CHAPTER II

LITERATURE REVIEW

2.1 REVIEW OF LITERATURE

There are lots of definitions about ERP in the literature. Many of the definitions for ERP focus on such properties of ERP as integrating processes, enabling optimization across the organization, elimination of complex links between computer systems, providing a common IT infrastructure, linking through the supply chain, adapting best industry and management practices for providing the right product at the right place at the right cost, tracking the status of a company’s day-to-day activities, achieving consistency and efficiency through standardization, enhancing of market value and firm performance through efficiency and effectiveness gains, providing a quicker response to customer requirements and creating common measures (Rao, 2000[25]; Bendoly and Jacobs, 2004[26]; Huang, Palliers, Pan, 2003[23]; Hunton et al 2003[27]). Hsu and Chen (2004)[28] discussed the importance of ERP into an integrated, process-oriented, information-driven and real time organization where Sarkis and Gunasekaran (2003)[29] stressed the effects of ERP on competition.

Oliver and Room (2002)[30] emphasized the improvement in image as a factor in ERP adoption. The other factor in ERP adoption is high percentage of failure in information system projects which caused a shift from individual development to standardized, pre-packaged software solutions (Scheer and Habermann, 2000)[31]. However; Sammon and Adam (2005)[32] noted that high rates of failure also exist in ERP project implementation due to combined effect of inadequate organizational analysis at the beginning of the project, the complexities of ERP market and complex implementation. Sprott (2000)[33] discussed that market leading enterprise applications represent some of the largest, most complex
applications on the plant and explained the reasons of complexity of ERP software as highly
generalized nature of packaged applications and the need to adapt and rapidly evolve to meet
requirements in different situations. Adam and Doherty (2000)[34] explained the reason of
complexity as requiring reliance on many different types of expertise often sourced outside
the organization.

Because of the problems with ERP, the image of ERP seems to have changed from a highly
promising into a highly demanding technology (Boersma and Kingma, 2005)[35]. Since ERP
system are profoundly complex pieces of software and costly systems (Davenport, 1998 [6],
Al-Mashari et al 2003[36], King and Burgess, 2006[37], Kumar et al 2003[38], Somers and
Nelson, 2003[3], Hsu and Chen, 2004[28]), installing them requires large investments of
money, time and expertise (Davenport, 1998 [6], King, Burgess, 2006[37]). Adam and
O’Doherty (2000)[34] state that though ERP systems have beneficial effects, these benefits
are matched with high level of risk because of complexities of ERP systems.

Soh et al 2000[39], reports that some companies even abandon implementation of ERP
projects or achieve only some of the benefits they aim ( Sammon and Adam, 2005[32], Al-
Mashari et al 2003[36]). King and Burgess, 2006[37] reports that many implementations of
ERP have been criticised regarding the time, cost and disruption caused by the
implementation and sometimes limited benefits once the systems become operational. Soh et
al 2000[39] points out about the problems caused by the difference between functionality
offered by the package and that required by the firm in ERP projects. While trying to adjust
the ERP software and the system in the enterprise, there will be some barriers. Barriers cause
firms to experience a decrease in organizational performance instead of realizing
improvements (Hirt and Swanson, 2001)[40].
Hawking et al 2004[41] discusses the role of barriers in limiting the realization of benefits and categorizes barriers as People, Processor Technology related barriers. Organizational change is one of the most important barriers encountered in transition new systems and business processes (Kumar et al 2003)[38] and is an important reason for the failures(Al-Mashari et al 2003[36]). The barriers should be solved before the system goes live. If the barriers are not solved, they may act as drivers of risks. Sumner (2000)[42] defines a risk as a problem that has not yet happened but which could cause some loss or threaten the success of your project if it did. Teltumbde 2000[43] defines risk as the measure of the degree of possible variation in the outcome or benefits of the project. He also relates the risk of ERP projects with the size of the investment and the complexity of the enterprise and categorizes risks as project management related risk, technology-related risks and process-related risks.

Luo and Strong 2004[34] point out those risks in ERP projects are relatively higher than they are in traditional projects. Somers and Nelson, 2004[3] claim that though supplementary redesign of business processes promises the highest return on investment, it also increases the level of complexity, risks and costs. Aladwani (2001)[44] explains the perceived risk as a reason for rejecting to use an ERP system. Teltumbde (2000)[43] relates the risks with intrinsic product design and suggests assessing the risks and the benefits carefully during the evaluation process and concludes that it’s impossible to succeed in a technological application unless people have positive attitudes about it and behave in ways that enable to get benefit from it.

