REVIEW OF LITERATURE
II - REVIEW OF LITERATURE

The review of literature has been done and presented in the following format:

A. Review of articles.
B. Studies on Materials Management.
C. Studies on Inventory Management.
D. Studies on Inventory Control.
E. Studies on Inventory Performance.
F. Studies on the use of Computers in Inventory Management & Control.
G. Studies on Spare Parts Management.

A. REVIEW OF ARTICLES

The article by VanDeMark and Robert L (1986) analyses the importance and functions of Material Control. They said Material control was the function that handled a company's largest investment -- its inventory. The material control system should match the company's unique characteristics. The materials manager should report to the chief executive to avoid function bias. The materials manager's primary tasks were designing, installing and operating the system. Material control had the same goals as other company functions: improved customer service at a lower cost. Internal problems were not important if the company was shipping on time and making money. Material control should include 4 basic functions. The first was production control, which
involved master planning, master scheduling, shop order preparation, loading, dispatching and expediting. Second, inventory control ordered material. Third, purchasing's main duty was sourcing. Fourth, warehousing involved the physical control of stores areas. Material control personnel needed training. All material control activities should be reviewed in light of company goals.

"Careful management of inventory investment is important", says Capicino and William C (1991) in their article on inventory performance. They have identified 3 important reasons for it: 1. Stock availability was a key dimension of customer service. 2. Effective management of working capital included inventory investment. 3. Low inventory was essential to operating flexibility. Companies that had been the most successful in meeting these challenges had addressed inventory on all 3 levels of the Strategic Inventory Management Pyramid. The base of this pyramid, inventory control, focused on building capabilities to achieve timely and accurate information on inventory status.

The 2nd level, inventory management, focused on the use of effective forecasting techniques and processes. The top level, strategic positioning, involved a variety of initiatives to change the rules of the game and permit quantum improvements. Such initiatives included: 1. inventory deployment, 2. lead time management, and 3. channel integration.
An article in Small Business Report (1987) on Inventory management to control cost and maximise profits said, that inventory management can improve operations in many ways, such as reducing inventory and handling costs, assuring availability of materials and processing orders efficiently. It begins with an audit of the present materials-management process, the review consisting of strategic, physical and operational audits. Results of these segments pinpointed as to how the present system was performing. There were various inventory systems that could be used when implementing an inventory management program: 1. ABC management, in which items were grouped according to their dollar-usage values, 2. just-in-time inventory planning, the ultimate goal of which was to reduce inventory significantly or eliminate it altogether, 3. materials requirement planning, which predicted material requirements using data from a variety of sources, and 4. manufacturing resource planning, a comprehensive system encompassing many areas, including scheduling, cash flow forecasting, and manpower planning.

Many companies have too many stockouts and too much inventory because their computerized systems, mathematical models and inventory algorithms treat all inventory alike. This situation has led many to believe that inventory control was precise. Aggregate inventory analysis based on systems, models and algorithms would yield approximations, but they do not work for every situation said Sandler et al (1986), in their article on Selective
Inventory Control. Selective inventory control was a preferable strategy and a method for such control was the Applied Pareto Principle, known as the ABC Classification System. This method could yield substantial inventory cost savings because it stratified inventory items by activity and unit value. The ABC system categorized items by such demand characteristics as normal demand, gambol demand, seasonal demand and circumstantial demand. Another important element was the required replenishment lead time, which governed purchase order strategies. An activity analysis determined into which category each inventory item falls.

Despite new manufacturing and production systems, long-standing problems of inventory management persist said Armstrong and David J (1985). They proposed some straightforward and logical techniques that will improve inventory performance without undue mathematical complexity. One technique was to make use of graphics to highlight inventory balance and performance and in the process, pinpoint ways to improve it. Another dealt with measuring the profitability of inventory. Like other assets, inventory should make a contribution to return on investment (ROI). The method of measuring ROI in inventory was a turn and earn calculation of gross margin return on inventory investment. Another technique was termed ABC and involved segmentation of the inventory based on distribution by sales value. Inventory managers interested in using these techniques optimally must
follow certain guidelines: 1. Identify responsibility for inventory management and performance. 2. Establish inventory goals. 3. Use different techniques for handling different classes of inventory.

Inventory is most firm's most valuable asset, one that if not properly managed could result in substantial losses. Doll and Robert E (1984). Yet they say that inventory management in many firms were subject to incompetence and ineffective controls. Effective inventory management required examination of the entire inventory system, from supply of inputs to distribution of outputs. An inventory evaluation and review technique (INVERT) was described for developing managerial competence in inventory control. As a first step in the INVERT process, the existing inventory control system was examined for performance. If physical controls were found to be inadequate, an inventory profile was developed, describing on-hand positions, usage patterns and item classifications. A functional review on an item-by-item basis was then performed, followed by development of a replenishment strategy for each active inventory item, along with a disposal strategy for items obsolete or in excess of need.

Ramalingam, P. (1981) explained that inventories represent the largest current asset for many organizations, but mismanaged inventory would be a liability for the smooth functioning and growth of a company. Therefore, inventory
control was vital. Inventory turnover was an important yardstick for assessing the inventory departmental efficiency. For achieving maximum benefits from inventory function, professional management principles must be followed in designing and implementing the basic management activities. A number of techniques and systems were available for planning and controlling inventories. Any well-planned inventory control system should have the following characteristics: 1. enable the company to install and operate the system at a reasonable cost, 2. facilitate the development and implementation of the system in a short time frame, 3. provide flexibility and adaptability with respect to changing conditions and needs, and 4. facilitate the measurement of performance and controlling of operations. The benefits from an effectively managed inventory function included reduction of capital investment in inventories and increased plant efficiency.

An article on materials management and purchasing by Zenz and Gary J (1981) has quoted that materials management (MM) centralizes responsibility for moving materials into and through the organization, and usually included several activities, including purchasing, production control, and inventory control. Organizational alternatives for MM ranged from a simplified MM organization to MM with a central staff operation and decentralized operational control. Centralization of MM helped to minimize conflicting objectives, held down inventory levels, improved morale, and made better use of on-line computer
facilities. Common erroneous arguments against MM were that no one person can handle all activities and that changing to MM was fraught with personnel and morale problems. Purchasing, when placed under MM: 1. helped to minimize material costs and added to the organization's profits, and 2. served as a good training ground for MM managers.

Excess inventory is definitely an operational liability say Toelle et al (1989) in their article on Excess Inventory: Financial asset or Operational liability. They have identified the causes of excess inventory as: 1. forecasting errors, 2. inventory record inaccuracies, 3. inadequate planning and execution times, 4. long or variable lead times, 5. obsolescence, and 6. master schedule smoothing. Any item not effectively serving as working stock, safety stock, anticipation stock, pipeline stock, or decoupling stock was excess inventory. Operational types of excess inventory were dead stock, degraded stock, and slow-moving stock. One approach to defining excess inventory levels for slow-moving items used economic analysis to determine an appropriate quantity of an item to be liquidated in order to minimize relevant costs.

Stout et al (1989) say that obsolete inventory creeps up on companies, and, therefore, they usually do not try to minimize the effects until after the fact. Such inventory could present a major problem since it represents assets that are basically locked up, showing no earning power and little promise of
recovery even with additional investment in the asset. Obsolescence resulted from one primary factor - nonexistent demand. Another key factor was lot sizing. In an effort to maximize efficiency and reduce setup costs by making more units, the manufacturer sometimes produces more than was needed. In order to minimize levels of obsolete inventories, a company should: 1. make sure that inventory levels were under control, 2. control the way in which orders were released, 3. monitor engineering change orders, and 4. minimize customer changes or, at the very least, incorporate their price into the quotes provided to the customer. Once excess or obsolete inventory has been identified, management must decide how to dispose of it; options included discounting and selling the inventory, using it internally, and modifying an obsolete item.

White and R. Douglas in their article on Streamlining inventory to serve better has explained how to control the slow moving items in an organisation. Slow-moving, inactive inventory, called sludge, is generated by almost all companies. As long as a company's sales grow quickly, sludge will not adversely affect customer service and probably will go unnoticed. However, as sales growth slows, the rise in total inventory will increase proportionately. Generation of sludge will continue, and sludge as a percentage of the entire inventory will start to grow and squeeze out the other inventory. Frequency of stockouts in best-selling items will rise and customer service will
be damaged. To prevent this, inventory should be cut by removing the existing sludge, and a system should be set up to prevent sludge from building up. Further, the sludge must be identified, and the most financially attractive way of removing it must be determined. Sludge removal options are a combination of 6 generic actions: 1. changing the price, 2. intensifying the sale effort, 3. selling as a different product, 4. selling through different channel, 5. selling to a different market, and 6. changing the product.

B. STUDIES ON MATERIALS MANAGEMENT

A study was carried out by Hendrick, M (1996) on Integrated Materials Management System (IMMS). The system aimed at providing a return on the investment which airlines have made in inventory which was not moving by providing access for other airlines to such materials. This actually added a new supply chain for the redistribution of spare parts for airlines to support aircraft maintenance. Through the development of pricing standards, this was accomplished in a manner which made it attractive for both the selling and buying airlines. IMMS provided visibility for each airline to stocks that were not currently required by all participating airlines involved in IMMS through the use of IT and communication facilities.

Many North American firms have established partnering arrangements with their suppliers for the purpose of improving the quality of their product or
service offerings. Staurt et al (1994) investigated on one such firm's use of supplier partnership for continuous improvement in quality and productivity. The study was unusual because both partnering and non-partnering approaches were employed during the course of the study providing data for contrasting statistical analysis. The study revealed the benefits achieved in productivity and quality from the firm's supplier partnering activities. The implications for management, along with the difficulties encountered in relating to traditional purchasing philosophies were discussed.

