Market-Driven Systems

Marknadsstyrda System

FRTN20

Lecture 4

Manufacturing Operation Management (MOM)

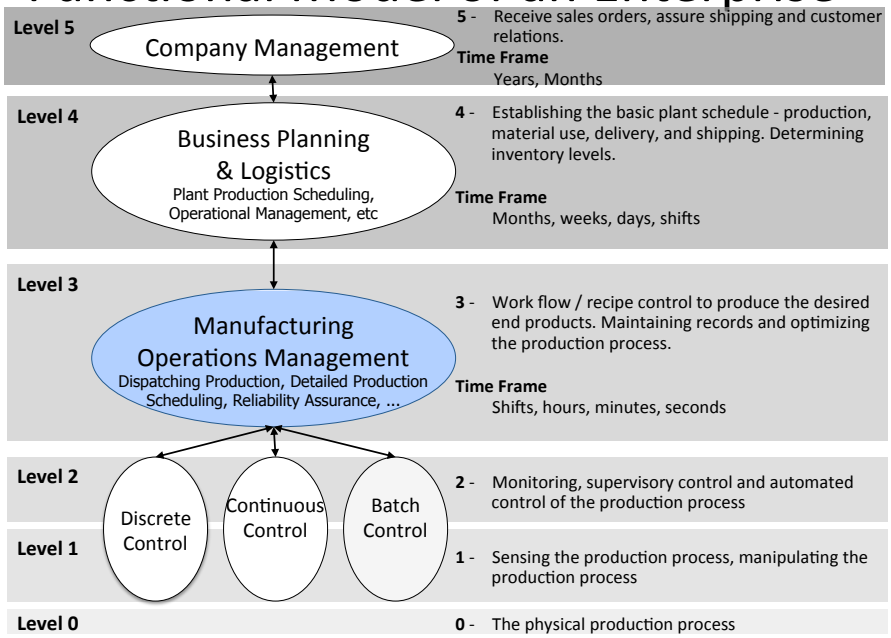
1

Content

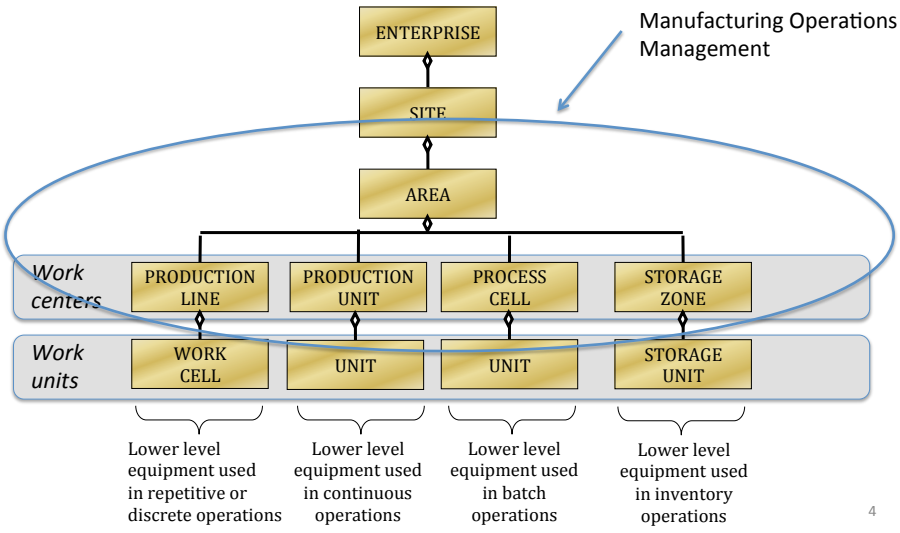
- Manufacturing Operation Management
- ISA95 standard

2

Functional Model of an Enterprise



Physical Model of an Enterprise



Manufacturing Operation Management

The interface between Enterprise Resource Planning (Level 4) and the Process Control (Level 1-2)

”The interface between the economy department and the engineering/automation department”

”Manufacturing Operation Management is those activities of a manufacturing facility that coordinate the personnel, equipment, material, and energy in the conversion of raw materials and/or parts into products.

Manufacturing operations management includes activities that may be performed by physical equipment, human effort, and information systems.” (from ISA95-Part3)

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MES versus MOM

- MES refers to the part of the manufacturing operation management that direcly relates to the production
  - Manufacturing Execution System
  - That is MES $\in$ MOM
- However, MES has changed meaning
  - Manufacturing Enterprise Solutions
  - Hence, MES $\approx$ MOM

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MES/MOM

- Standardized in ISA 95
  - ISA – International Society of Automation
  - ISA 95 is based upon
    - The Purdue Enterprise Reference Architecture (PERA)
    - The ISA 88 batch standard
    - The models defined by MESA International
      - MESA - Manufacturing Enterprise Solutions Association International
  - Development started year 2000, and is ongoing
  - Consists of 5 parts + part 6&7 under development

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Regulations – Standards - Guidelines

- Regulations (Rules)
  - Legal – Mandatory
  - US FDA (Food and Drug Administration) rules (CFR – Code Federal Regulation)
- Standards
  - Not mandatory
  - Quality, Commercial, industrial or other
  - Certification / Accreditation scheme
  - Example : ISO, ISA, IEC
- Guidelines / Guidances
  - Not mandatory
  - Represent current way of thinking
  - Example GAMP

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Standards

A standard does not tell you what you have to do (regulations do), but rather what you should do in order to be successful.

A standard has normally been developed with lots of thought and with input from many people with different knowledge and experience, i.e. a standard contains common and good knowledge.

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Standardization bodies in Sweden

ISO = International Organization for Standardization

IEC = International Electrotechnical Commission

ISO and IEC are two international standardization bodies with national mirror committees in most countries. In Sweden the mirror committees are:

SEK = Svensk elstandard (f.d. Svenska elektrotekniska kommitten)

SIS = Swedish Standards Institute

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ISA95

Enterprise-Control System Integration

- Part 1: Models and terminology
- Part 2: Object Model Attributes
- Part 3: Activity Models of Manufacturing Operations Management
- Part 4: Object Model Attributes used in Manufacturing Operations Management
- Part 5: Business to Manufacturing Transactions
- Part 6: Message Service Model
- Part 7: Alias Service Model

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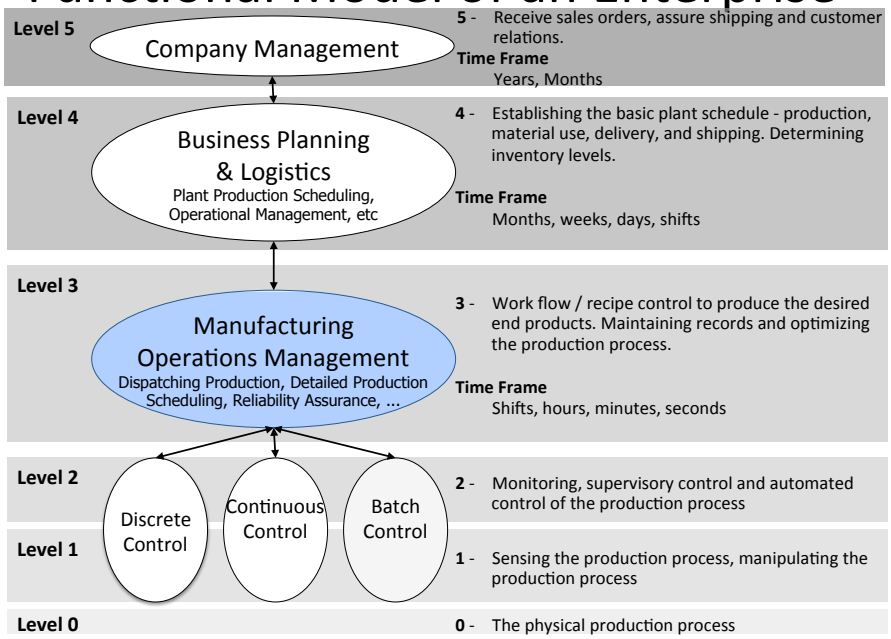
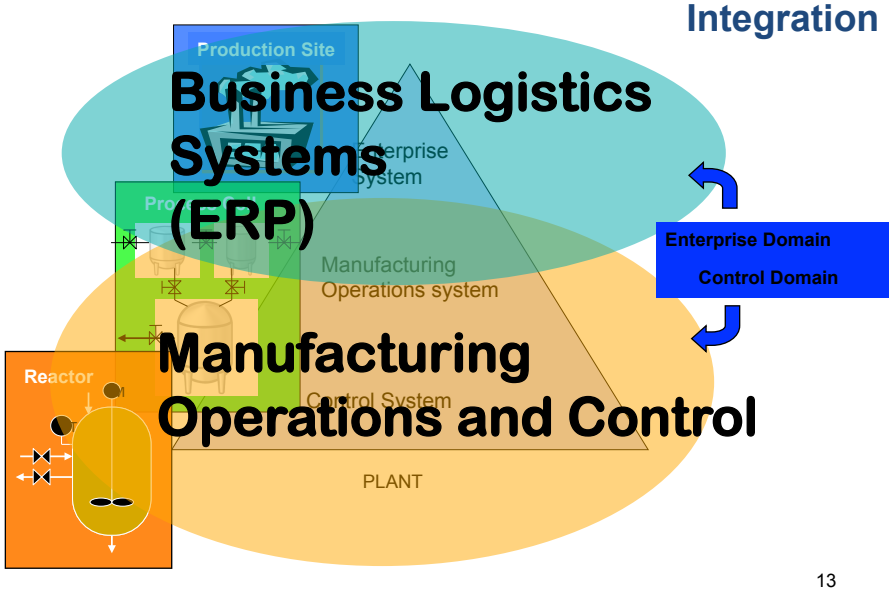
Functional Model of an Enterprise



