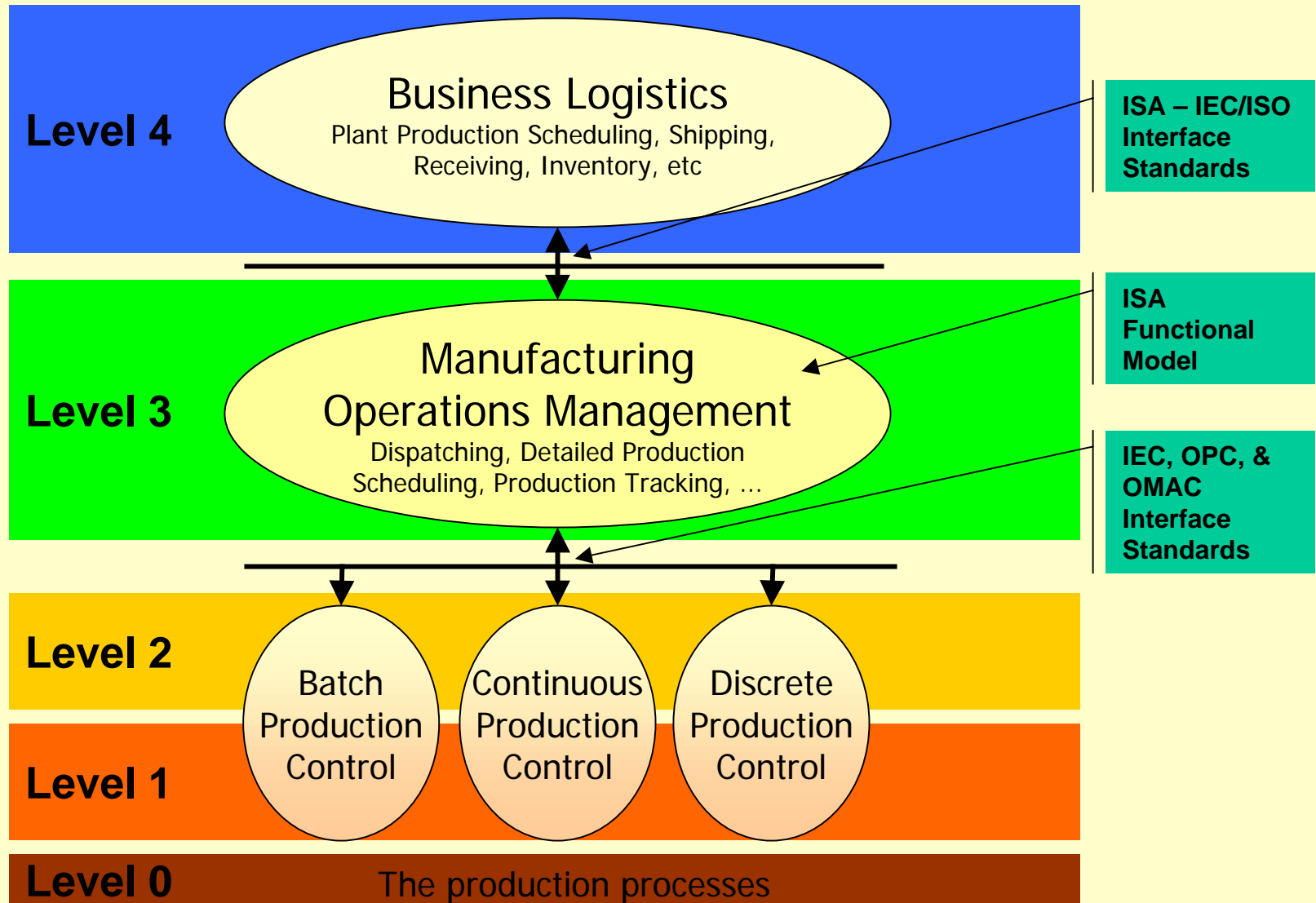
Implementations

- 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

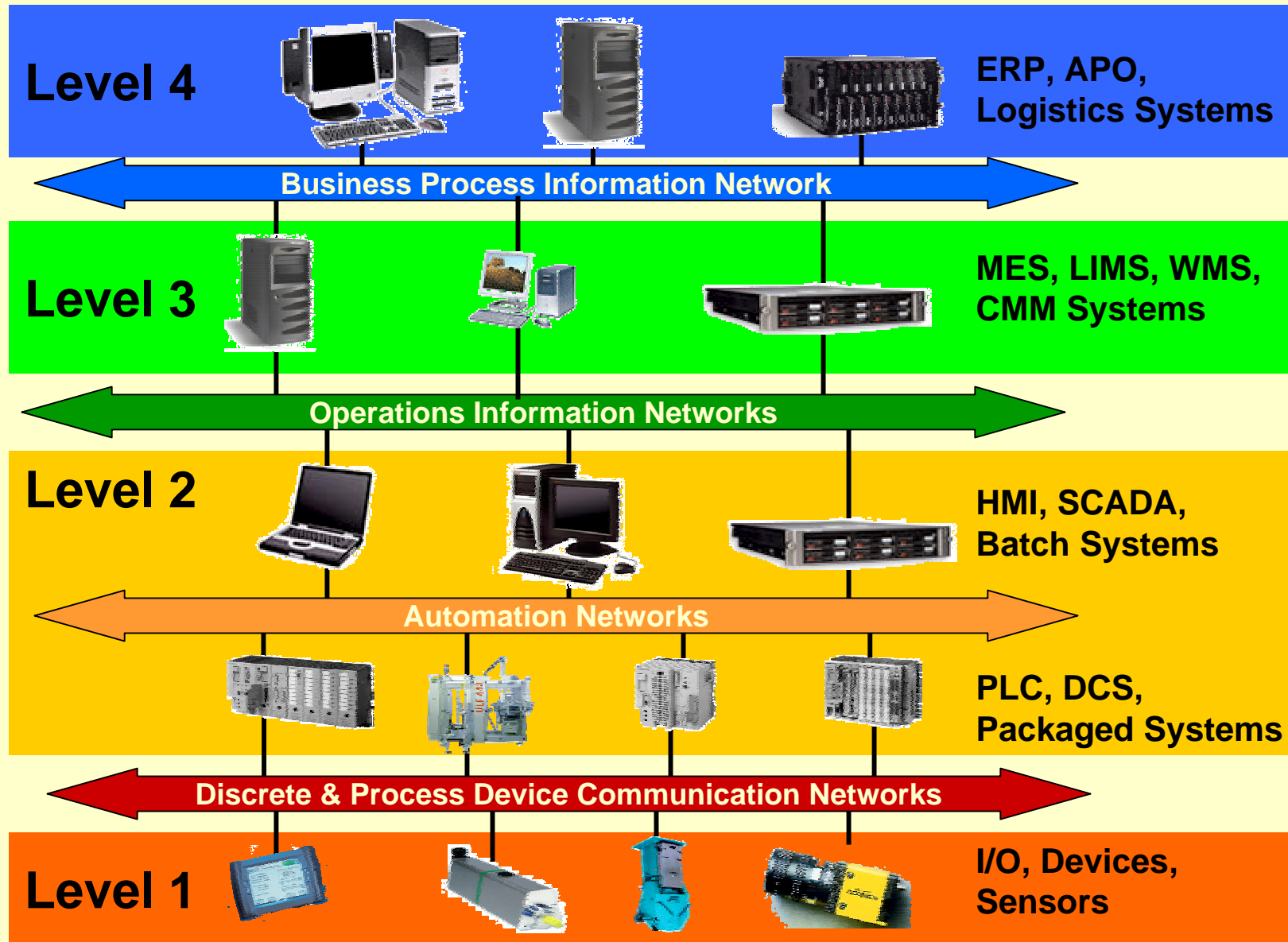
