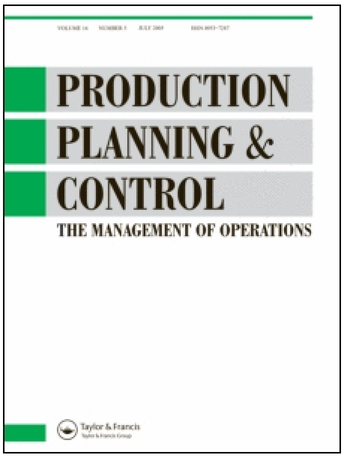

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Global supply chain control systems: a conceptual framework for the global control centre

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Global supply chain control systems: a conceptual framework for the global control centre

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The operation of global supply chains is challenging due to the complexity in product and information flows, diversity in sites, localisation and processes and the information processing needed for coordination and control. In order to be competitive, manufacturing supply networks should strive to use information to create transparent and visible demand patterns and to create an efficient balance of supply and demand by an integrated and coordinated manufacturing planning and control system. In this article, a framework for developing global control centres (GCCs) is presented that includes a global control model, performance measurement system, information and communications technology (ICT) and organisation of roles and responsibilities. The framework has been further tested in a company for realising a GCC. The main challenges for realisation include control issues, information handling and ICT and management of change and organisational resistance.

Keywords: global supply chain control; global operations management; case study; information and communications technology; manufacturing planning and control systems

1. Introduction

In recent years, there has been an increasing interest in supply chain management in both research and industry. In an operations management context, the supply chain perspective basically implies to expand the focus from internal operations in a single site/company to operations in a multi-site supply network. The main idea is to optimise supply chain operations in order to improve the overall performance.

For manufacturing planning and control (MPC), the supply chain perspective imposes challenges regarding coordination and integration (Vollmann *et al*. 2005). Lack of information sharing and transparency is often recognised as a key issue for companies that seek to increase coordination and integration in their supply chains. A highly transparent supply chain, where relevant information can be accessed in real time, can ensure that decision making and execution are consistent throughout the supply chain (Strandhagen *et al*. 2006).

A few attempts have been made to develop more integrated MPC concepts. Olhager and Wikner (2000) give an overview of various tools that can be used for MPC purposes in a single firm, including a toolbox of concepts and techniques, application system and performance measurement. Jonsson and Lindau (2002) present a supply chain planning studio concept that includes people and team, software functionality and studio environment. Rudberg and West (2008) describe the model factory concept for strategic decision making in global operations, which includes a model factory, network organisation and competence groups. However, in order to contribute to improved solutions for MPC in global supply networks, new concepts need to be deeply rooted in the supply chain perspective, incorporate decision making at a strategic as well as an operational level and be supported by empirical evidence.

There is a wide range of information and communications technology (ICT) that can be used to deal with the coordination and integration challenges in global MPC networks. Examples are enterprise resource planning (ERPII) systems, web interface devices for data exchange as extensive markup language (XML) and electronic data interchange (EDI). Transparent flows of information in the MPC network can be enabled by ICT such as sensor and radio frequency identification (RFID) technology, real-time monitoring system and visualisation applications.

This technology has enabled the development of dashboard concepts to improve transparency in operations planning and control. Performance dashboards are performance management systems that communicate strategic objectives and enable business

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people to measure, monitor and manage key processes (Eckerson 2005). Dashboards originate from the development of executive information systems and of control rooms in the process industry. Executive dashboards primarily aim to provide financial information to top and branch-level managers within the scope of their control (Atkinson *et al.* 1995) while process industry dashboards are designed to provide summary performance updates for specific processes (Chase *et al.* 2004). The concept of supply chain control dashboard has been developed to support control in a supply chain context. The supply chain dashboard represents a true supply chain perspective, enables visualisation of real-time information and supports control on all process levels, including shop floor processes (Strandhagen *et al.* 2006).

Through several research projects dealing with supply chain management at SINTEF, we have developed a conceptual framework for global MPC in supply networks. The scope of this framework is the single organisation, multi-site supply chain perspective, and is based on an integrated and coordinated MPC approach (Rudberg and Olhager 2003). The framework has been applied in a national research project called ORIGO, to design a global control centre (GCC) for planning and control in a global supply network.