Yang et al 2006[45] suggests that the key success factor for implementing ERP system is the people centred, and Light,2005[46] points out that the only way of achieving the perfect system is to involve end users. Owing to the importance of people in ERP implementation, people related measures were developed. Two of the measures developed are:
User satisfaction (Yang et al, 2006[45], Zhang et al 2005[14]).

Expectation success, defined as IT systems match with user’s expectations (Al-Mashari et al 2003)[34].

In order to better understand this burgeoning field, the ERP literature has been often classified into the following two categories: conceptual/theory building and empirical/theory testing.

2.2 Conceptual/theory building literature

In reviewing the conceptual research on ERP, three distinct research streams emerged. The first provides comprehensive overview of ERP systems and focuses on the fundamental corporate capabilities driving ERP as a strategic concept. These articles cover such aspects as research agendas; motivations and expectations; and proposals on how to analyze the value of ERP systems.

A second stream focuses on the details associated with implementing ERP systems and their relative success and cost. Specifically, the articles in this stream include topics such as the implementation procedures, critical success factors, pitfalls and complexities in ERP implementation, and successful strategies for effective ERP implementation.

The third stream focuses on the theoretical research models that have been developed. The theoretical research models covers aspects such as usage of modelling tools applied in ERP contexts, new business modelling approaches, and comparison between processes. The major studies done under this stream include: Al-Mudimighet al 2001[47].propose an integrative framework for ERP implementation based on an extensive review of literature and the essential elements that contribute to success in the context of ERP implementation.
Arinze and Anandarajan (2003)\cite{48} show how object oriented mapping methods can be used to rapidly configure ERP systems. Hedman (2000)\cite{49} presents a competing value approach enterprise systems framework to discuss enterprise systems from an organizational effectiveness perspective.

Park et al. (2005)\cite{50} present an object class extraction methodology of production planning and control system as a part of ERP environment. Sock et al. (2000)\cite{51}. Suggest a technological evolution approach to ERP adoption. Stensrud and Myrtveit (2003)\cite{52} propose the use of data envelopment analysis variable return to scale to measure the productivity of software projects. Stirna 2008\cite{53} analyzes the acquisition of enterprise modelling tools.

2.3 **Empirical/theory testing literature**

This deals with the assessment and specific ERP implementations. Most of the research under this stream has been done through field studies, questionnaire surveys or case studies illustrates the extent of ERP implementation and the effects of various factors on ERP implementation. Specifically, these studies cover different perspectives in particular situations such as: ERP impacts, applied theories to specific ERP issues, organizational change management, business process reengineering, people roles, and decision-making. The major empirical studies on theory testing include: Akkermans and van Helden(2002)\cite{4}analyze and explain project performance in one ERP implementation in the aviation industry.

Akkermans et al(2003)\cite{54}. Present results from a Delphi study on the future impact of ERP on supply chain management. Al-Mashari and Al-Mudimigh(2003)\cite{55} describes a case study of a failed implementation of ERP to reengineer the business processes of a major


Tarafdar and Roy (2003)[64] analyze the adoption of ERP systems in Indian organizations. Tatsiopoulos et al. (2003) [65] propose a structured risk management approach for the successful implementation of ERP systems. The application of the proposed methodology is demonstrated with a case study company from the oil industry. Trimmer et al. (2002)[66] and indicate support for the continuing use of critical success factors to help focus on the benefits of ERPs in rural health care. Schniederjans and Kim (2003)[67] discuss survey results on implementing ERPs with total quality management and business process reengineering. Shang et al. (2004)[68] examine the relationship between organizational culture and employees’ self-efficacy for a sample of 352 subjects.

Voordijk et al. (2003)[69] discuss the factors that lead to the success or failure of ERP in large construction firms. It is clear from the review of the literature that much work has been
done in the area of ERP implementation. However, what is lacking in the extant literature is a systematic, theory-linked study of characteristics of successful and unsuccessful ERP.

ERP allows companies to integrate various departmental informations. It has evolved from a human resource management application to a tool that spans IT management. For many users, an ERP is a “does it all” system that performs everything from entry of sales orders to customer service. It attempts to integrate the suppliers and customers with the manufacturing environment of the organisation. For example, a purchase entered in the order module passes the order to a manufacturing application, which in turn sends a materials request to the supply-chain module, which gets the necessary parts from suppliers and uses a logistics module to get them to the factory. At the same time the purchase transaction shows in general – a ledger module as revenue. The traditional application systems, which organisations generally employ, treat each transaction separately. They are built around the strong boundaries of specific functions that a specific application is meant to cater for. ERP stops treating these transactions separately as standalone activities and considers them to be a part of interlinked processes that make up the business (Gupta, 2000 [70]).