ISA 95 Control Hierarchy Levels



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

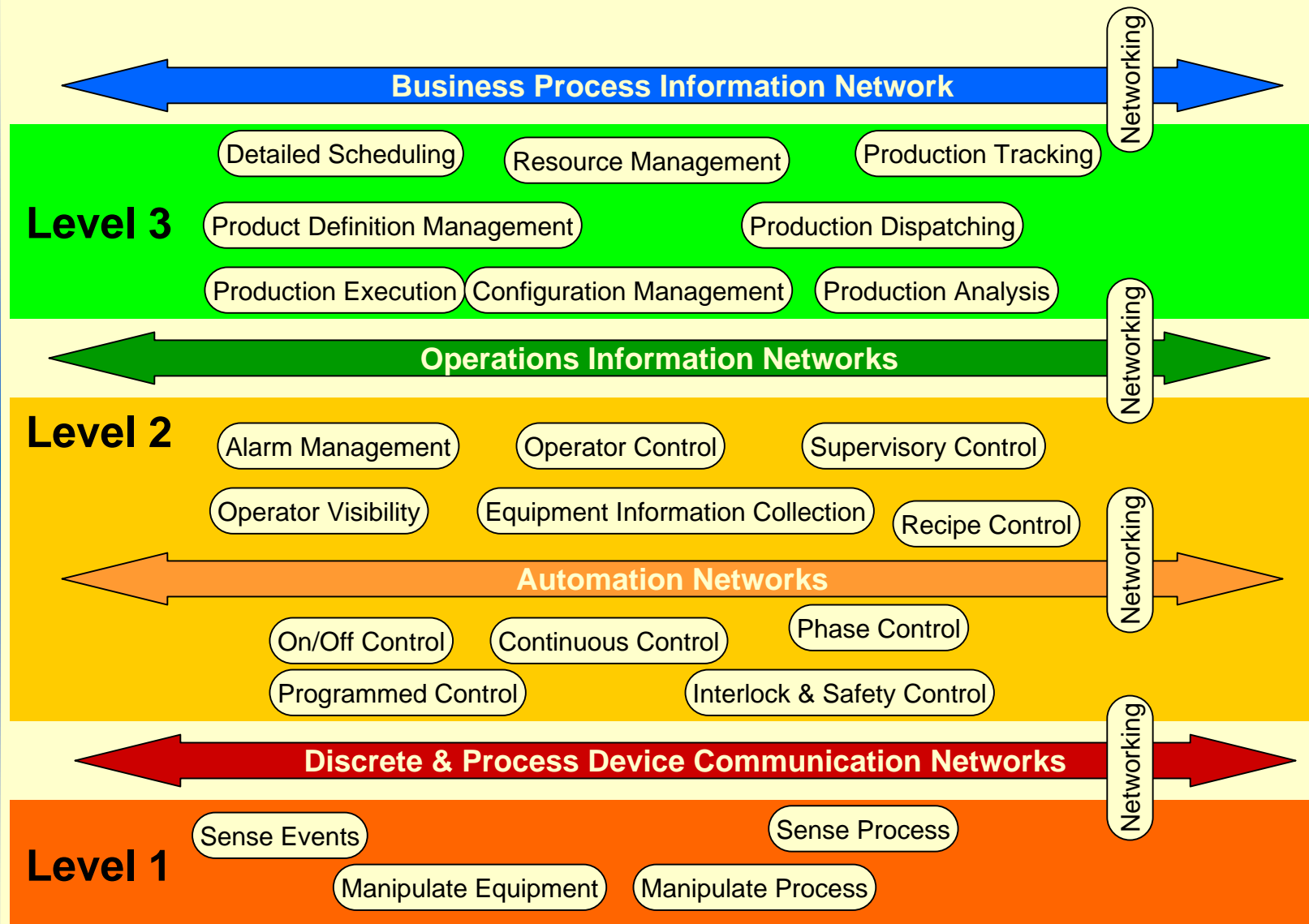
