Manufacturing

Moving Towards a Collaborative Supply Chain

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Material requirements planning

Material requirements planning (MRP) is a production planning and inventory control system used to manage manufacturing processes. Most MRP systems are software-based, while it is possible to conduct MRP by hand as well.

An MRP system is intended to simultaneously meet three objectives:

- Ensure materials and products are available for production and delivery to customers.
- Maintain the lowest possible level of inventory.
- Plan manufacturing activities, delivery schedules and purchasing activities.

History

Prior to MRP and before computers dominated the industry, reorder-point/reorder-quantity (ROP/ROQ) type methods like EOQ had been used in manufacturing and inventory management. In the 1960s, Joseph Orlicky studied the TOYOTA Manufacturing Program and developed Material Requirements Planning (MRP), and Oliver Wight and George Plossl then developed MRP into manufacturing resource planning (MRP II).[1] . Orlicky's book is entitled *The New Way of Life in Production and Inventory Management* (1975). By 1975, MRP was implemented in 150 companies. This number had grown to about 8,000 by 1981. In the 1980s, Joe Orlicky's MRP evolved into Oliver Wight's manufacturing resource planning (MRP II) which brings master scheduling, rough-cut capacity planning, capacity requirements planning and other concepts to classical MRP. By 1989, about one third of the software industry was MRP II software sold to American industry ($1.2 billion worth of software).[2]

The scope of MRP in manufacturing

The basic function of MRP system includes inventory control, bill of material processing and elementary scheduling. MRP helps organizations to maintain low inventory levels. It is used to plan manufacturing, purchasing and delivering activities.

"Manufacturing organizations, whatever their products, face the same daily practical problem - that customers want products to be available in a shorter time than it takes to make them. This means that some level of planning is required."

Companies need to control the types and quantities of materials they purchase, plan which products are to be produced and in what quantities and ensure that they are able to meet current and future customer demand, all at the lowest possible cost. Making a bad decision in any of these areas will make the company lose money. A few examples are given below:

- If a company purchases insufficient quantities of an item used in manufacturing, or the wrong item, they may be unable to meet contracts to supply products by the agreed date.
- If a company purchases excessive quantities of an item, money is being wasted - the excess quantity ties up cash while it remains as stock and may never even be used at all. However, some purchased items will have a minimum quantity that must be met, therefore, purchasing excess is necessary.
- Beginning production of an order at the wrong time can cause customer deadlines to be missed.

MRP is a tool to deal with these problems. It provides answers for several questions:

- *What* items are required?
- *How many* are required?
- *When* are they required?

MRP can be applied both to items that are purchased from outside suppliers and to sub-assemblies, produced internally, that are components of more complex items.

The data that must be considered include:

- The *end item* (or items) being created. This is sometimes called Independent Demand, or Level "0" on BOM (Bill of materials).
- How much is required at a time.
- When the quantities are required to meet demand.
- Shelf life of stored materials.
- Inventory status records. Records of *net* materials *available* for use already in stock (on hand) and materials on order from suppliers.
- Bills of materials. Details of the materials, components and sub-assemblies required to make each product.
- Planning Data. This includes all the restraints and directions to produce the end items. This includes such items as: Routings, Labor and Machine Standards, Quality and Testing Standards, Pull/Work Cell and Push commands, Lot sizing techniques (i.e. Fixed Lot Size, Lot-For-Lot, Economic Order Quantity), Scrap Percentages, and other inputs.

Outputs

There are two outputs and a variety of messages/reports:

- Output 1 is the "Recommended Production Schedule" which lays out a detailed schedule of the required minimum start and completion dates, with quantities, for each step of the Routing and Bill Of Material required to satisfy the demand from the Master Production Schedule (MPS).
- Output 2 is the "Recommended Purchasing Schedule". This lays out both the dates that the purchased items should be received into the facility AND the dates that the Purchase orders, or Blanket Order Release should occur to match the production schedules.

Messages and Reports:

- Purchase orders. An order to a supplier to provide materials.
- Reschedule notices. These *recommend* cancelling, increasing, delaying or speeding up existing orders.

Note that the *outputs* are *recommended*. Due to a variety of changing conditions in companies, since the last MRP / ERP system Re-Generation, the recommended outputs need to be reviewed by *trained* people to group orders for benefits in set-up or freight savings. These actions are beyond the linear calculations of the MRP computer software.

Problems with MRP systems

The major problem with MRP systems is the integrity of the data. If there are any errors in the inventory data, the bill of materials (commonly referred to as 'BOM') data, or the master production schedule, then the outputted data will also be incorrect (GIGO: Garbage in, garbage out). Most vendors of this type of system recommend at least 99% data integrity for the system to give useful results.

Another major problem with MRP systems is the requirement that the user specify how long it will take a factory to make a product from its component parts (assuming they are all available). Additionally, the system design also assumes that this "lead time" in manufacturing will be the same each time the item is made, without regard to quantity being made, or other items being made simultaneously in the factory.

A manufacturer may have factories in different cities or even countries. It is no good for an MRP system to say that we do not need to order some material because we have plenty thousands of miles away. The overall ERP system needs to be able to organize inventory and needs by individual factory, and intercommunicate needs in order to enable each factory to redistribute components in order to serve the overall enterprise.

This means that other systems in the enterprise need to work properly both before implementing an MRP system, and into the future. For example systems like variety reduction and engineering which makes sure that product comes out right first time (without defects) must be in place.

Production may be in progress for some part, whose design gets changed, with customer orders in the system for both the old design, and the new one, concurrently. The overall ERP system needs to have a system of coding parts such that the MRP will correctly calculate needs and tracking for both versions. Parts must be booked into and out of stores more regularly than the MRP calculations take place. Note, these other systems can well be manual systems, but must interface to the MRP. For example, a 'walk around' stock intake done just prior to the MRP calculations can be a practical solution for a small inventory (especially if it is an "open store").

The other major drawback of MRP is that takes no account of capacity in its calculations. This means it will give results that are impossible to implement due to manpower or machine or supplier capacity constraints. However this is largely dealt with by MRP II.

Generally, MRP II refers to a system with integrated financials. An MRP II system can include finite / infinite capacity planning. But, to be considered a true MRP II system must also include financials.

In the MRP II (or MRP2) concept, fluctuations in forecast data are taken into account by including simulation of the master production schedule, thus creating a long-term control[3] . A more general feature of MRP2 is its extension to purchasing, to marketing and to finance (integration of all the function of the company), ERP has been the next step.

See also

- Capacity requirements planning (CRP)
- CONWIP
- Theory of Constraints
- Enterprise resource planning (ERP)
- Just-in-time (JIT)
- Kanban
- Manufacturing resource planning (MRP II)
- Bill of materials (BOM)
- Modular BOM
- Configurable BOM

External links

- Is MRP a Planning System? [4]
- Materials requirements planning (MRP) a numeric example [5]
- MRP Software solutions and Guide [6]
- MRP in Excel Office [7]

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[3] Waldner, Jean-Baptiste (1992). *CIM: Principles of Computer Integrated Manufacturing*. Chichester: John Wiley & Sons. p. 46. ISBN 047193450X.

[4] http://www.advanced-planning.eu/advancedplanninge-342.htm

[5] http://people.brunel.ac.uk/~mastjjb/jeb/or/mrp.html

[6] http://comsoft.org/mrp-software/

[7] http://www.webandmacros.net/excel-mrp-macro.htm

Manufacturing resource planning

Manufacturing Resource Planning (**MRP II**) is defined by APICS as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP.

This is not exclusively a software function, but a marriage of people skills, dedication to data base accuracy, and computer resources. It is a total company management concept for using human resources more productively.

Key functions and features

MRP II is not a proprietary software system and can thus take many forms. It is almost impossible to visualize an MRP II system that does not use a computer, but an MRP II system can be based on either purchased–licensed or in-house software.

Almost every MRP II system is modular in construction. Characteristic basic modules in an MRP II system are:

- Master Production Schedule (MPS)
- Item Master Data (Technical Data)
- Bill of materials (BOM) (Technical Data)
- Production Resources Data (Manufacturing Technical Data)
- Inventories and Orders (Inventory Control)
- Purchasing management
- Material Requirements Planning (MRP)
- Shop Floor Control (SFC)
- Capacity planning or Capacity Requirements Planning (CRP)
- Standard Costing (Cost Control)
- Cost Reporting / Management (Cost Control)

together with auxiliary systems such as:

- Business Planning
- Lot Traceability
- Contract Management
- Tool Management
- Engineering Change Control
- Configuration Management
- Shop Floor Data Collection
- Sales Analysis and Forecasting
- Finite Capacity Scheduling (FCS)

and related systems such as:

- General Ledger
- Accounts Payable (Purchase Ledger)
- Accounts Receivable (Sales Ledger)
- Sales Order Management
- Distribution Requirements Planning (DRP)
- [Automated] Warehouse Management
- Project Management
- Technical Records
- Estimating
- Computer-aided design/Computer-aided manufacturing (CAD/CAM)

- CAPP

The MRP II system integrates these modules together so that they use common data and freely exchange information, in a model of how a manufacturing enterprise should and can operate. The MRP II approach is therefore very different from the “point solution” approach, where individual systems are deployed to help a company plan, control or manage a specific activity. MRP II is by definition fully integrated or at least fully interfaced.

Industry Specifics

MRP II systems have been implemented in most manufacturing industries. Some industries need specialised functions e.g. lot traceability in regulated manufacturing such as pharmaceuticals or food. Other industries can afford to disregard facilities required by others e.g. the tableware industry has few starting materials – mainly clay – and does not need complex materials planning. Capacity planning is the key to success in this as in many industries, and it is in those that MRP II is less appropriate.

MRP and MRPII: History and Evolution

Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRPII) are predecessors of Enterprise Resource Planning (ERP), a business information integration system. The development of these manufacturing coordination and integration methods and tools made today’s ERP systems possible. Both MRP and MRPII are still widely used, independently and as modules of more comprehensive ERP systems, but the original vision of integrated information systems as we know them today began with the development of MRP and MRPII in manufacturing.

The vision for MRP and MRPII was to centralize and integrate business information in a way that would facilitate decision making for production line managers and increase the efficiency of the production line overall. In the 1980s, manufacturers developed systems for calculating the resource requirements of a production run based on sales forecasts. In order to calculate the raw materials needed to produce products and to schedule the purchase of those materials along with the machine and labor time needed, production managers recognized that they would need to use computer and software technology to manage the information. Originally, manufacturing operations built custom software programs that ran on mainframes.

Material Requirements Planning (MRP) was an early iteration of the integrated information systems vision. MRP information systems helped managers determine the quantity and timing of raw materials purchases. Information systems that would assist managers with other parts of the manufacturing process, MRPII, followed. While MRP was primarily concerned with materials, MRPII was concerned with the integration of all aspects of the manufacturing process, including materials, finance and human relations.

Like today’s ERP systems, MRPII was designed to integrate a lot of information by way of a centralized database. However, the hardware, software, and relational database technology of the 1980s was not advanced enough to provide the speed and capacity to run these systems in real-time[1] , and the cost of these systems was prohibitive for most businesses. Nonetheless, the vision had been established, and shifts in the underlying business processes along with rapid advances in technology led to the more affordable enterprise and application integration systems that big businesses and many medium and smaller businesses use today (Monk and Wagner).

MRP and MRPII: General Concepts

Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRPII) are both incremental information integration business process strategies that are implemented using hardware and modular software applications linked to a central database that stores and delivers business data and information.

MRP is concerned primarily with manufacturing materials while MRPII is concerned with the coordination of the entire manufacturing production, including materials, finance, and human relations. The goal of MRPII is to provide consistent data to all players in the manufacturing process as the product moves through the production line.

Paper-based information systems and non-integrated computer systems that provide paper or disk outputs result in many information errors, including missing data, redundant data, numerical errors that result from being incorrectly keyed into the system, incorrect calculations based on numerical errors, and bad decisions based on incorrect or old data. In addition, some data is unreliable in non-integrated systems because the same data is categorized differently in the individual databases used by different functional areas.

MRPII systems begin with MRP, Material Requirements Planning. MRP allows for the input of sales forecasts from sales and marketing. These forecasts determine the raw materials demand. MRP and MRPII systems draw on a Master Production Schedule, the break down of specific plans for each product on a line. While MRP allows for the coordination of raw materials purchasing, MRPII facilitates the development of a detailed production schedule that accounts for machine and labor capacity, scheduling the production runs according to the arrival of materials. An MRPII output is a final labor and machine schedule. Data about the cost of production, including machine time, labor time and materials used, as well as final production numbers, is provided from the MRPII system to accounting and finance (Monk and Wagner).

Benefits

MRP II systems can provide:

- Better control of inventories
- Improved scheduling
- Productive relationships with suppliers

For Design / Engineering:

- Improved design control
- Better quality and quality control

For Financial and Costing:

- Reduced working capital for inventory
- Improved cash flow through quicker deliveries
- Accurate inventory records

Criticism

Authors like Pochet and Wolsey [2] argue that MRP and MRP II, as well as the planning modules in current APS and ERP systems, are actually sets of heuristics. Better production plans could be obtained by optimization over more powerful mathematical programming models, usually integer programming models. While they acknowledge that the use of heuristics, like those prescribed by MRP and MRP II, were necessary in the past due to lack of computational power to solve complex optimization models, this is no longer true.

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See also

- CONWIP
- C-VARWIP
- Enterprise resource planning (ERP)
- Just In Time (business)
- kanban
- Manufacturing
- Material requirements planning (MRP)
- Scheduling (production processes)
- Supply chain management
- Distribution Resource Planning
- Warehouse management system
- Warehouse control system

Enterprise resource planning

Enterprise Resource Planning (**ERP**) is an integrated computer-based system used to manage internal and external resources, including tangible assets, financial resources, materials, and human resources. Its purpose is to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders. Built on a centralized database and normally utilizing a common computing platform, ERP systems consolidate all business operations into a uniform and enterprise-wide system environment.[1]

An ERP system can either reside on a centralized server or be distributed across modular hardware and software units that provide "services" and communicate on a local area network. The distributed design allows a business to assemble modules from different vendors without the need for the placement of multiple copies of complex and expensive computer systems in areas which will not use their full capacity.[2]

Origin of the term

The initialism ERP was first employed by research and analysis firm Gartner Group in 1990 [3] as an extension of MRP (Material Requirements Planning; later manufacturing resource planning[4]) and CIM (Computer Integrated Manufacturing), and while not supplanting these terms, it has come to represent a larger whole. It came into use as makers of MRP software started to develop software applications beyond the manufacturing arena.[5] ERP systems now attempt to cover all core functions of an enterprise, regardless of the organization's business or charter. These systems can now be found in non-manufacturing businesses, non-profit organizations and governments.[6]

To be considered an ERP system, a software package should have the following traits:

- Should be integrated and operate in real time with no periodic batch updates.
- All applications should access one database to prevent redundant data and multiple data definitions.
- All modules should have the same look and feel.

- Users should be able to access any information in the system without needing integration work on the part of the IS department.[7]

Components

- Transactional Backbone
  - Financials
  - Distribution
  - Human Resources
  - Product lifecycle management
- Advanced Applications
  - Customer Relationship Management (CRM)
  - Supply chain management software
    - Purchasing
    - Manufacturing
    - Distribution (business)Distribution
  - Warehouse Management System
- Management Portal/Dashboard
  - Decision Support System

These modules can exist in a system or utilized in an ad-hoc fashion.