An overview of ERP systems including some of the most popular functions within each module is shown in Figure 1. However, the names and numbers of modules in an ERP system provided by various software vendors may differ. A typical system integrates all these functions by allowing its modules to share and transfer information by freely centralising information in a single database accessible by all modules Chen, (2001)[71].

The various modules of ERP include engineering data control (bill of materials, process plan and work centre data); sales, purchase and inventory (sales and distribution, inventory and purchase); material requirement planning (MRP); resource flow management (production scheduling, finance and human resources management); works documentation (work order,
shop order release, material issue release and route cards for parts and assemblies); shop floor control and management and others like costing, maintenance management, logistics management and MIS. Also, the model of ERP includes areas such as finance (financial accounting, treasury management, enterprise control and asset management), logistics (production planning, materials management, plant maintenance, quality management, project systems, sales and distribution), human resources (personnel management, training and development and skills inventory) and workflow (integrates the entire enterprise with flexible assignment of tasks and responsibilities to locations, positions, jobs, groups or individuals) (Siriginidi, 2000)[72].

Although an ERP system is a pure software package, it embodies established ways of doing business. Studies have illustrated that an ERP system is not just a pure software package to be tailored to an organisation but an organizational infrastructure that affects how people work and that it “imposes its own logic on a company’s strategy, organisation, and culture” (Davenport, 1998 [6];). For example, SAP R/3, as one of the major ERP vendors, currently stores over 1,000 predefined processes that represent financial, logistics and human resources best practices in a repository called “business engineer” (Scott and Kaindl, 2000[17]) as shown below in figure 1.
Figure 1: ERP organisational infrastructure of SAP R/3
The evolution of ERP is described below in order to better comprehend the ERP planning and implementation issues. Manufacturing enterprises involved in manufacturing, sales and distribution activities have been using computers for 30 years to improve productivity, profitability and information flow across the enterprise. ERP system traces its roots commencing from standard inventory control packages to material requirements planning (MRP), and manufacturing resource planning (MRP II). An inventory control system was the software designed to handle traditional inventory processes. It was one of the early business applications, which did not belong to the finance and accounting area.

In the 1970s, the production-oriented information systems were known by the name MRP. MRP at its core is a time phased order release system that schedules and releases manufacturing work orders and purchase orders, so that sub-assemblies and components arrive at the assembly station just as they are required. Some of the benefits of MRP are reduction of inventories, improved customer service, enhanced efficiency and effectiveness (Siriginidi, 2000)[72].

As competitive pressures increased and users became more sophisticated, MRP evolved and expanded to include more business functions such as product costing and marketing. In the early 1980s, MRP expanded from a material planning and control system to a company-wide system capable of planning virtually all the firm’s resources. This expanded approach was MRPII. A major purpose of MRPII is to integrate primary functions (i.e. production, marketing and finance) and other functions such as personnel, engineering and purchasing into the planning process to improve the efficiency of the manufacturing enterprise Chen, 2001[71]; Chung and Snyder, 2000[73]; Mabert et al., 2001[74]). MRPII has certain extensions like rough cut capacity planning and capacity requirements planning for
production scheduling on the shop floor as well as feedback from manufacturing shops on the progress of fabrication.

Since the 1980s, the number of MRPII installations has continued to increase, as MRPII applications became available on mini and micro computers (Siriginidi, 2000)[72]. Like MRP, MRPII focused on the manufacturing process. The next stage of MRPII evolution was just-in-time (JIT) methodology that combined with the plummeting price of computing to create the islands of automation in late 1980s. The Gartner Group of Stamford, CT, USA, coined the term ERP in the early 1970s to describe the business software system that is the latest enhancement of an MRPII system (encompasses all MRPII modules). A key difference between MRPII and ERP is that while MRPII has traditionally focused on the planning and scheduling of internal resources, ERP strives to plan and schedule supplier resources as well, based on the dynamic customer demands and schedules (Chen, 2001)[71].

The maturity stage of ERP occurred in the mid-1990s. The scope offered by ERP expanded to include other “back-office” functions such as order management, financial management, warehousing, distribution production, quality control, asset management and human resources management. The evolution of extended-ERP systems has further expanded in recent years to include more “front-office” functions, such as sales force and marketing automation, electronic commerce and supply chain management systems. The scope of ERP implementation encompasses what is often referred to as the entire value chain of the enterprise, from prospect and customer management through order fulfilment and delivery.