ISA95: Enterprise-Control System Integration



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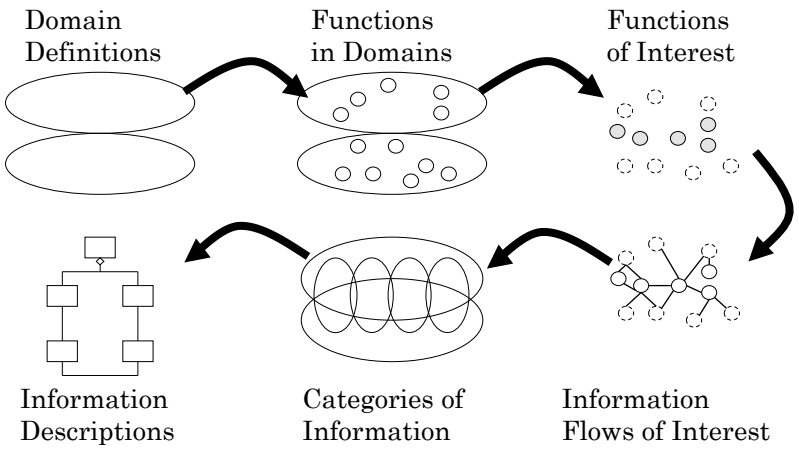
Outline of part 1



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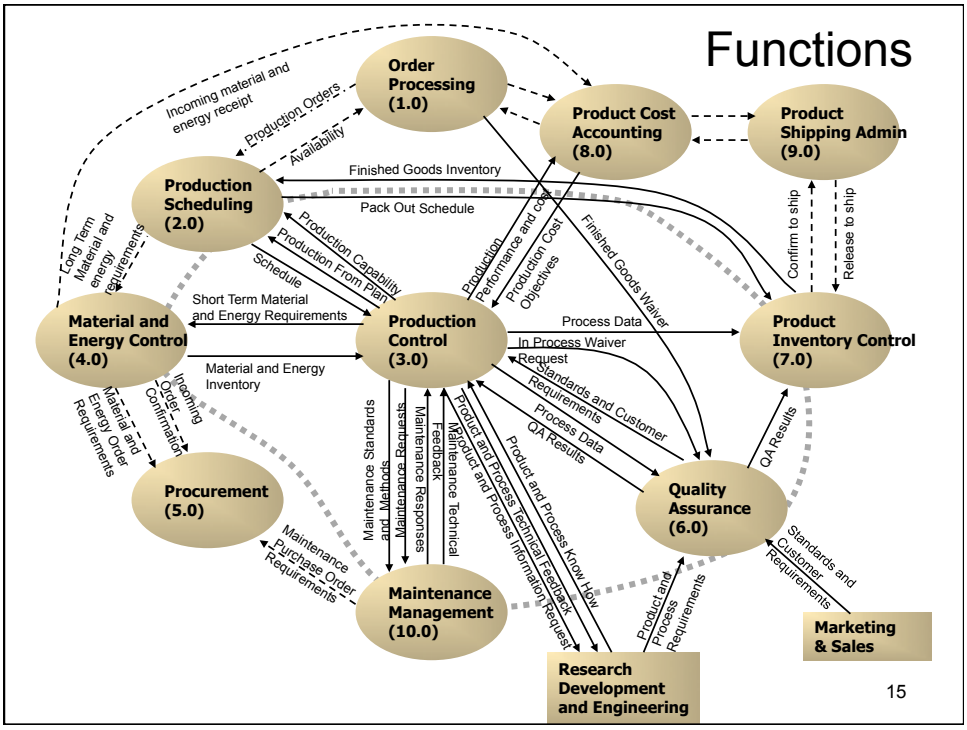
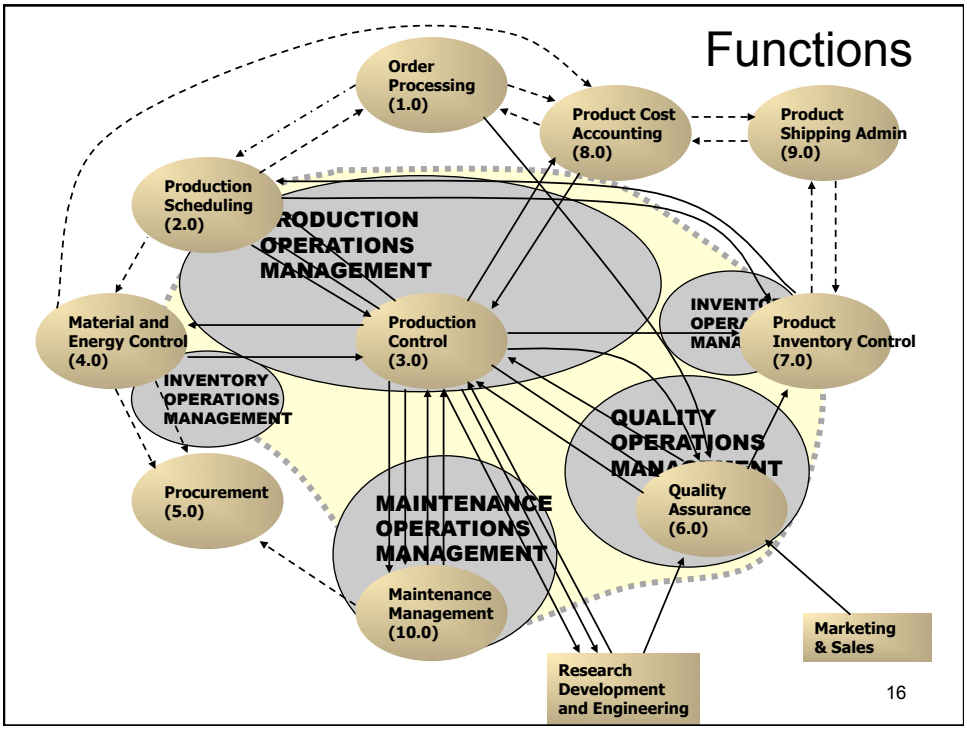

Functions
Order Processing (1.0)
Product Cost Accounting (8.0)
Product Shipping Admin (9.0)
Production Scheduling (2.0)
Material and Energy Control (4.0)
Production Control (3.0)
Product Inventory Control (7.0)
Procurement (5.0)
Quality Assurance (6.0)
Maintenance Management (10.0)
Marketing & Sales
Research Development and Engineering
Incoming material and energy receipt
Production Orders
Availability
Finished Goods Inventory
Pack Out Schedule
Confirm to ship
Release to ship
Long Term Material and energy requirements
Production Capability
Production From Plan
Schedule
Short Term Material and Energy Requirements
Material and Energy Inventory
Production Performance and cost
Production Cost Objectives
Finished Goods Waiver
Process Data
In Process Waiver Request
Standards and Customer Requirements
Process Data
QA Results
QA Results
Material and Energy Order Requirements
Incoming Order Confirmation
Maintenance Standards and Methods
Maintenance Requests
Maintenance Responses
Feedback
Maintenance Technical
Product and Process Technical Feedback
Product and Process Know How
Product and Process Information Request
Maintenance Purchase Order Requirements
Product and Process Requirements
Standards and Customer Requirements
15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Product Cost Accounting (8.0)
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Production Scheduling (2.0)
RODUCTION
OPERATIONS
MANAGEMENT
Material and Energy Control (4.0)
Production Control (3.0)
Product Inventory Control (7.0)
INVENTORY OPERATIONS MANAGEMENT
QUALITY OPERATIONS MANAGEMENT
Procurement (5.0)
Quality Assurance (6.0)
MAINTENANCE OPERATIONS MANAGEMENT
Maintenance Management (10.0)
Marketing & Sales
Research Development and Engineering
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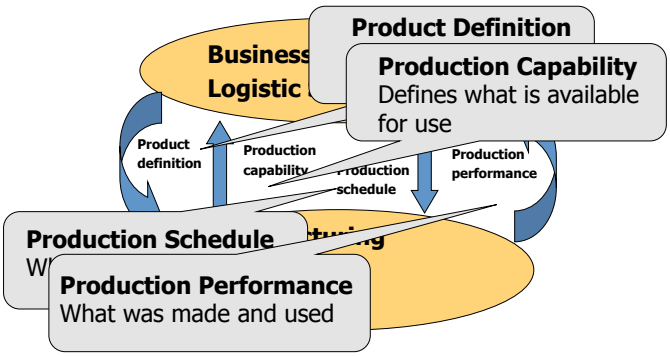
Categories of Information & Resources



4 categories of information:
- Product Definition
- Production Capability
- Production Schedule
- Production Performance

4 resources:
- Personnel
- Equipment
- Material
- Process Segment

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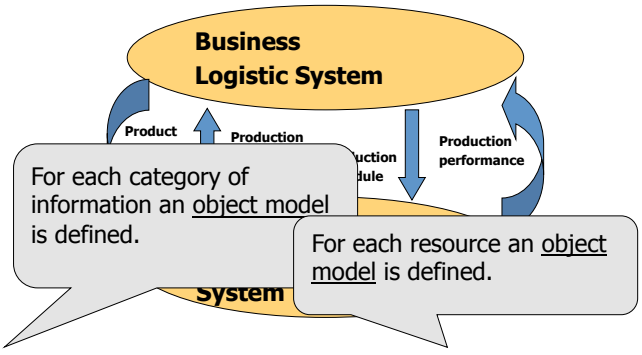
Object Models