Commercial applications

Manufacturing

> Engineering, bills of material, work orders, scheduling, capacity, workflow management, quality control, cost management, manufacturing process, manufacturing projects, manufacturing flow

Supply chain management

> Order to cash, inventory, order entry, purchasing, product configurator, supply chain planning, supplier scheduling, inspection of goods, claim processing, commission calculation

Financials

> General ledger, cash management, accounts payable, accounts receivable, fixed assets

Project management

> Costing, billing, time and expense, performance units, activity management

Human resources

> Human resources, payroll, training, time and attendance, rostering, benefits

Customer relationship management

> Sales and marketing, commissions, service, customer contact, call-center support

Data services

> Various "self-service" interfaces for customers, suppliers and/or employees

Access control

> Management of user privileges for various processes

History

The term "Enterprise resource planning" originally derived from manufacturing resource planning (MRP II) that followed material requirements planning (MRP).[8] MRP evolved into ERP when "routings" became a major part of the software architecture and a company's capacity planning activity also became a part of the standard software activity. ERP systems typically handle the manufacturing, logistics, distribution, inventory, shipping, invoicing, and accounting for a company. ERP software can aid in the control of many business activities, including sales, marketing, delivery, billing, production, inventory management, quality management, and human resource management.

ERP systems saw a large boost in sales in the 1990s as companies faced the Y2K problem in their legacy systems. Many companies took this opportunity to replace such information systems with ERP systems. This rapid growth in sales was followed by a slump in 1999, at which time most companies had already implemented their Y2K solution.[9]

ERP systems are often incorrectly called *back office systems*, indicating that customers and the general public are not directly involved. This is contrasted with *front office systems* like customer relationship management (CRM) systems that deal directly with the customers, or the eBusiness systems such as eCommerce, eGovernment, eTelecom, and eFinance, or supplier relationship management (SRM) systems.

ERP systems are cross-functional and enterprise-wide. All functional departments that are involved in operations or production are integrated in one system. In addition to areas such as manufacturing, warehousing, logistics, and information technology, this typically includes accounting, human resources, marketing and strategic management.

ERP II, a term coined in the early 2000s, is often used to describe what would be the next generation of ERP software. This new generation of software is web-based and allows both employees and external resources (such as suppliers and customers) real-time access to the system's data.

EAS — Enterprise Application Suite is a new name for formerly developed ERP systems which include (almost) all segments of business using ordinary Internet browsers as thin clients.

Though traditionally ERP packages have been on-premise installations, ERP systems are now also available as Software as a Service.

Best practices are incorporated into most ERP vendor's software packages. When implementing an ERP system, organizations can choose between customizing the software or modifying their business processes to the "best practice" function delivered in the "out-of-the-box" version of the software.

Prior to ERP, software was developed to fit individual processes of an individual business. Due to the complexities of most ERP systems and the negative consequences of a failed ERP implementation, most vendors have included "Best Practices" into their software. These "Best Practices" are what the Vendor deems as the most efficient way to carry out a particular business process in an Integrated Enterprise-Wide system.[10] A study conducted by Ludwigshafen University of Applied Science surveyed 192 companies and concluded that companies which implemented industry best practices decreased mission-critical project tasks such as configuration, documentation, testing and training. In addition, the use of best practices reduced over risk by 71% when compared to other software implementations.[11]

The use of best practices can make complying with requirements such as IFRS, Sarbanes-Oxley, or Basel II easier. They can also help where the process is a commodity such as electronic funds transfer. This is because the procedure of capturing and reporting legislative or commodity content can be readily codified within the ERP software, and then replicated with confidence across multiple businesses who have the same business requirement.

Implementation

Businesses have a wide scope of applications and processes throughout their functional units; producing ERP software systems that are typically complex and usually impose significant changes on staff work practices.[12] Implementing ERP software is typically too complex for "in-house" skill, so it is desirable and highly advised to hire outside consultants who are professionally trained to implement these systems. This is typically the most cost effective way. There are three types of services that may be employed for - Consulting, Customization, Support.[12] The length of time to implement an ERP system depends on the size of the business, the number of modules, the extent of customization, the scope of the change and the willingness of the customer to take ownership for the project. ERP systems are modular, so they don't all need be implemented at once. It can be divided into various stages, or phase-ins. The typical project is about 14 months and requires around 150 consultants.[13] A small project (e.g., a company of less than 100 staff) can be planned and delivered within 3–9 months; however, a large, multi-site or multi-country implementation can take years. The length of the implementations is closely tied to the amount of customization desired.[13]

To implement ERP systems, companies often seek the help of an ERP vendor or of third-party consulting companies. These firms typically provide three areas of professional services: consulting; customization; and support. The client organization can also employ independent program management, business analysis, change management, and UAT specialists to ensure their business requirements remain a priority during implementation.

Data Migration

Data migration is one of the most important activities in determining the success of an ERP implementation. Since many decisions must be made before migration, a significant amount of planning must occur. Unfortunately, data migration is the last activity before the production phase of an ERP implementation, and therefore receives minimal attention due to time constraints. The following are steps of a data migration strategy that can help with the success of an ERP implementation:[14]

1. Identifying the data to be migrated
2. Determining the timing of data migration
3. Generating the data templates
4. Freezing the tools for data migration
5. Deciding on migration related setups
6. Deciding on data archiving

Process preparation

ERP vendors have designed their systems around standard business processes, based upon best business practices. Different vendor(s) have different types of processes but they are all of a standard, modular nature. Firms that want to implement ERP systems are consequently forced to adapt their organizations to standardized processes as opposed to adapting the ERP package to the existing processes.[15] Neglecting to map current business processes prior to starting ERP implementation is a main reason for failure of ERP projects.[16] It is therefore crucial that organizations perform a thorough business process analysis before selecting an ERP vendor and setting off on the implementation track. This analysis should map out all present operational processes, enabling selection of an ERP vendor whose standard modules are most closely aligned with the established organization. Redesign can then be implemented to achieve further process congruence. Research indicates that the risk of business process mismatch is decreased by:

- linking each current organizational process to the organization's strategy;
- analyzing the effectiveness of each process in light of its current related business capability;
- understanding the automated solutions currently implemented.[17] [18]

ERP implementation is considerably more difficult (and politically charged) in organizations structured into nearly independent business units, each responsible for their own profit and loss, because they will each have different processes, business rules, data semantics, authorization hierarchies and decision centers.[19] Solutions include requirements coordination negotiated by local change management professionals or, if this is not possible, federated implementation using loosely integrated instances (e.g. linked via Master Data Management) specifically configured and/or customized to meet local needs.

A disadvantage usually attributed to ERP is that business process redesign to fit the standardized ERP modules can lead to a loss of competitive advantage. While documented cases exist where this has indeed materialized, other cases show that following thorough process preparation ERP systems can actually increase sustainable competitive advantage.[20] [21]

Configuration

Configuring an ERP system is largely a matter of balancing the way you want the system to work with the way the system lets you work. Begin by deciding which modules to install, then adjust the system using configuration tables to achieve the best possible fit in working with your company’s processes.

Modules — Most systems are modular simply for the flexibility of implementing some functions but not others. Some common modules, such as finance and accounting are adopted by nearly all companies implementing enterprise systems; others however such as human resource management are not needed by some companies and therefore not adopted. A service company for example will not likely need a module for manufacturing. Other times companies will not adopt a module because they already have their own proprietary system they believe to be superior. Generally speaking the greater number of modules selected, the greater the integration benefits, but also the increase in costs, risks and changes involved.

Configuration Tables – A configuration table enables a company to tailor a particular aspect of the system to the way it chooses to do business. For example, an organization can select the type of inventory accounting – FIFO or LIFO – it will employ or whether it wants to recognize revenue by geographical unit, product line, or distribution channel.

So what happens when the options the system allows just aren't good enough? At this point a company has two choices, both of which are not ideal. It can re-write some of the enterprise system’s code, or it can continue to use an existing system and build interfaces between it and the new enterprise system. Both options will add time and cost to the implementation process. Additionally they can dilute the system’s integration benefits. The more customized the system becomes the less possible seamless communication between suppliers and customers.

Consulting services

Many organizations do not have sufficient internal skills to implement an ERP project. This results in many organizations offering consulting services for ERP implementation. Typically, a consulting team is responsible for the entire ERP implementation including:

1. selecting
2. planning
3. training
4. testing
5. implementation
6. delivery

of any customized modules. Examples of customization includes creating processes and reports for compliance, additional product training; creation of process triggers and workflow; specialist advice to improve how the ERP is used in the business; system optimization; and assistance writing reports, complex data extracts or implementing Business Intelligence.

For most mid-sized companies, the cost of the implementation will range from around the list price of the ERP user licenses to up to twice this amount (depending on the level of customization required). Large companies, and especially those with multiple sites or countries, will often spend considerably more on the implementation than the cost of the user licenses—three to five times more is not uncommon for a multi-site implementation.

Unlike most single-purpose applications, ERP packages have historically included full source code and shipped with vendor-supported team IDEs for customizing and extending the delivered code. During the early years of ERP the guarantee of mature tools and support for extensive customization was an important sales argument when a potential customer was considering developing their own unique solution in-house, or assembling a cross-functional solution by integrating multiple "best of breed" applications.

"Core system" customization vs configuration

Increasingly, ERP vendors have tried to reduce the need for customization by providing built-in "configuration" tools to address most customers' needs for changing how the out-of-the-box core system works. Key differences between customization and configuration include:

- Customization is always optional, whereas some degree of configuration (e.g., setting up cost/profit centre structures, organisational trees, purchase approval rules, etc.) may be needed before the software will work at all.
- Configuration is available to all customers, whereas customization allows individual customer to implement proprietary "market-beating" processes.
- Configuration changes tend to be recorded as entries in vendor-supplied data tables, whereas customization usually requires some element of programming and/or changes to table structures or views.
- The effect of configuration changes on the performance of the system is relatively predictable and is largely the responsibility of the ERP vendor. The effect of customization is unpredictable and may require time-consuming stress testing by the implementation team.
- Configuration changes are almost always guaranteed to survive upgrades to new software versions. Some customizations (e.g. code that uses pre-defined "hooks" that are called before/after displaying data screens) will survive upgrades, though they will still need to be re-tested. More extensive customizations (e.g. those involving changes to fundamental data structures) will be overwritten during upgrades and must be re-implemented manually.

By this analysis, customizing an ERP package can be unexpectedly expensive and complicated, and tends to delay delivery of the obvious benefits of an integrated system. Nevertheless, customizing an ERP suite gives the scope to implement secret recipes for excellence in specific areas while ensuring that industry best practices are achieved in less sensitive areas.

Extensions

In this context, "Extensions" refers to ways that an ERP environment can be "extended" (supplemented) with third-party programs. It is technically easy to expose most ERP transactions to outside programs that do other things, e.g.:

- archiving, reporting and republishing (these are easiest to achieve, because they mainly address static data);
- performing transactional data captures, e.g. using scanners, tills or RFIDs (also relatively easy because they touch existing data);

However, because ERP applications typically contain sophisticated rules that control how data can be created or changed, some such functions can be very difficult to implement.

Advantages

In the absence of an ERP system, a large manufacturer may find itself with many software applications that cannot communicate or interface effectively with one another. Tasks that need to interface with one another may involve:

- ERP systems connect the necessary software in order for accurate forecasting to be done. This allows inventory levels to be kept at maximum efficiency and the company to be more profitable.
- Integration among different functional areas to ensure proper communication, productivity and efficiency
- Design engineering (how to best make the product)
- Order tracking, from acceptance through fulfillment
- The revenue cycle, from invoice through cash receipt
- Managing inter-dependencies of complex processes bill of materials
- Tracking the three-way match between purchase orders (what was ordered), inventory receipts (what arrived), and costing (what the vendor invoiced)
- The accounting for all of these tasks: tracking the revenue, cost and profit at a granular level.

ERP Systems centralize the data in one place. Benefits of this include:

- Eliminates the problem of synchronizing changes between multiple systems - consolidation of finance, marketing and sales, human resource, and manufacturing applications
- Permits control of business processes that cross functional boundaries
- Provides top-down view of the enterprise (no "islands of information"), real time information is available to management anywhere, anytime to make proper decisions.
- Reduces the risk of loss of sensitive data by consolidating multiple permissions and security models into a single structure.
- Shorten production leadtime and delivery time
- Facilitating business learning, empowering, and building common visions

Some security features are included within an ERP system to protect against both outsider crime, such as industrial espionage, and insider crime, such as embezzlement. A data-tampering scenario, for example, might involve a disgruntled employee intentionally modifying prices to below-the-breakeven point in order to attempt to interfere with the company's profit or other sabotage. ERP systems typically provide functionality for implementing internal controls to prevent actions of this kind. ERP vendors are also moving toward better integration with other kinds of information security tools.[22]

Disadvantages

Problems with ERP systems are mainly due to inadequate investment in ongoing training for the involved IT personnel - including those implementing and testing changes - as well as a lack of corporate policy protecting the integrity of the data in the ERP systems and the ways in which it is used.

Disadvantages

- Customization of the ERP software is limited...
- Re-engineering of business processes to fit the "industry standard" prescribed by the ERP system may lead to a loss of competitive advantage.
- ERP systems can be very expensive (This has led to a new category of "ERP light" solutions)
- ERPs are often seen as too rigid and too difficult to adapt to the specific workflow and business process of some companies—this is cited as one of the main causes of their failure.
- Many of the integrated links need high accuracy in other applications to work effectively. A company can achieve minimum standards, then over time "dirty data" will reduce the reliability of some applications.
- Once a system is established, switching costs are very high for any one of the partners (reducing flexibility and strategic control at the corporate level).

- The blurring of company boundaries can cause problems in accountability, lines of responsibility, and employee morale.
- Resistance in sharing sensitive internal information between departments can reduce the effectiveness of the software.
- Some large organizations may have multiple departments with separate, independent resources, missions, chains-of-command, etc, and consolidation into a single enterprise may yield limited benefits.

See also

- List of ERP software packages
- List of ERP vendors
- Accounting software
- Advanced Planning & Scheduling
- APICS
- Bill of materials (BOM)
- Business process management
- Configurable BOM (CBOM)
- Data migration
- Enterprise Feedback Management (EFM)
- Enterprise system
- E-procurement
- ERP modeling
- ERP for IT
- ERP System Selection Methodology
- Information technology management
- List of project management software
- Management information system
- Manufacturing Operations Management
- Modular BOM (MBOM)
- Order to cash
- Service Management
- Software as a Service
- Supply chain management
- Warehouse management system

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Just-in-time (business)

Just-in-time (**JIT**) is an inventory strategy that strives to improve a business's return on investment by reducing in-process inventory and associated carrying costs. Just In Time production method is also called the Toyota Production System. To meet JIT objectives, the process relies on signals or Kanban (看板 *Kanban*) between different points in the process, which tell production when to make the next part. Kanban are usually 'tickets' but can be simple visual signals, such as the presence or absence of a part on a shelf. Implemented correctly, JIT can improve a manufacturing organization's return on investment, quality, and efficiency.

Quick notice that stock depletion requires personnel to order new stock is critical to the inventory reduction at the center of JIT. This saves warehouse space and costs. However, the complete mechanism for making this work is often misunderstood.

For instance, its effective application cannot be independent of other key components of a lean manufacturing system or it can "...end up with the opposite of the desired result."[1] In recent years manufacturers have continued to try to hone forecasting methods (such as applying a trailing 13 week average as a better predictor for JIT planning,[2] however some research demonstrates that basing JIT on the presumption of stability is inherently flawed.[3]

Philosophy

Philosophy of JIT is simple: inventory is waste. JIT inventory systems expose hidden causes of inventory keeping, and are therefore not a simple solution for a company to adopt. The company must follow an array of new methods to manage the consequences of the change. The ideas in this way of working come from many different disciplines including statistics, industrial engineering, production management, and behavioral science. The JIT inventory philosophy defines how inventory is viewed and how it relates to management.

Inventory is seen as incurring costs, or waste, instead of adding and storing value, contrary to traditional accounting. This does not mean to say JIT is implemented without an awareness that removing inventory exposes pre-existing manufacturing issues. This way of working encourages businesses to eliminate inventory that does not compensate for manufacturing process issues, and to constantly improve those processes to require less inventory. Secondly, allowing any stock habituates management to stock keeping. Management may be tempted to keep stock to hide production problems. These problems include backups at work centers, machine reliability, process variability, lack of flexibility of employees and equipment, and inadequate capacity.