An enterprise, to stay competitive, has to not only identify information needs but also ensure that the information infrastructure provides the right support to serve the enterprise, its customers and suppliers. If it does not do so, then it runs the risk of being disconnected and excluded from future opportunities (Siriginidi, 2000)[72].
The technological evolution of ERP from MRP has been presented in detail by Chen (2001)[71] and Chung and Snyder (2000[73]). Information system technology evolved from mainframe-based computing through the client/server era to the Internet era. Earlier the ERP systems were developed only to work with huge mainframe computers. Most of the current ERP systems are based on the client/server solution model (Rao, 2000[25]; Siriginidi, 2000[72]). In a client/server environment, the server stores the data, maintaining their integrity and consistency and processes the requests of the user from the client desktops. The load of data processing and application logic is divided between the server and the client (Gupta, 2000 [70]).

Now, ERP vendors are – as many other software vendors – forced to move from a traditional client/server to a browser/Web server architecture in order to deliver e-business capabilities (Scheer and Habermann, 2000[31]). These systems are built with a clear separation of functional components. The user interface implemented using graphical user interface (GUI) techniques is deployed on client machines. Powerful server machines host the databases and business logic written as server procedures. The databases are built using relational database technology. Relational database systems have enabled the vendors to put in the necessary flexibility in terms of business logic and data structures to support parallel business practice implementations. These technologies in general have allowed the users to architect the system in such a way that installation, customisation and extensions are possible in shorter timeframes (Rao, 2000[25]).

2.4 Literature related to ERP vendors

The review of literature dealing with the vendors of ERP has some expected inferences. Business information systems can be either designed as custom applications or purchased as off-the-shelf standard solutions. The development of custom applications is generally
expensive and is often plagued by uncertainties, such as the selection of appropriate development tools, the duration of the development cycle, or the difficulties involved in assessing costs. Therefore, companies are radically changing their information technology strategies by purchasing off-the-shelf software packages instead of developing IT systems in-house. Out of more than 100 ERP providers worldwide, SAP-AG, Oracle, JD Edwards, PeopleSoft and Baan – collectively called the “Big Five” of ERP software vendors – control approximately 70 per cent of the ERP market share (Mabert et al., 2001)[74], Everdingen et al 2000 [50](Figure 3 below). The middle end products include SSA, BPCS, Inertia Movers, etc., that offer good functionality and could be implemented faster. The low-end products like QAD, MFG, PRD, etc., could be implemented very fast, but offer limited functionality (Rao, 2000)[25].

Source: Mabert et al. (2000); Coffey et al. (2000); Everdingen et al. (2000)

Figure 2: The “BIG FIVE” ERP software vendors

The key features of some of the popular ERP packages including MFO/PRO from Qad, IFS/AVALON, SAP, JD Edwards, BAAN IV, Marshal(R) and PeopleSoft, have been
provided in Siriginidi (2000)[72]. The top five ERP vendors have seen a growth rate of 61 per cent over the past year.

Although there are some differences in the marketing strategies and products of these five ERP vendors, they have similar offerings and shortcomings. Most ERP vendors still use the same basic model as MRP II for the manufacturing planning portion of their systems (Chung and Snyder, 2000)[73]. ERP has packaged processes best business practices in the form of a business blueprint. This blueprint could guide firms from the beginning phase of product engineering, including evaluation and analysis, to the final stages of product implementation. Many ERP systems also come with industry-specific solutions, or templates, that enhance the standard system by addressing key issues or business processes within an industry group (Mabert et al., 2001[74]).

Established in Germany in 1972, SAP AG, with 33 per cent market share, is the major ERP package vendor for the Fortune 500 companies. With more than 20,000 employees and estimated revenue of $8.1 billion in 2007 SAP is one of the largest software companies in the world. SAP R/3 is an integrated suite of financial, manufacturing, distribution, logistics, quality control and human resources application systems and can address or facilitate changes in the business processes (Al-Mashari and Zairi, 2006[75]; Mandal and Gunasekaran, 2002[97]). SAP offers modules for logistics and human resources and also expands its product line to supply chain management, sale force automation and data warehousing Yen et al., 2002[93].

PeopleSoft was founded in 1987 and went public in 1992 (O’Leary, 2000[77]). PeopleSoft can be scaled to accommodate from ten to 500 users. PeopleSoft dedicates its products (PeopleSoft) to human resource and client/server technology. They continue to prove its value in enterprise-wide applications and financial and supply chain applications.
Baan was founded in The Netherlands in 1978. Bann has approximately 3,000 clients in 5,000 sites worldwide (O’Leary, 2000[77]). It sells manufacturing software to companies that are wary of SAP product. It stocks up on small software suppliers, which results in a wider variety of product offerings. They continue to develop enterprise applications in areas that SAP and Oracle are less competitive.