In this article, we present our conceptual framework, which describes how companies can plan and control their operations in a global manufacturing supply network. The case company is Mustad, a multinational company incorporating a geographically widespread network of manufacturing facilities that provides fish hooks to customers worldwide. The current MPC structure is characterised by high supply chain design complexity and low level of network coordination. The purpose of this research is to show how Mustad will be able to manage its global manufacturing supply network by applying the conceptual framework.

The research methodology in this article is characterised by the purpose of the research and the authors' involvement in the concept development. The case study research strategy has formed the general study of the global operations of Mustad's manufacturing supply chain due to the need for in-depth insight of operations and planning and control processes (Eisenhardt 1989, Yin 1994). In this process, representatives from Mustad and the authors have mutually discussed and developed the elements in the GCC, following an action research methodology (Reason and Bradbury 2006). Mustad representatives have contributed with insight and empirical knowledge, and in workshops where elements in the concepts have been developed. The authors have both facilitated the process and contributed with knowledge. One of the authors has been the project manager and the other authors have been involved as research partners since the autumn of 2006. Both qualitative and quantitative data are used and analysed according to the case study strategy and action research methodology.

This article is organised as follows. First, the conceptual framework for GCCs is described. The GCC solution for Mustad is then presented, showing how the company can manage their global operations. Finally, we provide some key challenges that have importance in order to realise GCCs, and summarise the findings of this research.

2. A conceptual framework for GCCs

Supply networks can be divided into different types depending on specific characteristics (Rudberg and Olhager 2003). In global manufacturing networks, consisting of single-company and multi-site system, the MPC task can be fully operated, managed and organised under a single ownership structure. For such networks, centralised planning of capacity, material and distribution in the network, combined with local planning at each site (order deployment, shop floor operations, warehouse operations, transport), is most appropriate (Wortmann 2000).

The concept of GCCs aims at establishing coordinated and integrated operations control in supply networks and enabling efficient management of material flows and capacities in networks. Typical MPC processes include demand management, production, inventory and replenishment planning, monitoring and follow-up and strategic decision making. A GCC serves as an information and communication node that enables integrated operations activities and remote control in the supply network, across various geographical locations and organisational levels. Insight into and visualisation of processes and performance in the supply network are key elements of the centre. The GCC enables managers at each local node in the network to collaborate virtually and make decisions based on up-to-date information. Decisions are made both in decentralised and centralised settings where specified decisions are made locally at each node and other overall control tasks are made collectively by the virtual team in order to optimise the supply network. A number of issues need to be taken into consideration for the design of GCCs. These are further described below.

2.1. *Supply chain MPC*

Manufacturing planning and control in a multi-site supply network is to decide what, who, when and how to act in order to meet customer demands with the exact supply in a coordinated chain (Vollmann *et al.* 2005, Jonsson 2008). The MPC system must support cross-company processes in a manner that does not increase lead and response times, amplifications and inventory levels. Factories and distribution facilities affect the other nodes and, hence, cannot be managed in isolation (Shi and Gregory 1998). A holistic, integrated and coordinated MPC design that builds seamless processes across organisational and geographical boundaries is required.

The functionality and number of GCCs in a network will depend on the MPC task, which will depend on the network type (Wortmann 2000). Hierarchical supply networks can be planned centrally, and a single control centre might be sufficient. Collaborative networks with equal partners require communication and convergence of plans. Several control centres might be required for such networks.

For all networks, a central element in the MPC design is to create full visibility into the actual supply situation and the end-customers' needs. Being able to respond on insight and detailed knowledge about the current and future situation allows the actors to be more flexible in order to decide how and when they wish to fulfil demand requirements.

The MPC task will be performed locally and coordinated centrally. Local tasks are defined by each site's primary role in the network. This ensures a structured decision-making approach, which is based on an aggregate view combined with local insight.

2.2. *Global control model*

The control model constitutes the underlying logic and the defined control principles in the supply network, and is the formalisation of the MPC design (Alfnes 2005). It consists of descriptions and illustrations of how the flow of material and information should be, and what principles to use. The control model is typically based on the following building blocks:

- Customer order decoupling points (specifying the part of the supply chain that is controlled by customer order).
- Control principles and methods (specified for the chain and for each operations area).
- Main operations processes (operations and buffers).
- Operations areas (specifying the operations that constitute an area of responsibility).
- Material flow (specifying the main routes through the operations processes).
- Information flow (specifying the flow of information related to the supply chain).