4 categories of information:
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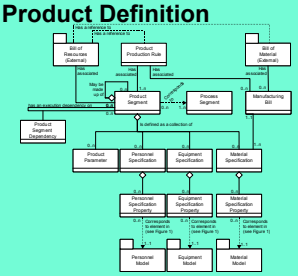
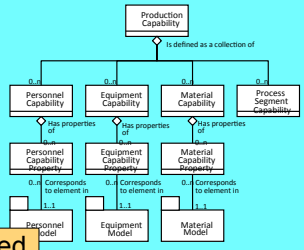
Object Models

Product Definition

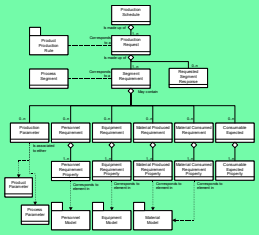


Production Capability

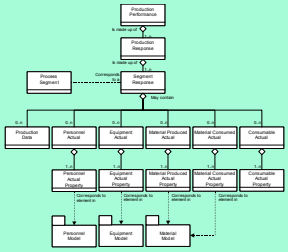


Described In UML

Production Scheudule



uction Performance



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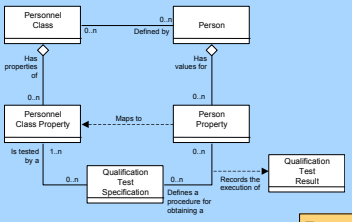
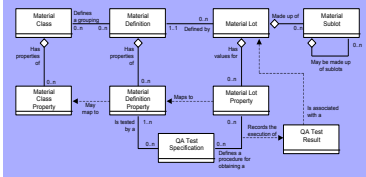
Object Models

Personnel Model

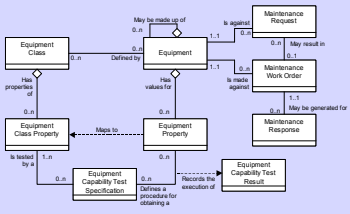


Material Model

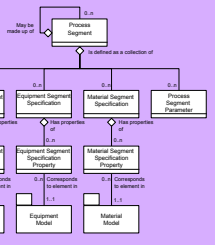


Described In UML

Equipment Model



Process Model



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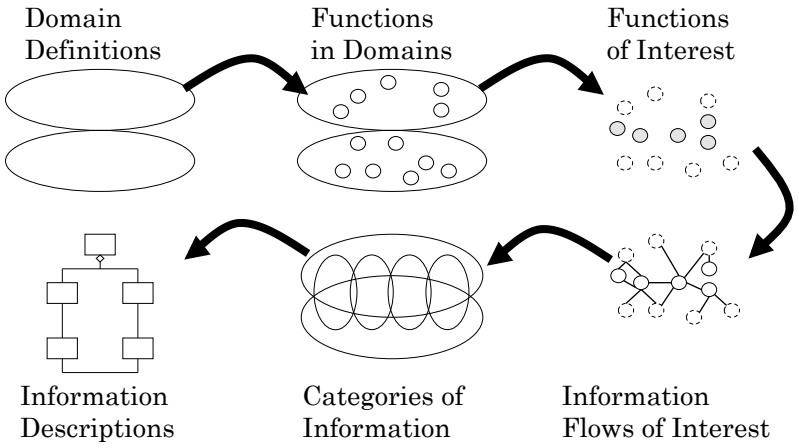
Outline of part 1



ISA95 Part 2

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Four Resources

Personnel

The personnel involved in manufacturing operations management

Equipment

The equipment (role based and physical assets) Involved in manufacturing operations management

Materials

The material involved in manufacturing operations management

Process Segments

A process segment specifies the capabilities needed for a production, maintenance, inventory or quality activitiy at the level of detail required to support Business processes.

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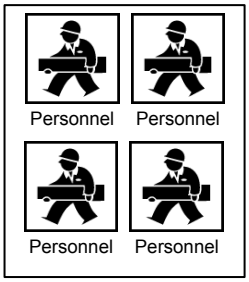
Four Resources - Personnel

Personnel resources managed for manuf. operations
- individuals
- groups of individuals



Update:
Personnel model moved to part 2,
Minor changes to the model

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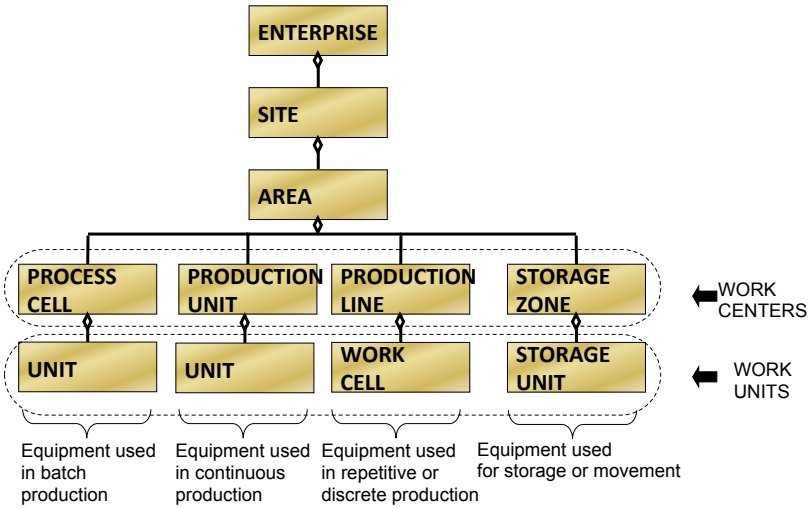
Four Resources - Equipment



Update Part 1: The equipment hierarchy is extended with eq. for storage.
Changes to the UML model

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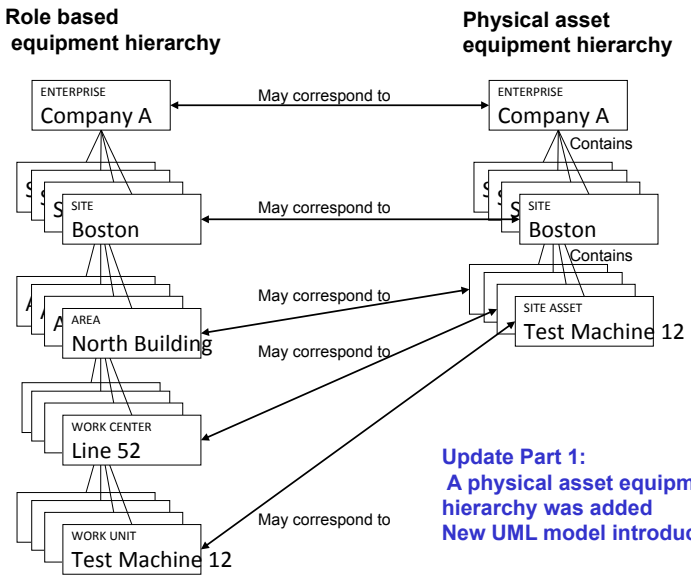

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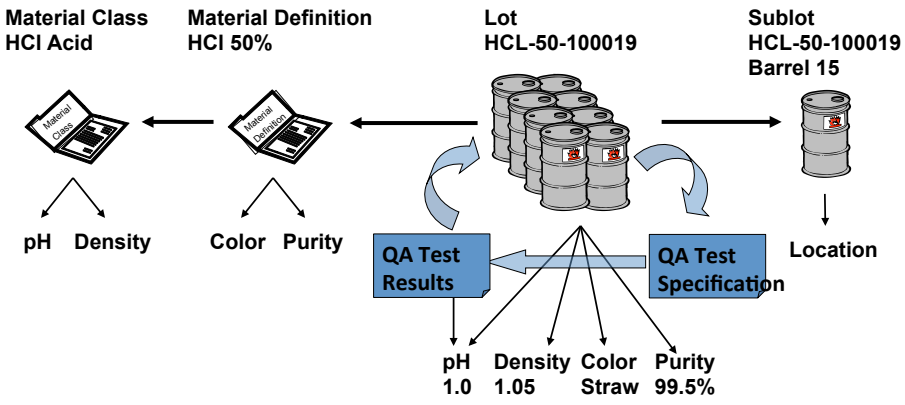
Four Resources - Material

- Material Definition Example
- Common material information



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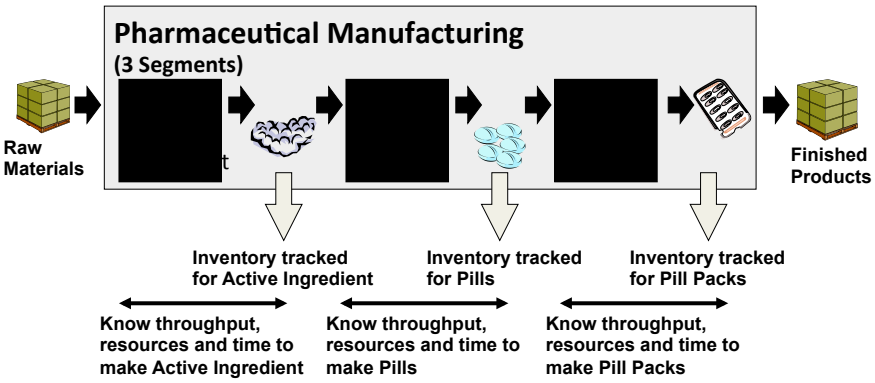
Resources - Process Segments

