5.1 Introduction

Supply chain management system has three major components. They are information flow, material flow, and cash flow. SCM systems are used to improve the speed and accuracy of information flow to make system effective and efficient, and to make fast and reliable cash flow. Functional requirements to achieve the above are discussed in this chapter.

Information Technology is the backbone of success of any SCM system, Cachon and Fisher [2000]. The development in cost reduction started from efficient utilization of facilities using statistical tools. With the predicted demand it sub-optimizes at different levels to minimize the cost of production planning and scheduling of everything on the basis of product consumption in the market, [Pinto and Grossmann, 1998]. Consumption of customer is monitored on real time basis and that information is used for planning and rescheduling of production, [Sahinidis and Grossman, 1991]. Movement of material from supplier retailer is on the basis of the new schedule. A strong support of computer network is essential for the success of SCM. Intranet, extranet and Internet can be used for the data collection and converting it into useful information. Suggestion for using these technologies in a refinery is given in this chapter. Data generation is another important area where refineries need a lot of impertinence. Same data is reproduced at different functional levels and this reduces the authenticity of information. Once data is generated, data must be used from the source itself at all functional levels, [Thonemann, 2002]. It will reduce redundancy of data. Main data generation is production department and planning, operation and control departments use it. Data generation and flow management in planning operation and control is discussed in this chapter.
5.2 Problem and objective

Management in the Petroleum Refining industry is dominated by Engineers, mainly chemical Engineers. Since they are technically trained their focus is mostly on refining operations and its improvement. Logistics is sidelined. Therefore Supply chain related data collection, recording, and information generation are the weak areas in a refinery. Data collection and entry into the computer is not made at the place of supply chain operation. Repetition of data collection and entry by different agencies is also common. This creates problems specially when there is difference between the values of the same data collected by different agencies. Lack of common standard norms of data collection and insufficient networking and data sharing is the main reason for this type of error.

Developing an information flow model for making SCM software for a refinery is the main objective of this chapter. Detailed study is made on the data collection methods at all stages from customer to the crude oil supplier and converting them to information to be used for decision making at different levels of management in a refinery. Main features required for the software are also discussed. Information flow at each module level must be developed and they must be integrated to get a complete information flow model. Different Information System tools and Technologies used in Supply chain Management are also presented in this chapter. The areas where each of these can be used in a Refinery supply chain are also pointed out here.

5.3 Supply Chain Management Components.

The nature of business enterprise is changing. Today's business is increasingly "boundary less" meaning that internal functional barriers are being eroded in favour of horizontal process management. The separation between suppliers, manufacturers, distributors, and customers is reducing. This is the idea of extended enterprise, which is transforming organization to complete in the market. According to Bowersox and Daugherty (1995), characteristics of modern supply chain are flexibility, quick response, reliability, and adaptability.
Information highway is the backbone of extended enterprise, sharing of information makes cross function and horizontal management possible. Characteristics of useful information are complete, reliable, timely, understandable, and verifiable, Marshel and Paul (2002). Information sharing between partners in the supply chain enables the responsive flow of product from raw material to the final customer.

![Diagram of supply chain components](image)

**Figure 5.1 Supply chain components**

Supply chain is the effect of a series of relationships between partners. This is based on the value-added exchange of information. Figure 5.1 illustrates this concept. Fund flow and material flow are the commercially significant part of supply chain. All these interactions should ideally take place in a healthy business environment, which is conducive for the growth of industry. These components are discussed in the sections that follow.

### 5.3.1. Materials Flow

Earlier the focus in industry was on process improvement alone to improve productivity. The process improvement will not directly increase profit as logistics does.
There is considerable scope in many refineries for better management of logistics costs and hence for profit leverage. Figure 5.2 highlights the possibility of improving profit when profit margins are low relative to distribution costs. A hidden cost of logistics is the interest charged on inventory, tanks, and pipelines. Because this is rarely separately identified by most management accounting systems. Any reduction in hidden cost will directly increase profit. So improvement in efficiency of logistics is easy and urgent area for competitiveness in the market.

The value chain activities (Figure 5.3) can be categorized as inbound logistics, internal logistics, outbound logistics, and marketing and sales. To gain competitive advantage over its rivals, a refinery must deliver value to its customer through performing these activities more effectively than its competitors or by performing the activities in a unique way that creates greater differentiation. Logistic management has the potential to assist the organization in the achievement of both cost/productivity advantage and a value advantage.
5.3.1.1. Inbound Logistics

Inbound logistics in a refinery involves locating crude oil supplier, making the contract, and arranging shipment from supplier to the purchaser, facility management in the unloading port, and transporting from unloading port to refinery and storage at refinery.

Published data is available to get details on quality of crude oil of each location in different part of the world. Suitable and economic crude can be selected and the refinery can enter into purchase agreement. Purchase agreement can be either long term or spot purchase. Once purchase is made schedule of delivery can be obtained and shipping companies can be contacted for transporting. Many shipping companies are doing this crude oil transporting in different capacity ships. Depending on the crude demand and facility at unloading port, the refinery can select the right type of ship through shipping agents. Managing facilities at unloading port includes checking of draft with port trust, availability of port facility, pilots, and availability of tugs. Normally these arrangements are done through shipping agents. Refineries do not directly involve into shipping activities, they will entrust clearing and forwarding agents with the schedule of ship arrivals. Follow up of ship arrivals also will be done by clearing and forwarding agent at unloading port. Transporting from port to refinery is usually through pipeline. These will be exclusive pipelines for crude oil transporting from port to refinery.

Logistic management has the potential to assist a refinery in the achievement of both cost and productivity advantage and value advantage. Figure 5.4 suggest ways in which productivity can be enhanced through logistics and the prospects for gaining a value advantage in the market place through customer service. In short the refineries that will be the leader in the market of the future will be those that have sought and achieved the twin peaks of excellence: they have gained both cost leadership and service leadership.