In a supply network, there will be a mixture of principles which must be aligned with the manufacturing environment and the actual control situation of the supply network. Automation can be built into the specified control model by converting the control principles into mathematical algorithms, expressions and logic. When this is combined with electronic software solutions and data calculation capacities, the operative MPC decisions as when to replenish, deliver and produce can be partly or fully automated.

2.3. *Performance and control indicators*

Performance and control indicators measure how well the operations in the supply chain are performed, and are critical for the current and future success of the supply chain. There are three major types of indicators: leading, lagging and diagnostic (Busi 2005). Leading indicators measure activities that have an effect on future performance, whereas lagging indicators, such as financial metrics, measure the output of past activity. Leading indicators measure activity either in its current state or in its future state, the latter being more powerful because it gives decision 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 because they signal the health of various processes (Niven 2002).

Supply chain metrics should contain both lagging and leading indicators, as well as diagnostic measures. Lagging indicators will provide for signals of how well the supply chain fulfils performance objectives regarding responsiveness, speed, efficiency and coordination (Vollmann *et al.* 2005). Leading and diagnostics indicators will support the monitoring of the current and future state of the supply chain processes. The indicators should be defined according to the major characteristics of the supply chain and the competitive situation.

2.4. *Decision support*

A primary role of GCCs is to provide decision support for the control of materials and information flow in the multi-site manufacturing supply chain. Decision areas typically include operational, tactical and strategic issues such as material planning and control, inventory management, and overall supply chain structure and design.

A GCC will consist of a set of analytical and methodological tools and techniques available for both local and global decision making such as systems for production scheduling, transport routing, network design etc. The tools will vary from simple quantitative calculations and qualitative analyses to advanced mathematical and statistical analytical programs. The decision support platform will require powerful electronic data processing capacity and will create fast and accurate information input when it is needed. This is decisive for adjusting capacity, reallocation of stock units, dispatching of rush orders and so on.

Decision support in a GCC is based on visual display of the relevant information that the team needs to be able to make decisions. A key solution is the performance dashboard, which presents and visualises key performance measurements that are used for control. The dashboard ensures that decisions are based on key performance indicators (KPIs) related to the overall performance of the network.

2.5. *ICT*

Access to update and real-time information is essential in a control centre. Real-time information leads to higher predictability and insight into the demand situation that can prevent the 'bullwhip effect' (Forrester 1961, Lee *et al*. 1997, Chen *et al*. 2000, Holweg *et al*. 2005). Decision making and control have to be performed in a setting where relevant information is accessible and updated, and can be accessed from any place in the supply network. Hence the incorporation of real-time-based process information in a GCC requires technology that can capture, process, store, extract and visualise a significant amount of information (Ling and Goddard 1988, Liff and Posey 2004).

In order to meet the different types of information demand, a GCC is founded on various ICT-based systems and applications such as business intelligence applications, ERP systems, RFID, production and inventory management systems, customer relationship management (CRM) systems and forecasting and planning tools.

2.6. *Roles and responsibility*

The organisation of GCC activities is team oriented. This type of structure ensures an efficient decision process and flexibility in allocation of tasks and responsibilities (Teasley *et al*. 2000, Kristensen *et al*. 2005). This structure gives further support for meeting customer service requirements. A GCC does not only serve as a single-point-of-contact for information and communication between manufacturing sites in the network, but also as an important interface towards external customers and suppliers. This means that the members of a GCC management team must be able to provide high quality services to all parts of the network, its suppliers and customers.

2.7. *Centre environment*

The network planning team is primarily physically located at the centre, in an open office environment. A GCC consists primarily of virtual workspaces and interfaces supporting collaboration between the GCC team and the local managers at the different manufacturing sites. Efficient communication is enabled through large projected displays, interactive whiteboards, wireless technologies, portable devices and video conference systems. When integrated, these various solutions support communication and information flow across sites and departments in the network and gather all information for decision making to the centre.

3. The GCC for fish hooks

In this section the conceptual framework is applied to Mustad.

3.1. *The Mustad supply chain – current state*

Mustad is the world leading supplier of fish hooks and fishing tackle. Mustad is the leading hook brand worldwide, and products are exported to more than 160 countries. Customer requirements differ within different geographical regions, application type (recreational, sport, industry, sea) and customer type (wholesalers, retailers, original equipment manufacturers). Mustad has facilities for manufacturing, assembly, packing and distribution in eight countries worldwide, including Norway, China, Singapore, Philippines, USA, Dominican Republic, Brazil and Portugal (Figures 1 and 2).

