Supply Chain Control Dashboards

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Abstract

This paper presents a concept of an ICT-based Supply Chain Control Dashboard supporting control of the material flow and processes. The concept is developed based on a methodology for mapping, modelling, analysing and redesigning the value chains for extended manufacturing enterprises, the Control Model.

The Supply Chain Dashboard supports the monitoring, analysis and management of the supply chain performance. It supports decision making by visually displaying in true time leading and lagging indicators in a supply chain process perspective. The dashboard offers support for the three application areas: monitoring, analysis and management and contain three types of indicators; performance, diagnostic and control, and allows drilldown and aggregation functionality

The Supply Chain Dashboard concept serves as basis for a Supply Chain studio that will allow rapid decision making based on real-time information at an aggregated level along the entire value chain.

1 Introduction

In today's global economy, manufacturing enterprises must be viewed in the context of their contribution to the total value chain. Extended or Virtual Enterprises, consisting of electronically mediated chains of suppliers, manufacturers, assemblers, distributors and customers compete to supply products to sources of demand. Authors stress that networked organisations will be the pre-dominant model of the future (Stevens at al 2001).

The trend in manufacturing has moved towards the optimisation of their total “supply” or “value” chain. The development and operations of Extended Manufacturing Enterprises often suffer from insufficient co-operation within the manufacturing company as well as from inefficient collaboration with customers and suppliers (Sanders and Premus 2005). In the majority of cases inefficient information and communication transparency and standardisation often causes poor collaboration and additional loops of adjustments and operational control in the value chain. Today a vast majority of the numerical demand analysis is based on forecasts and assumptions rather than real-time information and facts.

Successful operation of global value chain requires that decision making at all levels can be performed in a setting where relevant information is transparent and can be accessed from any place in the value chain in true time. The aim of this paper is to develop a concept of supply chain control dashboard for manufacturing enterprises. The research issues addressed in this paper is which information should be covered in the studio, how the relation between the operation model and the studio is, and how must the information be organized and displayed in the studio.

2 Research methodology

The aim of this paper is to develop a theoretical concept of a supply chain dashboard. Thus the research strategy followed is a combination of a theoretical discussion, and case studies that are exemplifying the suggested concept. Due to the characteristics of the research topic a considerable emphasis is put on the theoretical data.

The empirical data is collected from several case studies carried out in Norwegian industry. The case study approach is preferred due to the need for a deep and extensive study about thoughts and reflections of supply chain studio (Yin, 1994; Eisenhardt, 1998). Data is collected through discussions with key production and logistics representatives in the case companies, as well as abstractions of data from various mapping activities. This includes data as process descriptions, quantitative parameters as cost, time, frequencies, and volumes, performance measures, ICT-system descriptions, etc. The data sets are analyzed through traditional quantitative and qualitative approaches as statistical processing and textual interpretations of field notes. Additionally, similar case studies from other companies and research projects are used to illustrated specific aspects of the developed supply chain studio. These studies are notified in the text.

3 Operation of supply chain and the importance of information

Today one of the most significant competitive enablers is innovative supply chain systems based on collaborative models between companies which see the needs of coordinating the supply, production and delivery processes. Supply chain management, which according to Simchi-Levi et al. (2003) is *"a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produces and distributed at the right quantities, to the right locations, and the right time, in order to minimize system wide cost while satisfying service level requirements"*, is both a management philosophy and a strategy for active operation and integration of the company's market and supply relations. Here active operation means that the company together with suppliers and customers forms an aligned supply chain system with a holistic operation of the flow of material and information.

Collaboration in the supply chain has a wide range of forms with one common goal: to gain information and to create a transparent, visible demand pattern that paces the entire supply chain (Holweg et al. 2005). Information and visibility is considered as *"The Holy Grail"* leading to higher predictability and insight into the demand situation which will prevent the "bullwhip" and artificial demand amplification. The effect is a reduction in inventory level, improved service level, and a reduction in stock-out situations. Several studies have identified the problems caused by a lack of information and to what extent competitive advantages can be gained from a seamless supply chain (Forrester, 1961; Lee et al., 1997; Chen et al., 2000).

Even though formidable amount of information is created in the supply chain there is still is 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). As humans are we subjected to bounded rationality which means that we are endowed with limited, powerful analytical and data processing apparatus. However this does not imply irrationality. Instead, although bonded rational agents experience limits in forming and solving complex problems and in processing information they otherwise remain "intendedly" rational (Williamson, 1981). Thus 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 proliferation of information and communication technology (ICT), e-business solution and internet technology has enabled information sharing, new ways of working, and changed the way organisations interact and communicate. It opens up for an extended sharing, storing and distribution of information between manufacturers, their suppliers and their customers which have significant implications for operation of the supply chain (Silberberger 2003; Thoben et al. 2002). Thus, real time information is regarded as significant in the operation of supply chain leading to reduced inventory and cost levels, improved transactions efficiency and planning processes and better performance (Busi and Dreyer 2004).

4 What is a performance dashboard?

A performance dashboard is more than a screen with performance graphics on it: it is a complete business information system that is built on a business intelligence and data integration structure. A performance dashboard is very different from plain dashboards or scorecards. The latter are simply visual display mechanisms to deliver performance information in a user-friendly way, whereas performance dashboards knit together the data, applications, and rules that drive what users see on their screens.

"A performance dashboard is really a performance management system. It communicates strategic objectives and enables business people to measure, monitor, and manage the key activities and processes needed to achieve their goals" (Eckerson, 2005).

4.1 Historical context

Although dashboards have long been a fixture in automobiles and other vehicles, the concept is only recently adopted in industry. The dashboard basically has two historical roots in industry:

1 The development of executive information systems (EIS) in the 1980s, which aimed to provide (basically financial) information to top managers. Today, executive dashboards that provide managers with high level business intelligence are widespread in industry. A key feature of such dashboards is that they are tailored to what senior managers and branch-level management can control (Atkinson et. al, 1995).