The under lying philosophy behind the logistics concept is that of planning and co-ordination, the materials flow from source to user as an integrated system
rather than managing the goods flow as a series of independent activities. Thus under the logistics management regime the goal is to link the market place, the distribution network, the manufacturing processes, and the procurement activity in such a way that

Value advantage
- Tailored service
- Reliability
- Responsiveness

Superior Customer Value

Productivity advantage
- Logistic leverage opportunities
- Capacity utilization
- Asset turn
- Schedule integration

Figure 5.4 Gaining Competitive advantage through supply chain

customers are serviced at higher levels and yet at lower cost. In other words to achieve the goal of competitive advantage through both cost reduction and service enhancement.

5.3.1.2 Operational and internal Logistics

In this thesis refining operations in a refinery is termed as operations. Main Functions involved in operations are the control of delivery of crude oil from storage tanks to initial distillation columns, storage of distillates or streams in tanks, treatment of streams for converting into products, selection of processes for getting products, and blending operations.

To improve operations management and flexibility, logistics management must be improved. Flexibility in feeding from any crude oil tank to any distillation column and distillation column to any stream tank must be possible. As on today Indian refineries are designating certain tanks to store a set of fixed tanks and normally those tanks are kept filled with blended products. Storage of
blended products reduces flexibility and increases storage cost. If streams are stored in tanks, designation of tanks can be minimized and delivery from distillation columns can be less complicated. This will intern reduce number of trunks required for storage of products. Moreover a variety of products can be supplied to customers as per their varying demand. Internal logistics is a neglected area in almost all refineries. But internal logistics only can improve flexibility. So in the near future all Indian refineries will realize the importance of internal logistics.

5.3.1.3 Outbound Logistics

Outbound logistics involves the movement of refined products from refinery to customer. Two methods are in practice in India. One is refinery directly supplying to the retailer and the other is refinery supply to marketing companies and they distribute to retailers. For example Reliance Petrochemical Limited (RPL) is not having their own outlets instead they are selling to Indian Oil Corporation (IOC). IOC is doing their own refining and marketing. Indo-Burma Petroleum (IBP) is having only marketing no refinery. Refinery like KRL is having very few own outlets and marketing is mainly done by Hindustan Petroleum Limited (HPL).

Transportation can be using pipeline, ship, rail or road. As discussed in chapter 3, pipe line is the cheapest for bulk transporting but can not be easily used for small quantities. Small quantities in remote places can be supplied only through road. Coastal cities can be supplied through sea. The last option for main cities is rail.

5.3.1.4 Marketing and Sales

Marketing and sales were not treated as important activities in petroleum industry in India because the market was protected and supply was just sufficient to match the demand. Import of refined products were restricted by Government of India (GoI). April 2002 onwards Indian market is not price controlled and not free from competition. So far companies like RPL were not permitted to market
their products in India. But now any company can market their own products or import for marketing. This will necessitate extensive market surveys and sales promotion techniques. Till April 2002, companies were doing market research and sales promotion only for lubricating oil. Branding was also very well done in lubricating oil. Market analysis and research will be essential in the near future to compete with other companies by way of optimizing the inventory and inventory movement. Sales promotion through increased flexibility of products will be essential to retain customers. Increasing flexibility in product specification is branding of petroleum products. That is why refineries must be equipped to stock streams instead of blended products. Blended products reduce flexibility in addressing customer demand. Dealers in different locations in the country will demand diesel or petrol of different specification to satisfy their customers to perform better. So Marketing and sales will play an important role in the years to come.

5.3.2 Information Flow

Information is not considered as a major supply chain driver because it does not have a physical presence in the company. Information affects all parts of the supply chain in many ways. Information serves, as the connection between the supply chain's various stages, allowing them to co-ordinate their actions and brings about many of the benefits of maximizing total supply chain efficiency. Information is also crucial to the daily operations of each stage in a supply chain. The main considerations for information flow are for planning, for operations, and for management control.

Supply chain co-ordination occurs when all the different stages of a supply chain works towards the objective of maximizing total supply chain profitability rather than each stage devoting itself to its own profitability. Lack of co-ordination can result in a significant loss of supply chain profit. Managers must decide how to create this co-ordination in supply chain and what information must be shared in order to accomplish this goal. Co-ordination between different stages in a supply chain requires each stage to share appropriate information.
with other stages. For example, if the arrival pattern of ships is given in advance, the stock and oil department can take steps to receive oil in a structured manner and production department can schedule their operations as per the availability of crude oil.

Figure 5.5 Information flow within a refinery

Information flow can be separated into two. One is information flow within the refinery and the other is information flow from outside. Figure 5.5 explains information flow within a refinery, Information bank receives information from all the departments and supplies information to all departments for the better co-ordination among departments. Centralized information reduces redundancy and improves reliability. All the data must be collected from the source of data generation. Centralized information storage enforces better control on authenticity and privacy of data. In many refineries compartment data storage and retrieval is in practice. Transfer of data is either through floppy disc or through printouts. In both the cases possibility of error is high and timely availability and storage are major problems. Major partners in information flow in a refinery are Planning, operations, and control. Co-ordination among these departments is essential for the efficient running of a refinery.
5.3.2.1 Information flow for forecasting and planning

Forecasting is the art and science of making projections about what future needs and conditions will be. Obtaining forecasting information frequently means using sophisticated techniques to estimate future demand or market condition. Managers must decide how they will make forecasts and to what extent they will rely on them to make decisions. Refineries often use forecasts both on a tactical level to schedule production and on strategic level to determine capacity. Once a refinery creates a forecast, the refinery needs a plan to act on this forecast. Strategic planning transforms forecasts into plans of activity to satisfy the projected demand. A key decision-maker faces the problem of how to use strategic planning both at the stage of manager's stage in the supply chain and throughout the entire supply chain.