Traditionally, the supply network is characterised by fully decentralised control. Decisions regarding inventory levels and product programs are made independently on each site. Production and market forecasts are shared only in a limited degree, and there is an overall lack of coordination across the different supply chain sites. Mustad's fish hooks have a Y-shaped product variant structure, with very few raw materials (mainly steel wires) and a large number of sizes, shapes, surface treatments and packaging,

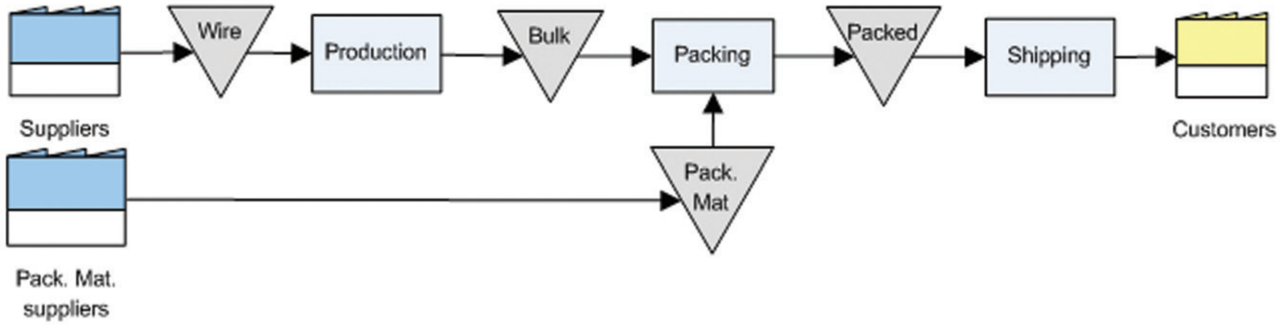

Figure 1. Mustad material flow.

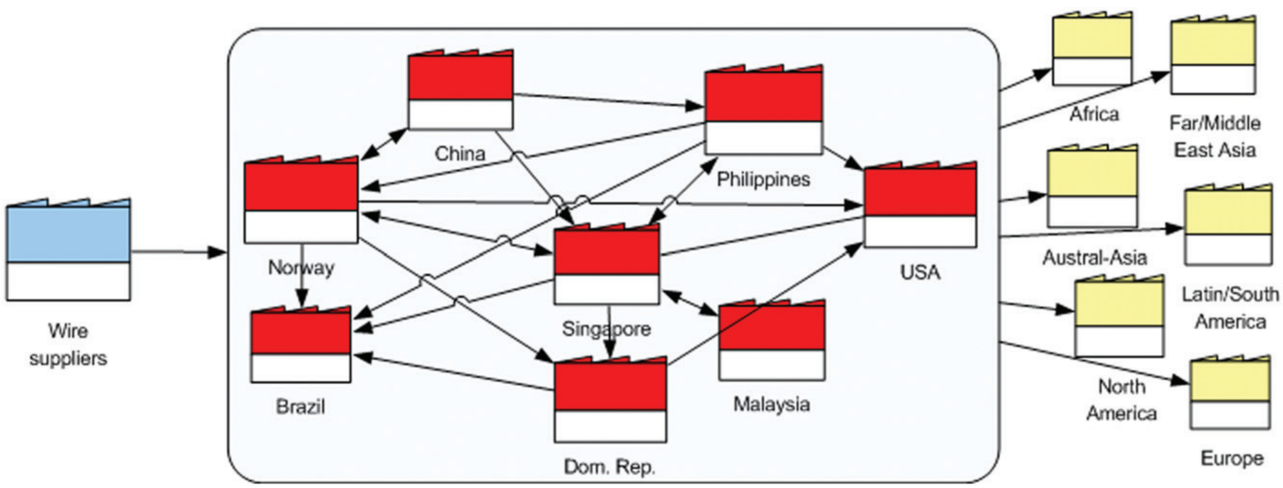

Figure 2. Overview of the Mustad supply network.

totalling about 12,000 finished product variants. In addition, Mustad is trading a range of complementary fishing equipment. A broad range of product variants is seen as a necessary condition for maintaining Mustad's leading position, and Mustad currently has about 20,000 stock keeping units (SKUs).