2 The development of control rooms in the process industry, where a few operators can monitor and control entire plants through their computer screens and keyboards. In contrast to executive dashboards, such "process dashboards" are designed to provide summary performance updates for specific processes (Chase et. al, 2004). They integrate information from a high number of automated equipment to a high level process model. The dashboard provides a selection of performance metrics presented in graphical form with colour-coding of trend lines, alarms in the form of exclamation marks, and so forth, to show when key indicators are nearing a problem level.

In the few last years, a range of software vendors provide commercial executive dashboard solutions[1]. These software products provide the technical architecture and functionality for executive dashboards. However, the actual dashboard building still requires extensive customisation. In manufacturing, the development of information architectures (such as manufacturing execution systems and enterprise resource planning systems) has enabled a performance Information is captured from (mainly automated) operational processes, integrated in enterprise models, and distributed to decisions makers with digital information at all levels in the enterprise.

[1] Examples of such solutions are the "Dashboard Manager" offered by Business Objects, the "Corda Center View", the "Cognos Visualizer", the "Compliance Management Dashboard" offered by Hyperion, and the "SAS Information Delivery Portal", and "SAP BW" (Helleland et.al. 2005)

4.2 Application areas

A performance dashboard consists of three application areas – monitoring, analysis, and management – that deliver related sets of functionality and consists of multiple components.

- The monitoring application conveys critical information at a glance using timely and relevant data, usually with graphical elements;
- the analysis application let users analyse and explore performance data across multiple dimensions and at different levels of detail to get the root cause of problems and issues;
- the management application fosters communication among executives, managers, and staff and gives executives continuous feedback across a range of critical activities, enabling them to "steer" their enterprises in the right direction.

4.3 Architecture

Most performance dashboards let users navigate through three layers of information:

- a summarised graphical view (key performance indicators and exception conditions)
- a multidimensional (e.g. customer, product group, or time) and hierarchical view (e.g. enterprise, department, operations area),
- and a detailed view (e.g. invoices, work orders, shipments)

Users can access the performance dashboard at any of these layers. Most dashboards also allow users to start at the summarised graphical view and drill down along fairly predefined pathways through the multidimensional and detailed views. Such layered architectures therefore conform to the natural sequence in which decisions makers want to handle information before they take action: monitor, analyse and examine. By starting at high-level views of information and drilling down, such architecture helps users to get to the root cause of issues quickly and intuitively.

4.4 Technology platform

A performance dashboard extracts information from source systems, and displays them on a top-level screen. The information to populate metrics is provided from a data store that delivers near real-time information to the dashboard, or pulled directly from the source systems. Custom application programming interfaces (APIs) or enterprise applications integration (EAI) middleware are often used to capture events from source systems, move them across a network, and update a data store within the performance dashboard in near real time. In addition, performance dashboards may query data directly, using SQL queries or enterprise integration middleware. Both techniques enable developers to populate metrics with data from a variety of sources, including data warehouses, operational systems, and external sources such as XML-based web pages.

5 Supply Chain Dashboard concept

This section explains the concept of a dashboard for supply chain control that has been developed. The concept has been the basis for development and testing in different cases and across different application areas.

The work has been performed working with following definition:

> *The Supply Chain Dashboard supports the monitoring, analysis and management of the supply chain performance. It supports decision making by visually displaying in true time leading and lagging indicators in a supply chain process perspective.*

The concept can be characterised by the following main issues and features (described more in detail in the following parts of this section):

- The dashboard must be based on, and be a visualisation of a model of the supply chain control. This model is denoted Control Model, as a part of a complete Operations Model
- The dashboard offers support for the three application areas: monitoring, analysis and management
- The dashboard contain three types of indicators; performance, diagnostic and control
- The dashboard utilises visualisation for speeding up the recognition process
- The dashboard must allow drilldown and aggregation functionality along the following: in time, in products, in actors/locations
- The dashboard must have inbuilt functionality for relating indicators in one-to-may and many-to-one product structures along the value chain
- The dashboard must contain simulation functionality for what-if analysis of possible decisions to adjust control indicators

The main benefits of applying the dashboard for supply chain control are:

- The access to true-time monitoring facilities at a high level
- A true value chain perspective (different from a single actor perspective)
- Speeding up recognition and decision making
- Integrated decision making (for instance purchasing and production control)

5.1 Control Model as basis for dashboard

The dashboard should support decision making of the operations (operation management). To succeed in this the dashboard concept must be developed in a one-to-one relation to control principles applied in the value chain. Therefore a generic visual model of the control aspects is defined as a vital part of an Operations Model.

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 value chain. A control model is normally developed by the following building blocks:

- customer order decoupling point (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)
- main operations processes (operations and buffers)
- operations areas (specifying which operations that is one area of responsibility)
- material flow (specifying main routes through the operations processes)
- information flow (specifying the flow of information related to value chain)

The Control Model is the key model in the comprehensive Operations Model. To develop a suitable Control Model is the core activity in an enterprise reengineering project. One of the application areas of the Control Model is to decompose the decisions-making process into operations areas, and thereby specify how different parts of the operations process are supported by different control principles and methods.

The Operations Model proposes six views that should be modelled, and provide examples of models that can be used to represent each view. These views are:

- resource view

- material view
- information view
- process view
- organisation view
- control view

The control view is the view that represented by the Control Model.

A framework that illustrates the relationships between these different views is shown in Figure 1, and denoted Operations Model.