In a refinery forecasting is mainly for product demand and crude oil availability and techniques used for forecasting is discussed in detail in Chapter 4. Information required for forecasting crude oil price and availability is available on services like Reuters net connection. Full details of crude oil and price are available in the published data. This information is available to subscribers only. On the basis of this information a refinery can decide up on purchase.

In the APM time demand was projected by GoI and was made available to marketing companies like IOC and refineries like KRL in the planning meeting as discussed in chapter 4. In post APM the demand projection can be the same but the market share of each company will not be the same. Marketing rights were restricted to a few companies in the APM time. But in the post APM marketing rights are not restricted. Companies like RIL will appear in the market with great power. So, each marketing company must do separate demand forecasting. Even stand alone refineries (refineries without marketing setup) will have to do their own demand forecast because their marketing companies demand fluctuation will affect the product holding of the company.
As given in the Figure 5.6 the major inputs are from crude oil markets and product market. Output of forecasting will be decision on when, where, what, and how much crude oil must be and products must be moved in the market.

Planning needs more input than forecasting. Planning based on the inputs from government policy, output of forecasting and availability of facility in the refinery. Planning in a refinery takes place at different stages. Annual planning in APM was national level (OEB). Each refinery target was given for the year depending on the capacity of refinery. Based on OEB suggestions, a monthly plan was drawn in SPM. Each refinery has to make their own production planning for each day. Everyday, a production meeting will be held to analyze the previous day’s performance and make plan for the day. Information on condition of facility like distillation units, availability of tanks, maintenance schedule etc. must be available for planning the day’s production. The demand for products also must be available for deciding on production. Government policy will be intimated in monthly plan and daily production must be tuned to government policies. Planning decision must directly reach the operations department for scheduling operations. Marketing effort must be there to minimize the value added inventory. This will necessitate transport planning. In short daily planning will trigger and direct the activities of operations department, marketing department, and stock oil department. In post APM scenario the planning will be more difficult because the demand for refined products may vary frequently. The market also need not be same and product quality demand also may change. So computerized integrated information flow may be needed to have better and accurate planning so that the efficiency of the refinery can be improved to compete with other refineries in the near by region.

Figure 5.6 Information flow for forecasting
5.3.2.2 Information flow for operations

Decision is taken in the planning meeting and second stage decision is taken in the department but to implement those decisions, it must be converted to information. Right information must reach the right place to have right course of action. In a refinery the specification of products are coming from laboratory and the operations are controlled accordingly. Product patterns are controlled by process department. Availability of tanks and pipelines are arranged by the stock and oil department. Products movement is controlled by marketing or sales department if the company is controlling marketing. If the refinery is stand-alone type, the product movement is controlled by marketing company. Integration of information is essential to have better combined performance of all departments. Data must be fed to the computer at the source of generation itself and it must be available at all the places where it is needed. For example, specification of sample taken from product line must be made available on computer and blending steps for making the product into required specification also must be available on the computer. So the implementation can be faster and data is generated for final specification. Information about the quality quantity in that tank is available to all concerned departments like sales, stock and oil, and production.

5.3.2.3 Information flow for control

Controlling is a continuous process of measuring actual results and comparing with plant results and find out deviation to take corrective actions. Major elements of control are (i) Chart out standard of performance (ii) measuring the present performance (iii) comparing the performance with standard performance and (iv) taking corrective steps if deviation is noticed.

In refinery the performance is normally, measured in capacity utilization. In APM period government used to give incentive for production of more than 100 % of installed capacity. Every month the performance can be planned to match with annual planning or even weekly planning can be done. Weekly and monthly performance can be measured by calculating cumulative daily
performance. At the end of every month the crude oil refined in MMT can be calculated. These values can be easily compared with the planned refining per month and if it is less than the planned, corrective action can be taken to compensate the lost production.

![Figure 5.7 Information flow for planning](image)

The controlling can be done well with a structured information flow. Daily production figures must be entered into the computer from the process department itself. This data can be used for remedial steps by OEC when they plan for the next month. Essential qualities of a control system are flexibility, prompt reporting, understandability, and economic feasibility. Control system must be flexible to have same performance level when plan changes. The reports must be available to the central information bank so that all concerned departments can retrieve the data for checking with plan and suggestions for correction if deviation is there.

![Figure 5.8 Control system](image)

Figure 5.8 shows a flow diagram of information flow for control. A well designed control system will help for better performance in a refinery because small changes will affect the quality of output of the product. Small changes in the distillation unit parameters will change the yield pattern and will affect the profit of the refinery. Controlling all the departments in tune with the strategic plan of the refinery need good quality information flow system.
5.3.3 Accounting Information System (AIS) for the Supply Chain

Important decisions in the AIS are (1) How to organize the accounting records in an organization to retrieve the data at appropriate place (2) How to design set proceedings to meet management and Government requirements (3) Value change management, gives stages of value addition taking place to the products while transforming from the raw material to finished product. Finding out correct answer to these questions is the prime objective of AIS. Dividing in to sub systems is essential for getting better solution to the problem.

5.3.3.1 Basic subsystems

- Expenditure cycle: involves activities of buying and paying for goods or services, payment by organization
- Production cycle: involves activities of converting raw material and labour in to finished goods.
- Human resource or payroll cycle: include activities of hiring and paying employees.
- Revenue cycle: involves activities of selling goods or services and collecting payment.
- Financing cycle: involves activities for obtaining necessary funds for running the organization; repay creditors and distribute profit to investors.

Management of cash flow is very critical in profit making because the amount involved is very high. Logistics normally does not include the fund
management in its prime activity. In supply chain management cash flow is also
given equal importance for performance improvement. To improve the speed of
movement of material, the payment of cash also must efficient. In Indian contest
payment system has a lot of weaknesses. Even the banking system is not
operating in the international standard, especially check dealings. So special case
and attention is needed in the area of cash flow. Business objectives of good cash
flow system are

- Efficient accounting system to support business processes
- Provide input for effective control of cost.
- Effective use of funds available.