In short, the just-in-time inventory system focus is having “the right material, at the right time, at the right place, and in the exact amount”, without the safety net of inventory. The JIT system has broad implications for implementers.

Transaction cost approach

JIT reduces inventory in a firm. However, a firm may simply be outsourcing their input inventory to suppliers, even if those suppliers don't use JIT (Naj 1993). Newman (1993) investigated this effect and found that suppliers in Japan charged JIT customers, on average, a 5% price premium.

Environmental concerns

During the birth of JIT, multiple daily deliveries were often made by bicycle. Increased scale has required a move to vans and lorries (trucks). Cusumano (1994) highlighted the potential and actual problems this causes with regard to gridlock and burning of fossil fuels. This violates three JIT waste guidelines:

1. Time—wasted in traffic jams
2. Inventory—specifically pipeline (in transport) inventory
3. Scrap—fuel burned while not physically moving

Price volatility

JIT implicitly assumes a level of input price stability that obviates the need to buy parts in advance of price rises. Where input prices are expected to rise, storing inventory may be desirable.

Quality volatility

JIT implicitly assumes that input parts quality remains constant over time. If not, firms may hoard high quality inputs. As with price volatility, a solution is to work with selected suppliers to help them improve their processes to reduce variation and costs. Longer term price agreements can then be negotiated and agreed-upon quality standards made the responsibility of the supplier. Fixing up of standards for volatility of quality according to the quality circle

Demand stability

Karmarker (1989) highlights the importance of relatively stable demand, which helps ensure efficient capital utilization rates. Karmarker argues that without significantly stable demand, JIT becomes untenable in high capital cost production.

Supply Stability

In the U.S., the 1992 railway strikes caused General Motors to idle a 75,000-worker plant because they had no supply.

JIT Implementation Design

Based on a diagram modeled after the one used by Hewlett-Packard's Boise plant to accomplish its JIT program.

1) **F** Design **F**low Process

```
- F Redesign/relayout for flow
      - L Reduce lot sizes
      - O Link operations
      - W Balance workstation capacity
      - M Preventive maintenance
      - S Reduce Setup Times
```

2) **Q** Total **q**uality control

```
- C worker compliance
      - I Automatic inspection
      - M quality measures
      - M fail-safe methods
      - W Worker participation
```

3) **S** Stabilize **S**chedule

```
- S Level Schedule
      - W establish freeze windows
      - UC Underutilize Capacity
```

4) **K** **K**anban Pull System

```
- D Demand pull
      - B Backflush
      - L Reduce lot sizes
```

5) **V** Work with **v**endors

```
- L Reduce lead time
      - D Frequent deliveries
      - U Project usage requirements
      - Q Quality Expectations
```

6) **I** Further reduce **i**nventory in other areas

```
S Stores
      - T Transit
      - C Implement Carroussel to reduce motion waste
      - C Implement Conveyor belts to reduce motion waste
```

7) **P** Improve **P**roduct Design

```
- P Standard Production Configuration
      - P Standardize and reduce the number of parts
      - P Process design with product design
      - Q Quality Expectations
```

Effects

A surprising effect was that factory response time fell to about a day. This improved customer satisfaction by providing vehicles within a day or two of the minimum economic shipping delay.

Also, the factory began building many vehicles to order, eliminating the risk they would not be sold. This improved the company's return on equity.

Since assemblers no longer had a choice of which part to use, every part had to fit perfectly. This caused a quality assurance crisis, which led to a dramatic improvement in product quality. Eventually, Toyota redesigned every part of its vehicles to widen tolerances, while simultaneously implementing careful statistical controls for quality control. Toyota had to test and train parts suppliers to assure quality and delivery. In some cases, the company eliminated multiple suppliers.

When a process or parts quality problem surfaced on the production line, the entire production line had to be slowed or even stopped. No inventory meant a line could not operate from in-process inventory while a production problem was fixed. Many people in Toyota predicted that the initiative would be abandoned for this reason. In the first week, line stops occurred almost hourly. But by the end of the first month, the rate had fallen to a few line stops per day. After six months, line stops had so little economic effect that Toyota installed an overhead pull-line, similar to a bus bell-pull, that let any worker on the line order a line stop for a process or quality problem. Even with this, line stops fell to a few per week.

The result was a factory that has been studied worldwide. It has been widely emulated, but not always with the expected results, as many firms fail to adopt the full system.[4]

The just-in-time philosophy was also applied to other segments of the supply chain in several types of industries. In the commercial sector, it meant eliminating one or all of the warehouses in the link between a factory and a retail establishment. Examples in sales, marketing, and customer service involve applying information systems and mobile hardware to deliver customer information as needed, and reducing waste by video conferencing to cut travel time[5] .

Benefits

Main benefits of JIT include:

- *Reduced setup time.* Cutting setup time allows the company to reduce or eliminate inventory for "changeover" time. The tool used here is SMED (single-minute exchange of dies).
- *The flow of goods from warehouse to shelves improves.* Small or individual piece lot sizes reduce lot delay inventories, which simplifies inventory flow and its management.
- *Employees with multiple skills are used more efficiently.* Having employees trained to work on different parts of the process allows companies to move workers where they are needed.
- *Production scheduling and work hour consistency synchronized with demand.* If there is no demand for a product at the time, it is not made. This saves the company money, either by not having to pay workers overtime or by having them focus on other work or participate in training.
- *Increased emphasis on supplier relationships.* A company without inventory does not want a supply system problem that creates a part shortage. This makes supplier relationships extremely important.
- *Supplies come in at regular intervals throughout the production day.* Supply is synchronized with production demand and the optimal amount of inventory is on hand at any time. When parts move directly from the truck to the point of assembly, the need for storage facilities is reduced.

Problems

Within a JIT system

Just-in-time operation leaves suppliers and downstream consumers open to supply shocks and large supply or demand changes. For internal reasons, Ohno saw this as a feature rather than a bug. He used an analogy of lowering the water level in a river to expose the rocks to explain how removing inventory showed where production flow was interrupted. Once barriers were exposed, they could be removed. Since one of the main barriers was rework, lowering inventory forced each shop to improve its own quality or cause a holdup downstream. A key tool to manage this weakness is production levelling to remove these variations. Just-in-time is a means to improving performance of the system, not an end.

Very low stock levels means shipments of the same part can come in several times per day. This means Toyota is especially susceptible to flow interruption. For that reason, Toyota uses two suppliers for most assemblies. As noted in Liker (2003), there was an exception to this rule that put the entire company at risk because of the 1997 Aisin fire. However, since Toyota also makes a point of maintaining high quality relations with its entire supplier network, several other suppliers immediately took up production of the Aisin-built parts by using existing capability and documentation. Thus, a strong, long-term relationship with a few suppliers is better than short-term, price-based relationships with many competing suppliers. Toyota uses this long-term relationship to send Toyota staff to help suppliers improve their processes. These interventions have been going on for twenty years and have created a more reliable supply chain, improved margins for Toyota and suppliers, and lowered prices for customers. Toyota encourages their suppliers to use JIT with their own suppliers.

Within a raw material stream

As noted by Liker (2003) and Womack and Jones (2003), it ultimately would be desirable to introduce synchronised flow and link JIT through the entire supply stream. However, none followed this in detail all the way back through the processes to the raw materials. With present technology, for example, an ear of corn cannot be grown and delivered to order. The same is true of most raw materials, which must be discovered and/or grown through natural processes that require time and must account for natural variability in weather and discovery. The part of this currently viewed as impossible is the *synchronised* part of flow and the *linked* part of JIT. It is for the reasons stated raw materials companies decouple their supply chain from their clients' demand by carrying large 'finished goods' stocks. Both flow and JIT can be implemented in isolated process islands within the raw materials stream. The challenge becomes to achieve that isolation by some means other than carrying huge stocks, as most do today.

Because of this, almost all value chains are split into a part made-to-forecast and a part that could, by using JIT, become make-to-order. Historically, the make-to-order part has often been within the retailer portion of the value chain. Toyota took Piggly Wiggly's supermarket replenishment system and drove it at least half way through their automobile factories. Their challenge today is to drive it all the way back to their goods-inwards dock. Of course, the mining of iron and making of steel is still not connected to an order for a particular car. Recognising JIT could be driven back up the supply chain has reaped Toyota huge benefits and a dominant position in the auto industry.

Note that the advent of the mini mill steelmaking facility is starting to challenge how far back JIT can be implemented, as the electric arc furnaces at the heart of many mini-mills can be started and stopped quickly, and steel grades changed rapidly.

Oil

It has been frequently charged that the oil industry has been influenced by JIT.[6] [7] [8]

The argument is presented as follows:

> The number of refineries in the United States has fallen from 279 in 1975 to 205 in 1990 and further to 149 in 2004. As a result, the industry is susceptible to supply shocks, which cause spikes in prices and subsequently reduction in domestic manufacturing output. The effects of hurricanes Katrina and Rita are given as an example: in 2005, Katrina caused the shutdown of 9 refineries in Louisiana and 6 more in Mississippi, and a large number of oil production and transfer facilities, resulting in the loss of 20% of the US domestic refinery output. Rita subsequently shut down refineries in Texas, further reducing output. The GDP figures for the third and fourth quarters showed a slowdown from 3.5% to 1.2% growth. Similar arguments were made in earlier crises.

Beside the obvious point that prices went up because of the reduction in supply and not for anything to do with the practice of JIT, JIT students and even oil & gas industry analysts question whether JIT as it has been developed by Ohno, Goldratt, and others is used by the petroleum industry. Companies routinely shut down facilities for reasons other than the application of JIT. One of those reasons may be economic rationalization: when the benefits of operating no longer outweigh the costs, including opportunity costs, the plant may be economically inefficient. JIT has never subscribed to such considerations directly; following Waddel and Bodek (2005), this ROI-based thinking conforms more to Brown-style accounting and Sloan management. Further, and more significantly, JIT calls for a reduction in inventory capacity, not production capacity. From 1975 to 1990 to 2005, the annual average stocks of gasoline have fallen by only 8.5% from 228,331 to 222,903 bbls to 208,986 (Energy Information Administration data). Stocks fluctuate seasonally by as much as 20,000 bbls. During the 2005 hurricane season, stocks never fell below 194,000 thousand bbls, while the low for the period 1990 to 2006 was 187,017 thousand bbls in 1997. This shows that while industry storage capacity has decreased in the last 30 years, it hasn't been drastically reduced as JIT practitioners would prefer.

Finally, as shown in a pair of articles in the Oil & Gas Journal, JIT does not seem to have been a goal of the industry. In Waguespack and Cantor (1996), the authors point out that JIT would require a significant change in the supplier/refiner relationship, but the changes in inventories in the oil industry exhibit none of those tendencies. Specifically, the relationships remain cost-driven among many competing suppliers rather than quality-based among a select few long-term relationships. They find that a large part of the shift came about because of the availability of short-haul crudes from Latin America. In the follow-up editorial, the Oil & Gas Journal claimed that "casually adopting popular business terminology that doesn't apply" had provided a "rhetorical bogey" to industry critics. Confessing that they had been as guilty as other media sources, they confirmed that "It also happens not to be accurate."

Business models following similar approach

Vendor-managed inventory

Vendor-managed inventory (VMI) employs the same principles as those of JIT inventory, however, the responsibilities of managing inventory is placed with the vendor in a vendor/customer relationship. Whether it’s a manufacturer managing inventory for a distributor, or a distributor managing inventory for their customers, the management role goes to the vendor.

An advantage of this business model is that the vendor may have industry experience and expertise that lets them better anticipate demand and inventory needs. The inventory planning and controlling is facilitated by applications that allow vendors access to their customer's inventory data.

Another advantage to the customer is that inventory cost usually remains on the vendor's books until used by the customer, even if parts or materials are on the customer's site.

Customer-managed inventory

With customer-managed inventory (CMI), the customer, as opposed to the vendor in a VMI model, has responsibility for all inventory decisions. This is similar to JIT inventory concepts. With a clear picture of their inventory and that of their supplier’s, the customer can anticipate fluctuations in demand and make inventory replenishment decisions accordingly.

See also

- CONWIP
- Demand Flow Technology
- Industrial engineering
- Just in case manufacturing
- Just in Sequence
- Lean consumption
- Lean manufacturing
- H2:Do
- Liquid logistics
- Theory of constraints
- Total quality management
- Vendor-managed inventory
- inventory proportionality

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Kanban

Kanban (or *kamban* in Hepburn romanization--kanji 看板, katakana カンバン, meaning "signboard" or "billboard") is a concept related to lean and just-in-time (JIT) production. According to Taiichi Ohno, the man credited with developing JIT, kanban is one means through which JIT is achieved.[1]

Kanban is not an inventory control system. Rather, it is a scheduling system that tells you what to produce, when to produce it, and how much to produce.

The need to maintain a high rate of improvements led Toyota to devise the kanban system. Kanban became an effective tool to support the running of the production system as a whole. In addition, it proved to be an excellent way for promoting improvements because reducing the number of kanban in circulation highlighted problem areas.[2]

Origins

The term *kanban* describes an embellished wooden or metal sign often representing a trademark or seal. *Kanban* became an important part of the Japanese mercantile scene in the 17th century, much like the military banners had been to the samurai. Visual puns, calligraphy and ingenious shapes were employed to indicate a trade and class of business or tradesman.

In the late 1940s, Toyota began studying supermarkets with a view to applying store and shelf-stocking techniques to the factory floor, figuring, in a supermarket, customers get what they need, at the needed time, and in the needed amount. Furthermore, the supermarket only stocks what it believes it will sell, and customers only take what they need because future supply is assured. This led Toyota to view a process as a customer of preceding processes, and the preceding processes as a kind of store. The customer process goes to this store to get needed components, and the store restocks. As in supermarkets, originally, signboards were used to guide "shoppers" to specific restocking locations.

"Kanban" uses the rate of demand to control the rate of production, passing demand from the end customer up through the chain of customer-store processes. In 1953, Toyota applied this logic in their main plant machine shop.[3]

Operation

An important determinant of the success of production scheduling based on "pushing" the demand is the quality of the demand forecast that can receive such "push."

Kanban, by contrast, is part of an approach of receiving the "pull" from the demand. Therefore, the supply or production is determined according to the actual demand of the customers. In contexts where supply time is lengthy and demand is difficult to forecast, the best one can do is to respond quickly to observed demand. This is exactly what a kanban system can help with: It is used as a demand signal that immediately propagates through the supply chain. This can be used to ensure that intermediate stocks held in the supply chain are better managed, usually smaller. Where the supply response cannot be quick enough to meet actual demand fluctuations, causing significant lost sales, then stock building may be deemed as appropriate which can be achieved by issuing more kanban. Taiichi Ohno states that to be effective kanban must follow strict rules of use[4] (Toyota, for example, has six simple rules, below) and that close monitoring of these rules is a never-ending task to ensure that the kanban does what is required.

Toyota's six rules

- Do not send defective products to the subsequent process
- The subsequent process comes to withdraw only what is needed
- Produce only the exact quantity withdrawn by the subsequent process
- Equalize production
- Kanban is a means to fine tuning
- Stabilize and rationalize the process

Three-bin system

A simple example of the kanban system implementation might be a "three-bin system" for the supplied parts (where there is no in-house manufacturing) — one bin on the factory floor (demand point), one bin in the factory store, and one bin at the suppliers' store. The bins usually have a removable card that contains the product details and other relevant information — the kanban card.

When the bin on the factory floor becomes empty, i.e, there is demand for parts, the empty bin and kanban cards are returned to the factory store. The factory store then replaces the bin on the factory floor with a full bin, which also contains a kanban card. The factory store then contacts the supplier's store and returns the now-empty bin with its kanban card. The supplier's inbound product bin with its kanban card is then delivered into the factory store completing the final step to the system. Thus the process will never run out of product and could be described as a loop, providing the exact amount required, with only one spare so there will never be an oversupply. This 'spare' bin allows for the uncertainty in supply, use and transport that are inherent in the system. The secret to a good kanban system is to calculate how many kanban cards are required for each product. Most factories using kanban use the coloured board system (Heijunka Box). This consists of a board created especially for holding the kanban cards.

