

SUPPLY AND VALUE CHAIN MANAGEMENT

AN ENTERPRISE MAPPING TOOL: THE OPERATIONS MODEL

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ABSTRACT

This paper presents the Operations Model, including a Control Model, developed to support reengineering of operational processes. The Operations Model is the key information carrier in an Enterprise Reengineering Methodology. The Operations Model contains six views to be mapped and modelled, and serve as basis for redesign of operational processes. The Enterprise Reengineering Methodology propose supporting tools and procedures for extensive mapping and modelling, partly standard mapping and modelling tools as well as elements developed specially for the methodology. The methodology furthermore defines a set of analytical methods and tools, as well as design guidelines. The mapping and modelling tools and templates support a rapid reengineering process, comprehensible for managers and decision-makers without detailed process insight, and with minimal resource consumption. Future development will be in the direction of automated mapping from ICT-based sources, improved guidelines for design, and performance dashboards based on the Control Model.

Keywords: Enterprise mapping, operational control, operations model.

INTRODUCTION

In today's global economy operational excellence is required for manufacturing companies. Competitiveness can only be obtained and maintained if operations management is developed in order to support market requirements and customer needs. It becomes essential to develop innovative demand oriented business models which are adapted to the products and manufacturing processes in the company, and to provide for a holistic supply chain orientation towards suppliers and customers. To reach operational excellence companies must reengineer their processes and systems in a systematic and creative way. Mapping and modelling are essential in reengineering processes where the aim is to bring companies from an AS-IS state to an improved TO-BE situation. As ICT is an enabler leading to increased competition between companies, and at the same time being an instrument which supports companies in gaining competitive advantages, the need for mapping and modelling increases even more. The aim of this paper is to describe the Operations Model and its applicability for mapping and modelling in reengineering projects. The Operations Model is the key information carrier in an Enterprise Reengineering Methodology developed at NTNU/SINTEF (Alfnes, 2005). This paper proposes the dataset and the modelling templates that are required to build such models.

The research strategy followed is a combination of a theoretical discussion, exploratory research and empirical data use. The empirical data is collected from a number of cases. The case study approach is preferred due to the need for a deep and extensive study about thoughts and reflections of operations models in supply chains. The data sets are analyzed through traditional quantitative and qualitative approaches as statistical processing and textual interpretations of field notes.

THE ENTERPRISE REENGINEERING METHODOLOGY

A definition of operations management is *"the design, operation, and improvement of the systems that create and deliver the firm's primary products and services"*. (Chase et al. 2004). A Control Model is a representation of how operations are organised and controlled in manufacturing (see Quistgaard et. al,

1989, Andersen et. al, 1998, Alfnes and Strandhagen, 2000). This Control Model is now further developed into applications for the entire manufacturing supply chain.

The Control Model is the key model in the comprehensive Operations Model. To develop an Operations Model is the core activity in a reengineering project to improve operational performance. Process reengineering requires in-depth understanding of the enterprise's current operational processes. The Enterprise Reengineering Methodology organises the reengineering process in six steps; see Figure 1. The process purpose and preliminary problem hypothesis are defined in the initial stage. These guide the choice of methods for the mapping and analysis stages.