Main functional requirement of a good information flow system is
discussed in the next section.

5.3.3.1 General ledger accounting

It must provide a comprehensive picture of external accounting and
accounts. It must automatically post all sub-ledger items in the appropriate
general ledger accounts (reconciliation accounts). It must facilitate
simultaneously updating of general ledger and cost accounting information
(figure 5.9). It must also support real – time evaluation of reports on current
accounting data, in the form of account displays financial statements with
different balance sheet versions and additional analysis. The cash flow system
must support integration with different taxes. Major stakes are sales taxes, excise
duty, provident fund of employees, customs charges for import of crude oil and
port charges for using the facilities at port.

5.3.3.2 Accounts payable

Accounts payable must record and administer accounting data from
supplier. It must be integrated with purchasing. Purchasing not only includes
crude oil and shipping but also chemical, spare parts maintenance and other
utilities. All the deliveries and invoices must recorded based on each supplier.
These data must give input for cash management and must support various kind
of other payments like freight. Present procedure for data entries and checking are given in Figure 5.10.

Data are drawn from three different departments for matching. Goods receipt data is taken from the stores warehouse department, purchase order data is taken from materials department and invoice data is taken from accounts department. Based on the quantity accepted from warehouse and other factors from purchase order data the cash to be paid is worked out. This amount is matched with the bill amount in invoice. Three-way bill matching not required in an efficient cash flow system. Two ways – bill matching is enough for a computerized system. Efficiency of the system will improve by two way bill matching. Figure 5.10 shows it.

![Diagram](image)

Figure 5.10 Three way bill matching procedure

Two way bill matching works on the basic assumption of having high level of accuracy in warehouse data and purchase order data (figure 5.11). It avoids the non-value adding activity of invoice registration. The bills can be passed on the basis of inputs from purchase order and goods receipt.

5.3.3.3 Accounts receivable

Accounts receivable must record and administer accounting data of all customers. It must be integrated with sales. All in account receivables must be recorded directly in the general ledger (GL). It must provide input directly for
credit management. It must support alarm reports on defaulters of payment and due date list etc.

5.3.3.4 Costing

Overhead cost controlling enables to plan, control allocates, and monitor overhead costs. Planning in the overhead supports specify standards, which enables to control costs and evaluate internal activities. All overhead costs must be assigned to the cost centers where they are incurred. At the end of a posting period, when all allocations have been made, the plan costs must be compared with the corresponding actual costs on the basis of the operating rate. Analysis of the resulting target/actual variance can be used for further managerial accounting measures within controlling.

![Diagram](https://via.placeholder.com/150)

*Figure 5.11 Two-way bill matching*

Cost center accounting must be used to determine where costs incur in the organization. To achieve this, costs must be assigned to such organizational areas where the costs incur. The recording and assignment of costs not only enables to carry out cost controlling but also provides vital preparation for the subsequent areas of cost accounting.

5.3.3.5 Treasury

Treasury must support cash management, cash budget management and treasury management. Cash management must support:

- Maintaining optimum amount of liquidity to meet required payments as they become due.
• Monitoring cash inflows and outflows

It must support various types of inputs and cheques. This also must facilitate information on status of the cash and liquidity forecast. Cash management must take care of short term cash management where medium and long term liquidity management must be supported by cash budget management.

Treasury management must support

• Management of financial transactions and positions.
• To provide flexibility in reporting of financial transactions & positions.

All the transactions must be closely monitored for the efficient performance of a supply chain management.

5.4 Supply Chain Management Efficiency Improvement Using Information Technology

Information technology adds quality and speed to the decision making and it is true in the case of supply chain management also.

5.4.1 Introduction

Logistics and supply chain management (SCM) has been influenced by developments in information technology (IT) and computer systems. The allocation decision of products to various outlets can be carried out centrally. Capture of relevant data, their transmission to the central decision-maker and the ability to manipulate them and communicate the decisions to all different departments, in time for the decision to be effective, is now possible. It is now realistically possible to plan with shorter planning horizons. Refineries can plan their operation on daily basis using it (figure 5.12). The two major reasons for the use of IT in SCM are the spatial spread of production and service activities and the time element in planning, both of which require data intensive decision making. To make such decision making possible, there has to be efficient, reliable and timely data capture, data availability at various locations, and the ease with which it can be manipulated for the purpose decision-making.
A further advantage of a computerized system is that reports and statistics, which allow the monitoring of supply chain performance, can be generated. Supply chain performance can be measured through an integrated information system. The IT segmentation speed of information ERP, software, e-supply chain and application of IT in a refinery are discussed in this section.
5.4.2 Segmentation of Information Technology

Information technology can be segmented in three dimensions. They are scope of application, functionality and stage of technological development. Each of these would further have the hardware and software aspects of technology.

5.4.2.1 Scope of Application

Based on the managerial scope of application, IT applications can be classified as Transaction Processing System (TPS), Management Information System (MIS), and Decision Support System (DSS)

- A TPS deals with individual transaction and interactions between different entities in a managerial system and is governed by simple logical rules of operations. The main role of a TPS is to ensure reliable information exchange and reduce the time of response, as compared to a manual system for the same purpose. For example the products moved from refinery by pipeline, ship, rail or road on a particular day could be traced easily in a computerized system whereas in manual system records must be examined. Data must be generated at the point of delivery for better and faster information at any time.

- A MIS goes one level further and provides information in various ways to managers at different levels. For example demand for each product in a particular month or area wise sales Figures of products like diesel, petrol, lubricating oil etc.