- Business view of production



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Resources - Process Segments

- Process Segment
  - Defines the segments of production available
  - From the business viewpoint
- Product Segment
  - Defines segments of production for a product
  - From the business viewpoint
  - Defines the resources and properties of the resources required for that segment of production
    - Personnel (e.g. 3 operators)
    - Equipment (e.g. 1 Milling Machine)
    - Material (e.g. 3 Ton Steel Bar)
    - Parameters (e.g. Color, Hole Size)

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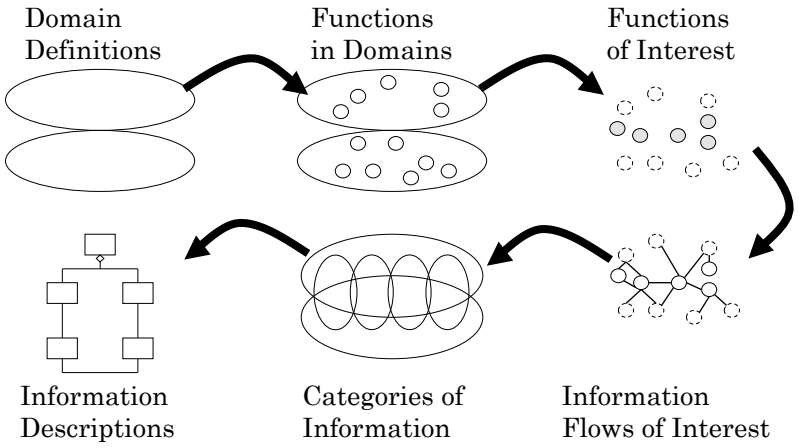
Outline of part 1



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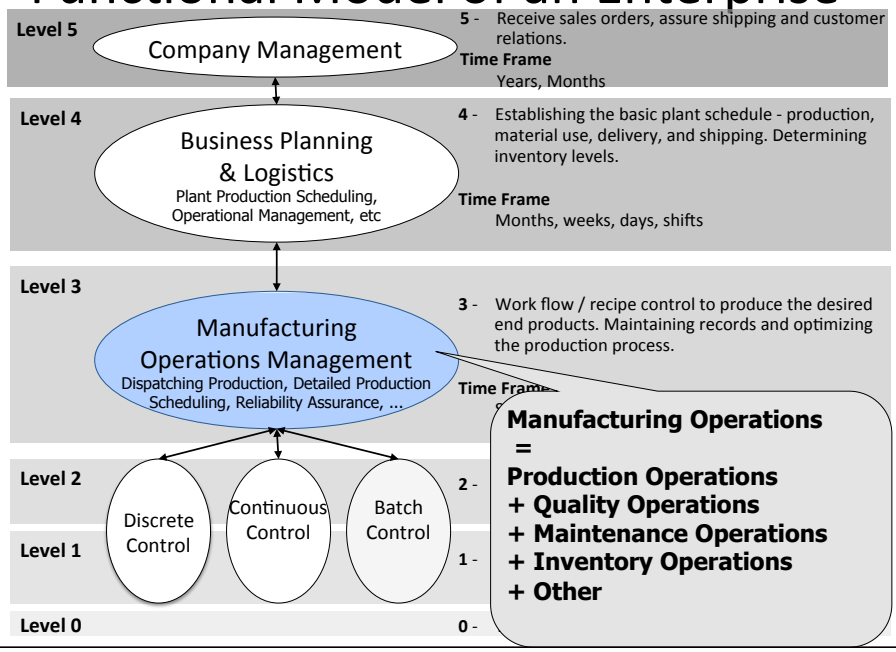
Functional Model of an Enterprise



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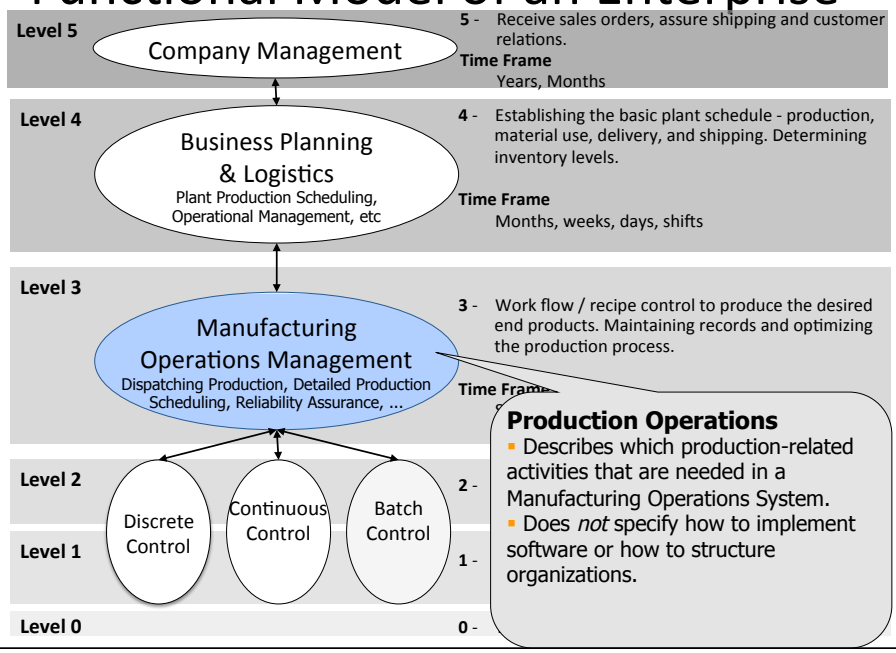
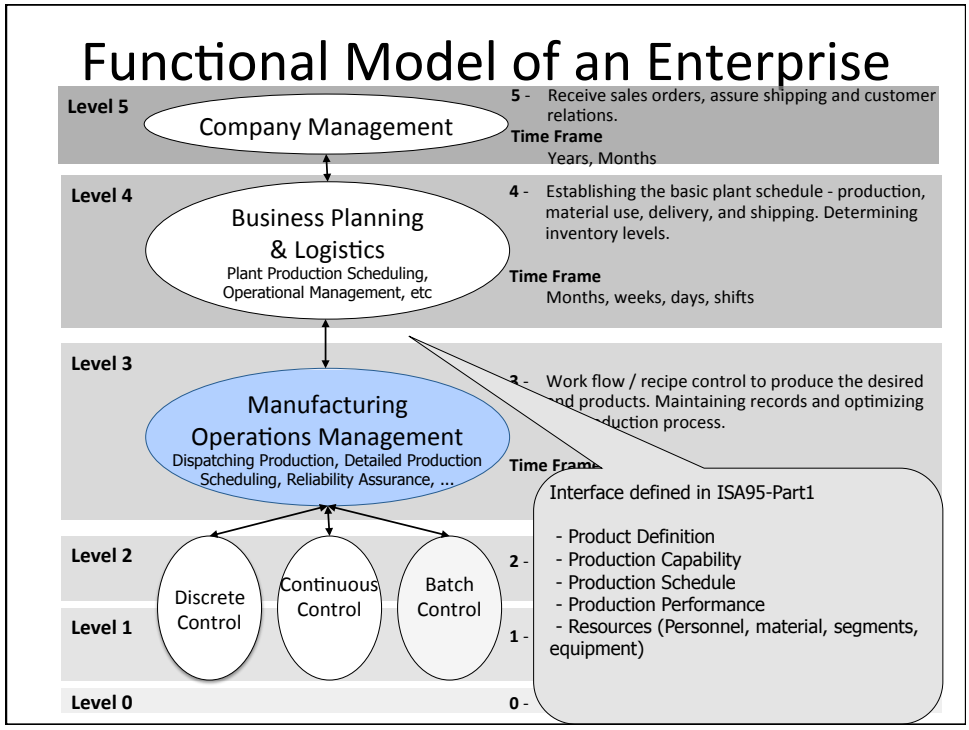
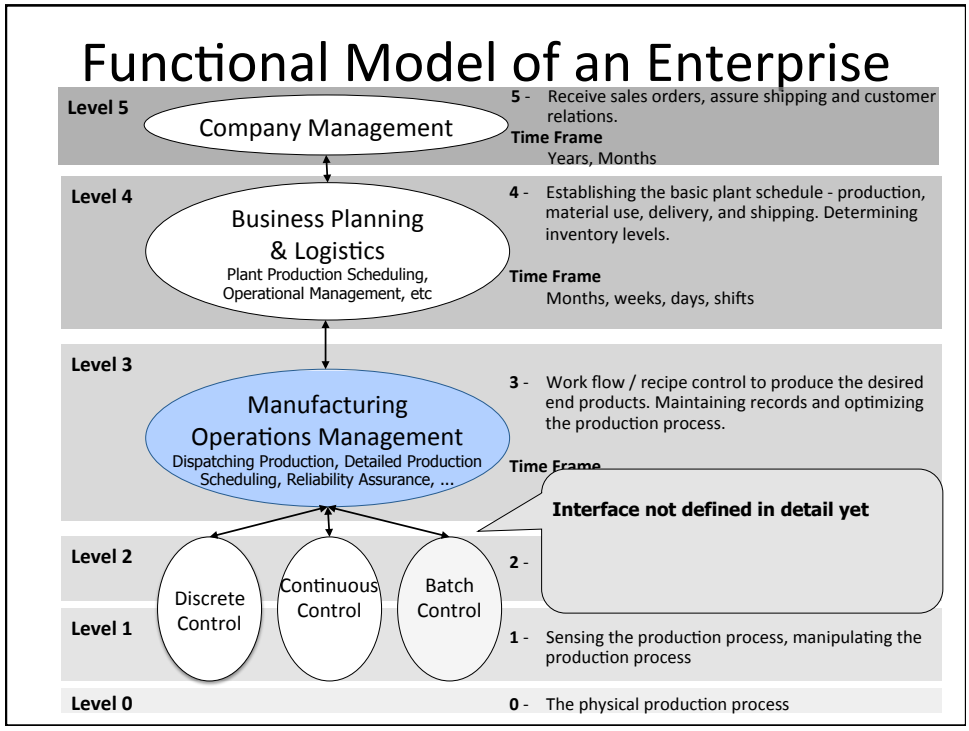