Carter et al (1994) conducted a study of 300 US purchasing personnel, sponsored by the Center for Advanced Purchasing Studies, the study has revealed several ideas about what purchasing organizations must do to attain total quality management goals. The 4 basic principles to be followed were:

1. The purchasing department must develop explicit purchasing/supply management goals and strategies.
2. The business planning process within the firm must give explicit recognition to purchasing and supply chain requirements.
3. Purchasing planning should emphasize the process and the plan.
4. Purchasing performance should be enhanced through a formal performance appraisal system linked to rewards and recognitions, training for purchasing professionals to enable them to exercise initiative and
enterprise, and encouraging risk taking without fear of punishment to develop creative approaches to achieving TQM goals.

Ansari, A, Modarress, and Batoul (1986) conducted a study on JIT practices in US companies. Japan's exceptional levels of productivity and product quality over the past 2 decades could be attributed to use of the JIT purchasing concept. The study revealed that JIT practices in US companies had yielded several benefits, including increased inventory turnover, increased delivery promises met and lower scrap cost. The greatest improvements, however, were in product quality and productivity. The study also revealed the problems associated with implementation of JIT purchasing, namely: 1. lack of support from suppliers, 2. lack of top management support, 3. low product quality, 4. lack of employee readiness and support, 5. lack of support from carrier companies, 6. lack of engineering support, and 7. lack of communication.

J. F. Smith, Jr. (1986) of General Motors of Canada Ltd., observed that distributors know how to use and implement the newer sales and inventory management techniques, such as just-in-time (JIT) inventory control will have an edge on their competition. The JIT concept placed emphasis on suppliers to provide high-quality, defect-free parts on a consistent basis. It forced discipline into a manufacturing system. Smith also noted significant savings in implementation of JIT at General Motors.
Prasad et al. (1990) carried out a study on economic consequences of Non-optimal Inventory Holdings in India and Iran. In the study, an input-output approach was used to determine total output and resources, respectively, involved in sectorwise inventories, and linear programming approach was used to work criteria for optimal, non-optimal, and lower and upper trends of Inventory Holdings (IH) during the period 1979-1980 for India and 1974 for Iran. An attempt was made to analyze economic consequences for non-optimal IH and to derive policy implications. Five models were used, each with the same objective function and thus the same non-negativity constraints. The objective functions of each were based on varied perceptions regarding factor scarcity or abundance in the 2 countries. Empirical results revealed that a shortage of total capacity or potential output existed because of a shortage of inventories rather than an over investment in inventories, with respect to both India and Iran for the periods under study. These findings contradicted an earlier study that blamed over investment in inventories for the Indian situation.

The steel industry basically is a make-to-order business, almost 75 per cent of all the inventory is in process. In a study conducted by Fiora et al. (1986) in controlling work-in-process inventory for steel makers, a lead-time model was presented based on the concept of input-output control. Assuming that the input equals the output, the amount of inventory in process was directly
related to the manufacturing lead times. The model called for 4 calculations to determine the required inventory level: 1. Define all possible product flows through a plant. 2. Determine how long a product takes to go through each step. 3. Calculate the yielded production requirements. 4. Calculate the in-process inventory. Then, ratios between work-in-process inventories and the other 3 types of inventory (warehouse, yielded material, and semi-finished) were calculated. The sum of the work-in-process inventory multiplied by each ratio was the target inventory level.

In a study conducted by Dale B.G. (1983), on the materials management system for a complex organisation, it was found that there was no single concept of what materials management really was and had many interpretations. Research and experience suggested that many managers in large organizations had a relative lack of appreciation of company-wide developments that could affect them. Materials management might work better in smaller to medium-sized organizations. Improvements could be made through coordination of meetings and regular presentations of new company developments by the people involved to groups of executives or managers.

Miller, Jeffrey G et al (1981) conducted a study on the organisation for materials management. A mailed survey in 1978 of 137 US manufacturing firms representing a cross section of the industry was done. The study
revealed a movement towards more integrated materials management forms. These forms included: 1. those fully integrated to distribution, and 2. partially integrated systems. The reporting relationship showed that most materials functions were reported to manufacturing. However, a surprisingly high proportion reported to the division general manager or the company president. From the analysis of characteristics of companies employing certain types of materials organization, a direct relationship was found to exist between the characteristics of the firm and the organization structure. Firms with highly differentiated materials and logistics structures usually had complex management tasks. Firms with few plants and completely standardized products tend toward integrated structures. Because of many contingency factors relating to size, variety of products, and operational scope, (local or global), it appeared that no one type of organization was best for all manufacturing entities.

Clendenen and Gary Wayne (1993) conducted a study on a restoration-based model for materials management in a global manufacturing environment. Globalization of manufacturing along with increased competition had made effective planning and control more important than ever. At the same time, it was more difficult than ever to achieve effective planning and control due to larger lead times and shorter product life cycles. The objective of this research was to explore the importance of control strategy on materials management
in global manufacturing networks. Control strategies in common use and others that had recently been proposed in the literature were reviewed and classified along a push/pull gradient. It was shown that one of them, the restoration control strategy, could be used to represent a wide range of pull systems as well as certain elements of push systems. Using concepts underlying the restoration strategy, two models were developed for aggregate planning in a global manufacturing network. One model required that all demands be met whereas the other allowed some sales to be lost. Application of either of the models to a specific network resulted in values for decision variables, including target inventories and restoration coefficients. Target inventories were aggregated values that could be disaggregated to finer levels of detail. Values for restoration coefficients help identify the best control strategy. Both models apply to multi-echelon networks of any design and under known demand. Both formulations were nonlinear, mixed-integer programming models that had proved to be difficult to solve for the general case. Relaxing the integrality constraints allowed the models to be solved using commercially available software although optimality could not be guaranteed due to non-convexity of constraints. The models were applied to a specific network. The restoration model with no lost sales was found to have severe limitations; however, the restoration model that allowed lost sales provided results that were stable. The relationships between the decision variables and holding costs, labour costs and demand variation were explored using the simulation technique of batch
means. Among other things, results indicated that a control strategy very similar to base stock was most appropriate for the specific network studied.

A study was conducted by Marais and Johannes Stefanus (1990) on an investigation into the materials management approach of semistate manufacturing enterprise in South Africa. This study was a business economics investigation into the materials management approach. The study was undertaken to obtain clarity concerning the materials management approach and to determine the extent to which such an approach could be applied in the ENTERPRISE. To realize the objectives of the study, a theoretical study was undertaken which served as a framework for the empirical study. Because of the important role played by materials in manufacturing enterprises materials management was concerned primarily with the purposeful management of materials supply activities. From the empirical study it was revealed that, because of the diverse fields of activity, the ENTERPRISE was not yet ready to switch to materials management, but that purposeful efforts might well be made which will lead to increased efficiency. Taken as a whole, this study offered a marshaled theoretical foundation and also showed that materials management was still one of the relatively undeveloped aspects of the endeavour of an enterprise towards increased productivity.
C. STUDIES ON INVENTORY MANAGEMENT

Prasad K.N et al (1996) carried out a study on import related inventory management in Indian economy. The importance of inventory management for improving overall performance and foreign exchange savings at sectorial as well as economy levels had been widely emphasized. A study was made of the impact of optimal use of imported inventories for public enterprises, public limited companies and private limited companies on optimisation of value added in a multiple objective dynamic input-output framework for 1986-1987 and 1990-1991 for the Indian economy. Empirical results of the study for 1990-1991 revealed not only the trade-off between optimal value added and imported inventories of the Indian companies, but also unidirectional movement of optimal value and some of the imported inventories with the extent of the diversification of the economy. Given the concern for high cost of imported inputs, the main conclusion was that management of the import-related inventories was a basic ingredient for the success of the ongoing structural reforms for the globalization of the economy.

Meyer and Harry (1990) conducted a study on inventory accuracy and its impact on savings to an organisation. The study was conducted at Leviton Manufacturing Company installing a computerized manufacturing resource planning (MRP II) system for scheduling its parts and finished goods production. To drive the system, distribution resource planning was also to
be instituted by identifying demand requirements for finished goods by item and warehouse. A prime requirement for both systems was a 95 per cent inventory accuracy level in terms of the computer count versus the physical count, by items, within a given location. Independent audits of the firm's 5 distribution centers' inventory accuracy revealed an average of 65 per cent. Worker productivity, equipment productivity, and line fill were reduced by inventory inaccuracy. For Leviton, the cost of implementing and continuing an inventory accuracy program was about $300,000 per year for all warehouses combined. The productivity savings were about $600,000 per year over the costs at the 65 per cent accuracy level. With 95 per cent inventory accuracy, the need for annual physical inventories were eliminated, generating additional savings of about $30,000 annually.

A study was conducted at Bimba Manufacturing, maker of pneumatic actuators, on MRP II implementation and its impact on customer service. The study revealed that MRP II implementation had allowed the company to slush down the lead-times, triple on time delivery performance and grow sales and market share. To accelerate the implementation process, Bimba used a variety of resources from the Oliver Weight companies/East of New London. Customer service had been enhanced dramatically. Lead times for non-standard items had been reduced from 4-6 weeks to less than one week. Stock items were down from 1-2 weeks to 1 day.
Goonatilake and Lalith (1990) carried out a study to assess the impact of inventory management in the manufacturing sector in developing countries. While proper inventory control was a significant factor in industrial development, most inventory control techniques and concepts currently in use by developed countries have been drafted largely to suit the specific industrial environment of these countries. Thus, any significant differences in the industrial environment of developing countries merit examination to assess their potential influence on the inventory management policies to be used. Considering, the general inventory control objectives, it could be concluded that inventory management policies in developing countries should focus more on the efficiency objective than the cost objective.