- A DSS has the provision for decision models in the relevant domains. A DSS will help to take decisions after considering the constraints. Options will be given by the system. For example number of ships for bringing crude oil to a port for a month can be decided with the help of a DSS. This problem has already been discussed in Chapter 4.
5.4.2.2 Functionality

The following major categories can be identified from the point of functionality:

**Data Capture, Display, and Organization.** This is the basic function of collection and monitoring the data and information to do with logistics and SCM. Data Collection includes recording inventory, production, resource availability (e.g., Tank availability), etc. using a variety manual and automated technologies. Data display is ideally in graphical form or formats that are close to what managers find convenient, such as tables. Data organization is achieved through a database management system and is briefly discussed in section 5.5.4.

In a refinery all the opening are done at different levels. Figure 5.11 desires the capture and transform and utilization of data. The most import and data generation points are process department, stock and oil, Delivery points and accounts sections. These generated data are used is by many other departments as shown in Figure 5.11.

**Communication.** An essential feature of SCM is that data is made available across spatially dispersed decision-making units. Communication of data across distances is now possible through a variety of technologies.
Figure 5.13 IT Functionality of a refinery
Competitive advantage in supply chain management is gained not simply through faster and cheaper communication of data. Ready access to transactional data does not automatically lead to better decision-making.

To effectively apply IT to manage its supply chain a refinery must distinguish between the form and function of transactional IT and Analytical IT. Transactional IT is concerned with acquiring, processing and communicating raw data about the company's past and current supply chain operations, and with the compilation and dissemination of reports summarizing these data, typical examples are general ledger systems, quarterly sales reports, and Enterprise Resource Planning (ERP) systems.

**Processing.** Analytical IT evaluates supply chain decisions based on models developed from supply chain decision databases, which are largely, but wholly derived from the company's transactional database, plus modeling systems and communication networks linking corporate databases to the decision databases. It is concerned with analyzing decisions short, medium, and long-term. Typical example is modeling for selection of crude oil form the world market or beating a new distribution center.

### 5.4.3 E-supply chain

The need for speed IT professionals place a high premium on speed when changing the value of Supply Chain Management solutions. How important is quicker access to supplies and buyers as a feature of web-based Supply Chain Management. 31% claims speed is extremely important. 26% says moderately important. 24% comments that speed is neither important nor not important. 11% of professionals feel speed is slightly important and 8% feels it is not at all important. To have the desired speed of information E-supply chain will help. Providing the right amount of relevant information to those who need to know it, when they need to know it is, in fact, effective SCM from information point of view. The e-supply chain will have customers and suppliers seamlessly linked together, throughout the world, exchanging information almost instantly. The velocity of relevant information flow will be so fast that responding to the
inevitable changes in expected vs. actual customer demand–driven (pull type) production and supporting processes that provide for faster changes in the actual material flow to match demand.

Fast access to relevant supply chain information can pay off handsomely in lowering costs, less inventory, higher quality decision-making and better customer services. One of the biggest cost savings is in the overhead activity associated with lots of paperwork and its inherent redundancies. The non-value added time of manual transaction processing could instead be focused on higher revenue creation activities without proportional increase in expenses. The result in lower inventories, better decision-making quality, reduced overhead costs, among other benefits makes e-supply chain Management a highly desirable strategy.

5.4.3.1 Developing an e-supply strategy

E-supply chain Management significantly changes the way in which business does business. As a result, management needs to change and serve markets. Methods used so far are not sufficient, especially companies seeking to increase market share. As more and more companies evolve new supply chain models, management is compelled to take the right actions or risk being left behind.

Just applying more software at the problem is not the right answer to the core issues of SCM. Although software is needed, it is very necessary to define the process of information flow that will activate material flow at the right time. Lessons learned by early adopters of new technologies is that overzealous adoption of those technologies without a carefully planned strategy can prove very costly, especially when the strategy is missed or not defined in the first place.

5.4.4 Technology Development Stages

IT developments in companies have evolved overtime through the following stages. These reflect an increasing trend towards meeting the goal of
supply chain management, despite several practical difficulties in implementing the changes smoothly.

- **Sub optimization:** This is optimizing the operations of each department. Typical example is selecting the purchase of crude considering all constraints using a mathematical model. Selection will be the best but it will not be considering the market demand predictions. So the selected crude oil need not give products, which are high in demand. This is commonly used in refineries.

- **Organization level and inter organization-integrated systems.**

  This is the planning in organization level. The systems developed are Electronic data Interchange (EDI) manufacturing recourse Planning (MRP), distribution Recourse Planning (DRP) and ERP

- **Integrated Systems.**

  Total integration of the organization is the feature. Customer to supplier is integrated through networking. Computational speed will be matching to operational decision – Making requirements.

### 5.4.5 Hardware Networking

The Hardware aspect of IT systems are described below. The main hardware systems which supports IT are Internet, Extranet, Intranet, and VSAT

**Intranet:** This is used to communicate within industry. Access to data collected is not open to all within industry also. It can be made available through networking of computers in each department. Authenticity of data is very high and sharing of information is good, decision-making becomes very fast. The main Advantage of intranet is less documentation and its storage. Paperless offices can be made using intranet. Privacy of data is very well maintained.

- **Extranet:** Connection between different offices in different locations can be attained through extranet. Privacy of data is maintained. Access is limited to permitted users.
Depots can be connected using and the product movement will be monitored.

- **Internet**: Information can be passed to anybody at any place in the world. Main disadvantage is privacy. Privacy is very limited in Internet but the reach is very good. Information, which does not require much privacy can be, used the mode of communication. Sales Figures or balance sheet of the company can be communicated through Internet.

- **VSAT**: This is online communication. All the data generated will be communicated to the host system. Selling fuel at an outlet can be communicated to the refinery at the time of dispensing itself. It captures data at the source and transmitted through a satellite transmitter. The receiver at refinery will receive the communication instantaneously. At any point of time the total sale of any product like petrol can be seen directly. Production planning and products movement can be controlled in a better way.