E-kanban systems

Many manufacturers have implemented electronic kanban systems.[5] Electronic kanban systems, or E-Kanban systems, help to eliminate common problems such as manual entry errors and lost cards.[6] E-Kanban systems can be integrated into enterprise resource planning (ERP) systems. Integrating E-Kanban systems into ERP systems allows for real-time demand signaling across the supply chain and improved visibility. Data pulled from E-Kanban systems can be used to optimize inventory levels by better tracking supplier lead and replenishment times.[7]

See also

- CONWIP
- C-VARWIP
- Enterprise resource planning (ERP)
- Just In Time (JIT)
- Manufacturing
- Material requirements planning (MRP)
- Manufacturing resource planning (MRP II)
- Scheduling (production processes)
- Supply chain management
- Drum-Buffer-Rope
- List of software development philosophies
- Lean software development
- Visual Control

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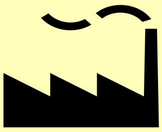
Theory of Constraints

Part of a series of articles on
Industry

Manufacturing methods Batch production • Job production Continuous production
Improvement methods LM • TPM • QRM • VDM TOC • Six Sigma • RCM
Information & communication ISA-88 • ISA-95 • ERP SAP • IEC 62264 • B2MML
Process control PLC • DCS

Theory of Constraints (TOC) is an overall management philosophy introduced by Dr. Eliyahu M. Goldratt in his 1984 book titled *The Goal*, that is geared to help organizations continually achieve their goal.[1] The title comes from the contention that any manageable system is limited in achieving more of its goal by a very small number of constraints, and that there is always at least one constraint. The TOC process seeks to identify the constraint and restructure the rest of the organization around it, through the use of the Five Focusing Steps.

Basics

Key assumption

The underlying premise of *Theory of Constraints* is that organizations can be measured and controlled by variations on three measures: throughput, operating expense, and investment. Throughput is money (or goal units) generated through sales. Investment is money the system invests in order to sell its goods and services. Operating expense is all the money the system spends in order to turn the investment into throughput. [2]

The five focusing steps

Theory of Constraints is based on the premise that the rate of goal achievement is limited by at least one constraining process. Only by increasing flow through the constraint can overall throughput be increased. [1]

Assuming the goal of the organization has been articulated (e.g., "Make money now and in the future") the steps are:

1. Identify the constraint (the resource or policy that prevents the organization from obtaining more of the goal)
2. Decide how to exploit the constraint (get the most capacity out of the constrained process)
3. Subordinate all other processes to above decision (align the whole system or organization to support the decision made above)
4. Elevate the constraint (make other major changes needed to break the constraint)
5. If, as a result of these steps, the constraint has moved, return to Step 1. Don't let inertia become the constraint. [3]

The five focusing steps aim to ensure ongoing improvement efforts are centered around the organization's constraints. In the TOC literature, this is referred to as the "Process of Ongoing Improvement" (POOGI).

These focusing steps are the key steps to developing the specific applications mentioned below.

Constraints

A constraint is anything that prevents the system from achieving more of its goal. There are many ways that constraints can show up, but a core principle within TOC is that there are not tens or hundreds of constraints. There is at least one and at most a few in any given system. Constraints can be internal or external to the system. An internal constraint is in evidence when the market demands more from the system than it can deliver. If this is the case, then the focus of the organization should be on discovering that constraint and following the five focusing steps to open it up (and potentially remove it). An external constraint exists when the system can produce more than the market will bear. If this is the case, then the organization should focus on mechanisms to create more demand for its products or services.

Types of (internal) constraints

- Equipment: The way equipment is currently used limits the ability of the system to produce more salable goods / services.
- People: Lack of skilled people limits the system. Mental models held by people can cause behaviour that becomes a constraint.
- Policy: A written or unwritten policy prevents the system from making more.

The concept of the constraint in *Theory of Constraints* differs from the constraint that shows up in mathematical optimization. In TOC, the constraint is used as a focusing mechanism for management of the system. In optimization, the constraint is written into the mathematical expressions to limit the scope of the solution (X can be no greater than 5).

Please note: Organizations have many problems with equipment, people, policies, etc. (A breakdown is just that - a breakdown - and is not a constraint in the true sense of the TOC concept) The constraint is the thing that is preventing the organization from getting more Throughput (typically, revenue through sales).

Buffers

Buffers are used throughout Theory of Constraints. They often result as part of the EXPLOIT and SUBORDINATE steps of the five focusing steps. Buffers are placed before the governing constraint, thus ensuring that the constraint is never starved. Buffers are also placed behind the constraint to prevent downstream failure to block the constraint's output. Buffers used in this way protect the constraint from variations in the rest of the system and should allow for normal variation of processing time and the occasional upset (Murphy) before and behind the constraint.

Buffers can be a bank of physical objects before a work center, waiting to be processed by that work center. Buffers ultimately buy you time, as in the time before work reaches the constraint and are often verbalized as time buffers. There should always be enough (but not excessive) work in the time queue before the constraint and adequate offloading space behind the constraint.

Buffers are *not* the small queue of work that sits before every work center in a Kanban system although it is similar if you regard the assembly line as the governing constraint. prerequisite in *Theory of Constraints* is that with one constraint in the system, all other parts of the system must have sufficient capacity to keep up with the work at the constraint and to catch up if time was lost. In a balanced line, as espoused by Kanban, when one work center goes down for a period longer than the buffer allows, then the entire system must wait until that work center is restored. In a TOC system, the only situation where work is in danger, is if the constraint is unable to process (either due to malfunction, sickness or a "hole" in the buffer - if something goes wrong that the time buffer can not protect).

Buffer management therefor represents a crucial attribute of the Theory of Constraints. There are many ways to do it, but the most often used is a visual system of designating the buffer in three colours: Green (OK), Yellow (Caution) and Red (Action required). Creating this kind of visibility enables the system as a whole to align and thus subordinate to the need of the constraint in a holistic manner. This can also be done daily in a central operations room that is accessible to everybody.

Plant types

There are four primary types of plants in the TOC lexicon. Draw the flow of material from the bottom of a page to the top, and you get the four types. They specify the general flow of materials through a system, and they provide some hints about where to look for typical problems. The four types can be combined in many ways in larger facilities.

- I-Plant: Material flows in a sequence, such as in an assembly line. The primary work is done in a straight sequence of events (one-to-one). The constraint is the slowest operation.
- A-Plant: The general flow of material is many-to-one, such as in a plant where many sub-assemblies converge for a final assembly. The primary problem in A-plants is in synchronizing the converging lines so that each supplies the final assembly point at the right time.
- V-Plant: The general flow of material is one-to-many, such as a plant that takes one raw material and can make many final products. Classic examples are meat rendering plants or a steel manufacturer. The primary problem in V-plants is "robbing" where one operation (A) immediately after a diverging point "steals" materials meant for the other operation (B). Once the material has been processed by A, it cannot come back and be run through B without significant rework.
- T-Plant: The general flow is that of an I-Plant (or has multiple lines), which then splits into many assemblies (many-to-many). Most manufactured parts are used in multiple assemblies and nearly all assemblies use multiple parts. Customized devices, such as computers, are good examples. T-plants suffer from both synchronization problems of A-plants (parts aren't all available for an assembly) and the robbing problems of V-plants (one assembly steals parts that could have been used in another).

For non-material systems, one can draw the flow of work or the flow of processes and arrive at similar basic structures. A project, for example is an A-shaped sequence of work, culminating in a delivered project.

Applications

The focusing steps, or this *Process of Ongoing Improvement* has been applied to Manufacturing, Project Management, Supply Chain / Distribution generated specific solutions. Other tools (mainly the TP) also led to TOC applications in the fields of Marketing and Sales, and Finance. The solution as applied to each of these areas are listed below.

Operations

Within manufacturing operations and operations management, the solution seeks to pull materials through the system, rather than push them into the system. The primary methodology use is Drum-Buffer-Rope (DBR)[4] and a variation called Simplified Drum-Buffer-Rope (S-DBR)[5] .

Drum-Buffer-Rope is a manufacturing execution methodology, named for its three components. The *drum* is the physical constraint of the plant: the work center or machine or operation that limits the ability of the entire system to produce more. The rest of the plant follows the beat of the drum. They make sure the drum has work and that anything the drum has processed does not get wasted.

The *buffer* protects the drum, so that it always has work flowing to it. Buffers in DBR have time as their unit of measure, rather than quantity of material. This makes the priority system operate strictly based on the time an order is expected to be at the drum. Traditional DBR usually calls for buffers at several points in the system: the constraint, synchronization points and at shipping. S-DBR has a buffer at shipping and manages the flow of work across the drum through a load planning mechanism.

The *rope* is the work release mechanism for the plant. Orders are released to the shop floor at one "buffer time" before they are due. In other words, if the buffer is 5 days, the order is released 5 days before it is due at the constraint. Putting work into the system earlier than this buffer time is likely to generate too-high work-in-process and slow down the entire system.

Supply chain / logistics

The solution for supply chain is to move to a replenishment to consumption model, rather than a forecast model.

- TOC-Distribution
- TOC-VMI (vendor managed inventory)

Finance and accounting

The solution for finance and accounting is to apply holistic thinking to the finance application. This has been termed throughput accounting.[6] Throughput accounting suggests that one examine the impact of investments and operational changes in terms of the impact on the throughput of the business. It is an alternative to cost accounting.

The primary measures for a TOC view of finance and accounting are: Throughput (T), Operating Expense (OE) and Investment (I). Throughput is calculated from Sales (S) - Totally Variable Cost (TVC). Totally Variable Cost usually considers the cost of raw materials that go into creating the item sold.

Project management

Critical Chain Project Management (CCPM) is utilized in this area.[7] CCPM is based on the idea that all projects look like A-plants: all activities converge to a final deliverable. As such, to protect the project, there must be internal buffers to protect synchronization points and a final project buffer to protect the overall project.

Marketing and sales

While originally focused on manufacturing and logistics, TOC has expanded lately into sales management and marketing. Its role is explicitly acknowledged in the field of sales process engineering[8] . For effective sales management one can apply Drum Buffer Rope to the sales process similar to the way it is applied to operations (see Reengineering the Sales Process book reference below). This technique is appropriate when your constraint is in the sales process itself or you just want an effective sales management technique and includes the topics of funnel management and conversion rates.

The TOC thinking processes

The Thinking Processes are a set of tools to help managers walk through the steps of initiating and implementing a project. When used in a logical flow, the Thinking Processes help walk through a buy-in process:

1. Gain agreement on the problem
2. Gain agreement on the direction for a solution
3. Gain agreement that the solution solves the problem
4. Agree to overcome any potential negative ramifications
5. Agree to overcome any obstacles to implementation

TOC practitioners sometimes refer to these in the negative as working through *layers of resistance* to a change.

Recently, the Current Reality Tree (CRT) and Future Reality Tree (FRT) have been applied to an argumentative academic paper [9] .

Development and practice

TOC was initiated by Dr. Eliyahu M. Goldratt, who is still the main driving force behind the development and practice of TOC. There is a network of individuals and small companies loosely coupled as practitioners around the world. TOC is sometimes referred to as "Constraint Management". TOC is a large body of knowledge with a strong guiding philosophy of growth.

Criticism

Criticisms that have been leveled against TOC include:

Claimed Suboptimality of Drum-Buffer-Rope

While TOC has been compared favorably to linear programming techniques[10] , D. Trietsch from University of Auckland argues that DBR methodology is inferior to competing methodologies. [11] [12] Linhares, from the Getulio Vargas Foundation, has shown that the TOC approach to establishing an optimal product mix is unlikely to yield optimum results, as it would imply that P=NP [13] .

Unacknowledged debt

Duncan (as cited by Steyn) [14] says that TOC borrows heavily from systems dynamics developed by Forrester in the 1950s and from statistical process control which dates back to World War II. And Noreen Smith and Mackey, in their independent report on TOC, point out that several key concepts in TOC "have been topics in management accounting textbooks for decades." [15]

People claim Goldratt's books fail to acknowledge that TOC borrows from more than 40 years of previous Management Science research and practice, particularly from PERT/CPM and JIT. A rebuttal to these criticisms is offered in Goldratt's "What is the *Theory of Constraints* and How Should it be Implemented?", and in his audio program, "Beyond The Goal". In these, Goldratt discusses the history of disciplinary sciences, compares the strengths and weaknesses of the various disciplines, and acknowledges the sources of information and inspiration for the Thinking Processes and Critical Chain methodologies. Articles published in the now-defunct Journal of *Theory of Constraints* referenced foundational materials. Goldratt published an article and gave talks[16] with the title "Standing on the Shoulders of Giants" in which he gives credit for many of the core ideas of Theory of Constraints. Goldratt has sought many times to show the correlation between various improvement methods. However, many Goldratt adherents often denigrate other methodologies as inferior to TOC.

See also

- Linear programming
- List of Theory of Constraints topics
- Systems thinking — Critical systems thinking — Joint decision traps
- Twelve leverage points by Donella Meadows
- Constraint (disambiguation)
- Thinklets
- Throughput

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External links

- What is TOC? [17] - In a video Dr. Eliyahu M. Goldratt Explains the definition of Theory of Constraints.
- An Online Guide To The Theory Of Constraints [18] - Fundamentals, Thinking Process, Production, Projects, Supply Chain,
- The Theory of Constraints in Plain English [19] - A simple example of constraint identification.
- *Theory of Constraints* [20] at Scholarpedia, curated by Dr. John Blackstone.
- Theory of Constraints - Short Term Capacity Optimization [21] A PowerPoint presentation about the Theory of Constraints and its process.

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[17] http://www.toc.tv?id=166

[18] http://www.dbrmfg.co.nz/

[19] http://idoinfotech.com/1331/management/toc-theory-of-constraints-basics/

[20] http://www.scholarpedia.org/article/Theory_of_Constraints

[21] http://www.wepapers.com/Papers/113031/Theory_of_Constraints.ppt

Bullwhip effect

The **Bullwhip Effect** (or *Whiplash Effect*) is an observed phenomenon in forecast-driven distribution channels. The concept has its roots in J Forrester's *Industrial Dynamics* (1961) and thus it is also known as the *Forrester Effect*. Since the oscillating demand magnification upstream a supply chain reminds someone of a cracking whip it became famous as the Bullwhip Effect.

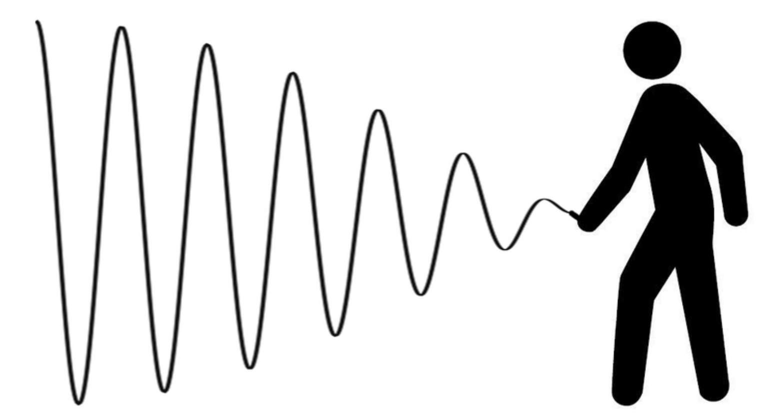
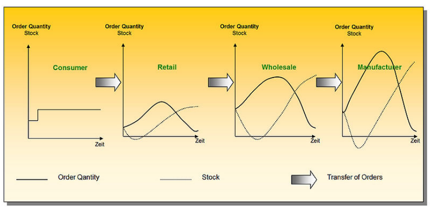


Illustration of the bullwhip effect: The final customer places an order (whip) and order fluctuations build up upstream the supply chain.