A study was conducted by Borg et al. (1990) on inventory structures and trends in Sweden and Finland. The study described and analysed inventory turnover level and trend in 24 manufacturing industries in Sweden and Finland during the years 1975, 1980, and 1985. While it was difficult to obtain equally defined and similarly structured data from both countries, the following general findings were revealed: 1. No great difference existed between the two countries concerning total inventory turnover, although the structure of the inventories varied greatly. 2. Inventory turnover levels varied significantly by branch of industry. 3. Only about 1/3 of the studied branches in both countries had
increased their total inventory turnover during the examined period. The pressure to speed up inventory turnover had been particularly strong in the engineering and metal products industries, where the share of inventory capital in relation to total capital invested was large.

Chikan et al. (1990) conducted a survey to analyse the familiarity with the practices of other nations in the field of production inventory management, as it was important due to the growing co-operation between geographic regions and nations of different cultural backgrounds. A valuation was made of a set of surveys carried out in Republic of Korea and Hungary. The survey covered, production - inventory practices in 2 industries: 1) non-fashion textiles, and 2) small machine tools. Approximately 50 responses were obtained from each industry to questions regarding the company profile, sales forecasting, production planning and scheduling, shop-floor control, purchasing and materials management. The results revealed very different production practices for each region and the findings failed to demonstrate which set of practices was better. The survey supported the concept that company practices reflect the conditions and requirements of the environment from both the economic-political and social-cultural point of view.

Joshi and Kailash (1990) carried out a study to illustrate the interaction between warehouse space requirements and materials management practices.
at Midex Engineering, a diversified company in India. A professionally trained materials management head was appointed and a new department was created to handle material planning and inventory control. Thus purchasing, materials planning, and warehouse operations were centralised under a single manager. A task force was established to study existing stocks, ordering and stocking policies and inventory control mechanisms. The task force: 1) tabulated and analysed the stock levels and consumption of all items. 2) Classified items as regularly consumed direct or indirect items or as special direct or indirect items. 3) Formulated inventory control and stocking policies for standardised and non-standardised categories of items, and 4) recognised the material storage area on the basis of new stocking policies. These improvements revised the original warehouse capacity problem of the company as per the results.

Silver and Edward A (1989) conducted a study to analyse the importance of materials management in the planning and execution of large scale construction projects. Materials management encompasses the procurement of equipment and material, follow-up, delivery to the job site, inventory control at the job site and disposal of surplus material at the end of the project. Interviews with senior materials management personnel of firms recently involved in large scale projects in the oil and gas industry in Western Canada highlighted a number of decision making concerns about
procurement and logistics. One concern was the tendency on the part of project management not to have materials management people involved early in the project. In addition, the nature of upstream engineering had been highly reactive rather than proactive. There was a marked need for closer cooperation between engineering and materials management.

Cannon, James F and Perry, James H (1990) investigated on the management strategy and execution of a major multi year effort to streamline and integrate the materials management process within the US postal service (USPS). Four major initiatives were under way to bring about an improved system performance. There were: (1) organisational restructuring (2) professional development (3) management systems improvement (4) strategic policy changes. Increased emphasis was placed on the fundamentals of requirements planning, integrated logistics support for new systems and equipment, inventory management, physical distribution and performance evaluation. The USPS was moving rapidly towards the development of an integrated information processing system and communication network. Common to all of the streamlining activities the study revealed that there were 7 basic concepts that form the foundation of the USPS materials management strategy. They were 1) Transaction Simplification 2) Inventory productivity 3) information substitution 4) standardisation 5) strategic vendor alliances 6) selective focus and 7) processing time reduction.
Hesse, S. Metal (1997) carried out study in a regional blood center in the Chicago area on management of platelets inventory. Platelets are a type of blood cell which can be transferred to seal a patient’s bleeding blood vessels. Blood centers extracted allogenic platelet’s from a donated unit of whole blood through a costly, time sensitive process. Patients typically received platelets transformed in batch of six to eight units. Platelet units not transferred within five days of the initial blood draw, must be destroyed. These characteristics made platelets a difficult product to manage efficiently. Hospitals and regional blood centers struggled to balance an adequate stock of platelet against the high cost of platelet outdating. The study conducted analysed the current demand driven platelet inventory management system and suggested periodic review inventory policies for effectiveness of managing the platelets inventory based on its characteristics.

Multimedia technology is making remarkable progress spreading from business applications to home uses. A study conducted by Nakasuji, A. et_al(1997) of an inventory management system using wireless handy terminals revealed that the system can exchange information in real time for outdoor and indoor uses. A wireless handy terminal equipped with a bar code reader makes possible easy information gathering and processing on site, as well as real-time communications with radio servers. Each server is connected to a host computer with standard LAN system, the Ethernet making it possible
to build the inventory management system using an existing system. The system realises perfect management of inventories and enhanced business efficiency.

Aimal.A carried out a study to outline the methodology and knowledge engineering approach to the development of an interactive inventory management system for the use in a manufacturing company in the U.K. The study developed a prototype system with an artificial intelligent language which provided a linkage between management and computer-integrated manufacturing (CIM), and was comprised of four major modules, and had a feedback loop which could be used for comparing the actual and estimated values and automatically updated the inventory records. The study had identified that the interactive system uses hierarchial decision rules for the inventory control domain and uses goal oriented interaction and back packing inference procedures which had potential benefits of; better resource planning and management, reduced inventory levels and production lead times and consistency in maintaining record integrity.

Carter, J.R and Ferrin, B.G (1996) carried out a study to analyse the importance of proper consideration of transportation cost for effective management of purchased component inventory order lot sizes. First the study analysed the advantages to the buyer of controlling inbound
transportation. Secondly, it analysed the impact of transportation costs on managing production inventories. Finally it showed the impact of transportation costs on the order lot sizes and the method for properly treating transportation costs in inventory management.

Chambers and Peters (1975) studied the materials administration as a corporate function which revealed that the administration of materials in an industrial situation was handled by a variety of people, in several different departments and usually with very better planning since it was more or less a sideline operation. But recent studies have demonstrated that the cost of materials and their administration could account for from 30 to 50 per cent of the final cost of production, and it was this realisation which has prompted efforts to systematise and smooth out the flow of material handling. One of the improvements which could be made was the centralisation of the administrative department directing to the manager most in need of material services. This not only simplified the organisation function but smoothed out the flow of orders which all too often got bottled up in the usual management. The feeling now was that companies were becoming materials oriented.

Siramli.N.C. (1979) conducted a study on the method for calculating inventory standards at Westing House Electric Corporation. Calculation of an inventory standard began with the division of total inventory into smaller classes...
of raw materials, components, work-in-progress, and finished products. After further breakdown into smaller subcategories, inventory segments were combined on an inventory flow chart. Inputs and outputs were then examined, and the inventory entered at either standard or actual costs. Comparison of the inventory standards with those that actually existed enabled the firm making inventory improvements. The study revealed improvements in the form of inventory reduction (capital saving), better profitability and better customer service with no increase in inventory.

In today's competitive market, companies are working diligently to reduce inventory, improve customer service, and produce only what brings immediate sales revenues. Johnson and Dennis (1995) carried out a study in a company that made machine parts for railroad cars to reduce the inventory, by re-laying out the facility, moving key personnel and designing work centers. The study revealed that the company engineer created an effective manufacturing methodology and addressed the inventory reduction issue by coming at it from a different direction. This success happened only with the commitment from the engineer's peers and with a bit of compromise in business practices.

Interfuth and Kerl (1994) conducted a survey of determination of safety stocks in a multi stage divergent inventory systems primarily to protect against
uncertainties in demand. The analysis of the optimal safety stock policy lead to the echelon concept and raised the central problem of stock imbalances in divergent systems. The study also revealed that for the special case of 2-stage distribution systems diverse concepts for safety stock determination with and without lot sizing. Approaches were distinguished using push and pull strategies, as well as those working with echelon and local inventory control policies.

Wilson and Michael J (1984) investigated on reduction of in-process inventory at Ford Motor, Kentucky Truck Plant in Louisville. Ford Motor installed an automated storage/retrieval system (AS/RS), which supported assembly operations and contributed to a major inventory reduction and just-in-time parts availability. The study revealed that the Inventory handling had been made less labour intensive, and in-process inventory had been slashed by 43 per cent. The entire AS/AR system was computer-controlled and required only 2 operators.

Kanet and John J investigated on inventory planning at Black & Decker Manufacturing Company. The company's material requirements planning system, was called as PACE- planned action and constant evaluation. The key features of the system were: 1.maintaining a sound material plan, 2.executing the plan, 3.inventory reduction analysis and 4.maintaining record integrity. The material plan involved 3 activities: 1.order planning, 2.order re-planning, and
3. engineering change analysis. The objective of the system was to create a plan that optimized cost with a high responsiveness to change. Effective execution of the plan was vital, and inventory reduction analysis actually involved 3 analyses: 1. excess and obsolete inventory analysis, 2. storeroom valuation analysis and 3. A-B-C analysis. Record integrity was maintained via an ongoing continuous cycle counting effort.