### 5.4.6 Integrated systems.

The full force of supply chain thinking enabled by developments in IT emerges in the area of integrated systems. These are hardware and software elements. They permit analysis and decision-making across functions and narrowly defined entities. Some of the important developments in these are discussed below.

#### 5.4.6.1 Geographical information Systems (GIS)

A technology that is suitable for use for management of logistics and SCM in spatially widespread operations is GIS. The technology captures the spatial characteristics of data and is typically map-based. Data can be conveniently represented as attributes with pointers to specific geographical areas through an appropriate database. Both location-wise and area-wise representation of data is possible. For logistics & SCM applications, the spatial information of the database is obtained by digitizing maps. This visual interface provided by such software is very powerful and allows a good level of interface decision-making by the user directly. It also permits the use of decision models built upon the basic GIS. This
enables decisions like market segmentation, location decisions, allocation decisions and routing decisions.

5.4.6.2 Electronic Data Interchange (EDI)

The spatial aspect of managing distribution and procurement systems can now be managed using EDI. This is a system highly structured message communication with tight pre decided formats of documents, which allows computers in different locations to communicate effectively with speed and reliability. There is a service provider through whom this transfer of data takes place, who provides translators between different formats and handles the EDI traffic between various sources and destinations. The uses of EDI requires adherence to certain standards. In addition to the hardware and software that a firm may have, EDI requires specific software that allows conversion from any application to an application free format.

5.4.6.3 MRP –II and DPR

High level of planning which includes capacity planning, some feedback in the planning based on individual process constraints and providing provision for some uncertainties, both internal and external is made possible under the framework of manufacturing resources planning (MRP-II)

On similar lines, Distribution Resources Planning (DRP) software attempts to synchronize the dispatch of multiple products to multiple locations based on orders placed.

5.4.6.4 Enterprise Resource Planning (ERP)

ERP systems are operational IT systems that gather information from across all of a company’s functions, resulting in the entire enterprise having a broader scope. ERP systems monitor material, order schedules, finished products and other information through out the organization, ERP systems help to make better supply chain decisions.
ERP systems are good at monitoring transactions out generally lack the analytical capability to determine what transactions ought to happen. They reside more in the operational area in the IT map than in the planning or strategic areas. ERP system track orders through the entire company from procurement to delivery. Today’s trend of using a product based instead of a function – based organizational structure has also helped make ERP systems more alternative because this structure increases the importance of the cross-functional scope that ERP systems provide.

ERP systems not only allow a company to track items through out the system, they also allow a company to automate processes. By automating processes, companies are often able to increase efficiency and reduce errors. It is also important that automating poor processes only guarantee that they will be executed poorly each time. So companies would review their processes before implementing ERP systems.

5.4.6.5 Supply Chain Management (SCM)

SCM systems are a combination of many of the preceding applications and are used to span the stages in the supply chain. SCM systems allow for a more global scope because they can span many supply chain stages with their different modules. SCM systems have the analytical capabilities to produce planning solutions and strategic level decisions. They do not usually span all of the supply chain stages, they rely on ERP systems to provide the information necessary to perform the analysis. SCM systems currently provide the highest level of functionality with respect to the vertical axis of the IT map.

Two features of SCM products are noteworthy. First the back end includes a number of analytical techniques based on the principles of optimization. The front end of SCM products provide more interfaces for model formulation and validation by users.
5.4.7 SCM Software

SCM software is described as "Effective supply chain management enables you to make informed decisions along the entire supply chain from acquiring raw materials to manufacturing products to distributing finished goods to the customer". ERP systems provide a great deal of planning capabilities the various materials, capacity and demand constraints are all considered separately in relative isolation of each other. The more leading edge SCM products are able to consider all the relevant information simultaneously and to perform real time simulations of adjustments within the constraints. Real time information throughout the entire supply chain is needed to make correct decisions and SCM products are designed to gather that real time information. Traditional ERP systems generally do not gather real time information from everywhere in the supply chain on the contrary they often contain static, dated information only related to subsections of the supply chain.

Most SCM products are being designed with the Internet in mind, including web front ends for suppliers and customers, and transactions being sent over the Internet instead of via the more expensive and complicated EDI. This section will examine two of the leading SCM software vendors and four of the leading ERP vendors and their SCM products.

- Manugistics

They developed the very first SCM software in 1980. They have steadily been adding new functionality to their SCM products and now have one of the fullest product lines in the SCM market. Manugistics offers products in Demand Planning, Supply Planning, Manufacturing scheduling, Transportation management, supply chain navigator, NETWORKS.

The first four are SCM products, Supply Chain Navigator is a graphical SCM modeling tool that allows the user to simulate supply chain changes, including cost analysis and to view the current status of all elements in the supply chain. Networks are an Internet based supply chain collaboration frameworks.
- **i2**

  i2 is formed to implement software from mathematical methods of supply chain optimisation. i2 has a product line similar to management. It includes: Demand planning, Distribution planning, Manufacturing planning, Transportation planning, Advanced scheduling, Order promising and data integration.

- **Baan**

  Company started in 1978 in Netherland. The first version of Bann’s next generation MRP software was released in 1987. In 1998, Baan created a separate business named baan supply chain solution (Baan SCS) to develop, implement and support their new suite of supply chain products. Their SCM products are tightly integrated with Baan ERP. Products include Baan SCS planner, Baan SCS Demand planner, Baan SCS Scheduler, Baan SCS execution.

- **SAP**

  SAP was founded in Germany in 1972 by four former IBM employees. Unlike many of its competitors, SAP has adopted a build your own philosophy when adding functionality to its ERP product suite. This is true for its ERP product suite. This is true for its SCM products also. Product line include supply chain cockpit, Available to promise (ATP), Advanced planning & scheduling (APS) and forecasting.