Causes



Bullwhip Efect

Because customer demand is rarely perfectly stable, businesses must forecast demand to properly position inventory and other resources. Forecasts are based on statistics, and they are rarely perfectly accurate. Because forecast errors are a given, companies often carry an inventory buffer called "safety stock". Moving up the supply chain from end-consumer to raw materials supplier, each supply chain participant has greater observed variation in demand and thus greater need for safety stock. In periods of rising demand, down-stream participants increase orders. In periods of falling demand, orders fall or stop to reduce inventory. The effect is that variations are amplified as one moves upstream in the supply chain (further from the customer). This sequence of events is well simulated by the Beer Distribution Game which was developed by the MIT Sloan School of Management in the 1960s.

The causes can further be divided into behavioral and operational causes:

Behavioural causes

- misuse of base-stock policies
- misperceptions of feedback and time delays
- panic ordering reactions after unmet demand
- perceived risk of other players' bounded rationality

Operational causes

- dependent demand processing
  - Forecast Errors
  - adjustment of inventory control parameters with each demand observation

- Lead time Variability (forecast error during replenishment lead time)
- lot-sizing/order synchronization
  - consolidation of demands
  - transaction motive
  - quantity discount
- trade promotion and forward buying
- anticipation of shortages
  - allocation rule of suppliers
  - shortage gaming
  - Lean and JIT style management of inventories and a chase production strategy

Consequences

In addition to greater safety stocks, the described effect can lead to either inefficient production or excessive inventory as the producer needs to fulfil the demand of its predecessor in the supply chain. This also leads to a low utilization of the distribution channel. In spite of having safety stocks there is still the hazard of stock-outs which result in poor customer service. Furthermore, the *Bullwhip effect* leads to a row of financial costs. Next to the (financially) hard measurable consequences of poor customer services and the damage of public image and loyalty an organization has to cope with the ramifications of failed fulfillment which can lead to contract penalties. Moreover the hiring and dismissals of employees to manage the demand variability induce further costs due to training and possible pay-offs.

Countermeasures

Theoretically the Bullwhip effect does not occur if all orders exactly meet the demand of each period. This is consistent with findings of supply chain experts who have recognized that the Bullwhip Effect is a problem in forecast-driven supply chains, and careful management of the effect is an important goal for Supply Chain Managers. Therefore it is necessary to extend the visibility of customer demand as far as possible. One way to achieve this is to establish a demand-driven supply chain which reacts to actual customer orders. In manufacturing, this concept is called Kanban. This model has been most successfully implemented in Wal-Mart's distribution system. Individual Wal-Mart stores transmit point-of-sale (POS) data from the cash register back to corporate headquarters several times a day. This demand information is used to queue shipments from the Wal-Mart distribution center to the store and from the supplier to the Wal-Mart distribution center. The result is near-perfect visibility of customer demand and inventory movement throughout the supply chain. Better information leads to better inventory positioning and lower costs throughout the supply chain. Barriers to the implementation of a demand-driven supply chain include the necessary investment in information technology and the creation of a corporate culture of flexibility and focus on customer demand. Another prerequisite is that all members of a supply chain recognize that they can gain more if they act as a whole which requires trustful collaboration and information sharing.

Methods intended to reduce uncertainty, variability, and lead time:

- Vendor Managed Inventory (VMI)
- Just In Time replenishment (JIT)
- Strategic partnership
- Information sharing
- smooth the flow of products
  - coordinate with retailers to spread deliveries evenly
  - reduce minimum batch sizes

- smaller and more frequent replenishments
- eliminate pathological incentives
  - every day low price policy
  - restrict returns and order cancellations
  - order allocation based on past sales instead of current size in case of shortage

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See also

- Beer Distribution Game
- Supply Chain Management

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Vendor-managed inventory

Vendor-managed inventory (VMI) is a family of business models in which the buyer of a product provides certain information to a supplier of that product and the supplier takes full responsibility for maintaining an agreed inventory of the material, usually at the buyer's consumption location (usually a store). A third-party logistics provider can also be involved to make sure that the buyer has the required level of inventory by adjusting the demand and supply gaps.

As a symbiotic relationship, VMI makes it less likely that a business will unintentionally become out of stock of a good and reduces inventory in the supply chain. Furthermore, vendor (supplier) representatives in a store benefit the vendor by ensuring the product is properly displayed and store staff are familiar with the features of the product line, all the while helping to clean and organize their product lines for the store.

One of the keys to making VMI work is shared risk. Often if the inventory does not sell, the vendor (supplier) will repurchase the product from the buyer (retailer). In other cases, the product may be in the possession of the retailer but is not owned by the retailer until the sale takes place, meaning that the retailer simply houses (and assists with the sale of) the product in exchange for a predetermined commission or profit. A special form of this commission business is scan-based trading whereas VMI is usually applied but not mandatory to be used.

This is one of the successful business models used by Wal-Mart and many other big box retailers. Oil companies often use technology to manage the gasoline inventories at the service stations that they supply (see Petrolsoft Corporation).Home Depot uses the technique with larger suppliers of manufactured goods (ie. Moen, Delta, RIDGID, Paulin). VMI helps foster a closer understanding between the supplier and manufacturer by using Electronic Data Interchange formats, EDI software and statistical methodologies to forecast and maintain correct inventory in the supply chain.

Vendors benefit from more control of displays and more contact to impart knowledge on employees; retailers benefit from reduced risk, better store staff knowledge (which builds brand loyalty for both the vendor and the retailer), and reduced display maintenance outlays

Consumers benefit from knowledgeable store staff who are in frequent and familiar contact with manufacturer (vendor) representatives when parts or service are required, store staff with good knowledge of most product lines offered by the entire range of vendors and therefore the ability to help the customer choose amongst competing products for items most suited to them, manufacturer-direct selection and service support being offered by the store.

See also

- Scan-based trading
- Consignment stock
- Electronic Data Interchange

What is Vendor Managed Inventory [1]

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Reverse logistics

Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics."[1] The reverse logistics process includes the management and the sale of surplus as well as returned equipment and machines from the hardware leasing business. Normally, logistics deal with events that bring the product towards the customer. In the case of reverse, the resource goes at least one step back in the supply chain. For instance, goods move from the customer to the distributor or to the manufacturer.[2]

Business implications

In today's marketplace, many retailers treat merchandise returns as individual, disjointed transactions. "The challenge for retailers and vendors is to process returns at a proficiency level that allows quick, efficient and cost-effective collection and return of merchandise. Customer requirements facilitate demand for a high standard of service that includes accuracy and timeliness. It’s the logistic company's responsibility to shorten the link from return origination to the time of resell."[3] By following returns management best practices, retailers can achieve a returns process that addresses both the operational and customer retention issues associated with merchandise returns.[4] Further, because of the connection between reverse logistics and customer retention, it has become a key component within Service Lifecycle Management (SLM), a business strategy aimed at retaining customers by bundling even more coordination of a company's services data together to achieve greater efficiency in its operations. Reverse logistics is more than just returns management, it is "activities related to returns avoidance, gatekeeping, disposal and all other after-market supply chain issues". [5] Returns management – increasingly being recognized as affecting competitive positioning – provides an important link between marketing and logistics. The broad nature of its cross-functional impact suggests that firms would benefit by improving internal integration efforts. In particular, a firm's ability to react to and plan for the influence of external factors on the returns management process is improved by such internal integration.[6] Third-party logistics providers see that up to 7% of an enterprise's gross sales are captured by return costs. Almost all reverse logistics contracts are customized to fit the size and type of company contracting. The 3PL's themselves realize 12% to 15% profits on this business.[7]

Return of unsold goods

In certain industries, goods are distributed to downstream members in the supply chain with the understanding that the goods may be returned for credit if they are not sold. Newspapers and magazines serve as examples. This acts as an incentive for downstream members to carry more stock, because the risk of obsolescence is borne by the upstream supply chain members. However, there is also a distinct risk attached to this logistics concept. The downstream member in the supply chain might exploit the situation by ordering more stock than is required and returning large volumes. In this way, the downstream partner is able to offer high level of service without carrying the risks associated with large inventories. The supplier effectively finances the inventory for the downstream member. It is therefore important to analyze customers’ account for hidden cost. [8]

External links

- Reverse Logistics Association [9]
- Reverse Logistics Magazine [10]
- Glossary of the Reverse Logistics Executive Council [11]
- Veltus Research: Organizing the chaos (a reverse logistics library) [12]
- Reverse Logistics Association "Reverse Logistics Lexicon" [13]

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Supply chain management

Supply chain management (SCM) is the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by end customers (Harland, 1996).[1] Supply Chain Management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption (supply chain).

Another definition is provided by the APICS Dictionary when it defines SCM as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally."

Idea

More common and accepted definitions of Supply Chain Management are:

- Supply Chain Management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et. al., 2001).[2]
- A customer focused definition is given by Hines (2004:p76) "Supply chain strategies require a total systems view of the linkages in the chain that work together efficiently to create customer satisfaction at the end point of delivery to the consumer. As a consequence costs must be lowered throughout the chain by driving out unnecessary costs and focusing attention on adding value. Throughput efficiency must be increased, bottlenecks

removed and performance measurement must focus on total systems efficiency and equitable reward distribution to those in the supply chain adding value. The supply chain system must be responsive to customer requirements." [3]

- Global Supply Chain Forum - Supply Chain Management is the integration of key business processes across the supply chain for the purpose of creating value for customers and stakeholders (Lambert, 2008)[4] .
- According to the Council of Supply Chain Management Professionals (CSCMP), Supply chain management encompasses the planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes the crucial components of coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. More recently, the loosely coupled, self-organizing network of businesses that cooperate to provide product and service offerings has been called the *Extended Enterprise*.

A supply chain, as opposed to supply chain management, is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer. Managing a supply chain is 'supply chain management' (Mentzer et. al., 2001).[5]

Supply chain management software includes tools or modules used to execute supply chain transactions, manage supplier relationships and control associated business processes.

Supply chain event management (abbreviated as SCEM) is a consideration of all possible events and factors that can disrupt a supply chain. With SCEM possible scenarios can be created and solutions devised.

Supply chain management problems

Supply chain management must address the following problems:

- **Distribution Network Configuration**: number, location and network missions of suppliers, production facilities, distribution centers, warehouses, cross-docks and customers.
- **Distribution Strategy**: questions of operating control (centralized, decentralized or shared); delivery scheme, e.g., direct shipment, pool point shipping, cross docking, DSD (direct store delivery), closed loop shipping; mode of transportation, e.g., motor carrier, including truckload, LTL, parcel; railroad; intermodal transport, including TOFC (trailer on flatcar) and COFC (container on flatcar); ocean freight; airfreight; replenishment strategy (e.g., pull, push or hybrid); and transportation control (e.g., owner-operated, private carrier, common carrier, contract carrier, or 3PL).
- **Trade-Offs in Logistical Activities**: The above activities must be well coordinated in order to achieve the lowest total logistics cost. Trade-offs may increase the total cost if only one of the activities is optimized. For example, full truckload (FTL) rates are more economical on a cost per pallet basis than less than truckload (LTL) shipments. If, however, a full truckload of a product is ordered to reduce transportation costs, there will be an increase in inventory holding costs which may increase total logistics costs. It is therefore imperative to take a systems approach when planning logistical activities. These trade-offs are key to developing the most efficient and effective Logistics and SCM strategy.
- **Information**: Integration of processes through the supply chain to share valuable information, including demand signals, forecasts, inventory, transportation, potential collaboration, etc.
- **Inventory Management**: Quantity and location of inventory, including raw materials, work-in-progress (WIP) and finished goods.
- **Cash-Flow**: Arranging the payment terms and methodologies for exchanging funds across entities within the supply chain.

Supply chain execution means managing and coordinating the movement of materials, information and funds across the supply chain. The flow is bi-directional.

Activities/functions

Supply chain management is a cross-function approach including managing the movement of raw materials into an organization, certain aspects of the internal processing of materials into finished goods, and the movement of finished goods out of the organization and toward the end-consumer. As organizations strive to focus on core competencies and becoming more flexible, they reduce their ownership of raw materials sources and distribution channels. These functions are increasingly being outsourced to other entities that can perform the activities better or more cost effectively. The effect is to increase the number of organizations involved in satisfying customer demand, while reducing management control of daily logistics operations. Less control and more supply chain partners led to the creation of supply chain management concepts. The purpose of supply chain management is to improve trust and collaboration among supply chain partners, thus improving inventory visibility and the velocity of inventory movement.

Several models have been proposed for understanding the activities required to manage material movements across organizational and functional boundaries. SCOR is a supply chain management model promoted by the Supply Chain Council. Another model is the SCM Model proposed by the Global Supply Chain Forum (GSCF). Supply chain activities can be grouped into strategic, tactical, and operational levels . The CSCMP has adopted The American Productivity & Quality Center (APQC) Process Classification Framework^{SM} a high-level, industry-neutral enterprise process model that allows organizations to see their business processes from a cross-industry viewpoint[6] .

Strategic

- Strategic network optimization, including the number, location, and size of warehousing, distribution centers, and facilities.
- Strategic partnerships with suppliers, distributors, and customers, creating communication channels for critical information and operational improvements such as cross docking, direct shipping, and third-party logistics.
- Product life cycle management, so that new and existing products can be optimally integrated into the supply chain and capacity management activities.
- Information technology chain operations.
- Where-to-make and make-buy decisions.
- Aligning overall organizational strategy with supply strategy.
- It is for long term and needs resource commitment.

Tactical

- Sourcing contracts and other purchasing decisions.
- Production decisions, including contracting, scheduling, and planning process definition.
- Inventory decisions, including quantity, location, and quality of inventory.
- Transportation strategy, including frequency, routes, and contracting.
- Benchmarking of all operations against competitors and implementation of best practices throughout the enterprise.
- Milestone payments.
- Focus on customer demand.

Operational

- Daily production and distribution planning, including all nodes in the supply chain.
- Production scheduling for each manufacturing facility in the supply chain (minute by minute).
- Demand planning and forecasting, coordinating the demand forecast of all customers and sharing the forecast with all suppliers.
- Sourcing planning, including current inventory and forecast demand, in collaboration with all suppliers.
- Inbound operations, including transportation from suppliers and receiving inventory.
- Production operations, including the consumption of materials and flow of finished goods.
- Outbound operations, including all fulfillment activities, warehousing and transportation to customers.
- Order promising, accounting for all constraints in the supply chain, including all suppliers, manufacturing facilities, distribution centers, and other customers.
- From production level to supply level accounting all transit damage cases & arrange to settlment at customer level by maintaining company loss through insurance company.

Supply chain management

Organizations increasingly find that they must rely on effective supply chains, or networks, to compete in the global market and networked economy.[7] In Peter Drucker's (1998) new management paradigms, this concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize entire business processes throughout a value chain of multiple companies.

During the past decades, globalization, outsourcing and information technology have enabled many organizations, such as Dell and Hewlett Packard, to successfully operate solid collaborative supply networks in which each specialized business partner focuses on only a few key strategic activities (Scott, 1993). This inter-organizational supply network can be acknowledged as a new form of organization. However, with the complicated interactions among the players, the network structure fits neither "market" nor "hierarchy" categories (Powell, 1990). It is not clear what kind of performance impacts different supply network structures could have on firms, and little is known about the coordination conditions and trade-offs that may exist among the players. From a systems perspective, a complex network structure can be decomposed into individual component firms (Zhang and Dilts, 2004). Traditionally, companies in a supply network concentrate on the inputs and outputs of the processes, with little concern for the internal management working of other individual players. Therefore, the choice of an internal management control structure is known to impact local firm performance (Mintzberg, 1979).