Oracle is the second-largest supplier of software in the world. Oracle was founded in 1977 in the USA (O’Leary, 2000[77]). It offers ERP applications designated to work with its database software. Oracle is a leading database software provider that sells most of its applications to manufacturers and consumer goods companies. Oracle intends to dominate its database software by leveraging over the ERP market (Yen et al., 2002[93]).

JD Edwards provides ERP applications (One World) for managing the enterprise and supply chain. Their integrated applications give customers control over their front office, manufacturing, logistics and distribution, human resources and finance processes. JD Edwards continues to allow its ERP solutions to operate in the computing environment and also to be XML enabled (Yen et al., 2002[93]). One World is designed for between five and 500 users (O’Leary, 2000[77]).

To summarise, such systems have a few common properties: they are based on a central, relational database, they are built on client/server architecture, and they consist of various functional modules. In addition to a base module, there are modules for general accounting, budgeting, fixed assets, sales order management, procurement, inventory management, customer service management, etc. ERP systems may support most functional units and processes of a company – if its structure and working procedures are not too far from the mainstream (Kueng et al., 2000[78]).
ERP is now considered to be the price of entry for running a business, and at least at present, for being connected to other enterprises in a network economy to create “business to business” electronic commerce (Boykin, 2001[79]). Furthermore, many multinationals restrict their business to only those companies that operate the same ERP software as the multinational firm. It is a fact that ERP is for big firms and smaller firms have to adjust their business model and approach according to the practices and software adopted by the big firms. With the opening up of the economy, small to medium sized enterprises (SMEs) have found the going very difficult. Since they do not have the robustness associated with large companies, SMEs have to tap the power of IT and an integrated information system to stay competitive and customer oriented. ERP is often considered the answer for their survival (Rao, 2000[25]). Therefore, the ERP software market has become one of today’s largest IT investments worldwide. A recent survey predicts that the spending on ERP will reach $66 billion in 2003 (Themistocleous et al., 2001[80]). It continues to be one of the largest, fastest-growing and most influential players in the application software industry in the next decade (Adam and O’doherty, 2000[34]; Yen et al., 2002[93]). There are several reasons why a continued growth of ERP projects is to be expected (Stensrud, 2001[81]):

(a) Continuous expansion of the capabilities of packages by adding functionality for new business functions such as sales force automation, supply-chain, order management, data warehousing, maintenance repair-and-overhaul, etc.

(b) Transitioning to Web-based applications leading to faster flow of information in the logistics chain.

(c) The emergence of e-commerce will increase demand for Web-based ERP systems.
(d) The share of ERP systems in certain geographical markets such as the former Eastern Bloc, Asia and South America is not widespread.

2.5 ERP packages and their evolution

ERP packages touch many aspects of a company’s internal and external operations. Consequently, successful deployment and use of ERP systems are critical to organizational performance and survival (Markus et al., 2000b[10]). Potential benefits include drastic declines in inventory, breakthrough reductions in working capital, abundant information about customer wants and needs, along with the ability to view and manage the extended enterprise of suppliers, alliances and customers as an integrated whole (Chen, 2001)[71]. In the manufacturing sector, ERP implementation has reduced inventories anywhere from 15 to 35 per cent (Gupta, 2000[70]). Among the most important attributes of ERP (Nah et al., 2001[82]; Soh et al., 2000[39]) are its abilities to:

(a) Automate and integrate business processes across organizational functions and locations;

(b) Enable implementation of all variations of best business practices with a view towards enhancing productivity;

(c) Share common data and practices across the entire enterprise in order to reduce errors; and

(d) Produce and access information in a real-time environment to facilitate rapid and better decisions and cost reductions.

Different technological and management scientists in India and abroad have conducted various macro as well as micro level studies on the enterprise resource planning which
automates most of the business functions. Their main findings have been discussed in the succeeding paras.