- **People Soft**

  People soft was founded in 1987, released their first Human Resource Management System (HRMS) software package in 1988. They started offering a manufacturing module in 1996. The SCM product line includes Enterprise planning, product planning and order promising.
Oracle corporation was formed in 1977. The SCM product line includes Materials management, Sales order management, Post sales customer service and Quality management.

The most important new feature of the new wave of SCM products must be the ability to give the end customer a “time to deliver” in real time. This is only possible to do accurately with a comprehensive SCM solutions being used throughout an organization and its suppliers and customers. This ability will be the result of all the separate pieces of information being available, such as current manufacturing capacity, parts availability, inventory levels at all locations, distribution capabilities and current and forecast product demand. This ability has been described by many experienced manufacturing manager as truly revolutionary, processing a strong SCM system is quickly becoming a requirement for competitive success in an increasing number of industries.

5.5 Application of SCM Software in a Refinery

Real time information throughout the entire supply chain is need to make correct decisions and SCM products must be designed to gather that real time information. The procedure required by a refinery to develop an efficient SCM system is discussed in this section.

5.5.1 Factors influencing design of logistic information system

Logistic information system being very complex the design must consider a lot of parameters. Organization culture also influences the system because the changes must be acceptable to the organization.
Figure 5.14 Factors influencing design of logistics information system

Figure 5.14 represent diagrammatically the relationship with each other factor with the information system.

5.5.2 Proposed Design of SCM information System for a Refinery

Total information flow can be divided in small modules for detailed analysis. Then these modules can be integrated to get the fully integrated model of information system.

5.5.2.1 Annual planning module

Annual planning module gives information on maintenance schedule, quantity of crude oil which is selected for purchase, and the expected net back from the processing of total crude oil. Crude price used for calculation is the landed price at refinery. Constraints like availability, distance, etc. are used for the selection of crude oil.
5.5.2.2 Crude procurement module

Procurement of crude oil made on the basis of net back available from each crude, days available for production, production capacity, etc. Important decisions to be taken in this module are ship scheduling, determination of number of ships to be arranged for bringing the determined crude quantity. Failure in module will lead to payment of demurrage and shipping costs.

5.5.2.3 Ship management module

Ship selected in the previous module must bring to the port in sequence, which is most favorable for the refinery in terms of production. Right sequence will avoid starving and blocking of crude oil.
5.5.2.4 Crude tank yard planning module

Crude receiving tank yard planning and organizing is important because the number tanks available for storage is limited. Capacity increase is very expensive and time consuming.

5.5.2.5 Process Planning and Operation Module

Distillation process is automated but the planning must be done on the base of product targets to be met to meet the market demand.
Quantity and type of crude to be processed next is the output of the module. The operations to be performed for getting the desired results also can be achieved from the module.

**5.5.2.6 Finished products tank yard plan and operation module**

Product distribution is controlled by the decisions from this module. Type of transport, quantity, quality, etc. are decided in this module. Transaction Processing System (TPS) will compute the details of transaction.

Information flow must start from the retail outlet. Present practice in almost all refineries in India is on the basis of projected data by Govt. of India. Since the production was not enough to meet the demand and competition was not there, refineries could manage very well. Due to decontrol of petroleum industry anybody can import and sell in the market. So the information generation must be accurate as much as possible to minimize the inventory holding and maximizing flexibility of products. Figure 5.12 shows the overhaul information flow in a refinery.

In the years to come, all the outlets will not be demanding diesel with same centane number. Requirement for products will change from location to location. For example in Kerala demand for diesel with low flash point will be higher in the cities. This will reduce fire hazard at the event of accident. Demand for diesel with high flash point will be preferred in the high ranges of Kerala. Temperature on the hill top will be low so the starting will be difficult for vehicles with diesel of low cetane number. This indicates the necessity for an accurate projection of demand on the basis of the product demand in the outlets. Earlier this was almost impossible to get the real demand at retail outlet. Consumption at retail outlet can be now collected on daily basis or even hourly basis if a company desires so. Billing must be done using computers. So the sales data is generated in the computer. By an internet connection these data can be communicated to the company. All the outlets can communicate their sales through internet and the company will get exact demand for each product on desired time interval. This generated data must be compared with the projected
data and the demand in the same time of previous year to make necessary corrections and reach the best and accurate demand projection. This projection must be the basis for all planning in a refinery. This will reduce the inventory holding and improve product movements.

Figure 5.18 Planning and Operation Models
Second data generation point is distillation column. A large number of products are made in the crude distillation unit and subsequent process. These products are fed to different tanks. Many industries are taking the manual or calculated measurement for records. These data need not be very accurate due to error in measurement and calculations. Real data generation is taking place when it is passing to the tank. So the measurement of quantity must be done from the pipeline itself using flow-measuring devices. This data will be the correct information, which is to be used for calculation of all products. Third data
generation point is sales. Sold products are moving through pipeline, ship, railway wagons and trucks. Almost all refineries in India is having automatic filling stations. From filling stations consolidated statements are being send to the accounts department either on soft copy or hardcopy. In both the cases some re-entry is required in the computer. This leads delay, errors and unnecessary labour. Quantity difference is a common complaint and normally this difference will be adjusted in fuel and oil losses. In the case of railway wagon filling, the quantity is checked only using dipsticks. It cannot be cross-checked. By using a flow-measuring device in the main pipeline the sum of all the measurements can be checked. In all the outlets there must be automatic flow measuring devices and the readings must automatically go to the computer. These computers can be connected through network if filling stations are within a reasonable distance. Internet can be utilized if the distance is more. This data must be used for all purposes of accounting and production. For example sales tax calculation can be done in the accounts department with this data. All departments can know what is the present product stock in the company. Normal practice is stock and oil department will prepare a report and submit to all concerned departments on the basis of measurement from each tank.