A study was conducted to analyse the improvement in inventory management practices in US manufacturing companies between 1982 and 1983 based on the data of the Bureau of Economic Analysis by Hirsch and Albert A (1996). The study analysed the inventory sales ratio, which showed clear evidence of increased long-run efficiency for some components after 1982. In addition 3 other potential avenues of improved inventory management were investigated: 1) Greater cyclical flexibility 2) faster adjustment to near-term desired levels, and 3) diminished buffer stock behaviour. For each aspect and each inventory component, several indicators were examined to assess the evidence for improved management. The incidence of positive assessments was then viewed across components to judge their overall role. Substantial evidence for improved long-run efficiency was largely confirmed to materials and work-in-process inventories in certain manufacturing industries.
Zijm et al. (1989) conducted a study on production planning and inventory management in the telecommunications industry. The study was conducted for a medium-sized telecommunication firm in the Netherlands. The objective of the study was to carefully review production planning and inventory control rules and, in particular, to quantify the possible reductions of stock levels as a result of certain well-defined actions to be initiated by the responsible management. This firm assembled exchanges for voice and data transmission, typically custom-made products that necessitated a complicated multistage, multi-item production process. Simple analytical and simulation techniques were used to study the consequences of a number of actions for the logistics of the production process and, more particularly, for the inventory levels, including the amount of work in process. With the aid of a decision support system constructed for the study, it was demonstrated that inventory levels could be dramatically reduced as a result of certain actions, such as a reduction of the subassembly lead time and a more intensive and up-to-date flow of information from the commercial to the production planning department. Inventory fluctuations appeared to be an important propagation mechanism for US business cycles. The significance of inventory fluctuations in the US business cycles were compared with the 4 major industrial economies of Europe - the UK, France, Germany, and Italy. A general model of aggregate inventory demand was developed which sought to encompass the models presented in recent studies of inventory behaviour. The model was estimated using quarterly and seasonally adjusted data for the 4
European economies. The preferred models that resulted were compared with the empirical evidence for the US. For the preferred models, the main explanatory variables were the lagged inventory stock (except France), unanticipated sales, and the rate of capacity utilization (except Italy). Anticipated sales were important for Italy while relative input prices were important in all countries except Italy.

Fodor and George. M (1988) carried out a study on Hands-on-inventory Management at Special-T-Metals Co., a division of Sun Distributors LP. The company imported 1/3 of its 35,000-item inventory, and a portion of profits were derived from offshore customers. Despite the fact that many items carry a 9-month lead-time, the Lenexa, Kansas, firm was able to maintain a 95 per cent service level. Manual inventory control procedures carried out on a Kardex system have been replaced by a turnkey computer package called ProfiTool from General Data Systems. The software helped the firm manage its $3.5-million inventory spread throughout 5 locations. The basis of the computerized inventory management system was a half-dozen stock status reports. For each of 300 product categories, reports were produced covering such information as quantity available, on-hand and customer on-order levels, and units sold over preceding 3- and 6-month periods. Special-T-Metals turned inventory at the rate of about 5 1/2 times yearly, up 15 per cent from previous performance. Automation had enabled the company to stock better and ship more complete orders.
Inventory management was correlated with the improvement of customer service, which was seen as an integral part of total quality management. Zeng and Zhaohui (1997) conducted a study on service considerations in replenishment strategies. Based on a few case studies in large companies, they have noticed that the effectiveness of controlling inventory was often evaluated by three common criteria: cost, inventory turns, and service level. Since the majority of the literature had focused on only cost and service, this research integrated the three dimensions into replenishment strategies and explored their interrelationships. Specifically, the dynamics of these three criteria were examined in the context of continuous \((s,Q)\) inventory systems, where \(s\) referred to the reorder point and \(Q\) to the order quantity. They considered three types of operating cost: ordering, holding, and shortage costs; three commonly used service measures: (a) probability of no stockout during a replenishment cycle; (b) fill rate; and (c) ready rate; and the inventory turnover ratio. The study examined the correspondence between the shortage cost-models and the service-constrained models; the possible types of constrained models based on the three management criteria; and the duality of service-and budget-constrained models for determining the modeling alternatives to optimise \((s,Q)\). Commonly assumed lead-time demand distributions, such as the uniform, the exponential, normal, the Gamma and the Weibull, have been studied. They had found that regardless of the type of distribution, probability of no stock-out during a replenishment cycle outperformed fill rate only when the economic
order quantity was significantly less than the standard deviation of lead-time demand. In addition, fill rate and an approximate ready rate were mathematically identical. The study had revealed that achieving high levels of service and achieving high inventory turns were contradictory. They had found that probability of no stockout during a replenishment cycle yielded a higher turnover ratio and lower operating cost than the same value of fill rate, only when the economic order quantity was significantly less than the standard deviation of lead-time demand.

Lutz and Christian Martin (1995) carried out a study on determination of buffer size and location in scheduling systems. The study dealt with problems of WIP inventory management and provided a simulation-search procedure, which could be used to determine inventory size and location requirements of a firm. It revealed that the size and location of WIP inventory was a combinatorial problem, which was a function of buffer sizes at each operation in a manufacturing line. The study identified specific inventory locations and minimal sizes, referred to as 'inventory profiles,' which supported manufacturing scheduling systems. Because of the complexity of the profiling process, simulation, combined with an artificial intelligence based search heuristic, was employed to address the problem. Simulation was used to model the manufacturing facility under study, while a Tabu Search metaheuristic was used
to analyze the simulated results, to direct the search process in the combinatorial environment, and to identify optimal or near optimal buffer profiles.

Kurawarwala and Abbas Ali (1993), made an attempt to provide an integrated framework for forecasting and inventory management of short life cycle products. Short product life cycles were becoming increasingly common in several consumer and industrial goods industries. Management of the marketing and production functions for these products presented significantly different challenges than those for longer lasting products. The timing of decisions and the information available for decision making were both affected by the shortened life cycles. The literature on forecasting and inventory management does not adequately address issues relating to short life cycle products. In the first part of this research the researchers developed growth models that could be used to obtain accurate monthly forecasts for the entire life cycle of the product. The models avoided the limiting data requirements of traditional methods. Instead, they extracted relevant information from past product histories and used the information on total life cycle sales and the peak sales timing. Empirical testing, on disguised real life data from a PC Manufacturer, validated these models. Model fit and forecast comparisons with traditional approaches revealed that the proposed models outperformed these approaches. Next, they modeled the inventory
management problem for the short life cycle environment. The uncertainty in demand was modeled through the uncertainty in the realized values of the parameters of the forecasting model. The high cost of terminal inventory, shortages and rapidly changing procurement costs were all included in the model. Extensions to the basic model were also developed. Using optimal control theory, they derived a solution that provided valuable information on procurement cutoff time and terminal service levels. A detailed real life example explained the characteristics of the policy and its relevance in decision making.

Many of the issues covered in the models were brought to their attention while implementing a forecasting model at a Personal Computer manufacturer. The benchmark monthly forecasts and the associated inventory levels provided information that could be very helpful in planning and controlling marketing, sales and production. By raising some issues this research also provides useful topics for further research in the area of management of short life cycle products.

The dissertation of Jung and Chul-Ho (1990) consisted of three essays in microeconomic theory, international monetary arrangements, open economy macroeconomics and econometrics. The first essay, 'Optimal Cash Management Policy by Firms and Its Application to International Reserves,' was in the
fields of microeconomic theory and international monetary arrangements. The second essay, 'Forecasting by Normal Mixture Model and Its Application to Foreign Exchange Rates,' was in the fields of econometrics and open economy macroeconomics. The third essay, 'Devising Unbiased Predictors in A Log linear Regression Model,' was in the field of econometrics. The first essay developed a continuous time stochastic framework for determining optimal cash management policy by firms. By applying basic ideas of inventory management theory, the analysis integrated and extended the work by Baumol, Tobin, Miller and Orr, and Frenkel and Jovanovic. The optimal cash management policy was derived and showed to depend on the rate of interest, on the mean and variance of net cash flow, and on the cost of portfolio adjustment. The optimal solution was obtained by minimizing total cost which was composed of transactions cost and cash holding cost. The solution was then compared with the one obtained by Frenkel and Jovanovic. This approach was also directly applied to the optimal management of international reserves.

The second essay explored a method of forecasting by normal mixture model (NMM) the researchers assumed that forecasters switch one individual model to another with some probability, depending on policy changes by the Federal Reserve Board and the Federal Government. Under the further assumption that the population distribution was a mixture of normal distributions, the researcher could estimate these models simultaneously. By using the estimate of the
parameters of the model, they could forecast the dependent variable. Identifiability of the NMM was proved, and some estimation and testing methods were discussed. This method was then applied to foreign exchange rate models. The results revealed that they could decrease the mean squared error of forecast error remarkably by using the NMM, as compared to the forecast error of each separate model. The third essay developed unbiased predictors in anti-logarithmic transformation. Four predictors were explored. Two of them were biased, but consistent. The other two were unbiased and consistent. A numerical example revealed the accuracy of each of these four predictors. Some suggestions were made about the decision of which predictor to use, as a function of the sample size.

Hasim and Arni (1988) conducted a study on application of inventory management practices to property portfolio control. The purpose of this study was to produce a portfolio management system for real estate investment using the concepts of inventory management and control. The study contained a survey of inventory control concepts followed by an introduction to real estate classification and investment. Similarities between inventory control and real estate management were identified and a model of property portfolio control was proposed. The proposed model had been simulated and it revealed to be reasonably acceptable as an analytic tool for real estate investment.
D. STUDIES ON INVENTORY CONTROL

The implementation and use of material requirements planning system in Northern Greece was studied by Manthu et al (1996). The efforts of the manufacturing companies to offer more advanced and quality products, fulfillment of consumer needs and faster delivery times, required efficient manufacturing controls and planning to ensure that productivity was maintained, stocks were minimised and resources were optimised. Material requirement planning (MRP) is a computerised information system for managing dependent demand inventory and scheduling stock replenishment orders. Although the use of these systems in industrially developed countries were extensive, in Greece it was still in its infancy.

The interaction of managerial tasks with MRP and the resulting effects on the adoption and its infusion were examined. The organisational context of the company before and after the implementation of MRP, the guidelines for its successful implementation, the level of MRP usage in the company, the problems encountered and the resulting benefits were the areas studied. The findings of the study indicated that the MRP system reduced inventories, improved deliveries and achieved better planning and control.