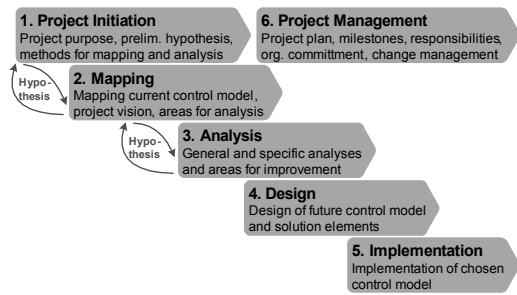


Figure 1: Enterprise Reengineering Methodology

Even though formidable amount of information is created in the supply chain there is still a challenge related to the absorption, utilisation and grasping of the information. Visualising, tracking and managing supply chains all become more complicated as firms pursue outsourcing strategies and delivery systems become increasingly global (Cooper & Gardner, 2003). In order to grasp large and complex amount of information there is a need for processing instruments and ways to represent and visualise information (Liff and Posey 2004). Visualising is to graphical represent information in forms of pictures, maps and illustrations in order to clarify and easily abstract, transfer and exchange knowledge. Emphasis should be put on what to visualise, how to visualise, and to clarify the specific information elements and the holistic picture. The Enterprise Reengineering Methodology propose supporting tools and procedures for extensive mapping and modelling, partly standard mapping and modelling tools as well as elements developed specially for the methodology. The methodology furthermore defines a set of analytical methods and tools, as well as design guidelines. These tools and guidelines are not presented in this paper. The Operations Model proposes six views that should be mapped and modelled, and provide examples of models that can be used to represent each view, see Figure 2.

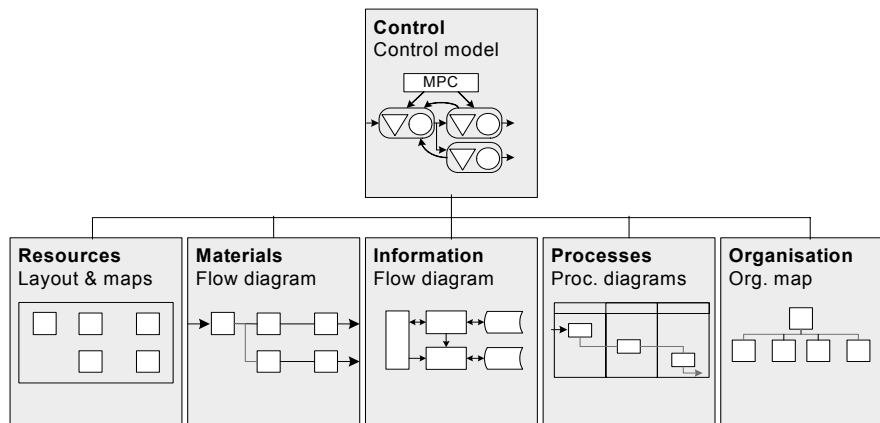


Figure 2: The Operations Model

The Control Model is the key model in the Operations Model, and consists of the following building blocks:

- customer order decoupling point, COPD (specifying which parts of the value chain that is controlled by customer orders)
- control principles and methods (specified for the chain and for each operations area)
- operations areas (specifying which operations that is one area of responsibility)

- main operations processes (operations and buffers)
- material flow (specifying main routes through the operations processes)
- information flow (specifying the flow of information related to value chain)

The latter three of these building blocks are high level version of the more detailed description of the other five views of the Operation Model.

A simplified example of a Control Model for a manufacturing enterprise is shown in figure 3. This model is based on a set of predefined templates and modelling principles. This Control Model may also serve as basis for a supply chain dashboard solution for the same enterprise (Strandhagen et.al., 2006).

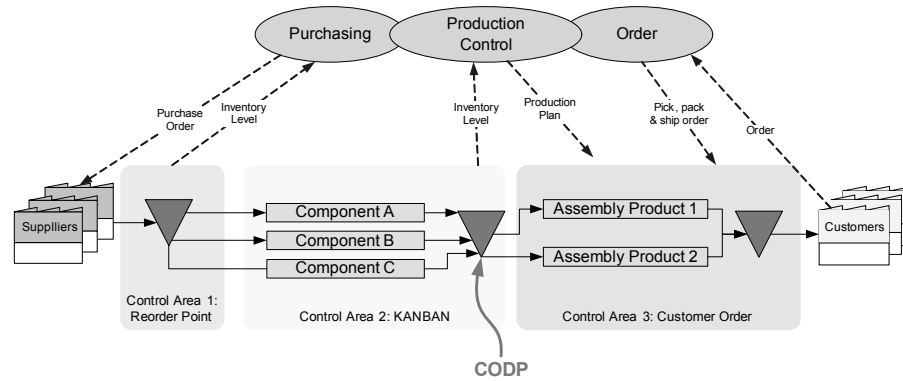


Figure 3 Control Model for Manufacturing Enterprises

In this simplified example, the Control Model shows the position of the CODP and the control principles applied in the different areas of the enterprise. Furthermore it shows the suppliers and customer, the main manufacturing processes, including assembly, the buffers/stores, the control areas and information flows, and administrative processes.

