INFORMATION SYSTEMS SUPPORT FOR MANUFACTURING PROCESSES

The standard S95 perspective

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Abstract: Manufacturing Execution Systems and Enterprise Resource Planning Systems support the Manufacturing Enterprise. The two families of systems have been developed independently, so they have grown without a scope or a strictly defined border. The feature overlapping between them raises relevant issues in the integration with control systems. This paper analyzes how different types of manufacturing processes are supported by ERP and MES, and how the standard developed by ISA: S95 defines the scope of each system. This standard also provides the separation of production from non-production processes. A paper mill enterprise case study is presented, where the business processes are identified and a system framework is proposed in accordance with the S95 hierarchy function model.

1 INTRODUCTION

Manufacturing Execution Systems and Enterprise Resource Planning Systems exist to support the manufacturing enterprise. As these two families of systems have been developed independently, they have grown without a scope or a strictly defined border.

MES systems were developed to support the production processes and have been extended to support quality control, warehouse and order management. ERP systems began supporting corporate activities such as finances, sales and distribution and then extended their scope to support quality control and production tracking. The overlapping features of production planning and quality control between both systems raises relevant issues in their integration with control systems of the plant-floor (Mark2000). This integration is required for systems to be able to completely support the value chain of manufacturing enterprises.

This context allows three possible scenarios:

- MES products evolve to support everything.
- ERP systems grow to support manufacturing.
- MES and ERP are integrated in order to keep the strong points of each one.

As the last option preserves the know-how from within each system, it implies a clear definition of the scope, boundaries and information flows between them.

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Instrument Automation and System Association formed a committee of system vendors to develop S95: Enterprise-Control System Integration Standard (S952000). This standard provides means to represent how ERP and MES are structured inside the Enterprise Architecture.

This paper analyzes how different types of manufacturing processes are supported by MES and ERP systems. To better illustrate these ideas a system framework is proposed in accordance with the S95 hierarchy function model for a paper mill enterprise.

2 MANUFACTURING PROCESSES

As business processes are the activities performed within the business during which the state of resources changes and which describe how work is done, it is possible to define manufacturing processes as business processes that transform physical resources. ANSI/ISA classifies manufacturing processes as discrete, continuous and batch. This allows classifying manufacturing processes according to resource type and their relationship with time, as present on
Table 1

Table 1: Manufacturing types

Manufacturing Process	Time Characteristic	Type of Input	Type of Output
Discrete	Discrete Time	Finite Discrete	Finite Discrete
Process Continuous	Continuous Time	Flow	Flow
Process Batch	Interval of Time	Finite not discrete	Finite not discrete

Discrete Manufacturing Processes are of two types: Assembling: Several items are aggregated to build one finished product (i.e. Auto Industry) and Disassembling: Product is split in several sub-products (i.e. Paper sheet production).

Manufacturing Batch Processes are based on a recipe that is executed during a finite period of time, consuming and producing finite quantities of products, called lots (i.e. Pharmaceuticals Industry).

Continuous Manufacturing Processes transform continuous input resources into continuous output resources (i.e. Steel and Pulp Industries).

There are industrial cases where the production chain process is based on the aggregation of several types of manufacturing processes. Production can be composed by a continuous process followed by a disassembling discrete process for cutting and an assembling discrete process for packing, as in the paper industry (Schroder1993).

3 MES AND ERP SYSTEMS

Systems to support quality and production planning have to handle the different characteristics of each manufacturing type described. The differences on Manufacturing Processes that have influences in the definition of applications are resumed on table 1.

Product identification is based on item number for Discrete Process, lot number for Batch Process and based on time interval or time instant on Continuous.

Table 2: System features / manufacturing types

	Discrete	Continuous	Batch
Identification	Item	Time	Lot
Production Planning entity	Bill of Material	Rate Recipe	Recipe
Quantities	Numbers of items	Recipe Ratio Based	Volume or Weight
Quality	Item based	Time based	Lot based
Trace	Item based	Flow based	Lot based

The identification type influences quality management, planning process and traceability implementations, as all these processes have to manipulate the product entity.

3.1 Overlapping features

The identification of the overlapping features between MES and ERP systems is presented in Table 3 where business activities are defined according to the value chain model (Porter1985).

Inbound Logistics include activities of planning, receiving and storing raw material,which are usually supported by ERP systems.

Manufacturing aggregates activities of planning and execution. It is the core capability of MES.

Quality control activity is usually well supported by MES systems. ERP systems' planning is usually based on Bill Material or Recipe entities that do not cover all Industries Operations requirements.

Outbound Logistics as Inbound Logistics are well supported by MES and ERP systems on storage management, planning and execution of delivery activities.

Sales are composed by the activities of order fulfilment, planning and invoicing which are supported by both systems. When the order deliver

dates have to be calculated to support production planning, MES suite better.

Service aggregates the activities of receiving and of processing a reclaim.

Support activities as Human Resources, Procurement and Administration are better suited in the scope of ERP systems.

Table 3: General Application Fit Comparison

Processes		ERP	MES
Inbound Logistics	Plan		
	Receive		
	Store		
Manufacturing	Plan		
	Execute		
	Control Quality		
Outbound Logistics	Plan		
	Store products		
	Deliver		
Sales and Marketing	Promoting		
	Selling		
Service	Receive Reclaims		
	Repair		
Human Resources			
Procurement			
Administration			

Fit	Well	Medium	No

The coexistence of both systems in a coherent and robust way is a challenge. The goal of the ANSI/ISA standard is to define a model to integrate these different systems solving the overlapping problem.