In the 21st century, changes in the business environment have contributed to the development of supply chain networks. First, as an outcome of globalization and the proliferation of multinational companies, joint ventures, strategic alliances and business partnerships, significant success factors were identified, complementing the earlier "Just-In-Time", "Lean Manufacturing" and "Agile Manufacturing" practices.[8] Second, technological changes, particularly the dramatic fall in information communication costs, which are a significant component of transaction costs, have led to changes in coordination among the members of the supply chain network (Coase, 1998).

Many researchers have recognized these kinds of supply network structures as a new organization form, using terms such as "Keiretsu", "Extended Enterprise", "Virtual Corporation", "Global Production Network", and "Next Generation Manufacturing System".[9] In general, such a structure can be defined as "a group of semi-independent organizations, each with their capabilities, which collaborate in ever-changing constellations to serve one or more markets in order to achieve some business goal specific to that collaboration" (Akkermans, 2001).

The security management system for supply chains is described in ISO/IEC 28000 and ISO/IEC 28001 and related standards published jointly by ISO and IEC.

Developments in Supply Chain Management

Six major movements can be observed in the evolution of supply chain management studies: Creation, Integration, and Globalization (Lavassani et al., 2008[a]), Specialization Phases One and Two, and SCM 2.0.

1. Creation Era

The term supply chain management was first coined by a U.S. industry consultant in the early 1980s. However, the concept of a supply chain in management was of great importance long before, in the early 20th century, especially with the creation of the assembly line. The characteristics of this era of supply chain management include the need for large-scale changes, re-engineering, downsizing driven by cost reduction programs, and widespread attention to the Japanese practice of management.

2. Integration Era

This era of supply chain management studies was highlighted with the development of Electronic Data Interchange (EDI) systems in the 1960s and developed through the 1990s by the introduction of Enterprise Resource Planning (ERP) systems. This era has continued to develop into the 21st century with the expansion of internet-based collaborative systems. This era of supply chain evolution is characterized by both increasing value-adding and cost reductions through integration.

3. Globalization Era

The third movement of supply chain management development, the globalization era, can be characterized by the attention given to global systems of supplier relationships and the expansion of supply chains over national boundaries and into other continents. Although the use of global sources in the supply chain of organizations can be traced back several decades (e.g., in the oil industry), it was not until the late 1980s that a considerable number of organizations started to integrate global sources into their core business. This era is characterized by the globalization of supply chain management in organizations with the goal of increasing their competitive advantage, value-adding, and reducing costs through global sourcing.

4. Specialization Era—Phase One: Outsourced Manufacturing and Distribution

In the 1990s industries began to focus on “core competencies” and adopted a specialization model. Companies abandoned vertical integration, sold off non-core operations, and outsourced those functions to other companies. This changed management requirements by extending the supply chain well beyond company walls and distributing management across specialized supply chain partnerships.

This transition also re-focused the fundamental perspectives of each respective organization. OEMs became brand owners that needed deep visibility into their supply base. They had to control the entire supply chain from above instead of from within. Contract manufacturers had to manage bills of material with different part numbering schemes from multiple OEMs and support customer requests for work -in-process visibility and vendor-managed inventory (VMI).

The specialization model creates manufacturing and distribution networks composed of multiple, individual supply chains specific to products, suppliers, and customers who work together to design, manufacture, distribute, market, sell, and service a product. The set of partners may change according to a given market, region, or channel, resulting in a proliferation of trading partner environments, each with its own unique characteristics and demands.

5. Specialization Era—Phase Two: Supply Chain Management as a Service

Specialization within the supply chain began in the 1980s with the inception of transportation brokerages, warehouse management, and non-asset-based carriers and has matured beyond transportation and logistics into aspects of supply planning, collaboration, execution and performance management.

At any given moment, market forces could demand changes from suppliers, logistics providers, locations and customers, and from any number of these specialized participants as components of supply chain networks. This variability has significant effects on the supply chain infrastructure, from the foundation layers of establishing and managing the electronic communication between the trading partners to more complex requirements including the configuration of the processes and work flows that are essential to the management of the network itself.

Supply chain specialization enables companies to improve their overall competencies in the same way that outsourced manufacturing and distribution has done; it allows them to focus on their core competencies and assemble networks of specific, best-in-class partners to contribute to the overall value chain itself, thereby increasing overall performance and efficiency. The ability to quickly obtain and deploy this domain-specific supply chain expertise without developing and maintaining an entirely unique and complex competency in house is the leading reason why supply chain specialization is gaining popularity.

Outsourced technology hosting for supply chain solutions debuted in the late 1990s and has taken root primarily in transportation and collaboration categories. This has progressed from the Application Service Provider (ASP) model from approximately 1998 through 2003 to the On-Demand model from approximately 2003-2006 to the Software as a Service (SaaS) model currently in focus today.

6. Supply Chain Management 2.0 (SCM 2.0)

Building on globalization and specialization, the term SCM 2.0 has been coined to describe both the changes within the supply chain itself as well as the evolution of the processes, methods and tools that manage it in this new "era".

Web 2.0 is defined as a trend in the use of the World Wide Web that is meant to increase creativity, information sharing, and collaboration among users. At its core, the common attribute that Web 2.0 brings is to help navigate the vast amount of information available on the Web in order to find what is being sought. It is the notion of a usable pathway. SCM 2.0 follows this notion into supply chain operations. It is the pathway to SCM results, a combination of the processes, methodologies, tools and delivery options to guide companies to their results quickly as the complexity and speed of the supply chain increase due to the effects of global competition, rapid price fluctuations, surging oil prices, short product life cycles, expanded specialization, near-/far- and off-shoring, and talent scarcity. SCM 2.0 leverages proven solutions designed to rapidly deliver results with the agility to quickly manage future change for continuous flexibility, value and success. This is delivered through competency networks composed of best-of-breed supply chain domain expertise to understand which elements, both operationally and organizationally, are the critical few that deliver the results as well as through intimate understanding of how to manage these elements to achieve desired results. Finally, the solutions are delivered in a variety of options, such as no-touch via business process outsourcing, mid-touch via managed services and software as a service (SaaS), or high touch in the traditional software deployment model.

Supply chain business process integration

Successful SCM requires a change from managing individual functions to integrating activities into key supply chain processes. An example scenario: the purchasing department places orders as requirements become known. The marketing department, responding to customer demand, communicates with several distributors and retailers as it attempts to determine ways to satisfy this demand. Information shared between supply chain partners can only be fully leveraged through process integration.

Supply chain business process integration involves collaborative work between buyers and suppliers, joint product development, common systems and shared information. According to Lambert and Cooper (2000), operating an integrated supply chain requires a continuous information flow. However, in many companies, management has reached the conclusion that optimizing the product flows cannot be accomplished without implementing a process approach to the business. The key supply chain processes stated by Lambert (2004) [10] are:

- Customer relationship management
- Customer service management
- Demand management
- Order fulfillment

- Manufacturing flow management
- Supplier relationship management
- Product development and commercialization
- Returns management

Much has been written about demand management. Best-in-Class companies have similar characteristics, which include the following: a) Internal and external collaboration b) Lead time reduction initiatives c) Tighter feedback from customer and market demand d) Customer level forecasting

One could suggest other key critical supply business processes which combine these processes stated by Lambert such as:

a. Customer service management
b. Procurement
c. Product development and commercialization
d. Manufacturing flow management/support
e. Physical distribution
f. Outsourcing/partnerships
g. Performance measurement

a) Customer service management process

Customer Relationship Management concerns the relationship between the organization and its customers. Customer service is the source of customer information. It also provides the customer with real-time information on scheduling and product availability through interfaces with the company's production and distribution operations. Successful organizations use the following steps to build customer relationships:

- determine mutually satisfying goals for organization and customers
- establish and maintain customer rapport
- produce positive feelings in the organization and the customers

b) Procurement process

Strategic plans are drawn up with suppliers to support the manufacturing flow management process and the development of new products. In firms where operations extend globally, sourcing should be managed on a global basis. The desired outcome is a win-win relationship where both parties benefit, and a reduction in time required for the design cycle and product development. Also, the purchasing function develops rapid communication systems, such as electronic data interchange (EDI) and Internet linkage to convey possible requirements more rapidly. Activities related to obtaining products and materials from outside suppliers involve resource planning, supply sourcing, negotiation, order placement, inbound transportation, storage, handling and quality assurance, many of which include the responsibility to coordinate with suppliers on matters of scheduling, supply continuity, hedging, and research into new sources or programs.

c) Product development and commercialization

Here, customers and suppliers must be integrated into the product development process in order to reduce time to market. As product life cycles shorten, the appropriate products must be developed and successfully launched with ever shorter time-schedules to remain competitive. According to Lambert and Cooper (2000), managers of the product development and commercialization process must:

1. coordinate with customer relationship management to identify customer-articulated needs;
2. select materials and suppliers in conjunction with procurement, and
3. develop production technology in manufacturing flow to manufacture and integrate into the best supply chain flow for the product/market combination.

d) Manufacturing flow management process

The manufacturing process produces and supplies products to the distribution channels based on past forecasts. Manufacturing processes must be flexible to respond to market changes and must accommodate mass customization. Orders are processes operating on a just-in-time (JIT) basis in minimum lot sizes. Also, changes in the manufacturing flow process lead to shorter cycle times, meaning improved responsiveness and efficiency in meeting customer demand. Activities related to planning, scheduling and supporting manufacturing operations, such as work-in-process storage, handling, transportation, and time phasing of components, inventory at manufacturing sites and maximum flexibility in the coordination of geographic and final assemblies postponement of physical distribution operations.

e) Physical distribution

This concerns movement of a finished product/service to customers. In physical distribution, the customer is the final destination of a marketing channel, and the availability of the product/service is a vital part of each channel participant's marketing effort. It is also through the physical distribution process that the time and space of customer service become an integral part of marketing, thus it links a marketing channel with its customers (e.g., links manufacturers, wholesalers, retailers).

f) Outsourcing/partnerships

This is not just outsourcing the procurement of materials and components, but also outsourcing of services that traditionally have been provided in-house. The logic of this trend is that the company will increasingly focus on those activities in the value chain where it has a distinctive advantage, and outsource everything else. This movement has been particularly evident in logistics where the provision of transport, warehousing and inventory control is increasingly subcontracted to specialists or logistics partners. Also, managing and controlling this network of partners and suppliers requires a blend of both central and local involvement. Hence, strategic decisions need to be taken centrally, with the monitoring and control of supplier performance and day-to-day liaison with logistics partners being best managed at a local level.

g) Performance measurement

Experts found a strong relationship from the largest arcs of supplier and customer integration to market share and profitability. Taking advantage of supplier capabilities and emphasizing a long-term supply chain perspective in customer relationships can both be correlated with firm performance. As logistics competency becomes a more critical factor in creating and maintaining competitive advantage, logistics measurement becomes increasingly important because the difference between profitable and unprofitable operations becomes more narrow. A.T. Kearney Consultants (1985) noted that firms engaging in comprehensive performance measurement realized improvements in overall productivity. According to experts, internal measures are generally collected and analyzed by the firm including

1. Cost
2. Customer Service
3. Productivity measures
4. Asset measurement, and
5. Quality.

External performance measurement is examined through customer perception measures and "best practice" benchmarking, and includes 1) customer perception measurement, and 2) best practice benchmarking.

h)Warehoising Management : As a case of reducing company cost & expenses, warehousing management is carrying the valuable role against operations. In case of perfect storing & office with all convenient facilities in company level, reducing manpower cost, dispatching authority with on time delivery, loading & unloading facilities with proper area, area for service station, stock management system etc.

Components of Supply Chain Management are as follows: 1. Standardization 2. Postponement 3. Customization

Theories of supply chain management

Currently there is a gap in the literature available on supply chain management studies: there is no theoretical support for explaining the existence and the boundaries of supply chain management. A few authors such as Halldorsson, et al. (2003), Ketchen and Hult (2006) and Lavassani, et al. (2008[b]) have tried to provide theoretical foundations for different areas related to supply chain by employing organizational theories. These theories include:

- Resource-Based View (RBV)
- Transaction Cost Analysis (TCA)
- Knowledge-Based View (KBV)
- Strategic Choice Theory (SCT)
- Agency Theory (AT)
- Institutional theory (InT)
- Systems Theory (ST)
- Network Perspective (NP)

Supply Chain Centroids

In the study of supply chain management, the concept of centroids has become an important economic consideration. A centroid is place that has a high proportion of a country's population and a high proportion of its manufacturing, generally within 500 mi (805 km). In the U.S., two major supply chain centroids have been defined, one near Dayton, Ohio and a second near Riverside, California.

The centroid near Dayton is particularly important because it is closest to the population center of the US and Canada. Dayton is within 500 miles of 60% of the population and manufacturing capacity of the U.S., as well as 60 percent of Canada's population[11] . The region includes the Interstate 70/75 interchange, which is one of the busiest in the nation with 154,000 vehicles passing through in a day. Of those, anywhere between 30 percent and 35 percent are trucks hauling goods. In addition, the I-75 corridor is home to the busiest north-south rail route east of the Mississippi. [12]

Tax efficient supply chain management

Tax Efficient Supply Chain Management is a business model which consider the effect of Tax in design and implementation of supply chain management. As the consequence of Globalization, business which is cross-nation should pay different tax rates in different countries. Due to the differences, global players have the opportunity to calculate and optimize supply chain based on tax efficiency[13] legally. It is used as a method of gaining more profit for company which owns global supply chain.

Supply chain sustainability

Supply chain sustainability is a business issue affecting an organization's supply chain or logistics network and is frequently quantified by comparison with SECH ratings. SECH ratings are defined as *social, ethical, cultural and health* footprints. Consumers have become more aware of the environmental impact of their purchases and companies' SECH ratings and, along with non-governmental organizations ([NGO]s), are setting the agenda for transitions to organically-grown foods, anti-sweatshop labor codes and locally-produced goods that support independent and small businesses. Because supply chains frequently account for over 75% of a company's carbon footprint[14] many organizations are exploring how they can reduce this and thus improve their SECH rating.

For example, in July, 2009 the U.S. based Wal-Mart corporation announced its intentions to create a global sustainability index that would rate products according to the environmental and social impact made while the products were manufactured and distributed. The sustainability rating index is intended to create environmental accountability in Wal-Mart's supply chain, and provide the motivation and infrastructure for other retail industry companies to do the same.[15]

Components of supply chain management integration

The management components of SCM

The SCM components are the third element of the four-square circulation framework. The level of integration and management of a business process link is a function of the number and level, ranging from low to high, of components added to the link (Ellram and Cooper, 1990; Houlihan, 1985). Consequently, adding more management components or increasing the level of each component can increase the level of integration of the business process link. The literature on business process re-engineering,[16] buyer-supplier relationships,[17] and SCM[18] suggests various possible components that must receive managerial attention when managing supply relationships. Lambert and Cooper (2000) identified the following components:

- Planning and control
- Work structure
- Organization structure
- Product flow facility structure
- Information flow facility structure
- Management methods
- Power and leadership structure
- Risk and reward structure
- Culture and attitude

However, a more careful examination of the existing literature[19] leads to a more comprehensive understanding of what should be the key critical supply chain components, the "branches" of the previous identified supply chain business processes, that is, what kind of relationship the components may have that are related to suppliers and customers. Bowersox and Closs states that the emphasis on cooperation represents the synergism leading to the highest level of joint achievement (Bowersox and Closs, 1996). A primary level channel participant is a business that is willing to participate in the inventory ownership responsibility or assume other aspects of financial risk, thus including primary level components (Bowersox and Closs, 1996). A secondary level participant (specialized) is a business that participates in channel relationships by performing essential services for primary participants, including secondary level components, which support primary participants. Third level channel participants and components that support the primary level channel participants and are the fundamental branches of the secondary level components may also be included.