Functional Model of an Enterprise
Level 5
Company Management
5 - Receive sales orders, assure shipping and customer relations.
Time Frame
Years, Months
Level 4
Business Planning & Logistics
Plant Production Scheduling, Operational Management, etc
4 - Establishing the basic plant schedule - production, material use, delivery, and shipping. Determining inventory levels.
Time Frame
Months, weeks, days, shifts
Level 3
Manufacturing Operations Management
Dispatching Production, Detailed Production Scheduling, Reliability Assurance, ...
3 - Work flow / recipe control to produce the desired
products. Maintaining records and optimizing
duction process.
Time Frame
Interface defined in ISA95-Part1
- Product Definition
- Production Capability
- Production Schedule
- Production Performance
- Resources (Personnel, material, segments, equipment)
Level 2
Discrete Control
Continuous Control
Batch Control
2 -
Level 1
1 -
Level 0
0 -


Functional Model of an Enterprise
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Time Frame
Years, Months
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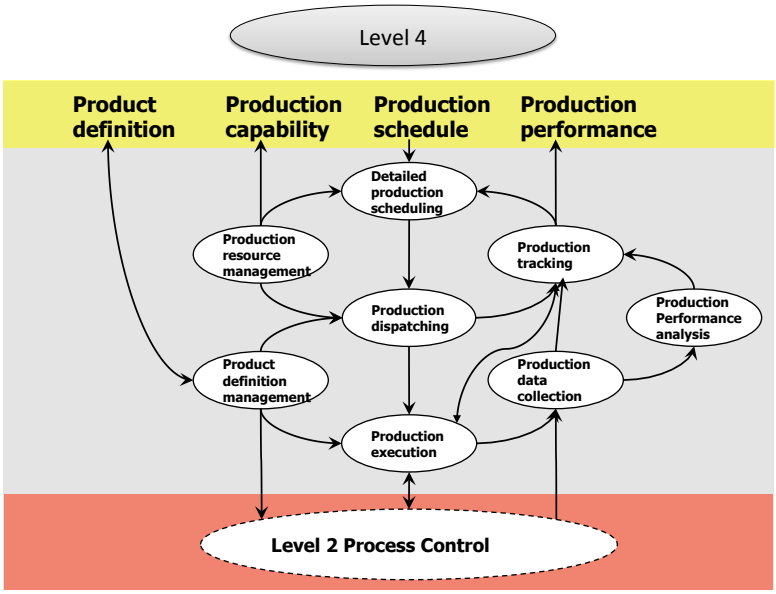
Time Frame
Months, weeks, days, shifts
Level 3
Manufacturing Operations Management
Dispatching Production, Detailed Production Scheduling, Reliability Assurance, ...
3 - Work flow / recipe control to produce the desired end products. Maintaining records and optimizing the production process.
Time Frame
Interface not defined in detail yet
Level 2
Discrete Control
Continuous Control
Batch Control
2 -
Level 1
1 - Sensing the production process, manipulating the production process
Level 0
0 - The physical production process

Activity Model



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Activities

- Production Resource Management
  - Maintain information about on the availability of production personnel, machines, and material
- Product Definition Management
  - Maintain recipes, assembly instructions, …
- Detailed Production Scheduling
  - Production scheduling taking into account limited capacities, changeover times, and cleaning
- Dispatching
  - Ensures that work orders are sent out and that tasks are assigned to shifts
- Execution Management
  - Ensures that the production personnel do indeed carry out the tasks
- Data Collection
  - Gathers production data
- Tracking
  - Transforms data into production reports, e.g., batch reports, to be used for tracing and geneaology
- Analysis
  - Provide support for production analysis

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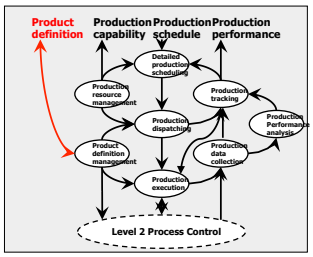
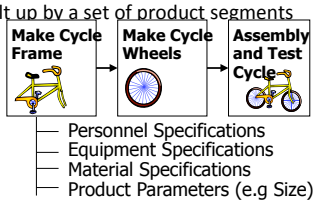
Example (I)



The business system sends down the *product definition* - the definition of how a certain product should be made.

- Product Definition

built up by a set of product segments



Manufacturing Bill
Frame : 1
Wheels : 2
Chain : 1
Seat : 1
Handlebars :1
Brake Pads : 4
...

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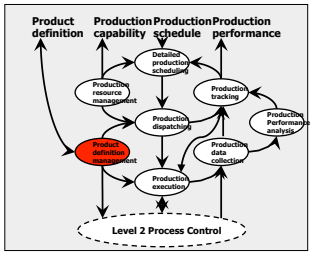
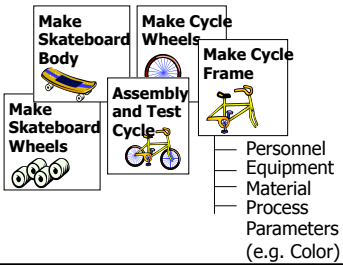
Example (II)



Product Definition Management takes care of all activities related to the new product.

The manufacturing system knows they can produce the product since each product segment corresponds to a process segment known to the manufacturing system.

Collection of defined **Process Segments**



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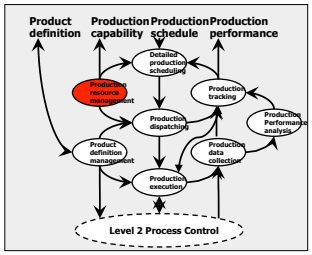
Example (III)

The *Product Resource Management* knows everything about the resources in the plant



Personnel

(Personnel Resources managed for Production)

Equipment

(Equipment Resources managed for Production)

Material

(Material Resources managed for Production)

Process Segment

(Product independent Segment of Production)

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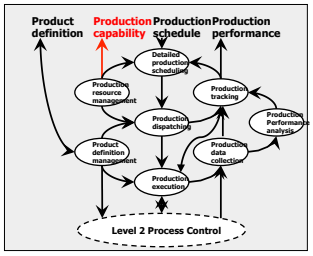
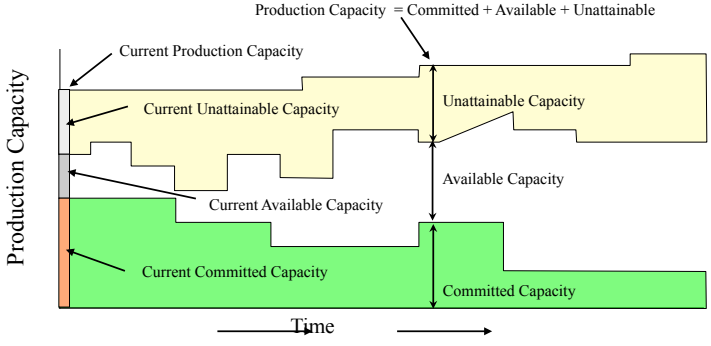
Example (IV)

The *Production Capability* – indicating what is currently available for use – is sent to the Business System





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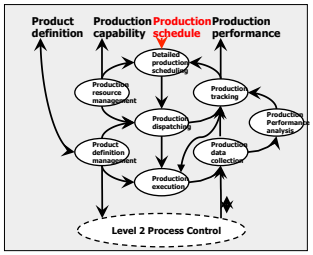
Example (V)

The Business System calculates a *Production Schedule* – what to make and use - and send it to the Manufacturing System.



Production Schedule

Male Bikes : 8
Women Bikes : 12
Trekking Bike : 20

Due date: Friday
...

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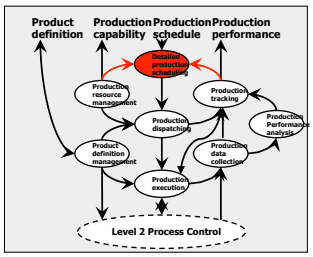
Example (V)

A *detailed production schedule* is calculated. It takes into account the actual status of equipment, personnel and materials, and current schedules in the plant (finite capacity scheduling).



Production Schedule

Male Bikes : 8
Women Bikes : 12
Trekking Bike : 20

Due date: Friday
...

Detailed Production Schedule
Due date: Thursday
...

The detailed production schedule determines the optimal use of resources. Production schedules might be splitted/merged.