To be able to create the elements of the Operations Model, including the Control Model, an extensive and systematic mapping and modelling must be performed. The remaining parts of this paper describe this process, the data sources and the modelling approaches. Furthermore a set of templates for modelling is described.

MAPPING STAGE 1: DATA COLLECTION

Without a clear understanding and definition of the customer requirements, and the operations capabilities involved in the reengineering project, an enterprise can not be effectively constructed. To gain this understanding requires the capture of data from the enterprise IT-systems (basically the ERP-systems), interviews with key personnel, the gathering of documents, and so on. Both requirements and capabilities must be thoroughly understood and must be the basis for the design of the enterprise.

Selection of data sources

In order to avoid a very excessive data collection, one should use all available data in a considered and structured way. This includes 'weighing' the evidence obtained from the four major data categories that are grouped together in table 1.

Table 1 Sources used in enterprise mapping (adapted from Towill, 1997)

<i>People contact Methods</i>	Interviews brainstorming cross-functional groups	<i>Numerical Techniques</i>	ERP data analysis statistical analysis time series analysis
<i>Written Documents</i>	accounts procedures minutes publications drawings	<i>Investigative Methods</i>	questionnaires walking the process activity sampling

The four categories are via people contact, documentation sources, numerical techniques, and investigative methods. It is an important skill on the part of the enterprise modeller to seek out and sift these sources to obtain a reliable map of the enterprise and which fully document the 'handovers' between the enterprise and its suppliers and customers. People contact methods are potentially the most rewarding of all sources but equally likely to provoke frustration and information bias (Towill, 1996). Effective mapping should therefore proceed in a recursive manner and include the proper combination of people-based, documentation based, numerical-methods-based, and investigation based methods. In many cases, a lot of the available numerical data has poor quality and reliability, and the data is rarely in a form suitable for mapping and analysis purposes. In addition, industrial data are often difficult to interpret. Any need for "second guessing" the meaning of data usually turns them into a liability. The extraction of useful information can therefore be cumbersome and expensive. This is especially the case for dynamic data such as demand patterns, stock-level variations and performance data. Structural data regarding products, equipment, and personnel are often more reliable, and easier to access from the ERP-system.

Although the investigative sources also are time consuming and expensive to pursue, they are often the only way to fully understand (and thereby reengineer) the enterprise. The processes involved are often complex and poorly documented. Consequently, it should be a normal practice not to accept the validity of a enterprise map unless there is supporting evidence either from activity sampling or alternative process flow analysis. Activity sampling involves a large number of instantaneous observations of one or more workers or equipment items in a representative period of time. The study enables an estimate of the proportion of total time spent in a activity. "Walking the processes" is often an easier approach, and can result in the most amazing insight into the real cause of poor performance.

The mapping dataset

A mapping dataset with information regarding resources, products, material flows, etc. should be constructed. This dataset should contain the necessary facts for the enterprise mapping. If possible, dynamic data regarding volumes, demand variations and performance should also be collected from the ERP-system. A specification of the data needed for each view in the operations model (resources, processes, materials, information, organisation, and control) is provided in table 2.

Such a mapping dataset provides the necessary basis to build a operations model-set for the existing situation. The data collection should limit itself to data that are easily available, and not dwell in too many details. The rule of thumb is to collect enough data to get an understanding of the situation, and not use too much effort in an excessive data analysis.

Table 2 The mapping dataset

Resources	Processes	Materials	Information	Organisation	Control
Layout - Product line - U-form - I-form - Cellular - Functional Resources - machines - handling eq. - transport eq. - personel Value chain network - Suppliers - Transporters - Wholesalers - Customers	Administrative processes - Order handling - Procurement - Billing - Etc. Physical processes - Value added - Non value added - Non value added, but necessary Support processes - Maintenance - Quality Value chain processes - demand mgmt - inventory mgmt - collaborative forecasting and control,	Products - Structure (BOM) - Characteristics - Demand pattern Material flow Inventories Material flow in value chain - Distribution (cross docking, CP, direct shipment) - Demand pattern at different actors	Information system design - Structure - Integration vs seperate - Visual deployment tool Information flow Value chain Information flow - Forecasts - Orders - etc. - Data comm. format	Structure - Hiearchial - Matrix - Process oriented Responsibility vs delegation - Teamwork - Individual - Skills - Knowledge Rewarding system Roles in the value chain - Roles of different actors - Contract principles	CODP Control areas Control principles Main KPI's Main processes Physical and administrative Repl. principles Value chain control - CODP position in the value chain - Control principles - Value chain KPI measures