Consequently, Lambert and Cooper's framework of supply chain components does not lead to any conclusion about what are the primary or secondary (specialized) level supply chain components (see Bowersox and Closs, 1996, p. 93). That is, what supply chain components should be viewed as primary or secondary, how should these components be structured in order to have a more comprehensive supply chain structure, and how to examine the supply chain as an integrative one (See above sections 2.1 and 3.1).

Reverse Supply Chain Reverse logistics is the process of managing the return of goods. Reverse logistics is also referred to as "Aftermarket Customer Services". In other words, any time money is taken from a company's warranty reserve or service logistics budget one can speak of a reverse logistics operation.

Supply chain systems and value

Supply chain systems configure value for those that organise the networks. Value is the additional revenue over and above the costs of building the network. Co-creating value and sharing the benefits appropriately to encourage effective participation is a key challenge for any supply system. Tony Hines defines value as follows: “Ultimately it is the customer who pays the price for service delivered that confirms value and not the producer who simply adds cost until that point” [20]

Global supply chain management

Global supply chains pose challenges regarding both quantity and value:

Supply and Value Chain Trends

- Globalization
- Increased cross border sourcing
- Collaboration for parts of value chain with low-cost providers
- Shared service centers for logistical and administrative functions
- Increasingly global operations, which require increasingly global coordination and planning to achieve global optimums
- Complex problems involve also midsized companies to an increasing degree,

These trends have many benefits for manufacturers because they make possible larger lot sizes, lower taxes, and better environments (culture, infrastructure, special tax zones, sophisticated OEM) for their products. Meanwhile, on top of the problems recognized in supply chain management, there will be many more challenges when the scope of supply chains is global. This is because with a supply chain of a larger scope, the lead time is much longer. Furthermore, there are more issues involved such as multi-currencies, different policies and different laws. The consequent problems include:1. different currencies and valuations in different countries; 2. different tax laws (Tax Efficient Supply Chain Management); 3. different trading protocols; 4. lack of transparency of cost and profit.

See also

- Beer distribution game
- Bullwhip effect
- Calculating demand forecast accuracy
- Customer-driven supply chain
- CRM
- Demand chain management
- Distribution
- Enterprise resource planning
- Industrial engineering
- Information technology management
- Integrated business planning
- Inventory
- Inventory control system
- Inventory management software
- Liquid logistics
- Logistic engineering
- Logistics
- Logistics management
- Offshoring Research Network
- Operations management
- Order fulfillment
- Procurement
- Haulage
- Procurement outsourcing
- Radio-frequency identification
- Reverse logistics
- Service management
- Strategic information system
- Supply chain management software
- Supply chain network
- Supply chain security
- Supply chain
- Supply management
- Tendering
- Value chain
- Value grid

- Logistics officer
- Management information system
- Military supply chain management
- Vendor-managed inventory
- Warehouse management system

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External links

- CIO Magazine's ABCs of Supply Chain Management [22]
- Academic blog on supply chain management [23]
- Inventory optimisation in supply chains [24]
- Reviews of Supply Chain Management Software [25]

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[22] http://www.cio.com/article/40940

[23] http://www.interorganisational.org

[24] http://www.inventory-management.de

[25] http://www.theeasybee.com/directory/supply-chain-management-scm-

Demand chain management

Demand chain management is the management of upstream and downstream relationships between suppliers and customers to deliver the best value to the customer at the least cost to the demand chain as a whole. The term demand chain management is used to denote the concept commonly referred to as supply chain management, however with special regard to the customer pull [1] . In that sense, demand chain management software tools bridge the gap between the customer relationship management and the supply chain management [2] . The organization's supply chain processes are managed to deliver best value according to the demand of the customers. A study of the university in Wageningen (the Netherlands) sees DCM as an extension of supply chain management, due to its incorporation of the market orientation perspective on its concept[3] . While the term "demand-driven supply chain or network" denotes a set of concepts, the term "demand-driven execution" or DDE is used to express the means of achieving those concepts.

Demand-driven supply network

A *Demand-driven supply network (DDSN)* is one method of supply chain management which involves building supply chains in response to demand signals. The main force of DDSN is that it is driven by customers demand. In comparison with the traditional supply chain, DDSN uses the pull technique. It gives DDSN market opportunities to share more information and to collaborate with others in the supply chain.

DDSN uses a capability model that consist of four levels. The first level is *Reacting*, the second level is *Anticipating*, the third level is *Collaborating* and the last level is *Orchestrating*. The first two levels focus on the internal supply chain while the last two levels concentrate on external relations throughout the Extended Enterprise[4] .

Competitive advantages

To create sustainable competitive advantages with DDSN, companies have to do deal with three conditions: *Alignment* (create shared incentives), *Agility* (respond quickly to short-term change) and *Adaptability* (adjust design of the supply chain)[5] .

Misconceptions

There are five common made misconceptions of demand driven (DDSN):[6] .

1. Companies might think they are demand driven because they have a good forecast of their company.
2. They have implemented lean manufacturing.
3. They have great data on all their customers.
4. They think it is a technology project and the corporate forecast is a demand visibility signal.
5. They have a better view of customers demand.

An important component of DDSN is DDM ("real-time" demand driven manufacturing). DDM gives customers the opportunity to say what they want, where and when.

Demand-driven Execution

Demand chain management is the same as supply chain management, but with emphasis on consumer pull vs. supplier push. [1] The demand chain begins with customers, then funnels through any resellers, distributors, and other business partners who help sell the company's products and services. The demand chain includes both direct and indirect sales forces. [7] Customers demand is hard to detect because out of stock situations (OOS) falsify data collected from POS-Terminals. According to studies of Corsten/Gruen (2002, 2008)[8] the OOS-rate is about 8%. For products under sales promotion OOS rates up to 30% exist. Reliable information about demand is necessary for

DCM therefore lowering OOS is a main factor for successful DCM.

Corsten and Gruen describe key factors for lowering OOS-rates:

- data accuracy
- forecast and order accuracy
- order quantity
- replenishment
- Capacity (time supply)
- Capacity (Packout) and Planogram Compliance
- Shelf Replenishment

Implementation of system supported processes leads to the new technology Extreme Transaction Processing described by Gartner Research [9] . This technology allows to process the huge amount of data (POS, RFID) in real time providing information for store managers, shelve managers and the supply chain.

Further reading

- Beyond CRM: The Critical Path to Successful Demand Chain Management [10]
- The Handbook for Becoming Demand Driven [11]

See also

- Supply chain
- Supply network
- Demand chain

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Supply-Chain Operations Reference

Supply-Chain Operations Reference-model (**SCOR**) is a process reference model developed by the management consulting firm PRTM and endorsed by the Supply-Chain Council (SCC) as the cross-industry de facto standard diagnostic tool for supply chain management. SCOR enables users to address, improve, and communicate supply chain management practices within and between all interested parties in the Extended Enterprise.

SCOR is a management tool, spanning from the supplier's supplier to the customer's customer. The model has been developed by the members [1] of the Council on a volunteer basis to describe the business activities associated with all phases of satisfying a customer's demand..

The model is based on 3 major "pillars":

- Process Modeling
- Performance Measurements
- Best Practices

The Process Modeling Pillar

By describing supply chains using process modeling building blocks, the model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be linked to describe the depth and breadth of virtually any supply chain.

SCOR is based on five distinct management processes: Plan, Source, Make, Deliver, and Return.

- *Plan* - Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production, and delivery requirements.
- *Source* - Processes that procure goods and services to meet planned or actual demand.
- *Make* - Processes that transform product to a finished state to meet planned or actual demand.
- *Deliver* - Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management.
- *Return* - Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support.

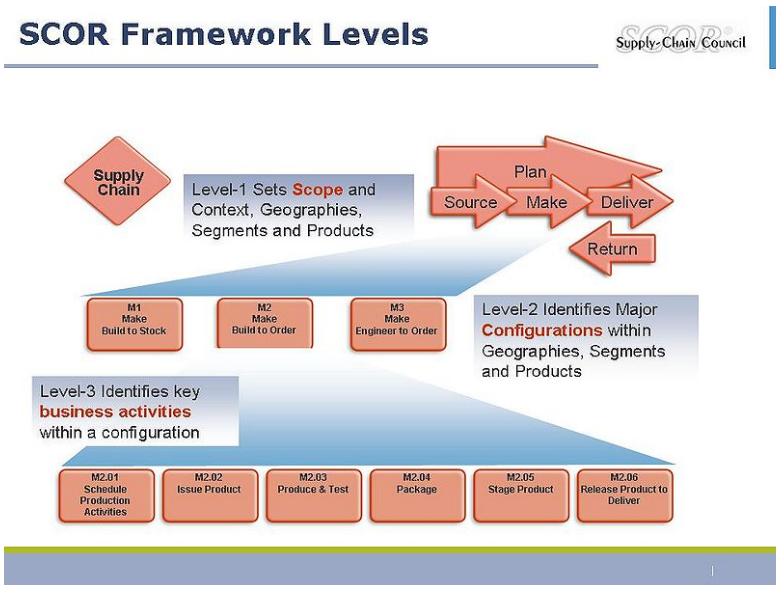
With all reference models, there is a specific scope that the model addresses. SCOR is no different and the model focuses on the following:

- All customer interactions, from order entry through paid invoice.
- All product (physical material and service) transactions, from your supplier’s supplier to your customer’s customer, including equipment, supplies, spare parts, bulk product, software, etc.
- All market interactions, from the understanding of aggregate demand to the fulfillment of each order.

SCOR does not attempt to describe every business process or activity. Relationships between these processes can be made to the SCOR and some have been noted within the model. Other key assumptions addressed by SCOR include: training, quality, information technology, and administration (not supply chain management). These areas are not explicitly addressed in the model but rather assumed to be a fundamental supporting process throughout the model.

SCOR provides three-levels of process detail. Each level of detail assists a company in defining scope (Level 1), configuration or type of supply chain (Level 2), process element details, including performance attributes (Level 3). Below level 3, companies decompose process elements and start implementing specific supply chain management practices. It is at this stage that companies define practices to achieve a competitive advantage, and adapt to changing business conditions.

SCOR is a process reference model designed for effective communication among supply chain partners. As an industry standard it also facilitates inter and intra supply chain collaboration, horizontal process integration, by explaining the relationships between processes (i.e., Plan-Source, Plan-Make, etc.). It also can be used as a data input to completing an analysis of configuration alternatives (e.g., Level 2) such as: Make-to-Stock or Make-To-Order. SCOR is used to describe, measure, and evaluate supply chains in support of strategic planning and continuous improvement.



SCOR Process Framework

In the example provided by the picture the Level 1 relates to the Make process. This means that the focus of the analysis will be concentrated on those processes that relate to the added-value activities that the model categorizes as Make processes.

Level 2 includes 3 sub-processes that are “children” of the Make “parent”. These children have a special tag - a letter (M) and a number (1, 2, or 3). This is the syntax of the SCOR model. The letter represents the initial of the process. The numbers identify the “scenario”, or “configuration”.

M1 equals a “Make build to stock” scenario. Products or services are produced against a forecast. M2 equals a “Make build to order” configuration. Products or services are produced against a real customer order in a just-in-time fashion. M3 stands for “Make engineer to order” configuration. In this case a blueprint of the final product is needed before any make activity can be performed.

Level 3 processes, also referred to as the business activities within a configuration, represent the best practice detailed processes that belong to each of the Level 2 “parents”.

The example shows the breakdown of the Level 2 process “Make build to order” into its Level 3 components identified from M2.01 to M2.06. Once again this is the SCOR syntax: letter-number-dot-serial number.

The model suggests that to perform a “Make build to order” process, there are 6 more detailed tasks that are usually performed. The model is not prescriptive, in the sense that it is not mandatory that all 6 processes are to be executed. It only represents what usually happens in the majority of organizations that compose the membership base of the Supply Chain Council.

The Level 3 processes reach a level of detail that cannot exceed the boundaries determined by the industry- agnostic and industry-standard nature of the SCOR model. Therefore all the set of activities and processes that build - for instance - the M2.03 “Produce & test” process will be company-specific, and therefore fall outside the model’s scope.

The Performance Measurements Pillar The SCOR model contains more than 150 key indicators that measure the performance of supply chain operations. These performance metrics derive from the experience and contribution of the Council members. As with the process modeling system, SCOR metrics are organized in a hierarchical structure. Level 1 metrics are at the most aggregated level, and are typically used by top decision makers to measure the performance of the company's overall supply chain. Level 1 Metrics are primary, high level measures that may cross multiple SCOR processes. Level 1 Metrics do not necessarily relate to a SCOR Level 1 process (PLAN, SOURCE, MAKE, DELIVER, RETURN).

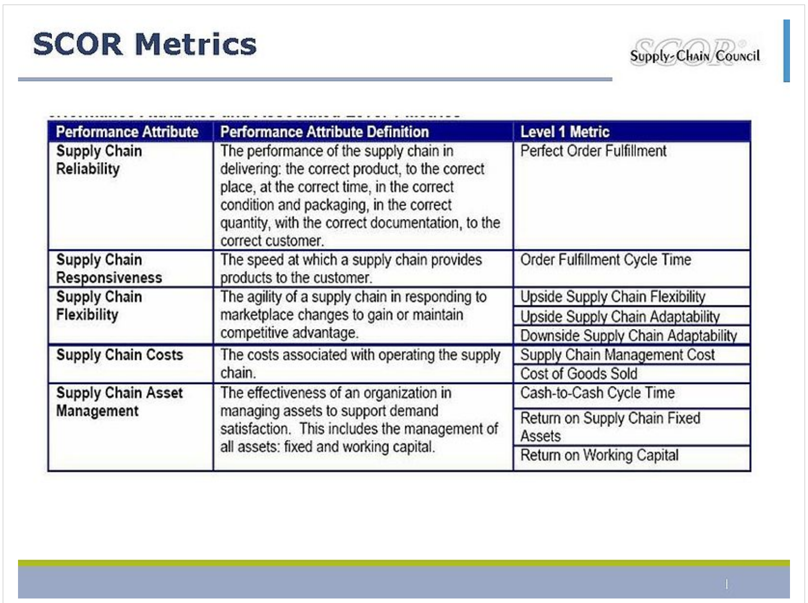
The metrics are used in conjunction with performance attributes. The Performance Attributes are characteristics of the supply chain that permit it to be analyzed and evaluated against other supply chains with competing strategies. Just as you would describe a physical object like a piece of lumber using standard characteristics (e.g., height, width, depth), a supply chain requires standard characteristics to be described. Without these characteristics it is extremely difficult to compare an organization that chooses to be the low-cost provider against an organization that chooses to compete on reliability and performance.

Associated with the Performance Attributes are the Level 1 Metrics. These Level 1 Metrics are the calculations by which an implementing organization can measure how successful they are in achieving their desired positioning within the competitive market space.

The metrics in the Model are hierarchical, just as the process elements are hierarchical. Level 1 Metrics are created from lower level calculations. (Level 1 Metrics are primary, high level measures that may cross multiple SCOR processes. Level 1 Metrics do not necessarily relate to a SCOR Level 1 process (PLAN, SOURCE, MAKE, DELIVER, RETURN). Lower level calculations (Level 2 metrics) are generally associated with a narrower subset of processes. For example, Delivery Performance is calculated as the total number of products delivered on time and in full based on a commit date.

The Best Practices Pillar

Once the performance of the supply chain operations has been measured and performance gaps identified, it becomes important to identify what activities should be performed to close those gaps. Over 430 executable practices derived from the experience of SCC members are available.



SCOR Metrics

Supply-Chain Council

Performance Attribute	Performance Attribute Definition	Level 1 Metric
Supply Chain Reliability	The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect Order Fulfillment
Supply Chain Responsiveness	The speed at which a supply chain provides products to the customer.	Order Fulfillment Cycle Time
Supply Chain Flexibility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Upside Supply Chain Flexibility Upside Supply Chain Adaptability Downside Supply Chain Adaptability
Supply Chain Costs	The costs associated with operating the supply chain.	Supply Chain Management Cost Cost of Goods Sold
Supply Chain Asset Management	The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-Cash Cycle Time Return on Supply Chain Fixed Assets Return on Working Capital

SCOR Performance Attributes and Level 1 Metrics

The SCOR model defines a best practice as a current, structured, proven and repeatable method for making a positive impact on desired operational results.