The major production processes at Mustad are machining, hardening, platening and packing. The hooks are produced in batches, and due to high set-up costs, the minimum production run is approximately 30,000 hooks. For small volume products, this implies that more than 1 year of demand is made in one batch. Finished goods inventories are buffers for demand and lead time variations. Inventory of bright hooks (before plating) and bulk hooks (before packing) are used as a buffer against production capacity constraints.

The main control strategy at Mustad is make-to-stock. Production, inventory and transportation control are all based on this strategy due to the characteristics of the products, production and the global structure of the supply chain (Fisher 1997). Retail customers are supplied within 48 hours from regional finished goods inventories. Other customers are supplied within 1 month, which leaves some flexibility in the choice of supply mode. In addition, a major proportion of customer orders are time planned orders with typical lead times of more than 3 months. Replenishment is based on traditional order point models and manual control.

The company has been facing major logistics challenges. The total stock turn is low, at about 1.5 years, meaning that a product is kept in stock for about 35 weeks in average. The lead times in their supply chain are large, with an average manufacturing lead time of 8–12 weeks, and transportation lead times between 1 and 12 weeks (depending on whether air or sea transport is used). In addition, the supply network is very complex because of the global localisation plants, warehouses and markets, and a high number of SKUs. Certain products can be produced only at certain sites, and there is a large degree of internal transactions and transportation. A mapping of material flows showed a true 'spaghetti' structure (Figure 2).

3.2. *The GCC*

Mustad wants to improve its efficiency and performance through a reengineering of its supply network. The reengineering effort encompasses structural changes (capacities, facility location and distribution structure) and MPC changes. A key element of its new strategy, and the focus of this article, is the development of a supply chain centre which utilises modern ICT to integrate and control its global operations.

The GCC will become the central information hub in the Mustad supply chain, and is based on a combination of various computer-based systems and information technology tools to capture, process, present, store and distribute the information needed. The main element in the GCC is illustrated in Figure 3. At the lowest level, it describes the main physical and administrative processes where operations are a local responsibility and where control information is created and transformed as input to the GCC. The main responsibility of the GCC is supply chain design, supply and demand management, aggregated MPC and monitoring. The centre is led by a manager, who participates in the corporate management team at Mustad.

The design of the GCC for Mustad is based on three major criteria guides. Firstly, all important activities and decisions across the supply network should be integrated and unified in the GCC in order to make all chains more efficient and responsive. Secondly, strategic, tactical and operation supply chain levels should be integrated in the GCC in order to create a supply network that supports corporate strategy. Thirdly, global supply chain control and the local control at each site are carried out collaboratively by virtual teams. The control centre is further described below.

3.2.1. *Supply chain MPC*

The physical supply network consists of suppliers, plants, warehouses and distribution centres, as well as raw materials, work-in progress inventory and finished products that flow between the facilities. Given the overall structure of the network, the control centre is responsible for how Mustad designs and manages each supply chain in order to find the right balance between demand and inventory level, transportation frequency and manufacturing volume. The supply chain design process consists of three major activities:

- Resource allocation, which includes determining where (on which plant) production and packing operations for different products are carried out, and the capacity levels each plant should have to meet demand fluctuations.
- Distribution structure and inventory positioning, which includes determining stocking points, network flows, transport modes and service levels.