Hammer and Champy. 2001[83] promoted the idea about ERP that “ERP is the most important tool for business process re-engineering”. They felt that the design of work flow in most large corporations was based on assumptions about technology, people and organizational goals that were no longer valid. They suggested seven principles of reengineering to streamline the work process and thereby achieve significant levels of improvement in quality, time management and cost:

1. Organize around outcomes, not tasks.

2. Identify all the process in an organization and prioritize them in order of re-design urgency.

3. Integrate information processing work into the real work that produces the information.

4. Treat geographically dispersed resources as through they were centralized.

5. Link parallel activities in the workflow instead of just integrating their results.

6. Put the decision point where the work is performed, and build control into the process.

7. Capture information once and at the source.

Manetti (2001) [84] argues that, ERP is on the verge of another major evolutionary advance with the following major changes occurring soon:
1. Broader use of web enabled systems to support closer coordination, especially in supply chains.

2. Greater artificial Intelligence (AI) driven systems supporting more powerful advanced planning.

3. Greater ERP presence in mid-range manufacturing, with more stable technology enabling less time and money for installation.


5. More third-party application (bolt-on) to perform specially applications accessed by middleware.

Glazer, senior advisor Tech par group argued that Bolt-on is ERP jargon for third party applications. More specifically, a Bolt-on is an artificially functionality or technology to complement ERP software. Bolt-on employ client specific business rules to meet unique needs. There are many useful applications of this type. The usual of connection to other organization with ERP systems is through software components.

Most of the software has historically been delivered as inflexible code focusing on its originally intended application. A much easier approach is the idea of components where separate, encapsulated software code is written that is easier to manage, upgrade and connect to host systems. Open systems can easily accept modifications, additions or linkages to external software. Components make open system possible.

Kara examines that external application to ERP systems were initially accessed through application programming interfaces (APIs), which can access ERP data. APIS are pieces of computer code at low level, which is time consuming, costly and difficult to maintain. A most
recent trend has been the development of software with the specific purpose of accessing application packages to ERP. Middleware is an enabling engine to tie applications together. Middleware removes the need for APIS. It can be divided into data oriented products.

Kaplan and Atkinson 1998 [85] has a separate view that after going live with the ERP implementation, it is not time to forget about ERP because it is “complete” stead, at that time the organization enters a stabilization period that typically drags down organizational performance. As a result, firms need to work to mitigate that negative effect. The firm also needs to build an organization to handle the day to day issues associated with the ERP system and management needs to determine what else must be done and whether the implementation matches the system plan. Also, management must address what upgrades, extensions or linkages can or should be made to the ERP system. Finally the firm needs to evaluate the success of the project”.

Allen and Kern (2001)[86] maintained that “implementation of an ERP system is a major investment and commitment for any organization. The size and complexity of ERP projects are the major factors that impact the cost of ERP implementations. Different Companies may implement the some ERP software in software in totally different approaches and the same company may integrate different ERP software applications by following the same procedures. However there are factors common to the success of ERP implementation regardless of the ERP systems they implement and the methodologies they use.

Pitney Bowes Spectrum data integrated solutions observed that ERP system if chosen judiciously, implemented correctly and used properly can produce dramatic improvements in productivity and efficiency and can make the organization more competitive. But there are many ways to maximize the capabilities of the ERP systems. ERP systems can produce positive ROI and capitalize on high profile delivered functionality such as automated
workflow and employee self service when implemented as part of a comprehensive business process optimization programmed.

Wang and Hamerman (2007)[87] have the view that SAP continues to either biggest player in the market with an estimated 43% of the market share or about $12.5 billion revenue in 2006. Oracle was second with 23% market share of $6.7 billion; however, it had the fastest growth rate of ERP vendors covered, growing at 29% from 2005 to 2006. Next in line was sage group with 5% market share, followed by Microsoft at 4% and SSA global at 3%. In July Atlanta based Inform Global solutions acquired SSA Global, both J.D Edwards and People Soft were acquired by oracle. The growth of the ERP market is fuelled by following three factors:

1. ERP vendors are offering new applications.

2. ERP vendors sell more licenses into their installed base.

3. ERP usage has spread to nearly every type of enterprise including retail, utilities, the public sector and healthcare organization.

Kimberling Eric President Panorma Consulting Solutions on implementation of best practices for ERP success in apr 2012 observed that implementing the ERP system is a change and it is human nature to resist change. So any ERP implementation will face some amount of resistance. The main reason for this resistance is fear-fear and uncertainty about what will happen. In the case of ERP implementations too, there will be fear among the employees. There will fear about the new system is all about, what changes it will introduce, how it will change the job profiles, how many jobs will be made redundant and how many employees will lose their jobs and so on.
2.6 Review of ERP in Defence Forces

In the thesis titled “Implementation Challenges for Army logistics enterprise resource planning IT Systems” Mark W Jones[88], author’s research focuses on Department of Defence (DoD), United State’s ERP implementation efforts ongoing in the Army, Navy, Air Force, and Marine Corps and provides a macro-level review of six DoD ERP implementations with a historical perspective reflecting the difficulty all have had in developing their respective ERP systems. It also reviews a micro-level review of the GCSS-MC (Global Combat Support System—Marine Corps) program which identifies systems engineering challenges the program has faced.