Moore and Richard Irby (1989) conducted a study on distribution inventory control systems. The research focused on large-scale distribution inventory systems to evaluate the impact of the inventory environment on inventory
system structure and policies. Much of traditional inventory theory was based on optimization of single items in single-level inventory settings. To complicate matters, the more complex inventory models were often constrained by unrealistic assumptions. As a result, many traditional inventory models were either not used because of complexity, or misapplied due to the lack of understanding of the assumptions used in model formulation. Many companies considered the 'inventory problem' to have been solved many years ago. However, in light of recent awareness of the relationship between inventory management and competitive posture, there was a continuing need to study the systems of innovative companies. This dissertation documented research of seven large companies in the United States, which were operating excellent inventory control systems in exceptionally challenging environments. The study identified techniques companies used to manage inventory systems with as many as hundreds of thousands of stock keeping units and scores of distribution centers. Seven case studies described the operations of major companies recommended by consultants and inventory professionals. Among the companies studied were: a manufacturer of ceiling fans, an importer of consumer electronics, a food distributor with nationwide operations, Federal Express, Westinghouse Distribution and Control Division, a large computer firm's worldwide service parts center, and TRW Automotive Replacement Parts Division. The case studies described the environment and operations of each company in six areas: (1) forecasting, (2) inventory model selection, (3) inventory cost
measurement, (4) methods for receipt, handling, storage and issue of items, (5) methods to record and account for items, and (6) performance measurement and exception reporting. The case studies related the characteristics of the inventory setting to the techniques and procedures used in each area. In synthesis, fifty-five guidelines were proposed for managing inventory operations.

In inventory management and control, when lead times were stochastic, a dual-sourcing technique in which the order quantity was procured by placing split-orders on two vendors could offer savings in holding and shortage costs, compared to the sole-sourcing technique. Although several studies had examined the costs and benefits associated with these two approaches in a qualitative and empirical way, theoretical research on this issue was scarce. Ramesh and Ranga Venkatesh (1989) carried out a research in this area, which was significant because, in the professional literature there was a considerable debate over the relative merits of the two techniques. In this dissertation, they formulated mathematical models of one- and two-vendor inventory systems under stochastic lead times and demand and examined their optimal total cost performance in the framework of single and multifactor experiments. They first analyzed a simplified base-case model assuming a uniform probability distribution for the lead times and a constant rate of demand. For the two-vendor system, they assumed that the lead-times for both the vendors were independent and identically distributed and that the order quantity was equally
split between the two vendors. They then progressively relaxed the assumptions and developed models of more complicated and realistic inventory systems. Besides the uniform distribution model, they investigated two additional models with exponentially distributed lead times: in one the lead times for the two vendors were identical and in the other they are different. For each model, their investigation covered the development of the mathematical model, formulation of the expression for the total expected cost as a function of the decision variables, derivation of optimal solutions, and experimentation over a wide range of parameter values, under both and dual-sourcing approaches. Finally, the experimental results were compared to evaluate the performance of the two techniques, and to develop guidelines for a cost-effective choice between the two.

An inventory control system with a regular review reorder base is inappropriate for slow moving item. A study conducted by Quey J. Yeh; and et al (1997) under this periodic review environment identified that there were many periods in which no demand occurred and thus no replenishment was needed. The study developed a simple graphical aid for choosing appropriate replenishment size in consistence with the derived service level without explicitly calculating the reorder point by assuming that the three variables demand size, demand intensity, and lead-time were all Gamma distributed when demand transaction occurred.
Salameh. M.K.; and Jaber.M.Y (1997) carried out a study to determine the optimum reserve stocks as well as the optimum amount to be transshipped in a multi-echelon inventory structure. When inventory systems at different locations operate autonomously, each location orders separately and is concerned only with its problems. Under a centralised inventory control procedure, all inventory decisions were made interactively taking into account the needs of the entire system. The study revealed that in a multi-echelon structure, transshipment of items between locations at the same level often proved to be economically rewarding when the carrying cost at one location was less than the carrying cost at another location. Based on these analysis the study determined the optimum stock to be stocked and transshipped.

Gas utilities are facing the challenge of operating in a new federally deregulated, more competitive environment. A study conducted by Vineyard.M.L. et_al (1997) at Memphis Light, Gas and Water Gas division in managing their natural gas capacity and inventories developed a planning model. The model enabled the gas division to develop a natural gas portfolio as well as establish policies and procedures to successfully manage their gas capacity and inventories. The implementation of the model had resulted in a first year projected earnings of $6.1 million.
Safizadeh.M.H and Rifzman.L.P (1997) conducted a study to investigate as to how process choice relates to production planning and inventory control decisions. They empirically examined the validity of deductively derived patterns exploring how production planning and inventory control decision affect operations performance. The findings revealed that production line and continuous flow plants used more of a level production strategy and carried less raw material and work-in-process inventory. The performance drives for these plants, through which the operations function excels, were effective utilisation of equipment, reduced finished goods inventory, and reduced setup down time. To gain forward demand visibility and batching economies, job and batch shops rely much more on backlogs in their planning process. These plants are more of production chase strategy and position inventory lower in the bills of materials. Four performance drivers for top-performing job and batch shops were: to find ways that better anticipate customers order, have a more responsive chase strategy, carry less raw materials or purchased inventory and shorten production planning horizon, partly through less reliance on backlogs.

Previous studies had shown that when splitting an order between 2 suppliers, the major benefit in inventory related costs were in the reduction of stockcosts due to the reduction of the effective lead-time and the effective lead-time demand. This finding implied that, among several suppliers, one should select the 2 suppliers with the lowest average lead-times. In contrast Zhao et al (1992)
carried out a study to show the important benefit was the reduction of average inventory. This benefit could be realized only when one selected a 2nd supplier with a suitably larger average lead time than the first supplier - a strategy that contradicted the selection rule implied by the earlier studies. Thus the study revealed that there was an economic trade off between this benefit and the more well known benefit of lower lead-time demand achieved by using suppliers with the lowest average lead times.

Kim et al.(1991), carried out a study of manufacturing companies concerning their inventory problems. Of the 203 usable responses, only 9 companies reported no inventory gain or loss in the recent year. The study revealed that the factors causing inventory gain or loss can be classified in 3 broad categories: errors, theft and others. Overall, more than 80% of the total inventory discrepancy in the responding companies was attributed to some type of inventory-related error. A recommendation as the end result of this survey was that a separate inventory error-tracking device be established as a subsystem within the company's overall inventory control system. In the process of controlling inventory errors, the management accountant played a vital role. Information on inventory errors for each division and/or each product should be channeled through the company's management accounting information system. Overseeing the procedure of inventory related transactions should be a responsibility of the management accountant.
Goonatilake, P. C. L. (1984) carried out a study on inventory problems in developing nations, during October 1979 – December 1983 in the industrial sector of Nigeria. The study revealed that ineffective inventory control was a major problem faced by industries in developing countries, and even the very fundamental inventory control concepts and methods were not used by most of the firms studied. Because of the heavy dependence on imported industrial raw materials and parts, and the endemic bureaucratic delays and related communication problems in developing nations, order lead times could not be calculated with any degree of accuracy. The high buffer stocks thus carried by manufacturers and the seeming disregard for the benefits of proper inventory control methods resulted in a high inventory cost. Of the 2 prime inventory control objectives - reducing cost and maintaining efficiency - manufacturers in developing countries were more concerned about the latter. There was a need for inventory control methods more suited to the specific conditions of developing countries.

A study was conducted at Stearns & Foster Co (1982) textile division on the implementation of a production and inventory control system. The system was from International Business Machines which resulted in a savings of $20000 monthly in inventory adjustments and had reduced inventory by 10 per cent. Based on a detailed analysis, Stearns & Foster installed 4 Copics modules: 1. inventory accounting, 2. bill of material for engineering and production data
control, 3. product cost calculations for cost planning and control, and 4. advanced function material requirements planning. One of the principal reasons for the company's success with the system was the decision to make Copic's the employees' program and responsibility. As a result, employees were enthusiastic about the system because they were using current, accurate information, and they had input into the design and implementation.

Reid, Robert A et al (1984) conducted a study on Inventory cost determination in the public sector organisation. Public sector service organizations often must maintain large inventories. Minimizing common-use stores operating costs while providing good user service required accurate cost information. The application of a methodology for determining the costs associated with procuring and storing inventory stock-keeping-units (SKUs) as well as the costs associated with operating the stores facility was studied. A cost study was conducted at a large government research and development facility. The 3 stage methodology produced the following results/outputs: 1. the ordering of cost per SKU, 2. the holding cost expressed as a percentage of average inventory value, and, 3. the stores operating cost per $100 of sale. The results indicated that approximately 1/2 of the stores labour costs were associated with the ordering cost component which, in turn, was dominated by the task of contract negotiation. Salary expenses were the major factor in the total costs for both the ordering and operations components.
Mohanty, R.P. Mathew and Saji (1984) carried out a study on user-oriented systems to improve performance of the manufacturing company. No commonly accepted approach existed to guide the professional in managing a production-inventory system effectively and comprehensively. Arguing that the production-inventory system was sufficiently heterogeneous and that a single model of an abstract canonical type was inadequate, a hybridized information system was developed. Existing operational problems were recognized and the accommodation of change was planned for. A proposed system consisted of seven steps: 1. material classification, 2. lead time analysis, 3. analysis of ordering and carrying costs, 4. procurement planning for A-class items, 5. safety stock determination, 6. procurement planning for Band C-class items, and 7. work-in-process control. The results of the study on the new system revealed that it reduced operational costs significantly and it also facilitated an awareness in users of the magnitude and structure of problems and solutions.

A study was carried out by Bourland et al. (1996) to analyse the impact of demand information to reduce inventories. The study was conducted at 2 factories, which used a standard periodic base stock policy for one particular item, but the equal-length production cycles of the 2 factories did not necessarily coincide. Both the industries held inventories to buffer the effects of uncertain orders and uncertain deliveries. The changes brought about by the exchange of timely information in inventories and service levels at both the
supplier and customer were examined. The results of the study revealed that inventory related benefits were particularly sensitive to demand variability, the service level provided by the supplier, and the degree to which the order and production cycles were out of phase.