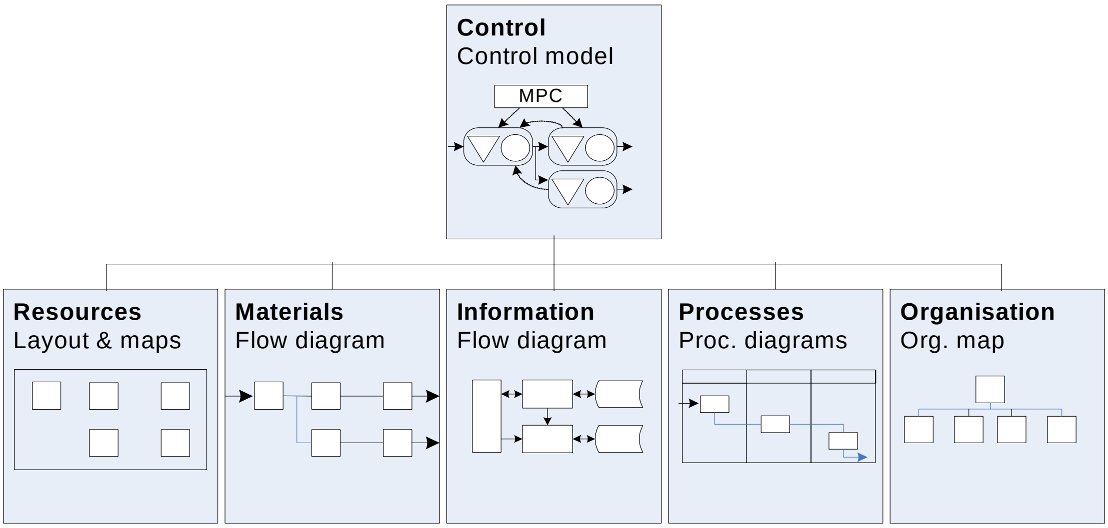

Figure 1: The Operation Model

Figure 1 shows the different views in an operations model-set and examples of models that can represent each view. Furthermore, it illustrates that the core concepts from each view should be synthesized in the Control Model.

A simplified example of a Control Model for a manufacturing enterprise is shown in figure 2. This model is based on a set of predefined templates and modelling principles. The core idea is that the supply chain dashboard solution for the same enterprise should be based on this Control Model, as shown in figure 3.

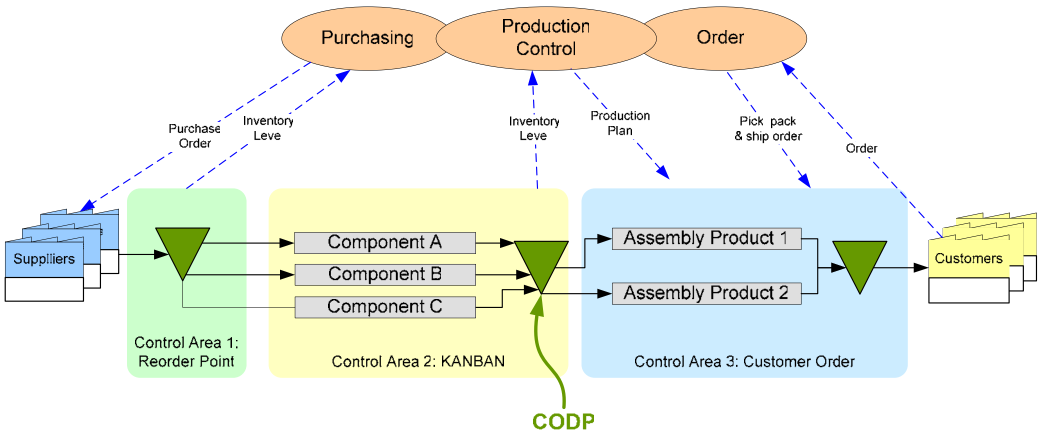

Figure 2 Control Model for Manufacturing Enterprise

In this simplified example, the Control Model shows the suppliers and customer, the main manufacturing processes, including assembly, the buffers/stores, the control areas and information flows and administrative processes.

Figure 3 shows the main dashboard screen for the value chain, where the same process, actors and control areas are found. In this mode value chain speed is chosen as the indicator, showing this indicator at the different stages/processes of the value chain. Arrows are used to indicate whether the speed is increasing or decreasing. More details of the facilities of the dashboard concept are described in the following sections.

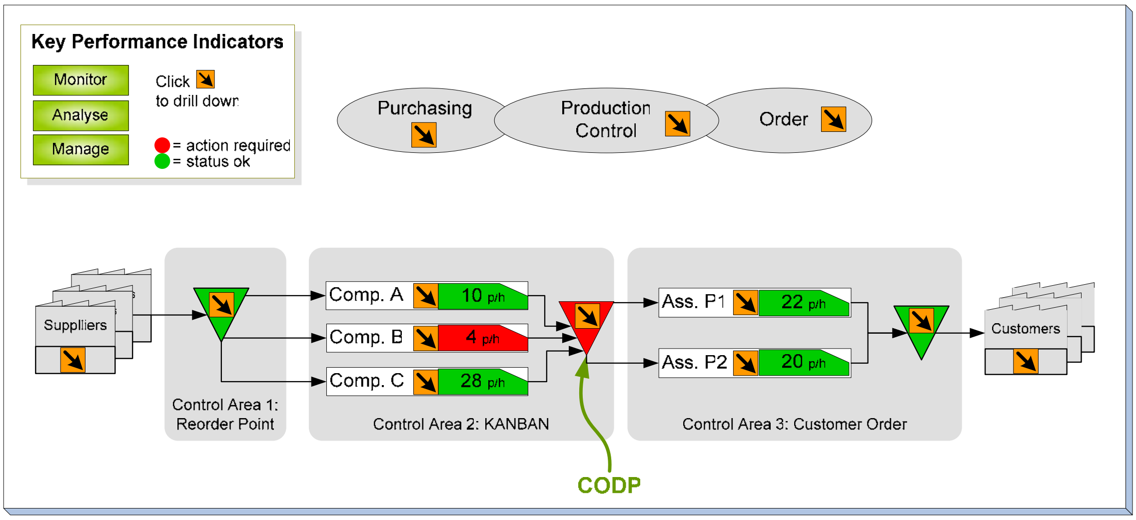

Figure 3 Supply Chain Dashboard based on a Control Model

5.2 The three application areas: monitoring, analysis and management

As defined by Eckerson (2005), a performance dashboard consists of three applications – monitoring, analysis, and management – that deliver related sets of functionality and consists of multiple components.