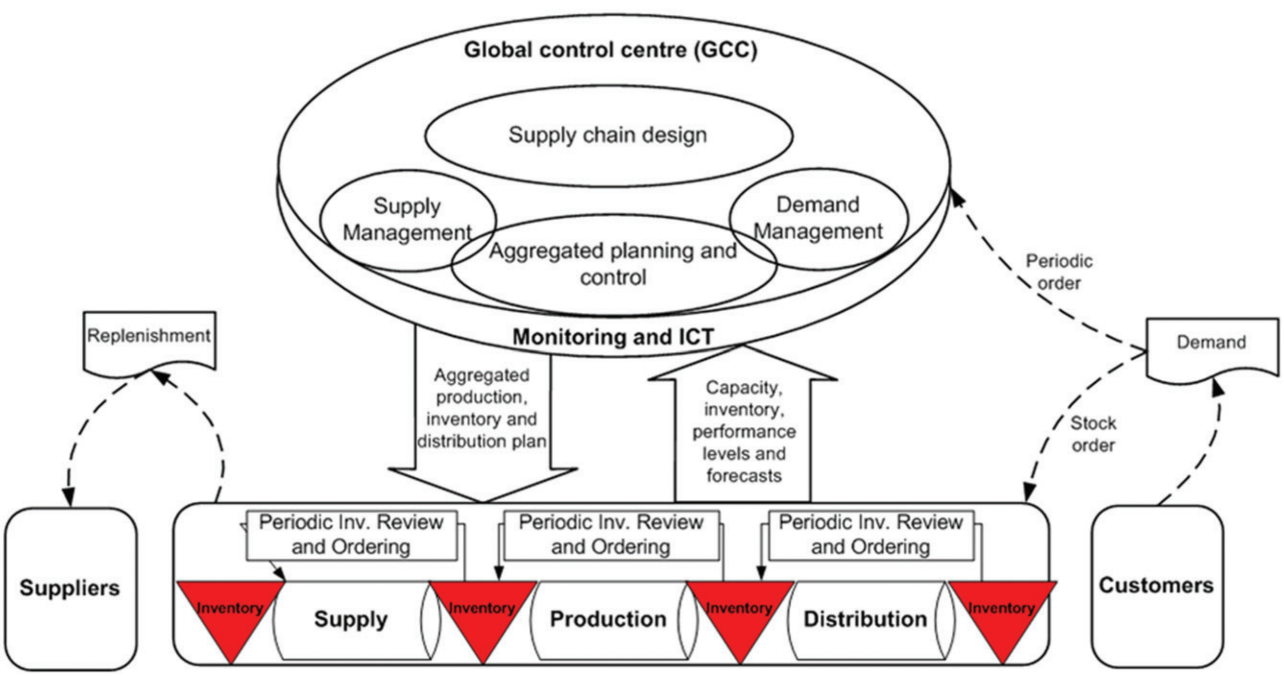

Figure 3. The GCC at Mustad.

- Diagnosis and strategic decisions support, which includes information gathering, analyses, process development and design and communication with the corporate management in Mustad.

3.2.2. *The global control model*

The MPC activities at the centre are based on a new and unified control model including new planning and control practices.

Firstly, a new global inventory positioning programme that aims to streamline material flows and inventory levels in the supply chain is developed. The programme is based on order history/input from local sales units, and defines products and service levels for each warehouse based on ABC classification. For small volume products, the programme defines whether they should be produced-to-order, packed-to-order or stored centrally (i.e. at one single location).

Secondly, demand management (forecasting, order entry, distribution planning and so on) should be carried out locally at each site, but give input for aggregated planning and control in the GCC. The local forecasts are basic building blocks for forecasts at all levels.

Thirdly, replenishment of stocks at all levels should be carried out locally based on a periodic review system. The quantity on hand of a particular item is determined at specific, fixed-time intervals, and the order quantity will equal the difference between on hand quantity and the maximum inventory level set by the GCC. The periodic review system is useful in this supply chain because of the high set-up costs in production. Items from several warehouses may then be coordinated and ordered together to make up a production run.

Fourth, large time planned orders should be controlled by the GCC. Based on the forecasted demand and capacity situation, due dates and volumes are promised, and the orders are integrated in an overall master plan. The master plan will consist of delivery schedules and maximum stock levels, and balance considerations of production, transport and total inventory costs. The master plan will thus serve as a framework for local planning and scheduling.

3.2.3. *Performance and control indicators*

A major task is to develop a performance measurement system for the entire network with uniform indicators that will constitute an essential input to the decision support solution at the GCC. Indicators must be valid and unambiguous for the supply chain to permit aggregation and facilitate comparison of measures across the supply chain. The performance system at Mustad should have the following KPIs:

- GCC: overall productivity (kpcs/day), inventory levels (in piece and currency), plan accuracy (%).
- Warehouse final goods: inventory levels (in pieces and currency), delivery precision (% delivered on-time).
- Packaging: productivity (kpcs/man-hours), plan accuracy (%).
- Warehouse bulk goods: inventory levels (in pieces and currency), delivery precision (% delivered on-time).
- Production: productivity (kpcs/man-hours), plan accuracy (%).