Another important activity is the receipt of crude oil. This data is also generated by measuring from the storage tank. This can be measured by automatic measuring devices in filling line and delivery line. This filling line will give the quantity pumped from ship to refinery and delivery line will give the quantity of crude oil used for production. Difference between these two will be the actual storage. These type of actual data will help in real time optimization. Other data generation points are also there in a refinery. They are less in volume but critically may be the same for many of the data generated like maintenance. Maintenance department is generating the data related to maintenance of any equipment. This data can be used for planning the availability of each equipment. The availability is taken from the history of each equipment. Shut down maintenance is another data useful for planning and scheduling. This give details on equipment history, product produced by it, price of equipment, maintenance
work carried out so far, and work orders. A number of equipment, which are
down and its work order also will be initiated by the maintenance department.
Inventory of chemicals and catalysts is another important information, which is
to be trucked well to minimize inventory. Production details must be made
available to the vendors through extranet. Extranet takes case of privacy of data.
This data can be utilized by the vendor to calculate consumption of chemicals and
catalysts. Inventory position also must be made available on the net. So the
vendor can plan his transportation of these items to the company as when
required. This will reduce the inventory holding. Responsibility of chemicals and
catalysts inventory can be transferred to the vendors. Paper work and monitory
of these items can be minimized.

Spares requirement is also generated at the planning stage of
maintenance. It must give information on spares inventory, category wise
inventory and short supply of critical spares. Plant monitoring is also requiring
database to conduct inspection and classification of tanks. A refinery requires
information on air pollution, ambient air quality, Effluent water quality, power
demand in each bus steam venting, condense draining, statutory compliance
reports on safety, accident free man hours, health level of employees against
standards and govt. policies and regulations.

Table 5.1 Details of data generated at each department along with their main process.

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<td>S&amp;OM</td>
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</table>

**Manage sales**

| Manage Institutional Sales | S&OM | Products movement today/ MTD (SPM Vs. Actual)        |
|                           |      | Products movement – trucks and wagons                |
|                           |      | Products movement – pipe line and tankers            |
|                           | F&A (sales) |                                                |

| Manage Direct Sales      | Marketing | Discount to customers                                |
|                         |          | Outstanding payments                                 |
|                         | S&OM      | Products movement today/ MTD (SPM Vs. Actual)        |
|                         | F&A (sales) |                                                |

**Operate Plant**

| Manage production | Manufacturing | Unit wise daily Net Back                            |
|                  |               | LPG Production                                      |
|                  |               | Production units charge                              |
|                  |               | VGO yield (Today / MTD) (Potential Vs. Actual)       |
|                  |               | CLO yield                                           |
|                  |               | Benzene yield                                       |
|                  |               | Toluene yield                                       |
|                  |               | Naphtha consumption for DHDS                        |
|                  |               | Hydrogen Production for DHDS                        |
|                  |               | Fuel Consumption – DHDS                             |
|                  |               | HSD/ LSD Stock - DHDS                               |

| Manage Quality | Lab | Quality giveaway                                     |
|               |     | Off specs product tanks daily as of                  |

<p>| Manage Inventory and movement | S &amp; OM | Crude Inventory – No. of days and 7 days plan Horizon |
|                              |        | Pending payment for crude received                   |
|                              |        | Payment made and crude not received                  |
|                              |        | Crude Inventory – not within norm                    |
|                              |        | Product Inventory                                    |
|                              |        | Intermediate Inventory                               |
|                              |        | Demurrage Loss                                       |
|                              |        | Inventory Age Analysis                               |
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5.5.3 High Level Data Model

Based on the source usage and nature of various information integrated, the data model is divided in three high level layers of information to be integrated. The third layer of information will come from process control and monitor layer. Process control instruments are the sources of this layer of information. The information management at this layer aims at attaining and maintaining the process stability.

The second layer of information is related to operations management activities. Functional activities that fall within the scope of this information layer are:
The objective of this layer of information management is to ascertain operation efficiency. The third layer consists of information on business management. Some of the functional activities for this layer are:

- Finance and accounts
- Materials
- Maintenance
- Projects
- Sales and distribution
- Human resource management

The main objective of information management at this layer is profit management. Combined functional activities of current layer are named as Business Management System. Figure 5.12 shows the schematic presentation system for a refinery like KRL. Some of the functional activities are interacting at more than one layer. For example materials management and maintenance activities are performing at both the operation management and business management level. Degree of integration of functions is the success of any information system software selected should support both horizontal and vertical integrate.

### 5.5.4 Features of a supply chain software

The main features required for supply chain management software are as given below:

- Planning
- Demand management
  - Forecasting
- Operating monitoring
- Constraint planning.
  - Enterprise
  - Distribution planning
  - In plant
  - Safety Stock buffers
  - Advanced material management
  - Detailed scheduling
- Engineering constraints
- Vendor managed inventory.
- Transportation
- Real time product consumption
- Physical distribution interface
- Service requirements
- Optimizers
- Integration

These are the main requirements of supply chain management software. Integration is the key function in the system. There are many software systems that sub optimizes at different level but the integration part is weak.

5.6 Conclusion

In a supply chain management system there are three key components. They are information flow, material flow, and cash flow. Success of SCM lies in the systematic control of all these flows. Standard methods are there for improving material flow. Better technologies are there for faster information sharing and use. Effective banking systems are there for faster transactions. But better monitoring and control is required to reap the benefits of SCM systems. Planning and control functions performed by logistic managers rely on quick and accurate relevant data. Building an Information System for data capture, storage, and use is the pre requisite of a good modern Supply Chain Management System.
The software system must have very good data collection facility from the source of data as much as possible. Single point data entry is the next stage if direct collection is not possible. Software system model must support all the functions in the refinery. The main functions in a refinery are process control and monitoring, operations management, and business management.

This chapter was devoted to discussion on an integrated (modular) information system model for managing supply chain activities in a refinery. The information system model presented focused on logistics planning and control. Such a model is necessary to integrate and implement the different planning models recommended in chapter four.