Chikan and Attila (1990) carried out a study to analyse the characteristics of the production-inventory systems of industrial companies in Hungary. The study used a questionnaire developed from an international project aimed to carry out cross-national comparisons. The study revealed that the general character and relatively low level of development of the production-inventory systems in Hungary were direct consequences of the specific environmental challenges firms faced. More advanced systems with a chance of successful implementation must be utilized, but not copied.

The National Association of Accountants investigated on inventory losses in order to develop a baseline of information for management accountants to use in assessing their inventory controls. The study reported by NEWTON and FRED.J (1988) revealed that the main causes of inventory losses and gains were: 1. unreported scrap, 2. misreported production counts, 3. in-accurate cost standards, 4. substituted material, 5. unrecorded engineering changes, and 6. misreported scrap. About 43 per cent of respondents indicated that a cushion was built into the inventory costing system to offset anticipated losses. The
study highlighted the following areas that management accountants should investigate: 1. identifying processes that incur scrap and emphasizing the importance of maintaining a record of scrap, 2. using standard costs if the volume of units is high and varied, 3. ensuring that engineering changes are properly authorized, and 4. reviewing the procedures for controlling use of material.

A study was conducted by Cetinkaya and Sila (1997) on myopic policies for inventory control. In this thesis they studied a typical retailer's problem characterized by a single item, periodic review of inventory levels in a multi-period setting, and stochastic demands. They considered the case of full backlogging where backorders were penalized via fixed and proportional backorder costs simultaneously. This treatment of backorder costs was a nonstandard aspect of the study. From a theoretical point of view the infinite horizon solution represented the limiting behaviour of the finite horizon case. Solving the infinite horizon problem had also its own practical benefits since its solution was easier to compute. Their motivation to study the infinite horizon case in the first place was pragmatic. They proved that a myopic base-stock policy was optimal for the infinite horizon case and this result provided a basis for the study. The study revealed that the optimal myopic policy could be computed easily for the Erlang demand and it could solve a disposal problem which arise under the myopic policy. The study also revealed that the finite horizon problem for a myopic policy was not optimal.
For the finite horizon problem computation of the exact policy might require a substantial effort. From a computational point of view, there was a need for developing a method that overcame this burden. The study also developed a model for such a method by restricting their attention to the class of myopic base-stock policies, and called the resulting policy the 'best myopic' policy.

Cheng and Feng (1997) carried out a study on optimal feedback policies in inventory models with markovian demands. The study dealt with single-item dynamic inventory control problems in fluctuating economic and marketing environments. Most classical inventory models assumed demand to be a simple random process independent of any environmental variables other than time. However, in real-life applications, many different factors such as economic conditions and marketing activities could have a major influence on demand.

The major task in this study was to provide optimal solutions for the Markovian models. Moreover, it was their interest to investigate the properties of these optimal solutions. Two types of dynamic inventory models with different Markovian demand processes and cost structures were developed in this study. First, for a fixed cost model where the distribution of demands in successive periods was described by a Markov chain, they revealed that an (s,S)-type policy was optimal for both the backlogging and lost sales cases. The model was further extended to incorporate supply constraints, and service level and
storage capacity constraints. Second, for a linear cost model where a Markovian decision process was used to describe the behavior of customer demand under the influence of promotional activities, they demonstrated that the optimal inventory policy was a modified base-stock type policy, and the optimal promotion policy was of threshold type.

A study was conducted by Katircioglu and Kaan K.(1997) on four important problems faced in the theory of inventory control. The first problem addressed was the issue of calculating optimal inventory policies in stochastic inventory problems, when unknown demand parameters were estimated from a sample of demand observations. A general framework for combining estimation and optimization problems was developed for a class of inventory problems when the demand distribution belonged to the scale-location family. The results of the study revealed that biasing the scale parameter estimated gave better inventory policies for both cost minimization and service achievement objectives.

The second problem identified and studied was a periodic review, single-product, single facility inventory problem with multiple customer classes, each requiring a different service level. Customer demands were random and independent with a stationary probability distribution. The objective was to find a stock allocation policy among the customers and an inventory replenishment policy so as to achieve target customer service levels with minimum possible inventory holding
cost. An easy-to-calculate myopic heuristic allocation-order policy was developed and its performance was tested through simulation.

The third problem addressed found an optimal inventory policy for a classical single-stage, single-product, unit demand, continuous review inventory problem where the inter-demand times were independent identically distributed random variables with increasing failure rate. Unmet demand was fully backlogged and orders arrive after a lead-time. The costs of backlogging and inventory carrying are linear. The objective was to minimize the long run average cost. If there was no fixed cost for placing an order, it was proved that a Delayed-\((s-1,s)\) policy was optimal. In case of a fixed order cost, a Delayed-\((s,S)\) policy was proved to be optimal.

The fourth problem, the same as the third was studied for a Poisson demand in the case of lost sales. No fixed cost for placing an order was assumed. For this problem, an optimal policy was unknown and it was commonly believed that an \((s-1,s)\) policy was sufficiently good. A new heuristic policy was suggested as an alternative, which used more information, but was myopic in nature and its performance was compared with that of \((s-1,s)\).

Lee and Chang Hwan (1994) carried a study on deterministic models for inventory control under continuous time-varying demand. This study addressed three aspects of inventory control systems subject to demand that varied continuously over time. 1.Ordering and preservation policies for continuously
deteriorating inventories. Control policies were developed for deterministic single-echelon inventories under the following two assumptions: (1) demand varied continuously over time, and (2) inventories deteriorated continuously over time. In a departure from the existing literature, they assumed that management had the option of preserving (reducing) the deterioration process at a cost. The objective was 1). to minimize the sum of holding, replenishment, deterioration, and preservation costs. 2). Near optimal ordering policies for multi-echelon inventory systems under continuous time-varying demand. A facility in series inventory model under continuous time-varying demand was studied. The assumptions of the model were: (i) Demand facing the bottom echelon was deterministic, continuous, and time varying. (ii) Replenishments were assumed to be instantaneous, and replenishments rates were assumed to be infinite in each echelon. (iii) The cost function included holding costs that varied over time and replenishment costs that were linear in the number of replenishments. 3. Management of deteriorating inventories for a two-echelon system under time-varying demand. The model consisted of two echelons: The second (bottom) echelon required input from the first (predecessor) echelon, and supplies continuous, deterministic, and time-varying demand over a finite planning horizon H. The inventories in both echelons were subject to deterioration. Replenishment was assumed to be instantaneous. The cost function included a replenishment cost linear in the number of replenishments,
holding cost varying over time, and a deterioration cost per item constant over time, under an exponential decay function.

A study was conducted by Lee and Yangjoo (1992) on production capacities and planned inventories on modeling, approximation and analysis. The study formulated and analyzed three models of production-inventory control systems having multiple stages of production, where each stage had, in addition to an input queue, a finite output buffer to store units already processed. In such systems intermediate and finished goods could be produced and stored in advance of demand to reduce customer waiting and backorders. They assumed Poisson demands and exponential production (service) times at each stage. The goals of this research were to develop computational methods, either exact or approximate, to measure system performance, and to use these methods to study important issues concerning the behavior of these systems.

First, they analyzed a simple model of a make-to-stock production system, controlled using a variant of the kanban system. The system consisted of two production stages in series. Each stage may produce defective items which were discarded. They showed how to compute performance measures exactly. They used the model to compare alternative product-test sites and to explore in detail the benefits of improving production quality.

Secondly, they explored a natural generalization of the classic tandem-queue model, designed specifically to represent make-to-stock production systems.
That was, the model described a tandem system operated with planned inventories, in addition to the queues of work that arouse also in make-to-order systems. This model was more complex than the first model, in allowing an arbitrary number of stages, but the control policy here was simpler, and there are no defects. They proposed and tested a tractable approximation scheme. The approximation appeared to be quite accurate as compared to simulation results.

Finally, they investigated a network-of-queues model, again representing a make-to-stock production system. The system consisted of several nodes and several items. The input-output relationships among the items formed a hierarchy or tree: Each item was produced at one of the nodes, using some other item as input. Again, a simple approximation scheme was developed and tested by computer simulation. Numerical results revealed that the approximation was quite accurate.

An and Bong-Geun (1989) conducted a study on modeling and estimating lead-time demand for a correlated demand structure with stochastic lead times for an inventory control system. Lead-time demand $L$ was a daily demand and $T$ was a stochastic lead-time. Knowledge of the distribution of $L$ was required for basic inventory decisions for example, determining the reorder point (ROP). In this study, an ARIMA process was considered for modeling the daily demand. $L$ then was expressed with random errors to facilitate investigation on the property
of 'L'. The expression of the four moments of 'L' was derived explicitly without parametric assumption on both T and daily demand. The distribution of 'L' was estimated by the Pearson system, a normal approximation and the Chebyshev expansion based on the moments of 'L'. In the numerical investigation, the ROP at a given stock-out probability was estimated with arbitrary lead-time and random error for ARIMA (1,1) demand. The performance of the methods were evaluated by the cumulative probability of the estimated ROP. The Pearson system and the Chebyshev expansion performed extremely well for various situations. The normal approximation, however, underestimated the ROP especially when the lead-time was skewed.

The ROP was estimated based on the samples of 'L' by some non-parametric methods such as the sample quantile and the bootstrap in addition to the above methods. For a small sample size of 10 lead times, all methods showed a tendency of underestimation. For moderate sample size of 30 lead times, four methods except normal approximation provided good estimates with comparable bias. Bootstrap had substantially smaller variation than any other methods. Sample quantile had the most variation. The Pearson system had a tendency of overestimation with the second largest variation. The Chebyshev expansion performed well with the second smallest variation. Accurate lead-time estimates were essential for effectiveness operation of an inventory control system. However, since many lead-time fluctuations were in fact discontinuous in nature
and were randomly generated, there was a need to understand for updating mechanism for estimation of lead-time.