- The monitoring application conveys critical information at a glance using timely and relevant data. Typically this means that the dashboard use is that of watching; if the values are within expectation nothing is done. Alert functions are important features of this application areas;
- The analysis application let users analyse and explore performance data across multiple dimensions and at different levels of detail to get the root cause of problems and issues. In this application area it is typically that diagnostics indictors are related to performance indictors to understand the causes, and explain changes that have occurred. The dashboard use in this application area is more like the business intelligence approach, but based on a predefined set.
- The management application fosters communication among executives, managers, and staff. Typically this application is a mixture of following performance, diagnostic and control indicators.

5.3 Three types of indicators; leading, lagging, and diagnostic

Metrics used in performance dashboards are typically called key performance indicators because they measure how well the enterprise or individual perform an activity that is critical for the current and future success of the company. There are three major types of KPIs:

leading, lagging, and diagnostic. *Leading indicators* measure activities that have a significant effect on future performance, whereas *lagging indicators*, such as most financial metrics, measure the output of past activity. Leading indicators measure activity either in its current state (e.g. number of products produced today) or in a future state (e.g. number of products scheduled for the next two weeks), the latter being more powerful because it gives decisions makers more time to influence the outcome. Some measures do not necessarily fit into a leading and lagging indicator category, but they are still important to capture. In most cases, these metrics signal the health of various processes. Niven (2002) calls these types of KPIs *diagnostic metrics*.

A supply chain dashboard should contain lagging indicators that quantifies the degree to which a supply chain fulfils performance objectives regarding costs, quality, delivery precision, delivery time, and innovativeness. Such indicators are output parameters, and their current values have often very limited influence on what will happen next in the supply chain.

The dashboard should also use leading and diagnostic metrics to support the monitoring of the current and future state of processes. Examples of indicators that can be used to measure the state of the supply chain today and in the future are:

- number of products sold per hour
- number of products produced per hour
- number of orders/order lines per day
- product defects per million
- stock levels
- the location, destination and cargo of trucks
- demand variation per day

These numbers are compared with recent historical data, such as performance during the past several hours, days or weeks. When performance goes above or below an expected norm, the system triggers an alert.

5.4 Visualisation for speeding up the recognition process

Graphics are used to speed up the modelling, the recognition process and the decisions making at three levels in the models and the dashboard:

- Graphical templates are used to create the elements of the control model
- Relations and flows are visualised rather than described by words and tables
- Values and metrics are displayed by graphics and symbols rather than tables

The latter of these is shown in Figure 4. Rather than showing the table of the left hand part of Figure 4, the graphics of the right hand part is implemented in the dashboard.

Customer response time (days)

	Customer 1	Customer 2	Customer 3
Order 1	5	13	6
Order 2	4	14	8
Order 3	3	15	9
Order 4	3	18	8
Order 5	2	13	7
Order 6	3	13	3
Order 7	6	15	3
Order 8	7	6	3
Order 9	7	7	4
Order 10	5	9	6
Order 11	4	5	5
Avg	4,5	11,6	5,6
Min	2	5	3
Max	7	18	9

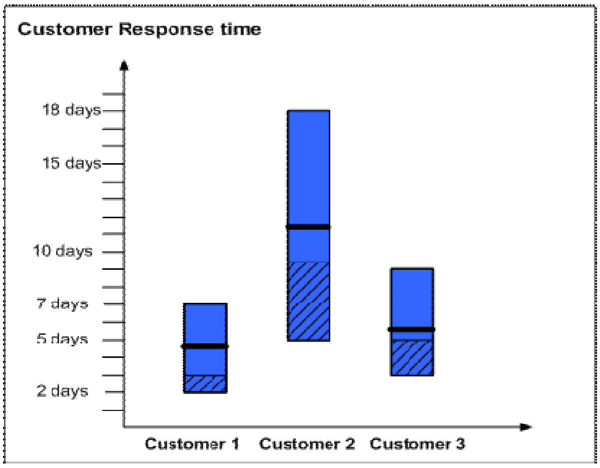

Figure 4 The supply chain dashboard should enable easy performance display and analysis

5.5 Drilldown and aggregation facilities

Dependent of the information needs and the use of the dashboard, data can be accessed at several layers. In table 1 a set of drill down and aggregation dimensions and detail levels are suggested based on the categories organisation, process, resources, geography, products, and time.

Table 1: Possible dimensions and levels of detail

Organisation	Process	Resources	Geography	Products	Time
Supply chain	Supply chain	Supply Chain	Global	Total	Year
Company	Enterprise	Company	Continent	Product	Month
Department	Process	Department	Region	Component	Week
Operations area	Sub-process	Machines/personel	Country	Part	Day
Individual	Activity		City	Material	Hour

5.6 Functionality and indicators for enhancing transparency in the supply chain

Transparency can be improved by dashboards that allow decisions makers to see the total material flow of their particular product in the supply chain. Figure 5 illustrates a simplified example of a product structure where the end product, a car is separated into different modules (e.g. wheel suspensions) and components (e.g. bolts).

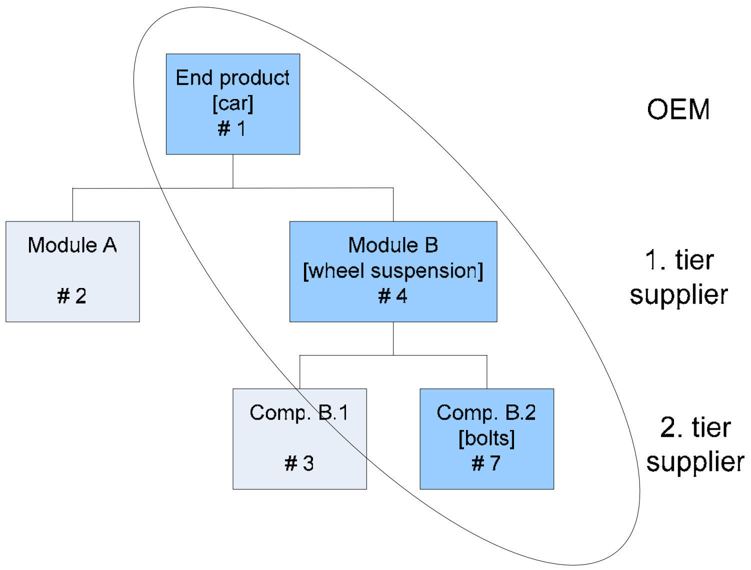

Figure 5 A typical BOM in the car industry

Figure 5 indicates the number of item for different actors along the supply chain. A car has 4 wheel suspensions, while every wheel suspension has (among many other components) 7 bolts. The dashboard should allow each actor in this chain to see the material flow of their particular product. This concept is illustrated in Figure 6.