It recommends that it is important for the Army to take a hard look at how the current ERP solutions have been developed and determine alternate ways to develop similar systems in the future. The research also suggests that the Army cannot afford the billions of dollars that have been spent on multiple system developments and needs to figure out a way to consolidate efforts between the Service Components. These consolidated efforts may provide not only an expedited system development effort but also a common system that can be centrally managed and used to breakdown the unique stove pipe processes within each Service and transform logistics chain management of modern times.

While analysing the use of ERP systems in the Army which is becoming the method of choice to develop small increments of capability rapidly the researcher mentions that the old method of developing a large amount of capability in one increment is too costly, takes too long, and may possibly result in implementing out-dated technology by the time the software is released for use. An ERP system can be developed one business application at a time and provide a foundation for all other business applications to be added later.
The researcher further mentions that each Service Component of the Army is essentially trying to accomplish the same goal in modernizing their aging logistics IT systems. Functionally, each Service Component is developing redundant capability. Development of logistics ERP systems in the Army has been plagued by cost overruns and schedule delays in the Army, Air Force, Navy, and Marine Corps. All Services have experienced similar program management and system engineering challenges recognized by the GAO (General Accounting Office) and continue to struggle with development of their ERP systems.

This thesis analyzes six of the logistics ERP efforts currently ongoing in the DoD and provides an analysis to support the development of a single integrated ERP system to be used by all four Services. The use of ERP systems in the DoD is becoming the method of choice to develop small increments of capability rapidly. The old method of developing a large amount of capability in one increment is too costly, takes too long, and may possibly result in implementing out-dated technology by the time the software is released for use. An ERP system can be developed one business application at a time and provide a foundation for all other business applications to be added later. The ERP may be implemented in its entirety, but it is very complex and can take up to several years to implement. The ERP may be implemented using only a core module without any business process reengineering; it is relatively inexpensive but may not provide all of the needed functionality. Alternatively, the ERP may be implemented using only a selection of its core ERP modules along with significant business process reengineering. This methodology is exactly what the Marine Corps decided to do, implement the supply and maintenance management capability of the Oracle E-Business ERP in one small increment and defer the development of other business areas such as Warehousing, Transportation, Planning, Finance, Human Resources, and Engineering to other increments. In particular, the Marine Corps has decided to develop capabilities to address immediate ground based logistics chain management shortfalls as
defined by the requirements in the GCSS-MC Capability Development Document. The purpose of this thesis is to investigate the ERP development efforts in DoD, understand what makes implementation of these development efforts so difficult, and provide a recommendation as to an alternate way to develop and implement a single ERP system across all of the DoD. By first addressing this limited functionality, the Program Office increased potential success of meeting schedule timelines within budget. However, since the inception of the GCSS-MC program, the development effort has still been prone to cost and schedule overruns.

The following questions were analyzed by the authors:

(a) What are the DoD ERP IT system implementation challenges in the Army, Air Force, Navy, and Marine Corps?

(b) What are the GCSS-MC system engineering technical and functional challenges with regards to the design and build of the GCSS-MC system?

Implementation challenges were identified by the author to highlight the difficulties that DoD ERP programs experience and will serve as data for a recommendation of how to implement future DoD ERP developments.

The researcher concludes that each Service Component of the DoD is essentially trying to accomplish the same thing by modernizing aging logistics IT systems and streamlining multiple systems into one complete, coherent, and accurate logistics chain management system. All have common implementation strategies but each has unique requirements that represent the core business processes of each Service. All have experienced similar program management and systems engineering challenges recognized by the GAO and continue to struggle with development of their ERP systems.
Many of the GAO identified weak areas impact each Service’s ability to accurately determine the time it will take to design, build, test, and field their respective ERP system. The government allowed GCSS-MC program to field the basic capability of supply and maintenance management sooner to the war fighter and speed up the process of eliminating the legacy supply and maintenance systems.

The application of a COTS product in an environment is much different from that in the private sector. COTS products do not provide unique Army or Service Component functional and technical capabilities to support things such as mobility of troops and poor communication networks in austere environments. This is much different than stationary brick and mortar buildings with solid and stable communication links. Therefore, the perception of buying a COTS product to minimize development effort is exactly that, a perception.