Conceptual Topology – IT View



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

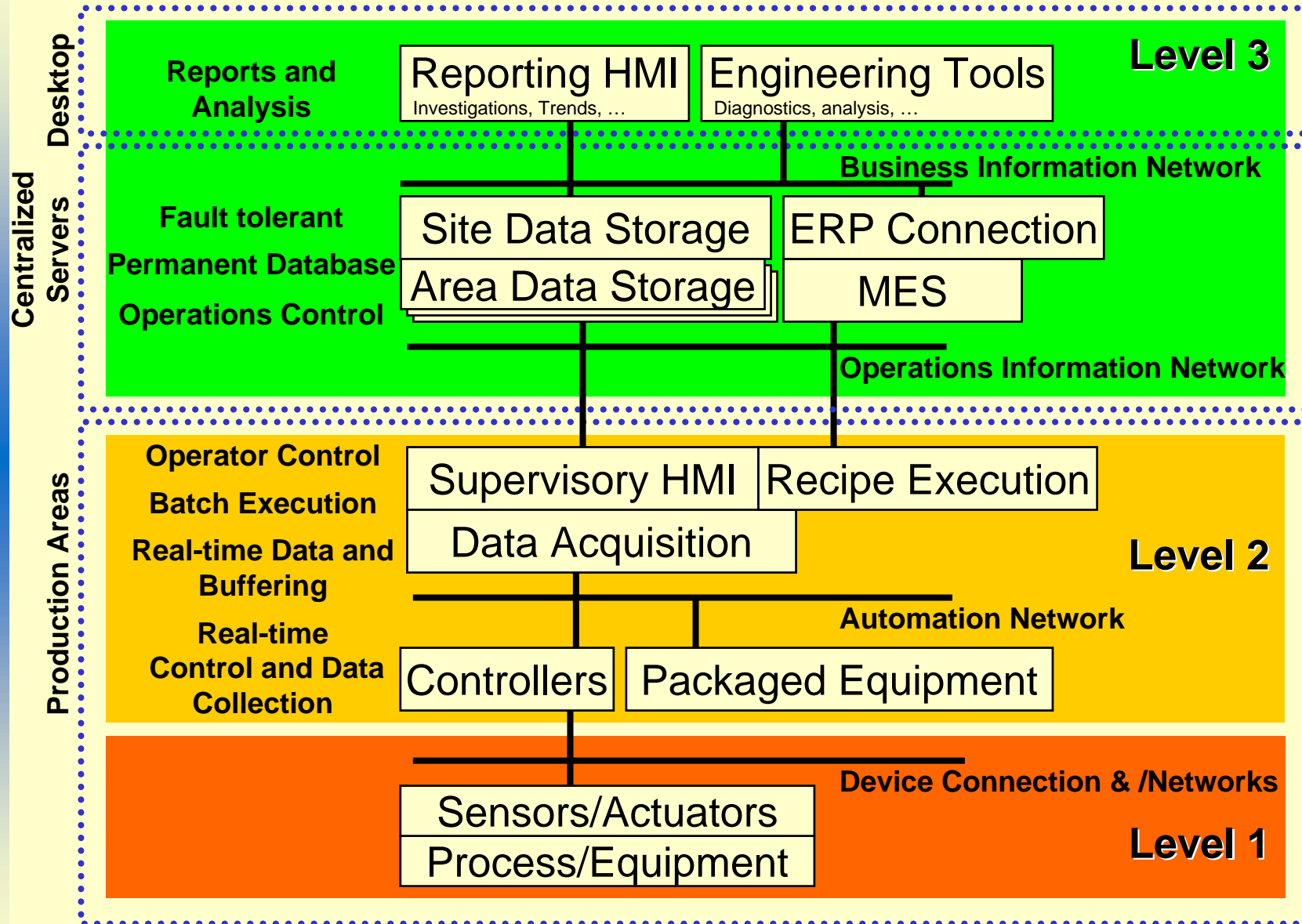
Functional Areas – From ISA 95 & 88