4 ANSI/ISA S95 STANDARD

"The ANSI/ISA S95 standard – Control Systems Integration provides standard models and terminology for defining the interfaces between an enterprise's business systems and manufacturing control systems".

S95 was developed to provide a common model of integration, a standard terminology to define system requirements and integration between different software vendors. S95 is based on three models: Hierarchy Model, Functional Model and Object Information Model. (S952000)

4.1 Support of different Manufacturing types

The analysis of S95, lead to the following differences in the models, when changing the manufacturing process type.

Equipment Hierarchy Model
Discrete: Production line and work cell are defined.
Continuous: Products units are defined.
Batch: Process cell and unit are defined.

Product Segment of the Information Model
Discrete: defines operation as assembly steps
Continuous: defines operation as unit-operations
Batch: defines operation as same location operations

Process Segment on the Information Model
Identifies the capability that can be defined in absolute or rate units.

The implementation of S95 guaranties that MES and ERP are independent from the manufacturing type, as layer 0, 1 and 2 systems, supports the differences.

5 CASE STUDY

Paper Mill Enterprise Processes were analyzed in order to propose a system framework in accordance with the S95 hierarchy function model. The paper production process was selected as it provides a scenario where continuous, discrete and batch processes are used in the same production chain.

The following methodology was applied to build the framework in figure 3:

1. Business process modelling of a Paper Mill.
2. Identify the features of ERP and MES, and which business process they support.
3. Follow S95 Hierarchy Functional Model to identify the activities of each level.
4. From S95 Functional Model identify the processes that should be supported by level 3 and by level 4 systems.
5. From point 3 and 4 infer which MES or ERP component should support each process.

In the diagram MES was split into components considering the activities defined on hierarchy functional model of S95.

6 CONCLUSION AND FUTURE WORK

"A major business challenge for large enterprises is to achieve the proper level of decentralization that is to assign responsibility and decision making to the appropriate organization level" (NIST1999).

S95's hierarchy models provide a powerful tool to build a manufacturing enterprise system framework where the decentralization concept is applied on the Information Systems Architecture.

Although the standard defines an object information model, it only provides a functional approach. This leads to a lack of clear definition between functions and objects entities and hardens its application when following a business process oriented methodology.

An issue under research is how the information entities could be defined to guarantee the information integrity across system components and from levels 2 throw level 4.

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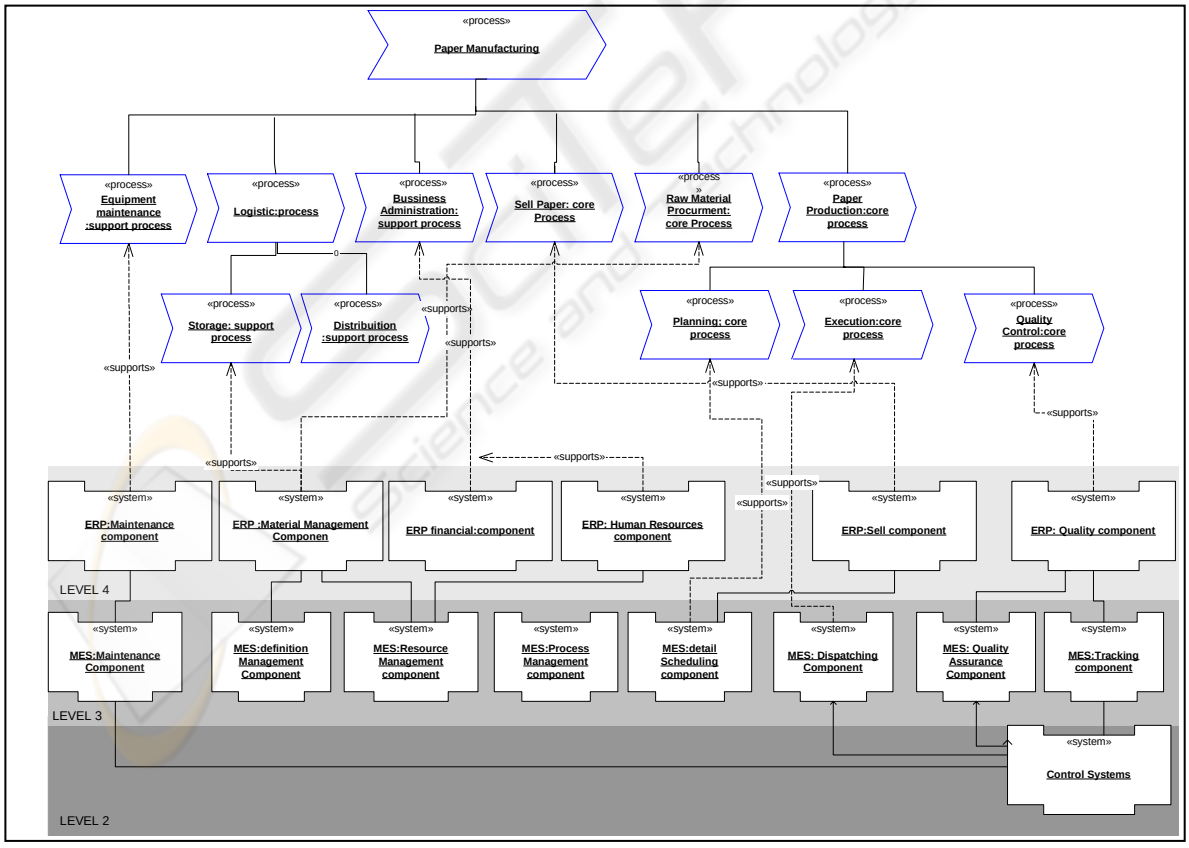

Figure 1: Paper Production Process-System using CEO framework (Vasconcelos2001)