Note that the mapping should provide a clear understanding and definition of market requirements (which should be specified in the control category). Without such an understanding, an enterprise can not be effectively constructed. The requirements of the enterprise will vary by customer, by product, by locations etc. The mapping should provide a clear statement of due date expectations, service requirements, and methods of acquisition and delivery etc. for each market segment. Furthermore, the performance measures for the project must be defined and measured. In many cases, performance data can be extracted from the ERP-system. However, firms often do not record the information vital to their own improvement activities. In such cases, a system has to be put in place to measure the current performance. For example, if the ERP-system keeps track of order releases and completion dates, then lead time can be constructed. Another way is to use a paper trail, such as a tagging sheet that accompanies the job throughout the process.

MAPPING STAGE 2: THE AS-IS OPERATIONS MODEL

The mapping aims to create high-level, graphical representations of the enterprise (the AS-IS operations model) that can support understanding, debate and redesign. The AS-IS operations model should be based on facts that are gained from the initial data collection and analysis, and provide graphical representations for each view of the enterprise. The six modelling views and some suggested modelling templates are described below:

Resources: A map of the current layout of all equipment should be included. An overall layout shows the current allocation and utilisation of factory space (how much space that is devoted to different operations, inventories etc). A more detailed layout, that shows the location of all equipment and each process in the plant, is some times required for further analysis of the material flow.

Materials: A high level mapping provides an overall picture of the material flow, and enables decisions makers to highlight material flow inefficiencies. Material flow mapping emphasise move distances and showing flow pattern - to scale – with a facility layout or a geographical map as a background. To do a

high level material flow mapping, take some representative samples of high volume products or parts and trace their movement through the manufacturing system or supply chain. Some template symbols for material flow mapping are proposed in Figure 4.

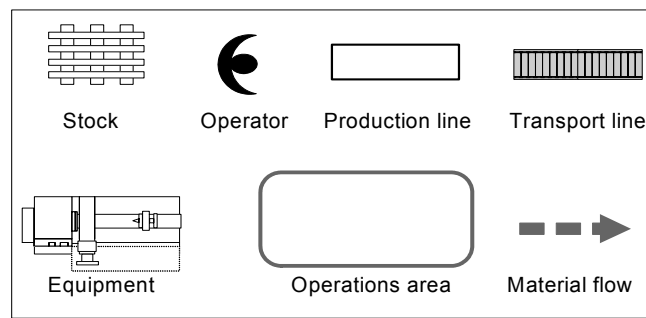


Figure 4 Template symbols for material flow modelling

Processes: From a process perspective, an enterprise is a group of activities that transforms raw materials into products and perform managerial transactions. Process mapping means to document the activities and how they are related in terms of process stages and flows. The process mapping should result in process maps that illustrate the processing steps for each targeted product family in manufacturing and office operations. A process map is schematic and shows the logical relations between activities. The term stage (or task) is used to indicate that multiple activities have been pulled together for analysis purposes. Several standard graphical formats exist, for example flow charts, input/output diagrams, and IDEF0 diagrams, but any consistent presentation of the processes will do.

Some template symbols for process mapping in administrative and manufacturing operations are proposed in Figure 5.