A study was carried out by Kim and Tae Hyun (1987) on an evaluation of lead-time updating strategies for an inventory control system. The study proposed three updating strategies, continuous, periodic, and triggering, which determine when to update lead time; it evaluated the performance of each strategy in relation to other factors such as forecasting technique, lead time pattern, lead time variability, service level, and cost structure.

A FORTRAN computer model simulated inventory-ordering decisions and performance data were collected for dependent variables. An Analysis of Variance (ANOVA) was used to statistically analyze the results across all environments tested and the paired-sample t-tests were carried out to compare the three updating strategies under each specific environment caused by unique levels of the experimental factors.

The study indicated that the updating strategy was an important factor for inventory management. The continuous updating strategy showed better performance than the periodic updating strategy and triggering updating strategy. However, there were no statistically significant differences in performance among the three updating strategies across all environments tested. According to the results of t-test, there were statistically significant differences in performance among the three updating strategies under a specific
condition. The condition was a seasonal lead-time pattern with low variability of lead-time. The continuous updating strategy was better than the other two updating strategies under the condition and normally provided the best performance when combined with exponential smoothing. In addition, the results revealed that updating strategy has a strong relationship to lead time pattern and lead time variability; however, its correlation to forecasting technique was less significant. The relationships between forecasting technique and lead-time pattern, and between forecasting technique and lead-time variability were not found to be statistically significant.

Chen and Fangruo (1993) carried out a study on multi-echelon stochastic inventory systems with centralised stock information. As information technology (e.g., Electronic Data Interchange or EDI) proliferates, more and more companies now possessed centralized stock information for their inventory systems. This study examined how the centralized stock information could be used to improve inventory management. They considered several multi-echelon networks with centralized stock information and stochastic demand. These included serial, assembly, and one-warehouse multi-retailer systems. A natural replenishment strategy based on centralized stock information was to replenish each stage of a multi-echelon system according to its echelon stock level. The echelon stock of a stage was the aggregate inventory level of the subsystem consisting of the stage and all its downstream stages. Such replenishment
strategies were in a sharp contrast with those based on installation stock information under which each stage replenished its inventory according to its local stock level. They studied a class of control policies—the so-called \((R,nQ)\) policies—that operated according to echelon stock levels. An echelon stock \((R,nQ)\) policy at a stage orders an integer multiple of 'Q', the base lot-size, once its echelon stock level falls to or below \(R\), the reorder point. Such policies are easy to implement, and were similar to the widely used reorder-point order-quantity policies in practice. The study examined the cost effectiveness of echelon stock \((R,nQ)\) policies which consisted of three main steps: (1) performance evaluation of any given policy in the class, (2) optimization within the class, and (3) benchmarking. The first two steps were based on observations of the operation details of echelon stock \((R,nQ)\) policies, and the third step was carried out by comparing the minimum costs of echelon stock \((R,nQ)\) policies with lower bounds on the minimum achievable costs (by any policy) of the systems. The benchmarking studies conducted by the authors for serial and one-warehouse multi-retailer systems revealed that echelon stock \((R,nQ)\) policies were close to optimal. They also compared echelon stock \((R,nQ)\) policies with their installation-stock counterpart.

E. STUDIES ON INVENTORY PERFORMANCE

In a study conducted by Gossard and Gary (1996) to identify a new way to measure inventory performance. The financial impact of inventories were
reviewed and the information from the material requirement plan or order point system was used for setting individual objectives for inventory reduction, measuring performance by inventory segment and monitoring continuous improvement. The inventory quality ratio (IQR) puts a focus on inventory management priorities and measures true inventory performance. The IQR logic divided inventory into 3 groups: 1) items with future requirements 2) items with no future requirements but with recent past usage, and 3) items with neither. The items in these groups were then stratified into typical ABC-type classifications using their future dollar requirements, their past dollar usage or their current balances on hand respectively. A rule on target inventory level was set for each item based on its classification. The balance on hand of each item was compared to the rule, and the dollars of each item were categorized as active, excess, slow moving and non-moving.

Pope, James A et-al conducted a study to analyse the measures and techniques that provided the feedback needed to evaluate and control the performance of an order point inventory system. The feedback mechanism required the inclusion of measures that evaluated the validity of economic order quantity values. Measures useful in tracking and evaluating the performance of an order point inventory system included: 1) the inventory turnover rate measures for total inventory, categories of items, and individuals items, 2) feedback measures for determining if order points were set properly, and 3) customer service as
measured by stockouts and fill rates. Techniques for detecting changes in the inventory system were: 1) monitoring the turnover 2) backing the inventory to sales ratio 3) periodic checking to see if all items were active, and 4) monthly compilation of a supply distribution report.

In a study conducted to analyse the comprehensive programs to control the costs of maintenance, repair and operations (MRO) purchasing (1998), Richard S. Cadwaller noted the steps to control. According to him the first step was to establish a baseline in which the primary objective was to measure the cost-control procedures, the level of service and the quality of information labour. The measurements provided a quantitative assessment of what is actually occurring in the business and serve as a baseline for measuring improvements once the new program was implemented. The next step was to generate performance data and analyse this information to identify places where unnecessary work could be eliminated. Drawing a flow chart diagram of all the work performed made it easier to see how workflow could be improved. The final step was to implement improvement programs in functional areas. Cadwallader noted that one manufacturing firm saved $6 million annually by implementing this MRO improvement program.

Stukhart et al (1986) carried out a study sponsored by Construction Industry Institute (CII) to determine the cost-effectiveness of materials management
systems. Cost-effectiveness -- a method of measuring the contribution of materials to the overall project objectives -- was achieved through the deliberate actions of personnel. Integrated materials management produced both measurable and subjective benefits. The study incorporated 20 case studies into a CII source document to demonstrate the successful use of proactive integrated materials management, which required that functional materials managers sell their services to project managers. The preliminary findings of the study revealed that surplus was reduced and field operations were improved when materials management was adopted.

Mady and Tawfik (1991) carried out a study on inventory investments and structure of the industry. The study was conducted with a sample of 44 manufacturing companies representing 5 industry groups in Egypt. The analysis of the study revealed that the type of industry was determinant factor of both the inventory-to-total-assets ratio (AIR) and the inventory structure at the firm level. AIR indicated significant positive correlation with the materials cost ratio, the finished product inventory ratio, and the 'others' inventory ratio, but a negative correlation with the raw materials inventory ratio (RMR). The study showed that raw materials and purchased components deserve the most attention in Egyptian industry. A negative correlation was found between RMR and the company's value added. With more vertical integration, a firm could reduce its RMR. The effect of the type of production-inventory system on the
company's work-in-process inventory requirements (WPR) was confirmed. WPR was relatively low in both the engineering and food groups.

Silver and Allan (1985) conducted a study to increase the inventory turnover. They illustrated it by a "distribution of sales and inventory by value report," an ABC inventory management strategy. In this ABC approach, A items were reordered on an order-up-to-level basis, with a relatively low level of safety stock maintained. Larger quantities of B and C items were ordered perhaps 2 or 3 months stock at a time, and more safety stock were carried. As a result, the costs of acquisition were reduced for a relatively slight increase in the costs of carrying inventory in stock. Customer service was also improved by maintaining a higher level of safety stock for B and C items. The results revealed an improved inventory turnover rates, reduced back orders and a reduced number of line items issued on stock purchase orders.

Burns and Kevin (1996) reported the efforts taken by 3M and RS components to reduce supply-chain costs in 1994. 3M and RS components started a joint initiative aimed at dramatically reducing supply chain costs. This initiative resulted from a recognition by both parties that their relationship was under-utilizing their joint resources and that up to 70 per cent of the operational costs could be associated with supply chain issues. The essence of partnership was a joint approach to solve problems which resulted in reducing unnecessarily time
consuming tasks where both companies profited from additional resources. RS was able to help 3M re-engineer its purchasing process and create a bespoke solution called Managed Stock Replenishment. The process was developed and implemented at 3M's Aycliffe manufacturing plant near Darlington and involved 3M outsourcing part of its stores inventory management to RS components.

A major problem in Egypt's industrial sector was excess inventory investment. Understanding the problem required a thorough and diagnostic investigation of inventory performance for the entire industry and for each industry group. The inventory performance in the industrial public sector was studied by Mady and M.Tawfik (1990) over a 6-year period, using conventional inventory performance measurements. The relationship between inventory performance and other financial indicators at the company level were also analysed. The research sample included 44 public manufacturing enterprises, representing 5 Egyptian industries: 1. textiles, weaving, and garment, 2. food-processing, 3. chemicals, 4. engineering, and 5. metals and refractories. Two dependent variables were used to measure annual inventory performance for each group: 1. conventional inventory turnover rate, and 2. value-added inventory turnover rate. Results indicate that inventory management may positively affect company's profitability.

A study was carried out on inventory investment in South Africa by Smith and Herman (1995). The contributions of research on inventory investment, as
analysed in the literature from the period between the wars to the early 1980s, were invaluable. Comprehensive descriptions by Abramovitz (1950), Stanback (1962) and Mack (1967) had defined useful elements for the analysis of inventory investment. When the contribution of inventory investment to the gross domestic product in the downswing and upswing phases of the economy was analysed, they noticed that it strengthened the upswing and downswing. Although total inventory investment, on a quarterly basis, lagged by one quarter and industrial and commercial inventory investment coincided with the business cycle, more specific deductions could only be made with monthly data. The structural change in inventory holdings since the middle of the 1970's was probably related to more effective inventory management techniques that were possible because of advanced computer technology and more reliable delivery systems.

F. STUDIES ON THE USE OF COMPUTERS IN INVENTORY MANAGEMENT AND CONTROL

In a study conducted by Cope.J et al(1997) on a network / database server to replace an outdated inventory tracking and control process, it presented a better system on SQL database which would provide greater efficiency and productivity to the company by allowing its employees access to an inventory database that updated in real time. The multitasking operating system and modern networking methods were the tools that would provide the company
with the ability to keep its employees on top of inventory issues. The study illustrated the practicality and benefits of taking advantage of the multitasking, networking and processing capabilities of modern computers and operating systems.