3.2.4. *ICT and decision support*

The core decisions support in the GCC is provided by a multi-site and central ERP system. The ERP system includes functionality for supply chain planning and for local planning at each site, and is implemented locally at the different sites as well as at the GCC. This permits an information hub model supporting the capture of information on a local level and aggregation on a global level. Standard ERP functionality for sales and operations planning, master production scheduling, material and capacity planning and inventory planning will be used in the GCC. In addition, customised decision support is developed for supply chain design planning. Shared standards and formats are applied in order to facilitate an efficient flow of information and avoid format conversion. The ERP system is further integrated with CRM system and other support systems implemented at the centre. This integrated network of ICT-based systems and applications constitutes an infrastructure for the realisation of a consistent and congruent control model for the global supply network.

3.2.5. *Roles and responsibilities*

For Mustad, it is important to establish an organisational structure that truly supports the process towards becoming a supply chain oriented company. The organisational model must clearly define the relationship between the individual sites, the GCC team, and the headquarters. The GCC team consists of managers located at the centre. In addition, managers representing the specific local sites are part of the extended GCC team. The responsibility of the GCC team is both at a strategic and a tactical level, including, for instance, monitoring overall performance, planning and setting direction in order to match supply and demand, and utilising resources effectively in the entire supply network. The team is responsible for the following supply chain planning and control activities:

- Overall supply chain design, including strategic decisions regarding structure, nodes and linkages, and internal transactions in the network.
- Demand management, including market/demand monitoring, aggregated forecasting, order entry and processing of time planned orders.
- Aggregate planning and control, including monitoring of capacity, inventory and transport levels, and determining a master plan for production, packaging and distribution operations in the supply chain.
- Supply management, including supplier selection and assessment, and replenishment of raw material.
- Monitoring of supply chain performance and communication with local managers.

The local responsibility for the supply chain is somewhat reduced, as the overall control activities are transferred to the GCC team. Each local node is responsible for detailed production planning and scheduling, inventory management and replenishment, local demand management of make-to-stock orders and local distribution planning.

3.2.6. *Centre environment*

Mustad will develop a centre environment that improves the collaborative effectiveness and efficiency in the global network. The centre is designed to integrate physical arenas and virtual tools in a visual collaborative environment, and should enable the GCC team and local decision makers to collaborate globally on planning and control. The centre uses video conference systems and interactive whiteboards to visualise and share information from the ERP-system, production system and customers.

3.3. *Potential benefits*

The GCC is not fully implemented and, therefore, no data of the benefits of such a centre exist. However, based on the case study, company personnel and researchers collaboratively identified these potential benefits of a GCC at Mustad (Table 1).

As Table 1 indicates, the primary expected benefits of the GCC include improved responsiveness in the supply chain through lead time reduction, shorter delivery time and increased reliability and reduced inventory, transportation and administrative costs. Additionally, the quality and the efficiency in decision making and the coordination and control of the supply chain, are expected to increase.

4. Challenges

A number of challenges that are critical for realisation have been identified through the development of a GCC in Mustad. Some of them are specific for the Mustad case, and others are believed to have general implications for similar cases. These challenges are further described below.

4.1. *Global supply chain control*

Developing a global control model for Mustad implies a multidimensional approach dealing with several control parameters. The main control strategy at Mustad is make-to-stock, but there are several exceptions to this strategy. Slow moving items and products sold to limited market segments must be produced and transported by order, contradicting the main strategy. The development of planning methods that allocate inventory orders and customer orders to the same resources might be challenging. In addition, the implementation of global control through the GCC, combined with local control of each site, creates a number of challenges:

- Multi-site capacity planning. The level of automation, number of employees and lead times required to perform a certain operation will differ from site to site. The cost of adding extra capacity (because of wages etc.) will also differ from site to site. Overall capacity and demand calculations are, therefore, not straightforward.
- Supply chain integration requires standardisation. It is not until Mustad has reached a common understanding of processes, systems, roles and KPIs on a global scale that the major achievements from the supply chain orientation will be achieved. However, the GCC can serve as a central support for this standardisation process.
- Cultural differences. The way the new control model is adopted at each site might vary because of local differences in attitudes, traditions and knowledge levels.

Table 1. Potential benefits of the GCC.