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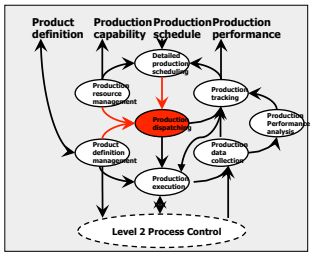
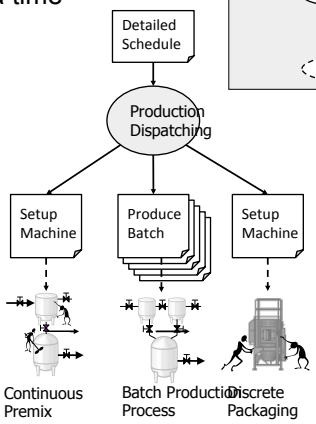
Example (VI)

The entries in the detailed production schedule are dispatched - a request for starting the production is sent to to equipment or personnel (at a time decided by the scheduler).

- Start batches
- Send work instructions
- Start production runs

Production Dispatching also controls the amount of work in progress.





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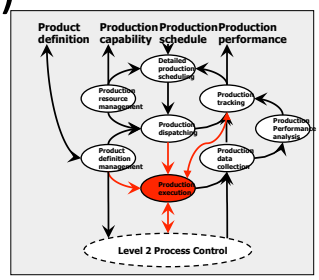
Example (VII)

Production Execution executes the dispatched work

- the execution of fully automated equipment is carried out by the Process Control System
- The execution of manual or semi-automated procedures is assured

Production Execution assures visibility of the execution in progress.



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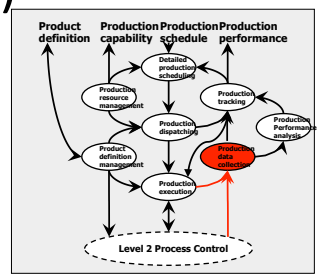
Example (VIII)



Production Data Collection collects data from the process control system

- sensor readings,
- equipment states,
- event data,
- operator entered data,
- operator actions,
- everything of importance
  in the making of a product.

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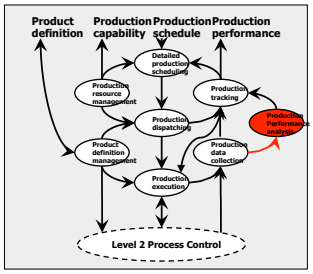
Example (IX)



Different types of analyses have to be performed in order to confirm and optimize the production.
This activity is assured by the *Production Performance Analysis*

- Product Analysis: in-process testing
- Production Analysis: equipment utilization
- Process Analysis: golden/unsuccessful production runs

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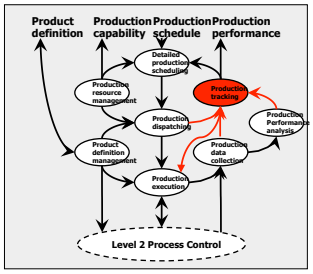
Example (X)



Production Tracking tracks the production

- Movement of material
- Start and end time of segments
- Etc ..

It summarizes and reports information about

- Personnel, Material and equipment
- Cost and performance analysis results.
- Product Genealogy
  - EU: "The Health and Consumer Protection Directorate"
  - USA: " The USA Bioterrorism Act"

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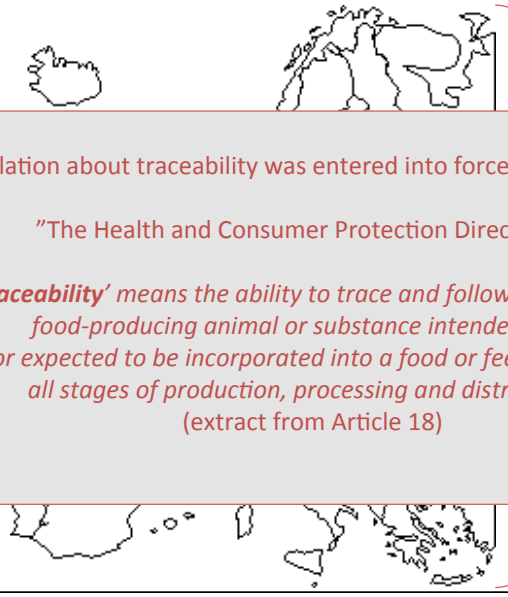
EU



Legislation about traceability was entered into force 1 January 2005

"The Health and Consumer Protection Directorate"

*'**Traceability**' means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution.*
(extract from Article 18)

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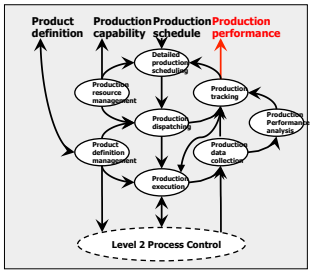
Example (XI)

The *production performance* – what was made and used – must be reported back to the Business System for further use in calculating Business metrices.



Production Performance

Male Bikes : 8 (8)
Women Bikes : 10 (12)
Trekking Bike : 20 (20)

Ready by:
Thursday 10.30
(Friday)
...

Production Response

WomenBikes :10
Ready by:
Thursday 10:30
...

The results from one/several production runs might need to be slit/merged in order to match with the production schedules.

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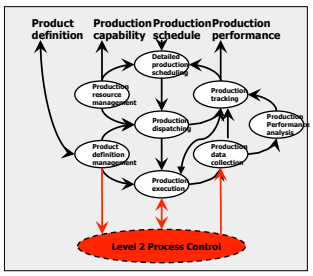
Example (XII)



The interface with the *Process Control System* is Outside the scoop of ISA S95

For an MES vendor this is a very important task

- *Easy integration*
- *Additional advantages for end-user*
- *Same look and feel*

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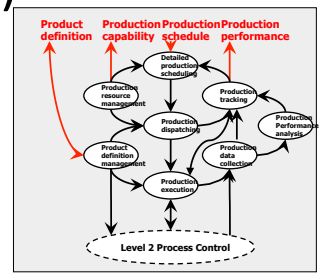
Example (XIII)

The interface with the *Business and Logistics system* is defined within ISA S95



For an MES vendor this is a very important task

- *Easy integration with various ERP vendors*
- *Additional advantages for end-user*
- *Refered to as B2MML*

(Business to Manufacturing Markup Language)

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Functional Model of an Enterprise

Level 5 — Company Management

5 - Receive sales orders, assure shipping and customer relations.

Time Frame Years, Months

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

4 - Establishing the basic plant schedule - production, material use, delivery, and shipping. Determining inventory levels.

Time Frame Months, weeks, days, shifts

Level 3 — Manufacturing Operations Management
Dispatching Production, Detailed Production Scheduling, Reliability Assurance, ...

3 - Work flow / recipe control to produce the desired end products. Maintaining records and optimizing the production process.

Time Fram...

Level 2 — Discrete Control, Continuous Control, Batch Control

2 -

Level 1

1 -

Level 0

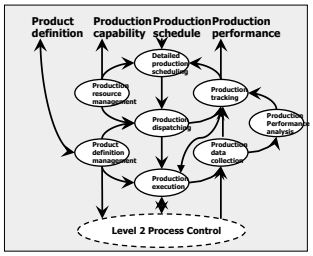
0 -

Manufacturing Operations
=
Production Operations
+ Quality Operations
+ Maintenance Operations
+ Inventory Operations
+ Other

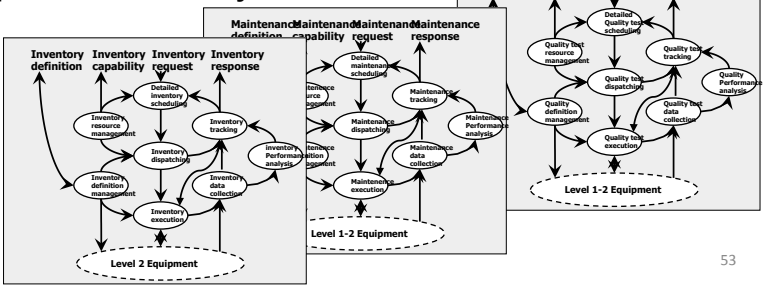
Other Activity Models

Activity models are defined for

- **Production operations**
- **Maintenance Operations**
- **Quality Assurance Operations**
- **Inventory Operations**



Other Operations are briefly mentioned.