Zahariev and Zaharey (1990) conducted a study to analyse the influence of information system on inventory management in an electronic data processing environment. Improving inventory management required a separation of the contradiction between the tendency to increase inventories as a result of inaccurate information and the need for a more secure supply because of search material resources. Also required was the separation of the need to reduce inventory size from the need to reduce storage and maintenance costs. The study presented an automated information system that provided information on hand inventories in the warehouses of a trading company and its customers and regulated deliveries from the suppliers warehouse. The system made provisions for cases where customers informed the trade organisation that suppliers had accumulated above-rate inventories. When suppliers failed to stop deliveries of material resources in general use for these customers, the suppliers incurred penalties according to rate regulations for above-rate inventories.

Johnson et al (1991) reported the results of a study conducted of 50 Midwest manufacturing companies on inventory control systems. The survey revealed that
some 60 per cent of the companies were planning major changes in their inventory control systems and that 40 per cent were dissatisfied with their current inventory control systems. The indication that both production and scheduling and bill of materials were considered to be computerized functions points to an increasing demand for computer resources within production. Large companies had successfully instituted computerized inventory and production controls. To institute such systems, smaller organizations had take the following steps: 1. Complete an accurate description of the current inventory control system. 2. Add computer capability to the existing systems. 3. Reassess the company's relationship with vendors. 4. Train personnel and educate management. Management information systems (MIS) personnel must understand the needs, advantages, and requirement of information handling within production and inventory control.

G. STUDIES ON SPARES PARTS MANAGEMENT

Sugianto.L.F and Mielezaiski.W(1997), identified that the cost of acquiring and storing parts generally lied between 5 per cent to 7 per cent of the total electricity generative cost. Considering the amount of funds invested in the spare parts inventory, most generation divisions in power industry try to optimise their investment. A research study was conducted by the above author on an application of an optimal resource allocation method with the use of a dynamic programming to optimise spare parts inventory. The study considered the power
plant availability as the objective function; and inventory budget as the constraint. Thus, for a given budget, dynamic programming configures a spare parts inventory, which attains the highest availability level. This approach has been implemented as a decision support systems which assisted inventory managers and engineers to optimise their inventory policy for a base load unit and a peaking unit.

Dohi.T: Shibuya.T: and Osaki.S(1997) developed two kinds of continuous time cyclic inventory models with stochastic lead times and expedited ordering options. The order form under consideration is similar to that arising in the spare parts inventory management. The research considered the control problem to determine the timing for the regular order and the optimal policy, which minimises the long run average cost. The study has presented numerical examples to evaluate the uncertainty of stochastic lead times and the optimal inventory policy, which is composed of both the ordering time and the order quantity.

Cummings, C.F.(1996) studied the aspect of operations management which was vital for business success, namely inventory control and minimisation of cost distribution systems. Manufacturing and service industries required the distribution of goods through several levels of inventory to provide satisfactory service to customers. The costs associated with inventory were a significant
percentage of total annual sales value. Model building and simulation was the 
method used to research the performance of four main systems of material 
control. The methods compared were: (1) base stock system (2) order point’s 
system (3) periodic review and (4) just-in-time. These four methods were 
applied to a three level distribution system and the economic performance and 
effectiveness of each method was compared. From this study it was concluded 
that just in time was the most economic and overall best method. The base 
stock system yielded the least stockouts but required the highest average stocks 
and was expensive.

Ashayeri J et al (1996) conducted a study in the field of service parts inventory 
in the computer industry. The industry was highly competitive and products had 
to be repaired as quickly as possible, since slow repair could lead to loss of 
future business to competitors with better service reputations. A good reputation 
was closely linked to the availability of spare parts on the market. The study 
elaborated on the management and control of service parts inventory and gave a 
briefly overview of the literature. The study presented the solution approach 
adopted and the results indicated that significant savings can be achieved 
/realised through good management of service parts inventory.

Mc Cleary and Boyd T (1989) studied the improved point-to-point delivery system 
implemented at the University of Michigan Medical Center by the way of UPS.
The study revealed that the planning process started with an analysis of departmental delivery locations. Centralised delivery locations were identified and later formalised through institutional policy and procedure. Each department was given a discrete delivery code. A 30 per cent reduction in delivery locations was achieved, and few packages were in the undeliverable category due to insufficient or in correct addresses. The (UPS) United Parcel Service point-to-point delivery system was implemented in (FEDEA) Federal Express in June 1987. Benefits to the Center were 1) decreased distribution cost 2) improvements in service levels 3) improved efficiency of the remaining deliveries accomplished by materials management staff, and 4) a decrease in the time needed to initiate a requisition as a result of the use of delivery codes.

Plant machineries parts suppliers could be of great help to buyers in managing spare parts inventories. A study conducted by Philips and Thomas.E (1978) revealed that the suppliers could provide helpful information in the following area. Suppliers often had special arrangements for quick order processing so that customers do not have to stock certain spare parts in their inventory. A minimum inventory level was usually needed however, in machine parts that wear-out most frequently. Good suppliers also recommended the parts and quantities of inventory that their customers needed. Suppliers used economic order quantity technique to advise their customers on the expected life of machine parts to hold down inventory levels. Other valuable information
provided by suppliers included; (1) buyback policies or possible outlets for extra or obsolete parts, and (2) advice or handling inventory management problems.

In a study conducted by Lawrenson and James (1986) on Effective spares management, they identified that an important goal of spare parts management was to minimize the total cost of inventory holding, stock-outs, and ordering. The 2 vital resources available for this management were people and facilities. The study revealed that the spares operation should be planned in the context of the main business, with the plan including long-range planning, intermediate policy-making and short-term scheduling. It laid emphasis to have a complete understanding of the basics of stock control, stores and supply management which was vital. The study also revealed that cataloging the inventory avoided confusion and error by exact, unambiguous identification. Further it also provided a framework for the regenerated information system outlining the steps involved in it as 1.Study present procedures. 2.Consider the benefits of integration. 3.Define the functional requirement. 4.Draw the system outline. 5.Structure the data logically.

Schroeder et al (1986) conducted a study on various approaches to manage the cost of materials. As direct labour is reduced by automation, the task of lowering materials cost has become much more urgent. Materials costs may account for 60 per cent or more of a products manufactured cost, yet managers pay too little
attention to these costs. Hence the study was conducted to manage the materials cost as aggressively as any other costs. The study identified five ways to reduce materials costs and they were: 1. Insist on high quality and timely deliveries. 2. Change the product design. 3. Realign the supplier network. 4. Improve the way the firm deals with suppliers. 5. Improve the way the firm organizes for materials management. The study also proposed a materials management audit questionnaire for self-evaluation of materials management practices.

Gary Peterson (1991) Operations Manager, investigated on the reduction of manufacturing costs through an improved Material Requirement Planning function at Gage Talker's corporation. The study revealed that the new system had features to suit the company needs, including: 1. accounting integration, 2. simplified screens to facilitate training, 3. full technical support, 4. complete manufacturing resource planning functionality, and 5. affordability. The new system integrated manufacturing and accounting functions through shared data. This new, more accurate scheduling and tracking system has reduced the company's inventory levels by 40 per cent.

Gelinas and Tom (1991) shared their experience of Mike Kennedy of Chrysler Transport Inc. with parts inventory control and the Vehicle Maintenance Reporting Standard (VMRS). The software system Kennedy selected provided
with several features to support the VMRS, parts inventory control, providing online information, easy reference of part members and others. Kennedy reported that the parts inventory went from $4,200,000 in 1987 to $3,600,000 in 1991, a 15 per cent reduction.

For low-usage items (so-called C items), it makes sense to have rather low control costs, i.e., a simple control procedure. Silver and Edward.A (1991) conducted a study to determine a simple graphical aid for selecting either the reorder point in a continuous-review, reorder point, order quantity system or the order-up-to-level in a periodic-review, order-up-to-level system. The development was based on a Poisson distribution of demand during a lead-time (and review interval), which was likely to be appropriate for low-usage items. The study revealed that the simplicity of the method was consistent with the need for very low control costs for such items, particularly for smaller firms lacking computer software and mathematically sophisticated employees.

A study was conducted by Perry and James H (1990) to examine the lead-time management in the Department Of Defense (DOD) and the private sector environments. Drawing on data collected from private sector firms, DOD vendors, and DOD inventory managers, empirical differences in lead-time profiles were developed and analyzed. The results of the study showed that, for the private firms, 2 clearly different procurement lead-time patterns emerged.
For those firms competing in almost exclusively non-DOD markets, lead times ranged from 45 days to about one year. For those private firms that were primarily DOD suppliers, procurement lead times of 150-500 days were typical. The DOD procurement lead times were substantially longer than private sector lead times. The lead-time disparities existed even when the item procured, the supplier, and the external market conditions were held constant. The common characteristic among the private sector firms with successful lead-time management was highly visible, very active, and continuing involvement by top management.

A study was conducted by Duchessi et al (1988) to enable a firm to integrate managerial logic for the purpose of controlling its total spares inventory. The top-down method classifies spares into distinct categories and linked appropriate controls with each category. It identified spares that do not have to be stocked and identified critical spares that, if not in stock, resulted in excessive downtime costs. To facilitate development of a comprehensive top-down program, 4 steps were recommended: 1.constructing a mutually exclusive and collectively exhaustive set of categories for classifying spare parts into homogeneous classes, 2.associating controls with each category by management, 3.selecting and developing suitable systems for a specific management control specification, and 4.implementing the first 3 steps by management. An inventory cost-part
criticality matrix was designed with each of the 9 cells containing spares with different cost-criticality traits.