Supply chain measure	Reduced costs/increased efficiency	Improved service/quality
Supply chain coordination and integration between sites	Increased utilisation of production and planning resources (economies of scale) Increased efficiency in delivery and shorter lead times Improved efficiency in inventories and transportation	Opportunities for developing additional services such as transportation tracking Opportunities to centralise common functions e.g. sourcing of products Redesign of supply chain structure, reduced complexity
Forming a GCC team, combination of competences	Reduced need for moving tasks between multiple functions Increased efficiency in decision-making processes Increased logistics support to internal sites	Higher level of responsiveness, better positioned for dealing with deviations Single-point-of-contact: one interface toward external partners Combination of competences gives better/more informed decisions
Focus on market needs, integration of functions	Shorter time for decision-making Reduced administrative/transaction costs	Increased focus on customer needs Quicker response to market demand and improved customer service levels Timely orders and delivery
A common platform for decision support	Increased efficiency in decision-making processes Increased coordination of IT, information and communication structures	Information gathered at one single place Improved data quality Improved coherence, common understanding

4.2. *Performance measurement*

It will be challenging for Mustad to develop a performance measurement system for the entire supply network, with uniform indicators that will constitute an essential input to the decision support solution at the GCC. This is due to the diversity in how the operations are performed. The technology and automation levels differ and so will the performance in the specific site. Indicators must be valid and unambiguous for the supply chain to permit aggregation and facilitate comparison of measures across the supply network. Indicators must be linked to vision, strategies and performance objectives defined for the entire system.

4.3. *Information handling and ICT*

As the GCC decision support heavily depends on information, issues regarding information and data management need to be dealt with. Firstly, aspects related to information sharing such as data quality, willingness to share information, confidentiality data security, availability of data and the large data volumes need to be considered to ensure a highly reliable planning system. Secondly, there are critical aspects related to technology selection and implementation. The ICT platform needs to have enough capacity to deal with the extensive amounts of data gathered from various sources. The system has to permit easy integration with other systems and interfaces, and there must be an overall coherence in information and IT support throughout the supply chain. Existing systems may need to be substituted entirely, or can be integrated with new applications. Thirdly, aspects related to aggregation and visualisation of information in order to display large amounts of information to enable efficient decision making further need to be considered. Information can be aggregated in many ways (per product group, per site, per customer, over time) and values can be shown as average, min–max, and basically a range of statistical measures.

4.4. *Change management*

For Mustad, it is important to establish an organisational structure that truly supports the process towards becoming a supply chain oriented company. The organisational model will have to clearly define the relationships between the individual sites, the GCC team and the headquarters, and how each organisational unit should work to optimise the performance of the whole network. A major challenge might be the local resistance to a re-organisation from autonomous units into centrally coordinated supply chain units. Loss of control and responsibility can lead to resistance and unexpected behaviour when management responsibility is transferred to the GCC team and the frame of operations is defined centrally. This organisational change needs to be supported by an incentive system that ensures a coordinated behaviour in the network.

5. Concluding remarks

In today's global economy, coordination and control of decentralised supply chains are important competitive issues due to increased outsourcing and specialisation of manufacturing activities. In order to be competitive, manufacturing supply networks should strive to use information to create transparent and visible demand patterns and to create an efficient balance of supply and demand by having an integrated and coordinated MPC system. In order to handle this complex situation, there is a need for developing new control concepts and tools based on information sharing and ICT. Vollmann *et al.* (2005) argue for the e-based MPC system, which utilises ICT as enabler for an integrated and unified MPC system in the supply network. This will create immediate access to demand information and thus reduce response time and increase flexibility.

As a contribution to this challenge, we have developed a concept for global control, the GCC, and shown how a centre can be developed for unified planning of Mustad's supply network. Mustad's supply network is a single-company and multi-site system, which means that the MPC task will be fully operated, managed and organised under a single ownership structure, a hierarchy (Child and Faulkner 1998). In terms of being hierarchical, the management team of Mustad can effectively make decisions and govern the multi-site system. Non-hierarchical networks, however, consist of several autonomous companies where the unified autocracy in the hierarchy is missing, which means that the realisation of GCCs must be the result of a collective decision made by the participants. Handling conflicting interests and harmonising processes and resources are aspects that will have to be embedded in the GCC framework in order to be applied in an inter-firm context.

The GCC as it is presented in this article has been approved by the Mustad management team and a centre will be implemented in 2009.

This research contributes with state-of-the-art knowledge for MPC in supply networks and insight into issues of complexity that need to be solved. Contributions to practice include the specific description of main components of the concept and its realisation in the Mustad supply chain. Challenges for the realisation of the concept have been addressed and thus they contribute to insight into development needs and resource requirements. The GCC is now being further developed for non-hierarchical networks.

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