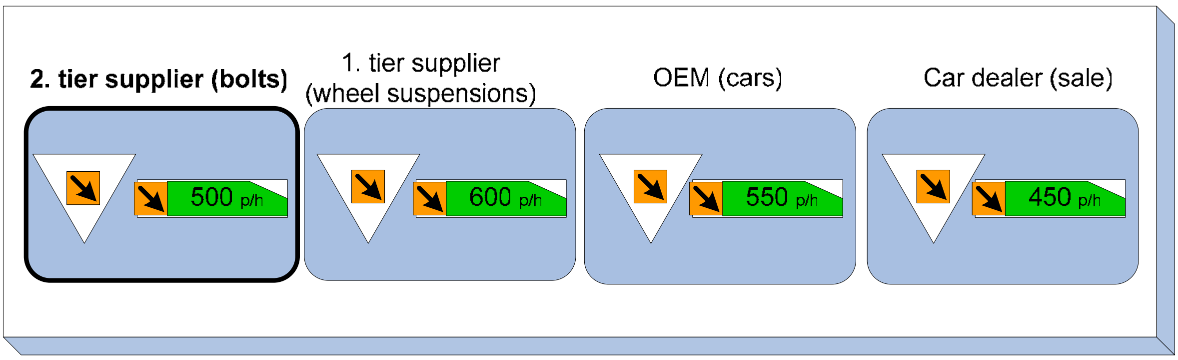

Figure 6: The 2 tier suppliers view of the material flow (as no. of bolts) in the supply chain

Figure 6 shows an dashboard example for the 2 tier supplier, which are able to monitor (and act upon) the flow of bolts in the entire supply chain.

5.7 Simulation facilities

Simulation capabilities are integrated into the dashboard in order to evaluate off-line the building blocks specified within the Control Model, such as policies, procedures, and material and information flows. A variety of output measures, such as costs, inventory levels and customer service, can be estimated for current and alternative configurations. In addition, the effect of alternative procurement, production and distribution plans can be assessed for different possible future scenarios. The simulation techniques can be very varied and include all from simple static deterministic cost calculations and analytic queuing models to advanced dynamic discrete-event simulation models.

6 Cases

The concept has been basis for development and testing in different cases and across different application areas. Table 2 contains a list of examples.

Table 2: Examples of applications

Company/value chain	Purpose
Slaughter company	On-line control of the number of animals slaughtered, i.e produced versus planned production
Pharmacy value chain (Automed)	On-line control of flow of material (storage levels and…)
Supplier –OEM value chain	Value chain performance measurement
Car part manufacturer (RCT)	On-line monitoring of process parameters and number of produced parts

Two of these cases are described in this chapter.

6.1 Case RCT

Raufoss Technology (RCT) develops and manufactures aluminium alloy chassis components for the automotive industry. Due to a substantial contract with General Motors (GM), RCT built a new plant at Raufoss, Norway, where production was started up in January 2002. As a 1st and 2nd tier supplier to the automotive industry, RCT faced extreme customer demands of zero defects, 100 % delivery precision, and contractual annual improvement. The combination of these demands, together with high volumes of identical parts, fully automated manufacturing, a small number of suppliers and very few components, made RCT very vulnerable to any kind of disturbances.

As an initiative to address some of these challenges, a Supply Chain Coordination Centre (SCCC) was established at Raufoss, where an essential element was the implementation of new ICT solutions integrated with the existing ERP system – in the form of a Supply Chain Dashboard. The framework for the dashboard is depicted in Figure 7.