 Current - Must not be emerging (bleeding edge) and must not be antiquated

 Structured - Has clearly stated Goal, Scope, Process, and Procedure

 Proven - Success has been demonstrated in a working environment.

 Repeatable - The practice has been proven in multiple environments.

 Method- Used in a very broad sense to indicate: business process, practice, organizational strategy, enabling technology, business relationship, business model, as well as information or knowledge management.

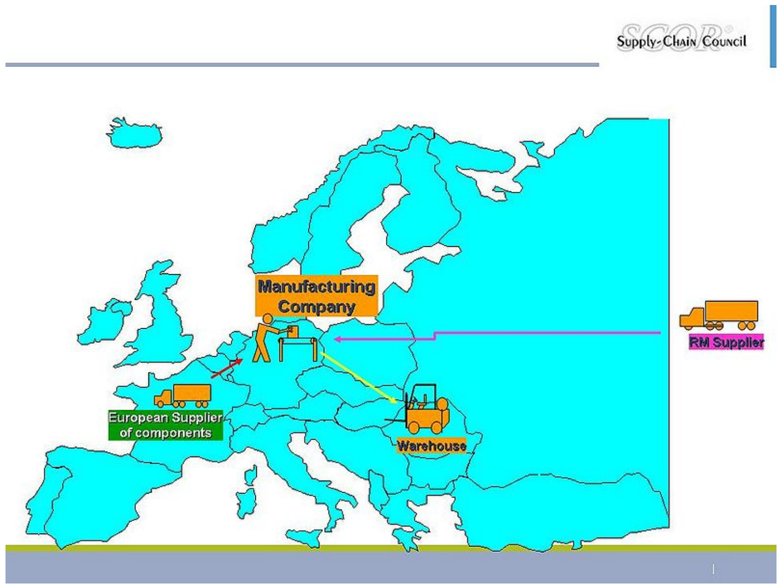
 Positive impact on desired operational results The practice shows operational improvement related to the stated goal and could be linked to Key Metric(s). The impact should show either as gain (increase in speed, revenues, quality) or reduction (resource utilizations, costs, loss, returns, etc.).

An example of how to use SCOR

The example is of a simple supply chain.

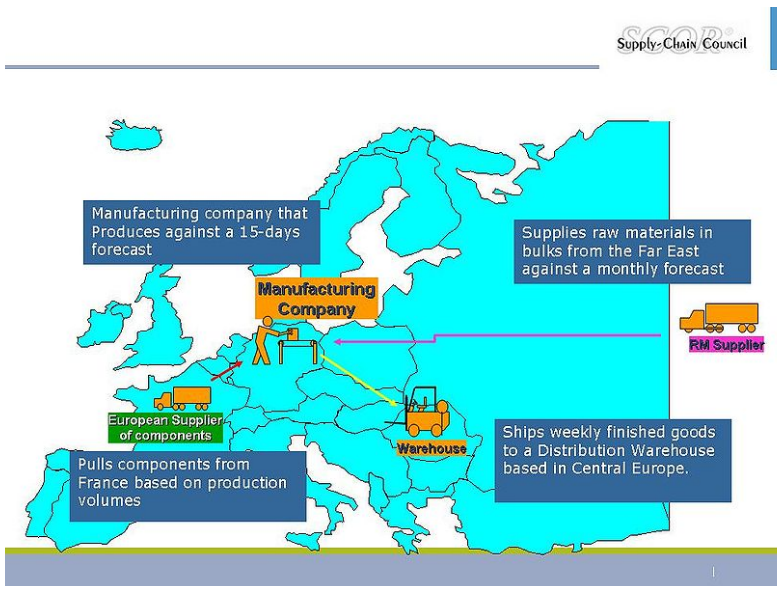
The picture alone cannot adequately describe what production strategy the manufacturing company has decided to adopt. It is no easier to figure out how the material is supplied from the two suppliers. For example, is the material delivered against a forecast or is it pulled based on real consumption?

Even in its apparent simplicity this picture does not represent a standard. Without a more extensive description the picture does not help interpret what is actually happening in this supply chain. Descriptive text could be added to the images to help explain the whole process.

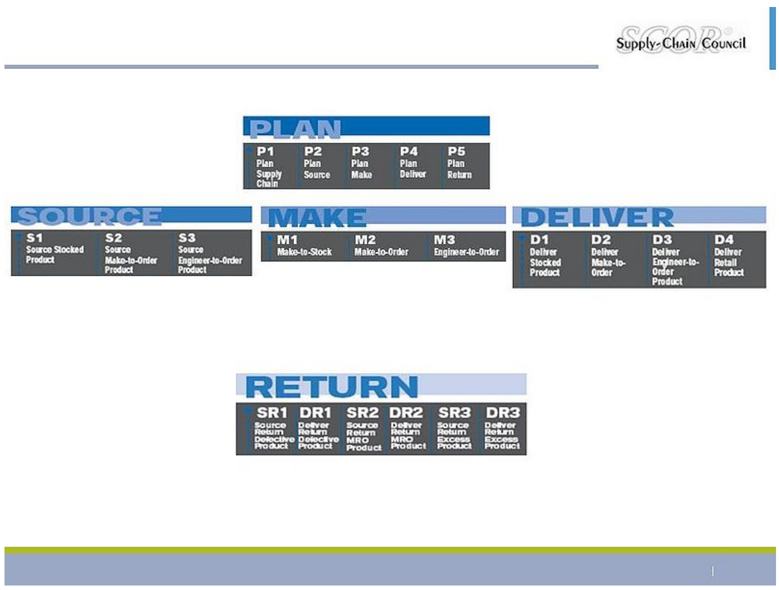


Example of supply chain

SCOR improves on this by offering a "standard" solution. The first step is to recover the Level 1 and Level 2 process descriptions.



Some additional descriptions for the supply chain



Caption from SCOR 8.0

In order to keep the example simple and direct, it focuses only on the central processes: Source, Make, and Deliver. This reflects the general practice of members who focus first of all on these three process scopes. Only in a second step do they apply Plan and Return to map all their supply chain processes.

The description of the manufacturing company reads “Manufacturing company That Produces against a 15-day forecast”. The key word here is “forecast”. What is the SCOR scenario that resembles a production based on forecast? The answer is, M1 (Make build to stock).

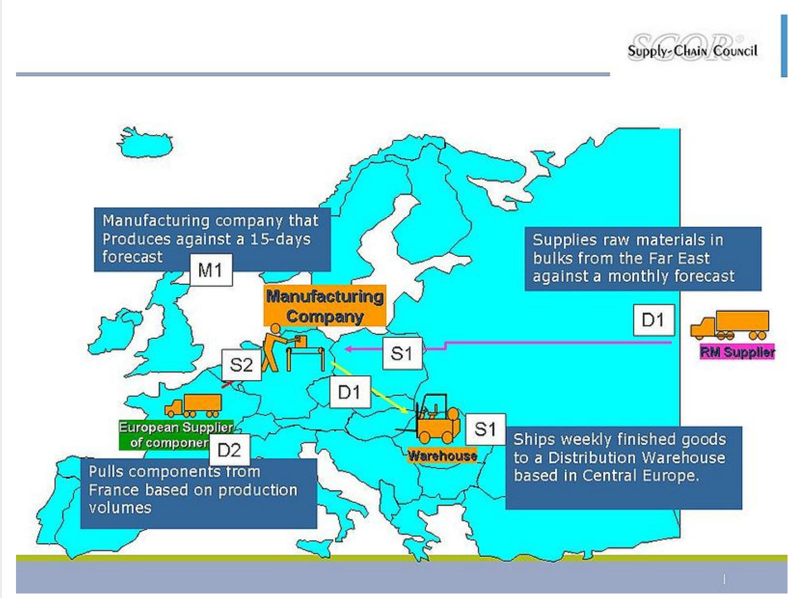
How does the company supply materials from the Far East? The box reads “Supplies raw materials in bulks from the Far East against a monthly forecast”. “Forecast” is again the keyword. How a process of supply based on a forecast be represented? The process is “Source”. The picture from the SCOR manual shows that the process S1 “Source Stocked Product” exactly corresponds to the needs of this example.

With the French supplier, the company “Pulls components from France based on production volumes”. The key word here is “pulls”, as it describes a "just-in-time" strategy adopted with this supplier. What is the syntax used by SCOR to represent a pull-mode supply? The Source process descriptions in SCOR 8.0 offers a description that resonates well with the needs of the example: S2 “Source Make-to-Order Product”.

Lastly, the distribution strategy chosen by the manufacturing company is “Ship weekly finished goods to a Distribution Warehouse based in Central Europe”. The description suggests that a weekly shipment is closer to a forecast-based rather than a just-in-time policy. A shipment is a delivery process, so we must look under the “Deliver” tree. By browsing the Level 2 processes in the model we must look for a process configuration that corresponds to the forecast-based policy. We find that in D1 “Deliver Stocked Product”.

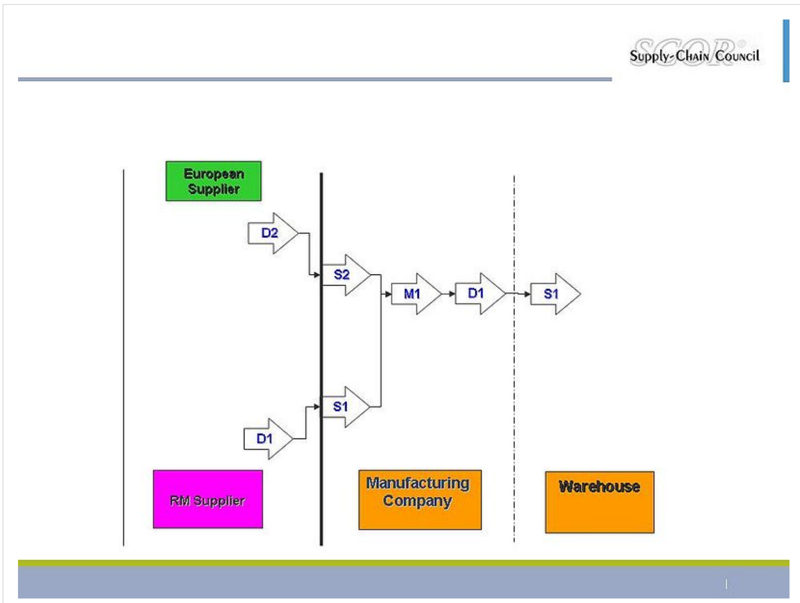
The SCOR paradigm demands that whenever a unit of the chain supplies, there must be some other unit that delivers. Similarly, any delivery process requires a correspondent supply process at the other end of the link. So the mapping of the processes of the supply chain is completed, and can be depicted as in the following illustration.

We see now that we don't need any more the descriptions in the boxes. By just reading the SCOR syntax we immediately capture the salient processes that occur in this chain.



Completed mappings of the supply chain processes with SCOR

The syntax of the model allows "to speak the same language". As a matter of fact, is we were to use the "orthodox" representation of a SCOR mapping, we would build a "thread diagram" like the one in the below picture. This is perfectly correspondent to the initial geographical picture, but it contains much more embedded information (we can call it a meta-model) in a more structured and elegant way. The arrows themselves represent the direction of the material flow.



SCOR thread diagram

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External links

- Supply-Chain Council website [3]
- Industry Week, May 1 2008: SCOR Goes Green [4]

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Collaborative planning, forecasting, and replenishment

Collaborative Planning, Forecasting and Replenishment (CPFR) is a concept that aims to enhance supply chain integration by supporting and assisting joint practices. CPFR seeks cooperative management of inventory through joint visibility and replenishment of products throughout the supply chain. Information shared between suppliers and retailers aids in planning and satisfying customer demands through a supportive system of shared information. This allows for continuous updating of inventory and upcoming requirements, making the end-to-end supply chain process more efficient. Efficiency is created through the decrease expenditures for merchandising, inventory, logistics, and transportation across all trading partners.

CPFR Origins

CPFR began as a 1995 initiative co-led by Wal-Mart's Vice President of Supply Chain, Chief Information Officer, Vice President of Application Development, and the Cambridge, Massachusetts software and strategy firm, Benchmarking Partners. The Open Source initiative, was originally called CFAR (pronounced See-Far, for Collaborative Forecasting and Replenishment). According to an October 21, 1996 Business Week article entitled *Clearing the Cobwebs from the Stockroom, New Internet software may make forecasting a snap*, "Benchmarking developed CFAR with funding from Wal-Mart, IBM, SAP, and Manugistics. The latter two are makers of accounting and supply chain management software, respectively. To promote CFAR as a standard, Benchmarking has posted specifications on the Web and briefed more than 250 companies, including Sears, J.C. Penney, and Gillette. About 20 companies are implementing CFAR."

Warner Lambert (now part of Pfizer) served as the first pilot for CFAR. The pilot's results were publicly announced at a CFAR industry session at Harvard University, July 30, 1996 of executives from Wal-Mart's suppliers as well as other retailers and the Uniform Code Council. Benchmarking Partners then presented CFAR to the Board of Directors of the Voluntary Interindustry Commerce Standards Committee (VICS). VICS established an industry committee to prepare for rolling CFAR out as an international standard. The original committee was co-chaired by the Vice President of Customer Marketing from Nabisco and the Vice President of Supply chain from Wal-Mart. Based on the suggestion of Procter & Gamble's Vice President of Supply Chain, the standard was renamed CPFR to emphasize the role of planning in the collaborative process.

The first publication of the VICS CPFR Voluntary Guidelines came out in 1998. Currently there are committees "to develop business guidelines and roadmaps for various collaborative scenarios, which include upstream suppliers, suppliers of finished goods and retailers, which integrate demand and supply planning and execution. The committee is continuing to improve the existing guidelines, tools and critical first steps that enable the implementation of CPFR." [1] These committees gained experience from pilot studies which have occurred over the past six years. VICS continues to lead much of the research and implementation of CPFR through its guidelines and project investigations.

CPFR Model

The CPFR model presents the aspects in which industries focus. The model provides a basic framework for the flow of information, goods, and services. In the retail industry the “retailer typically fills the buyer role, a manufacturer fills the seller role, and the consumer is the end customer.”[4] The center of the model is represented as the consumer, followed by the middle ring of the retailer, and finally the outside ring being the manufacturer. Each ring of the model represents different functions within the CPFR model. The consumer drives demand for goods and services while the retailer is the provider of goods and services. The manufacturer supplies the retailer stores with product as demand for product is pulled through the supply chain by the end user, being the consumer.

Some of the main processes shown in the model can be found in the second ring that has arrows in a circular pattern. This is displayed with collaboration arrangement, joint business plan, sales forecasting, order fulfillment etc. This stage will be described in detail below:

“Strategy & Planning, Collaboration Arrangement is the process of setting the business goals for the relationship, defining the scope of collaboration and assigning roles, responsibilities, checkpoints and escalation procedures. The Joint Business Plan then identifies the significant events that affect supply and demand in the planning period, such as promotions, inventory policy changes, store openings/closings, and product introductions.”[4]

“Demand & Supply Management is broken into Sales Forecasting, which projects consumer demand at the point of sale, and Order Planning/Forecasting, which determines future product ordering and delivery requirements based upon the sales forecast, inventory positions, transit lead times, and other factors.”[5]

“Execution consists of Order Generation, which transitions forecasts to firm demand, and Order Fulfillment, the process of producing, shipping, delivering, and stocking products for consumer purchase.”[6]

“Analysis tasks include Exception Management, the active monitoring of planning and operations for out-of-bounds conditions, and Performance Assessment, the calculation of key metrics to evaluate the achievement of business goals, uncover trends or develop alternative strategies”[7] Wal-mart supply chain and logistics management.

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