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

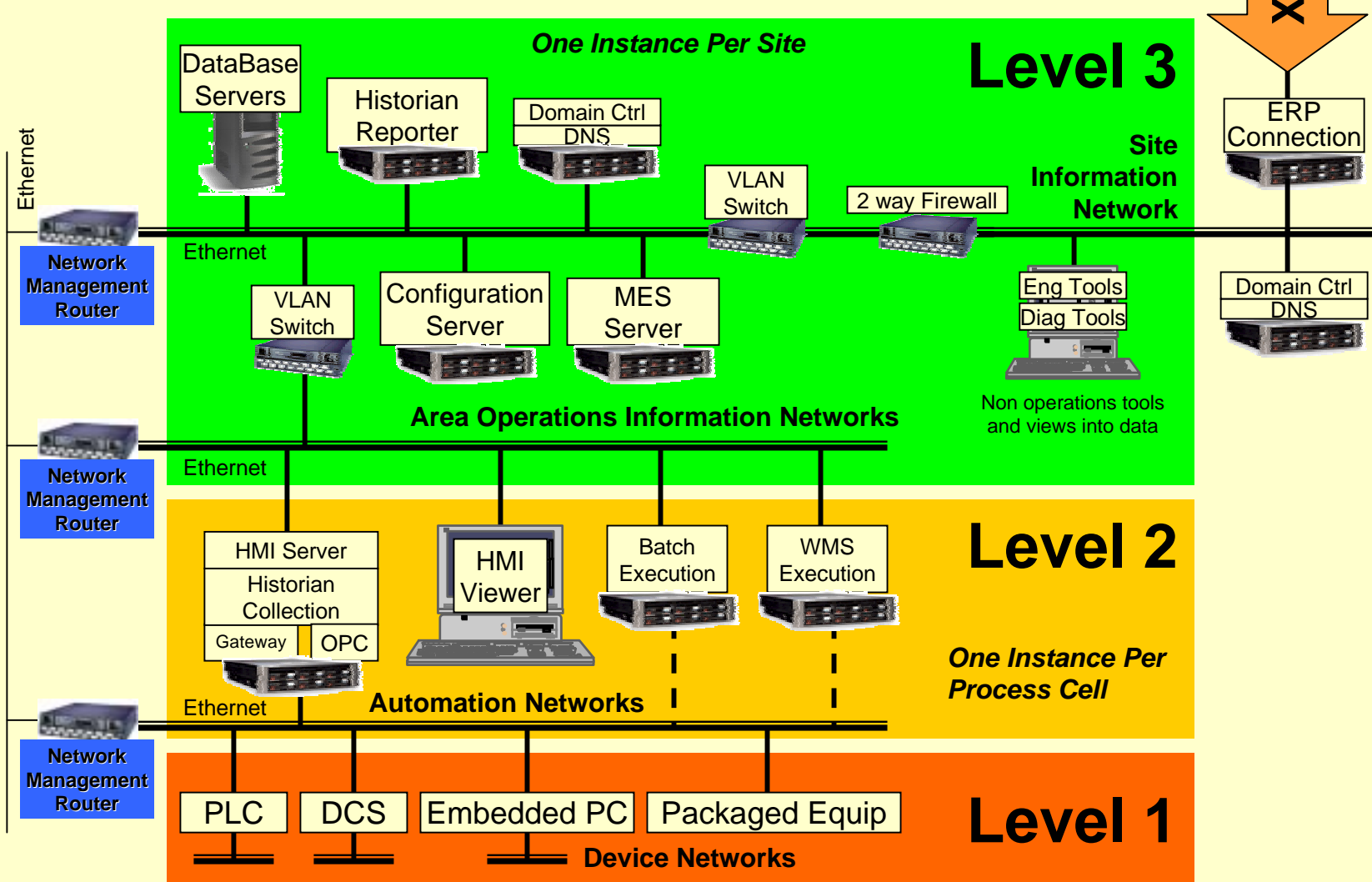
Logical Architecture – IT View



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
 - ...

Physical Architecture – IT View



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