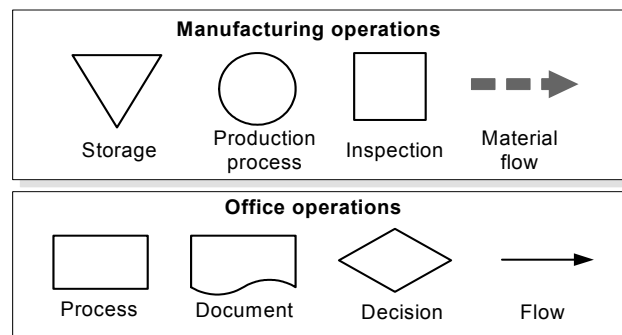


Figure 5 Template symbols for process mapping

The mapping of *manufacturing processes* includes all process steps from reception, part production, subassembly, final assembly and shipment. In many cases it is preferable to start with the final product. Take some high volume product families and map their process steps backwards through the manufacturing system. It is also preferable to start by mapping high-level processes. This ensures that the overall picture is provided in a reasonable amount of time. Details can be added later if needed. The mapping of *administrative processes* includes the whole order processing cycle from order entry, credit checking, quote writing, design engineering, production and inventory allocation, shipment, and invoicing. Use customer and market information to identify families of "information deliverables" or office processing "outcomes". Such a deliverable might be a quotation, a production plan, an invoice, or a folder containing production specifications for a physical item. A family of deliverables require similar processing steps through the office.

Information: From an information perspective, an enterprise is a group of function executions (transforming an input state into an output state) supported by information flows. Some of the functions and flows in this "information system" are automated, and a array of techniques can be used by systems analysts to model the IT-infrastructure. Common examples are IDEF0, Data Flow Diagrams, and Entity Relation Diagrams (Kubeck, 1995) However, such techniques are meant for detailed modelling and programming, and are not very suited to provide an overall picture of the total information system. A combination of a "rich picture" (Checkland and Scholes, 2004) and a Data Flow Diagram (a "rich Data Flow Diagram") should therefore be developed in order to model systems, functions, databases, users and dataflow. Some template symbols for information flow mapping are proposed in Figure 6.

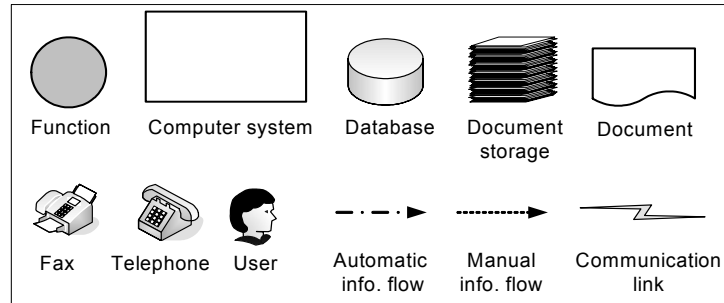


Figure 6 Template symbols for information flow modelling

The result of an information flow mapping is an informal representation that allows the user to understand the existing IT-infrastructure and how the technology affect work processes and information flows.

Organisation: The personnel should be mapped in an organisational chart, which shows the distribution of responsibilities, authorities and competencies in the work organisation.

Control: From a control view, the enterprise can be seen as a network of organizational entities (decisions and operations centres), each having some degree of autonomy and intelligence to solve problems in its area of competence, and communicating with other enterprise entities. A control view should therefore provide a "decomposed" representation of the enterprise that highlights local requirements (Chen and Doumeingts, 1996). It is possible to model the complete enterprise (both manufacturing and office operations), as being composed of several smaller operations areas with workstations that perform "like" functions. Such a control model represents a holistic synthesis (with a special focus on control issues) of the other models that are developed in the mapping. Some template symbols for developing control models are proposed in figure 7.

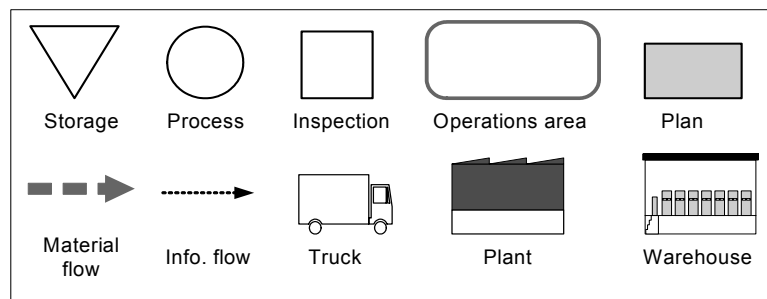


Figure 7 Template symbols for developing control models

An example of the overall control model for the M-24 production line at Hydro Aluminium Structures (HAST) is shown in figure 8.