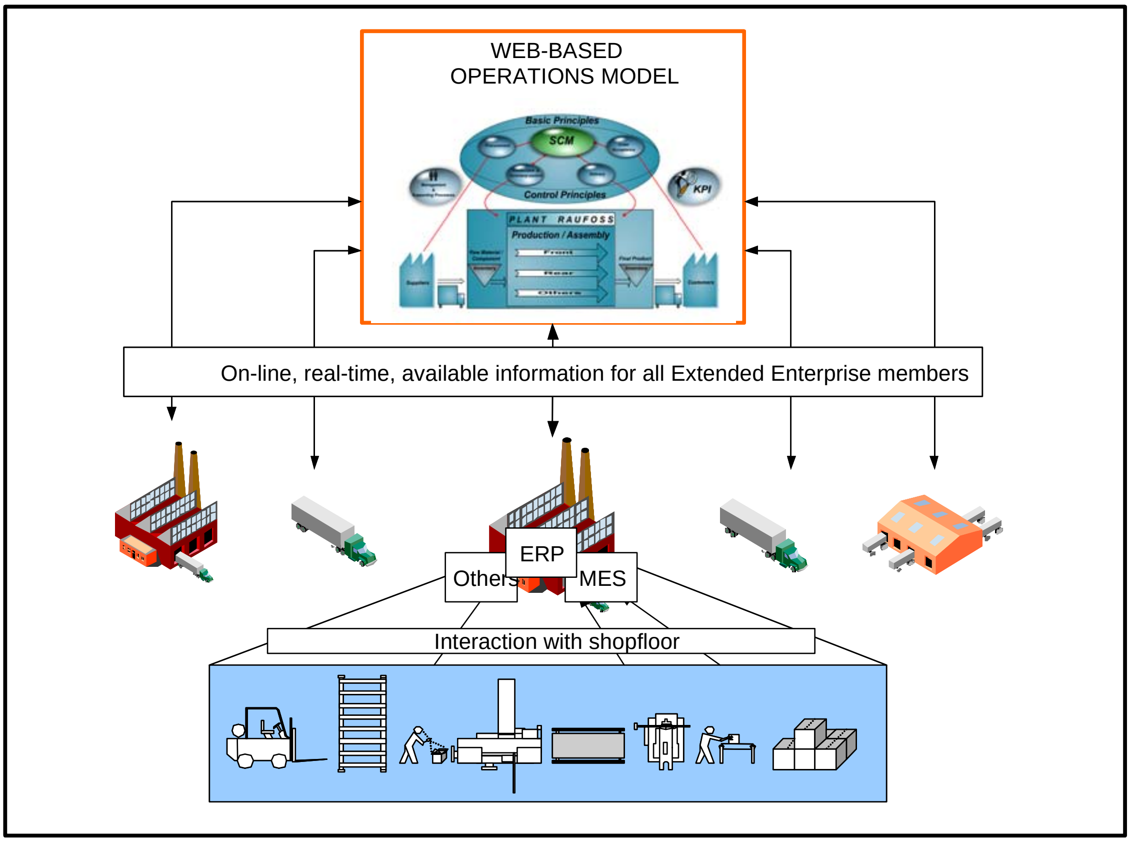

Figure 7: Framework for Supply Chain Dashboard (Source: Johnsen, 2003)

One view of this dashboard was the RCT Dashboard which addressed the organisation of internal operations of the factory. To respond to customer demands, RCT was dependent on knowledgeable operators working in teams, controlling resources and tasks based on real time information. The dashboard integrated the different information systems and was made accessible to operators through the company Intranet.

At the basis of the RCT Dashboard was the RCT Operations Model, specifying control areas, material and information flow and the planning process. Material flow and manufacturing process status data was visualised at computer workstations on the shop floor. In addition, to enable fast response to changes, this supported the team based organisation and a highly motivated work force. Maintenance, tool changes etc. became easier to synchronise to the manufacturing rate. The production status data was collected by Siemens WinCC production data collection system, and both visualised on the shop floor and communicated to the ERP system and the SCCC team. Figure 8 shows a screen shot from the RCT Dashboard at the lowest level of operations.

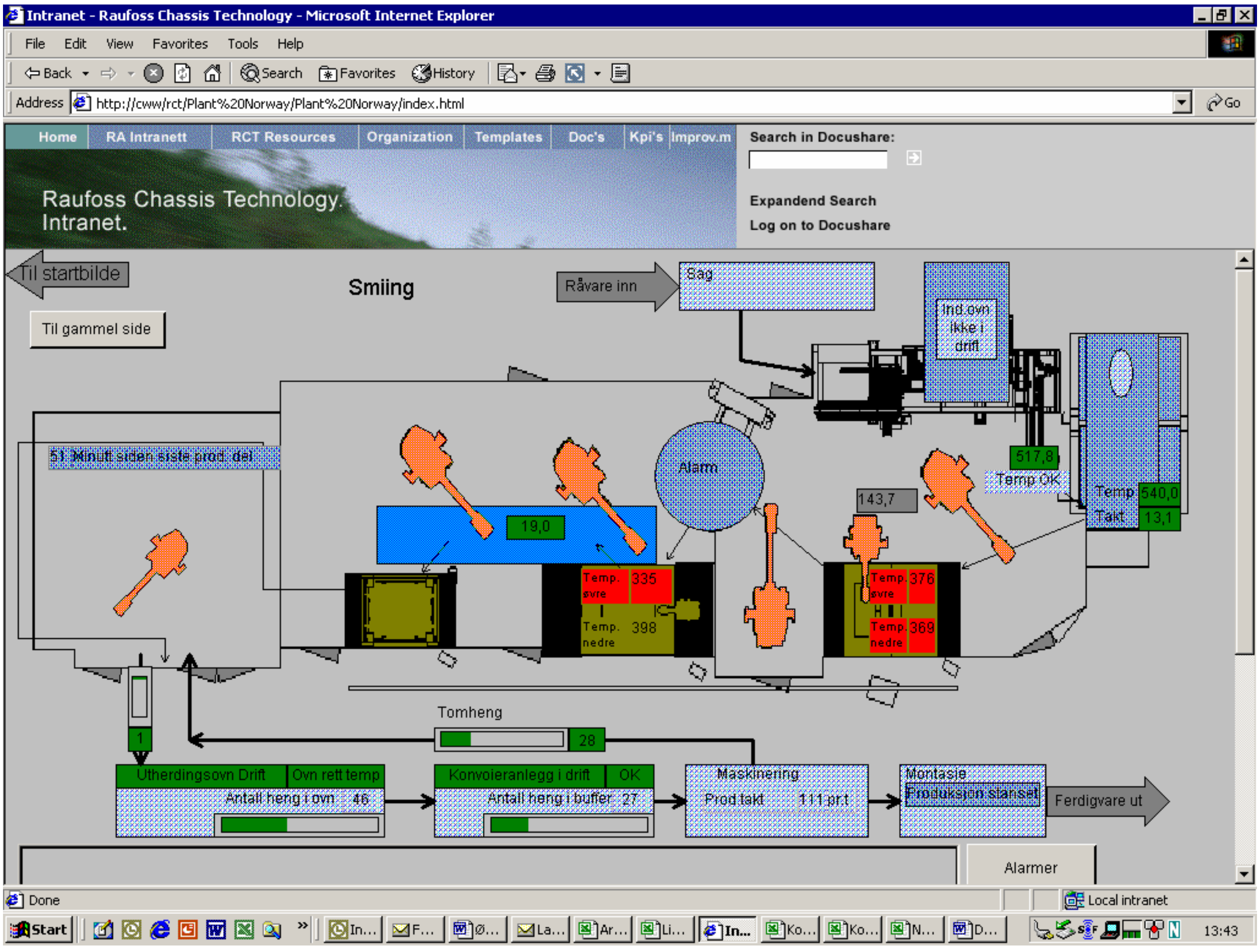

Figure 8: Screen shot of WinCC at RCT – lowest level of detail

This particular screen contains a simplified layout of the manufacturing line with red, yellow or green lights on different stations along the line. Green light is an "OK" signal, while a red light means the specific station is in alarm status, and has stopped. Yellow light means the station is unstable, with process parameters outside control limits but not outside tolerance limits. This is similar to the Toyota Production System ANDON principle (Monden, 1998).