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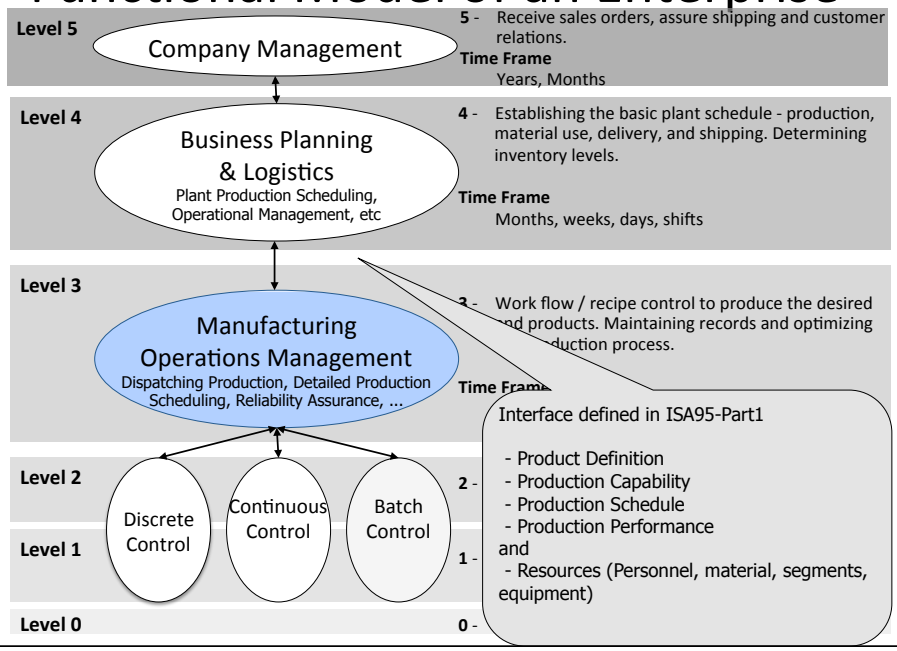
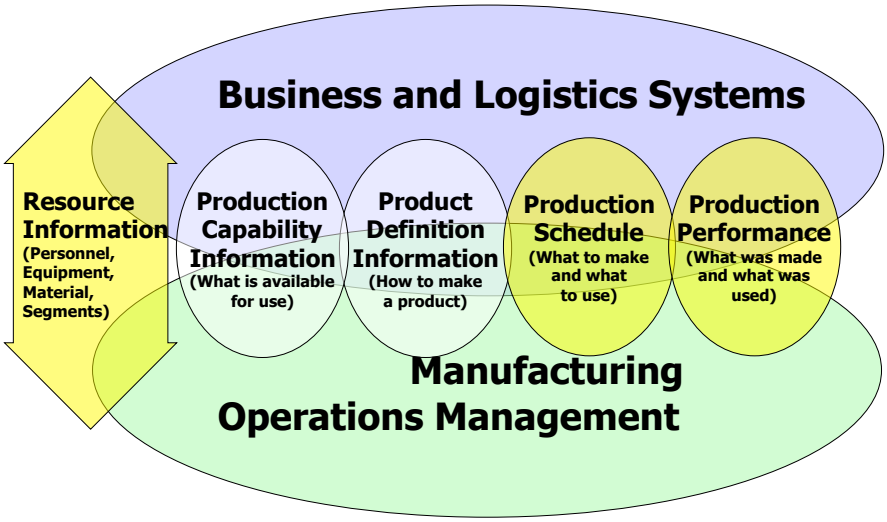
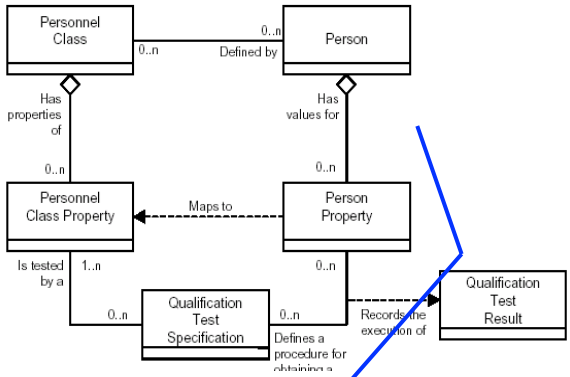
Functional Model of an Enterprise



Exchanged Information in ISA 95



55



ISA95.00.01 Personnel model

ISA95.00.02 Personnel Attributes

Attribute Name	Description	Examples
ID	A unique identification of a specific person, within the scope of the information exchanged (*production capability, production schedule, production performance, …*) The ID shall be used in other parts of the model when the *person* needs to be identified, such as the *production capability* for this person, or a *production response* identifying the person.	999-123-4567 Jane W Smith - #2 Employee 23
Description	Additional information about the resource.	"Person Information" "Person Information" "Person Information"
Name	The name of the individual. This is meant as an additional identification of the resource, but only as information and not as a unique value.	Joe Smith III Jane Bubba

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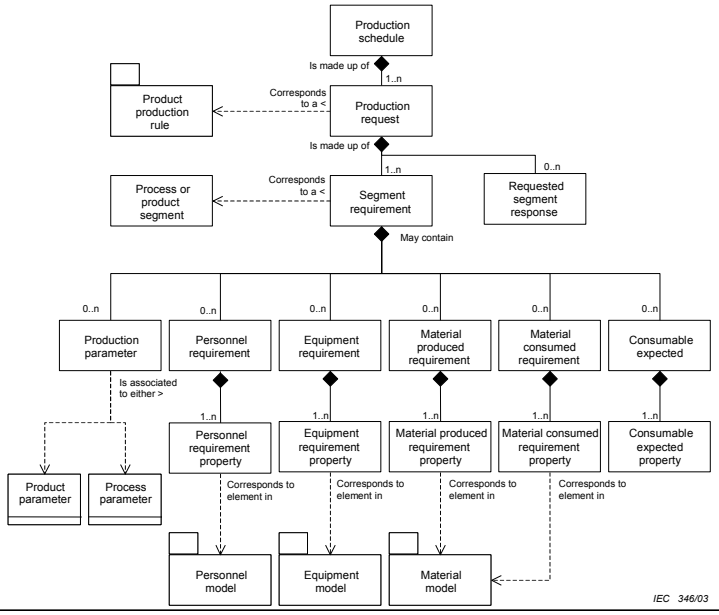
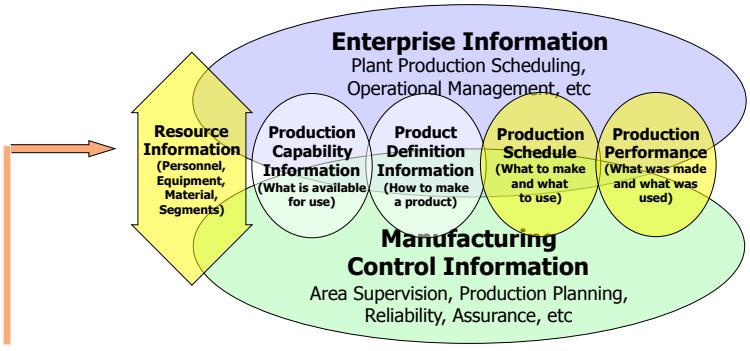
Categories of Information - Production Schedule



B2MML



The standard (part 1 and 2) defines WHAT Information to be exchanged

B2MML suggest one way of HOW this information should be exchanged

BSMML - Business-2-Manufacturing Markup Language

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B2MML – the ISA95 XML Schemas

The XML schema for Personnel model

```
<PersonType>
        <ID> 101</ID>
        <Description>Employment Number</Description>
        <PersonName>John Smith</ PersonName >
        <PersonProperty>
                <ID>date-of-birth</ID>
                <Description>indicates when a person is born</Description>
                <Value>1943-03-23</Value>
                <Value Unit of Measure> integer </Value Unit of Measure>

                <ID>sex</ID>
                <Description>indicates the sex of a person</Description>
                <Value>male</Value>
                <Value Unit of Measure>{female,male}</Value Unit of M.>
        </ PersonProperty >
        <PersonnelClassID>{night-shift-operator, engineer}</PersonnelClassID>
</PersonType>
```

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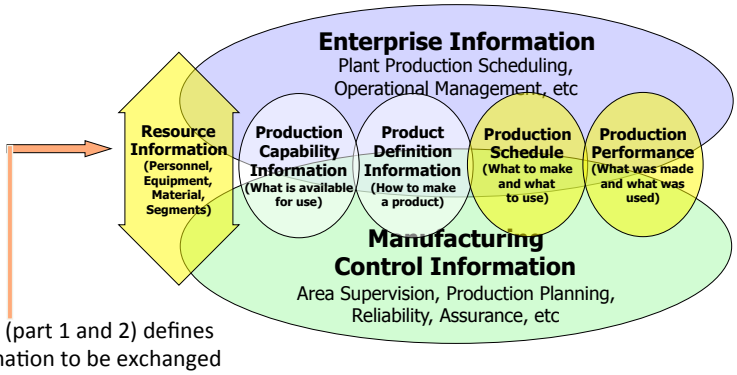
ISA95 part 5



The standard (part 1 and 2) defines
WHAT Information to be exchanged

B2MML suggest one way of HOW
this information could be exchanged

ISA 95 Part 5: Business to Manufacturing transactions.
Part 5 contains VERBS that states what to do with the exchanged info.

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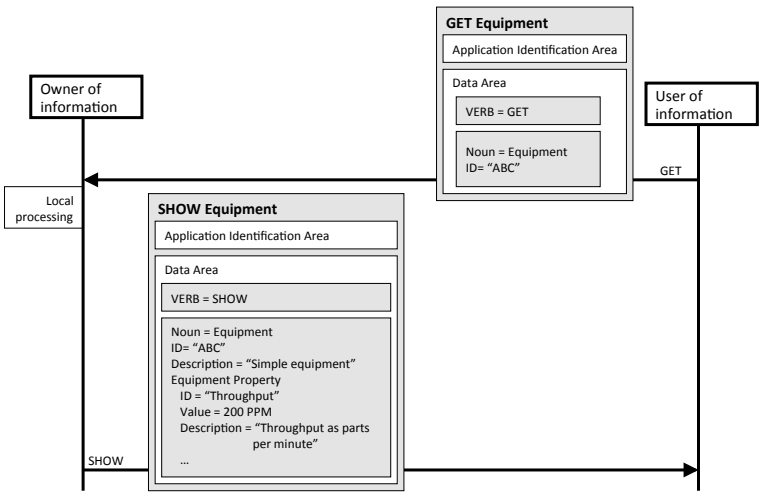
ISA 95 Part 5 - Typical Transaction