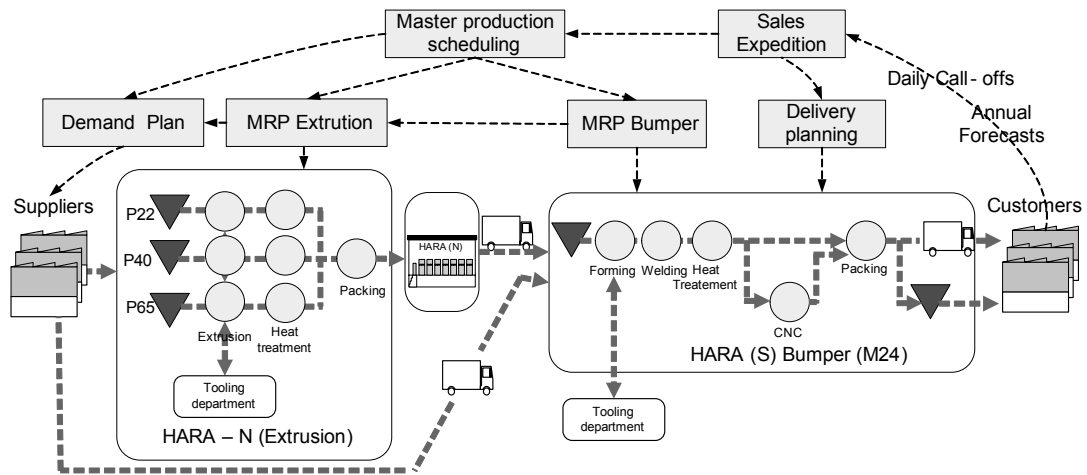


Figure 8 Control model for HAST

The views that are proposed reflect distinct, though complementary, perspectives of the enterprise. In spite of the fact that the models involved are describing the same enterprise, each of them is unique and stands alone because each serves quite different purposes. For example, a resource layout drawing exists independently of, and is clearly different from, a process model diagram. Looking at a layout drawing tells very little about the work flows. Only assumptions can be made about the processes, depending upon how descriptively named the resources are in the layout model (and vice versa for the process model). The type of models and modelling methods used depends on the purpose of the enterprise engineering effort, and the targeted decisions area (supply network, process technology, layout, job design, planning and control). For some purposes, a synthesis of the different views can be useful. Even though the same concepts are modelled twice in such a model-set, the synthesised representation can provide an overall picture that are useful for understanding and communication.

CONCLUSIONS AND FURTHER RESEARCH

This paper has presented an Operations Model, including a Control Model, developed to support reengineering of operational processes in The Enterprise Reengineering Methodology. The methodology has been applied in reengineering of more than twenty manufacturing enterprises. The Operations Model contains six views to be mapped and modelled, and provides examples of symbols that can be used to represent each view. The Operations Model can be used to generate coarse description models of the enterprise operations. The description models enable managers to map, analyse and redesign operations. A first set of template symbols for modelling of each view is developed. The template set is unified across the views, allowing an interrelated model set. The templates support the ability to create visual models for improved understanding and communication in analysing and redesign of operation management systems. The research gives an improved understanding of the use of enterprise models in reengineering manufacturing enterprises. They provide tools for mapping, analyse and redesign of operations in where:

- They can be developed in a short period of time, and with a moderated consumption of resources
- They use a language and tools comprehensible by managers and decisions-makers
- They can be used to generate the AS-IS and TO-BE models and thereby facilitate design and implementation of improved operational processes

The main limitations of the methodology, models and templates are:

- The manufacturing enterprise focus different from a true supply chain perspective
- The need for human interaction in mapping of information from ICT systems

Main future research areas are

- To change and expand focus of methodology and models into a true supply chain perspective
- To improve the template set and to allow for direct mapping based on ICT systems and databases

- To improve the guidelines for design
 - To integrate quantitative decision support tools into the model-set
 - To establish a set of design elements for operations strategy development
 - To use the Operations Model as basis for developing Control Dashboards and Studios
- These areas will be pursued in several ongoing research projects at NTNU/SINTEF.

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