6.2 Case Automed

A holistic and balanced view of the production, distribution and demand system in the pharmaceutical business will lead to a efficient, responsive, leaner and timeliness supply chain. Coordinating supply and demand across the various companies in the supply chain has significant importance in order to secure reliable deliveries in a industry characterised of global production and logistics, and often high value and essential products. A decrease in inventory levels, reduced costs, shorter lead time, lesser stock out situations, etc. are some of the effects of an integrated supply chain operation model in this sector (Figure 9). In the AUTOMED project a Control Model is developed between Actavis (a global manufacturer of generic pharmaceuticals), Apokjeden (a Norwegian wholesaler of pharmaceuticals) and Apotek1 (a Norwegian pharmacy retail chain) in order to allow automated replenishment of pharmaceuticals based on point-of-sale-data (POS-data).

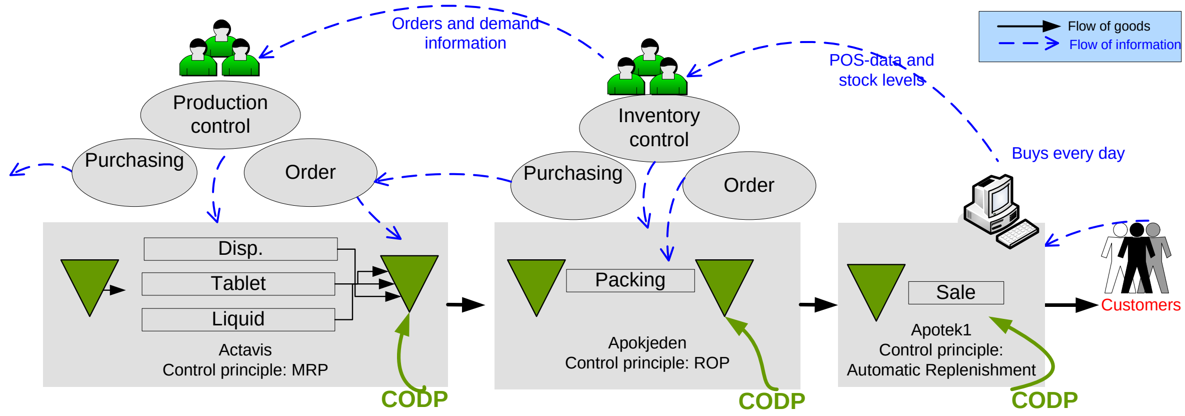

Figure 9: Supply chain Control Model for AUTOMED

Figure 9 shows how the order and control processes generate production, packing and delivery actions based on real time demand information. Each pharmacy gets continuously replenishment deliveries from the wholesaler which is electronically executed based on POS-data and stock level information. The planning and control processes in each company are integrated. Between the companies the planning and control function is coordinated and based on a make/delivery to order strategy. Due to the characteristics of the operations model the customer order decoupling point (CODP) is placed after production (finished goods inventory) and after the wholesalers packing operation.

Such a holistic and integrated approach actualizes the need for information and knowledge about status and performance of the total flow of material and information in the supply chain. In order to act, plan and improve the companies need a real time and joint picture of key system characteristics and due to this the idea to develop a supply chain dashboard came up. The intention of the dashboard is to act as a central coordinating unit, generating planning and control information, offering monitoring and analyze capacity and most important of all to abstract and visualize key information elements Figure 10.