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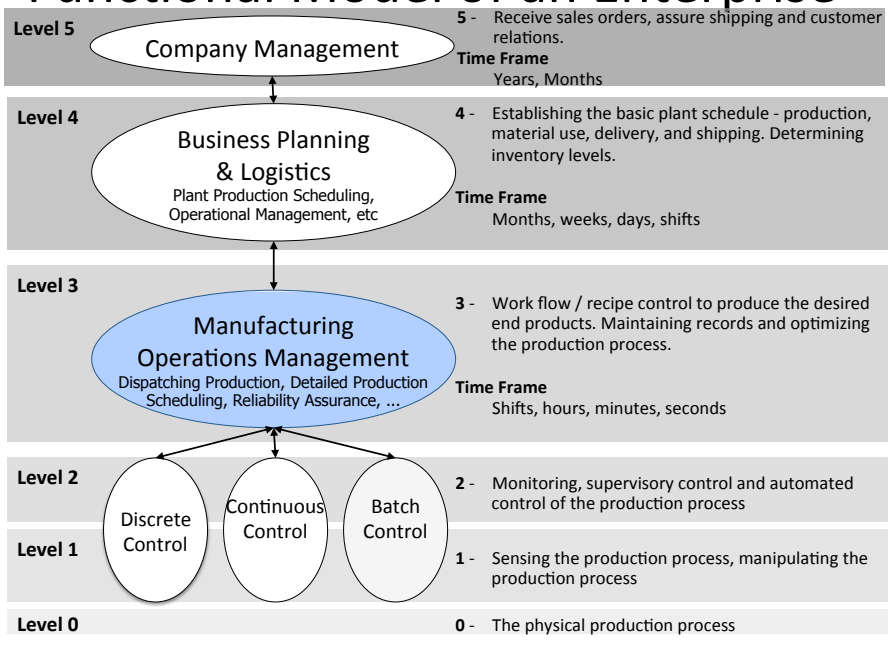
Functional Model of an Enterprise



ISA 95 Actual Benefits

- A success story for standards

- ERP-to-MES Integration
  - Projects cut from 9-12 months to weeks
  - Mostly due to reduced IT involvement/conflict
- MES Requirements
  - Requirement development cut from 9-12 months to weeks
  - Mostly due to predefined requirements lists
- Industry acceptance
  - End users are using it in requirements
  - MES vendors are supporting it in their products
  - ERP vendors are supporting it in their products

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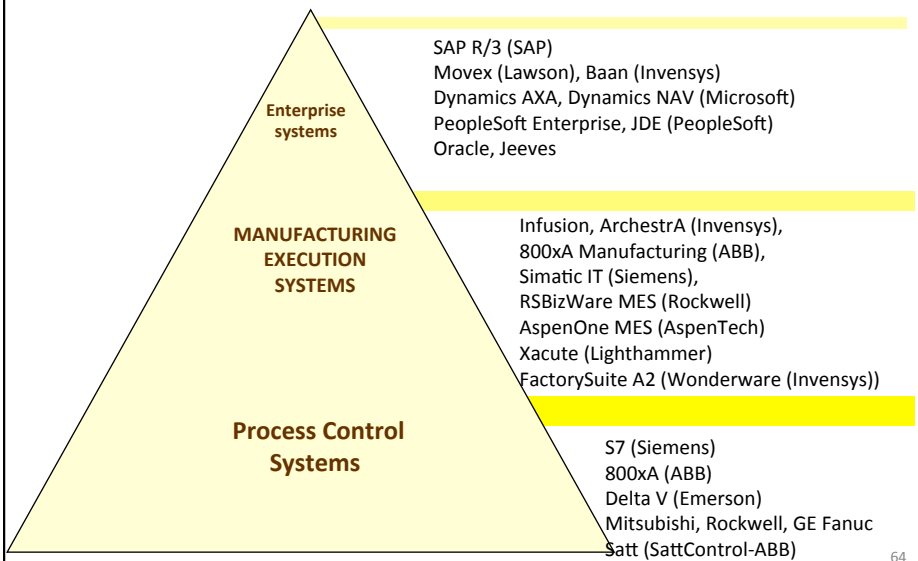
Industrial systems



SAP R/3 (SAP)
Movex (Lawson), Baan (Invensys)
Dynamics AXA, Dynamics NAV (Microsoft)
PeopleSoft Enterprise, JDE (PeopleSoft)
Oracle, Jeeves

Infusion, ArchestrA (Invensys),
800xA Manufacturing (ABB),
Simatic IT (Siemens),
RSBizWare MES (Rockwell)
AspenOne MES (AspenTech)
Xacute (Lighthammer)
FactorySuite A2 (Wonderware (Invensys))

S7 (Siemens)
800xA (ABB)
Delta V (Emerson)
Mitsubishi, Rockwell, GE Fanuc
Satt (SattControl-ABB)

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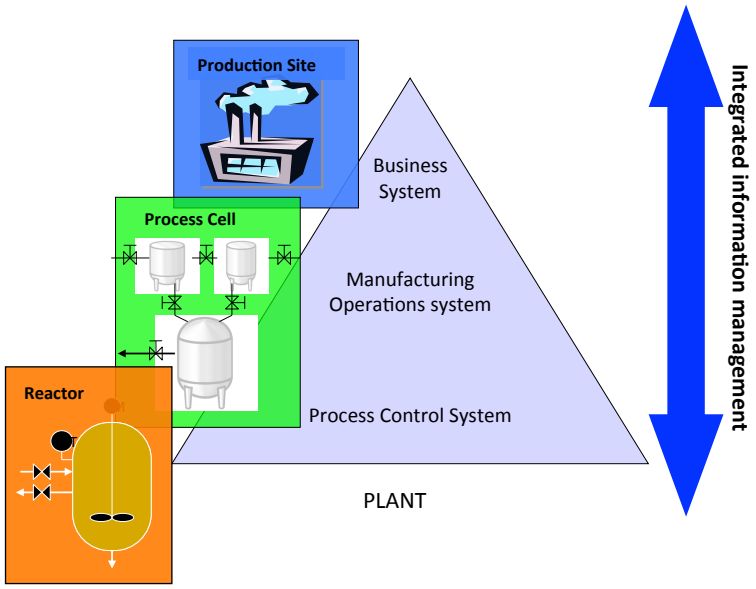
Production Control



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Visibility into plant operations is now being seen as a major hurdle to improving business performance

(Source: Forrester Research)

What are your biggest problems with global manufacturing?" Percentage of 50 global manufacturing companies responding:	
Poor visibility into plant operations	38%
Inaccurate demand forecasting	36%
Poor communication	24%
Supply shortfalls	18%
Poor customer satisfaction	8%

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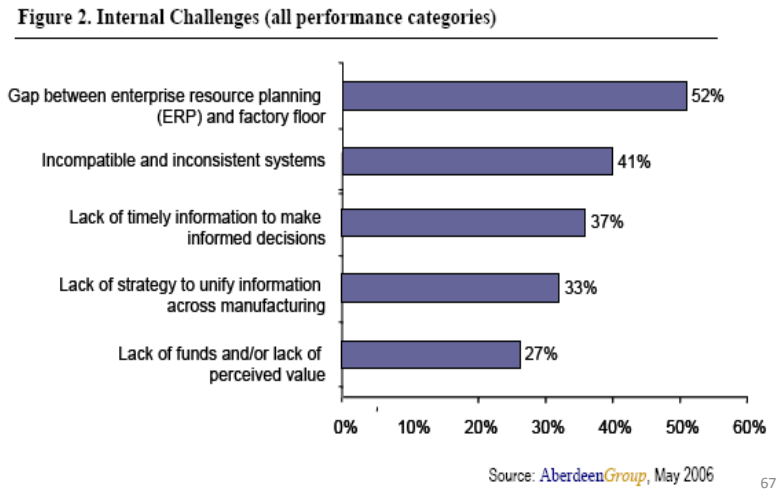
What Manufacturers Consider the Major Challenges they are Facing!



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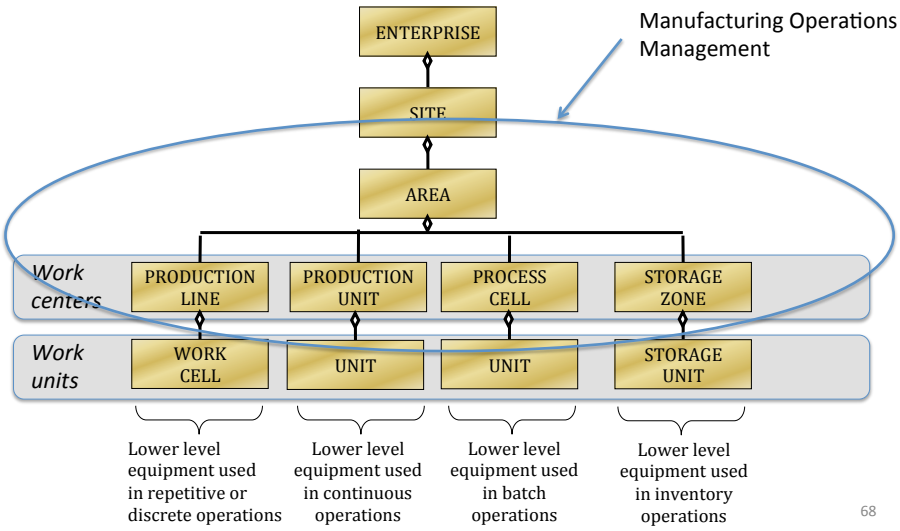
Physical Model of an Enterprise



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Functional Model of an Enterprise