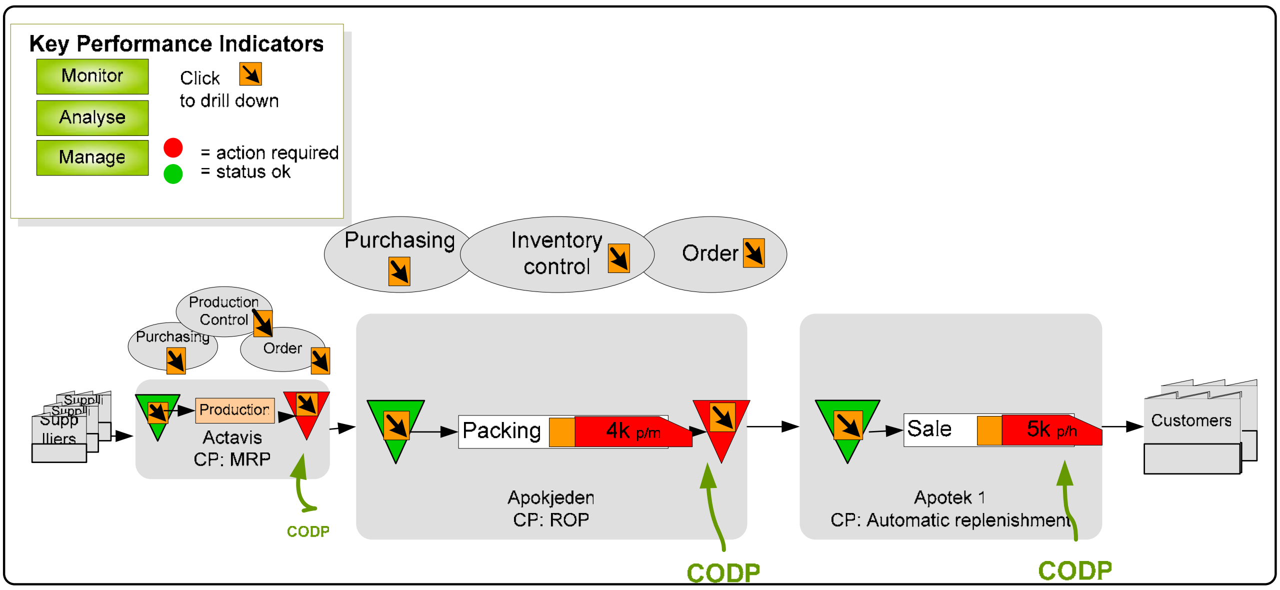

Figure 10: AUTOMED supply chain dashboard

Figure 10 illustrates the AUTOMED supply chain dashboard level 1 which show a status of the activity and throughput level at a given period. Here we see the speed and level of production, packing and sale per hour and how the levels relate to a given capacity. Symbols with red marks show either a lack of capacity or excess capacity at inventories, production of packing facilities. Green symbols illustrate an accepted activity level. Orange marked symbols has a drilldown function which means that lower level of time, product, process/actor/location can be displayed.

7 Towards a Supply chain control studio

Supply chain dashboards provide decisions makers with timely and accurate information, and enable them to control the supply chain more efficiently. However, the building of a dashboard is just the first step in the development of efficient supply chain control. The next step is to develop "Supply Chain Control Studios" – environments for efficient decision making and collaboration.

Figure 11: Example of a Supply Chain Control Studio

Figure 11 show a supply chain control studio. Integration of ICT systems can make digital information available across traditional company boarders and functions. ICT systems gather and visualises information from the ERP-system, production system and customers. Examples of technologies that can be included in the studio are large projected displays, interactive whiteboards, wireless keyboard and mouse, and an SMS system for wireless coordination of team activities. Combined, these technologies facilitate creative flow across different working situations.

Traditional functional organisation is sufficient for administration and production of standard products with stable demand, and low requirements regarding delivery time and delivery precision. Demand for fast response time, variable demand and high delivery precision require a new way of organising people - team organisation. Through team organisation you reduce the amount of levels in the decision process and avoid frequent changes of responsibility. The different functions and tasks are gathered in a team, and this gives effective decision making and control.

Decision makers in a studio should be organised as a team performing the tasks together while accessing the same information. This reduces the number of functional borders in the decision process, and makes it possible to avoid frequent changes of responsibility. Thus, the organisation becomes more flexible and responsive with teams. Alternatively, each decision maker can be given total responsibility for all control tasks associated with one special customer or product family. Both alternatives secure Single Point Of Contact and an organisation performing all control tasks related to orders, production and procurement fast and effectively

Introduction of supply chain control studios throughout the supply chain enable effective collaboration between the actors. Figure 12 illustrate the concept of a virtual supply chain control studio that connects the individual studios at the different actors.

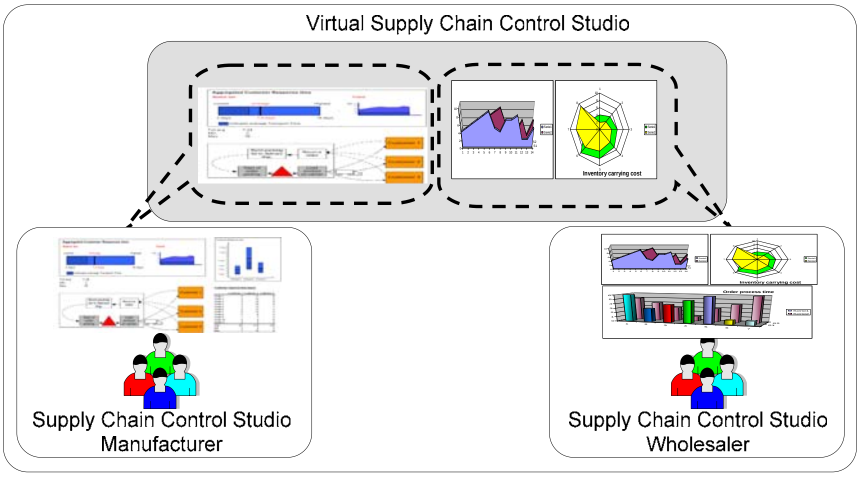

Figure 12: Virtual Supply Chain Control Studio

Through the construction of a set of integrated Control Studios, different actors in the supply chain can make joint decisions and see the consequences of their own decisions. The result is a more synchronised material flow and more complete deliveries.

8 Conclusions

In today's global economy, manufacturing enterprises must be viewed in the context of their contribution to the total value chain. Collaboration in the supply chain has a wide range of forms with one common goal: to gain information and to create a transparent, visible demand pattern that paces the entire supply chain. Even though formidable amount of information is created in the supply chain there is still is a challenge related to the absorption, utilisation and grasping of the information.

As a contribution to close this gap a concept for a Supply Chain Dashboard that supports the monitoring, analysis and management of the supply chain performance has been developed. It supports decision making by visually displaying in true time leading and lagging indicators in a supply chain process perspective.

The concept can be characterised by the following main issues and features:

- The dashboard must be based on, and be a visualisation of a Control Model of the supply chain
- The dashboard offers support for the three application areas: monitoring, analysis and management and contain three types of indicators; performance, diagnostic and control
- The dashboard utilises visualisation and allows drilldown and aggregation functionality

The main benefits of applying the dashboard for supply chain control are:

- The access to true-time monitoring facilities at a high level
- A true value chain perspective (different from a single actor perspective)
- Speeding up recognition and decision making
- Integrated decision making (for instance purchasing and production control)

The Supply Chain Dashboard concept has been applied as the basis for several case-implementations across different application areas. In these cases pilot implementations have been developed leading to decrease in inventory levels, reduced costs, shorter lead time and lesser stock out situations.

The Supply Chain Dashboard concept serves as basis for the next research step which is to develop "Supply Chain Control Studios" – environments for efficient decision making and collaboration. Main efforts to achieve the realisation of such studios are the development, definition and implementation of leading and diagnostics indicators, as well as the ICT platforms.

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