In nutshell the researcher concludes that development of a single integrated ERP system provides many advantages as mentioned below:

(a) Reduction of the number of logistics IT systems to maintain – saves billions of development and sustainment dollars,

(b) Asset visibility across Services - locate and provide gear to war fighter faster and more efficiently,

(c) Shared data in same place - logistics data available to all Services to make better informed Command and Control decisions,

(d) Common transportation and distribution - reduce number of deliveries and get gear to war fighter quicker,
(e) Procurement streamlining - shared transactional procurement data to eliminate unnecessary duplication of gear.

There is a large amount of literature available of the implementation process and the challenges thereof but most of these are specific to the type of core industry using that particular ERP package, hence a generic review of literature is not pragmatic. However, there are some common factors regarding the implementation process that are the same irrespective of the type of industry where ERP is being implemented. In this research more emphasis is laid on these factors.

ERP systems are enterprise-wide on-line interactive systems that support cross-functional processes using a common database. ERP systems are designed to provide, at least in theory, seamless integration of processes across functional areas with improved workflow, standardization of various business practices, and access to real-time up-to-date data.

ERP systems are complex and implementing one can be a challenging, time consuming and expensive project for any company (Davenport, 1998 [6]). An ERP implementation can take many years to complete, and cost tens of millions of dollars for a moderate size firm and upwards of $100 million for large international organizations Mabert et al.,2000[74]. Even with significant investments in time and resources, there is no guarantee of a successful outcome. Despite the large installed base of ERP systems, academic research in this area is relatively new. Like many other new Information Technology (IT) areas, much of the initial literature in ERP consists of articles or case studies either in the business press or in practitioner focused journals. Many of these articles provide anecdotal information based on a few successes or failures. These publications have chronicled both some high profile failures and extensive difficulties at such companies as FoxMeyer and Hershey Food Corporation (Diederich, 1998[89]; Nelson and Ramstad, 1999[90]), and some model
implementations. Also, several authors (Piturro, 1999[8]; Zuckerman, 1999[91]) emphasize that ERP is a key ingredient for gaining competitive advantage, streamlining operations, and having “lean” manufacturing. As a testimonial for this viewpoint, they point to tens of thousands of companies around the world who have implemented or are planning to implement ERP systems.

2.7 Other aspects of ERP implementation

More recently, several academically oriented papers have dealt with various aspects of ERP (Davenport, 1998 [6]; McAfee, 1999[92]; Everdingen et al., 2000[58]; Mabert et al., 2000[74]). Davenport looks at the reasons for implementing ERP systems and the challenges of the implementation project itself. McAfee [92], look at operational performance. McAfee reports on a longitudinal experiment at a computer manufacturing facility to determine the impact of an ERP system on operational performance. His research shows that operational performance measures improve significantly on pre-ERP levels four months after implementation. McAfee proposes a longer time frame for such a study. Stratman and Roth propose an integrated conceptual model of “ERP Competence” which they define as comprised of several organizational aptitudes including strategic planning, executive commitment, project management, IT skills and change management. They argue that a firms ERP Competence must be used effectively in order to truly harness the capabilities of an ERP system for competitive advantage. Everdingen et al.(2000) and Mabert et al. (2000) both use surveys to systematically study a variety of issues. Van Everdigen et al. in a survey of 2647 European companies across all industry types determined adoption and penetration of ERP by functionality.

Mabert et al.(2000) surveyed manufacturing companies in the US to study penetration of ERP, motivation, implementation strategies, modules and functionalities implemented, and
operational benefits in the manufacturing sector. While the above practitioner and academic research provides valuable insights into both ERP effective use and implementation process issues, we feel a more systematic empirical analysis of ERP implementations is essential for understanding key factors that lead to a successful implementation, as measured by on-time and on/under-budget performance.

This research also addresses this issue by reporting on and analyzing the results of a survey of companies who have implemented ERP systems. More specifically, this paper empirically investigates whether there are key differences in the approaches by companies that managed their implementations ‘‘on-time’’ and/or ‘‘on/under-budget’’ versus the firms that did not. These are two success measures often cited by companies for ERP implementations (Mabert et al., 2000, 2001). Logistic regression models are used to classify companies that are able to accomplish their implementations on-time and then on/under-budget based upon a set of input variables. All results are based on the responses from this survey.

One of the most widely-cited variables critical to the successful implementation of a large customized system is top management support (Ginzberg 1981[93]). Given the cross-functional nature and large budget of a typical ERP implementation, the extent of top management support appears to be an important characteristic. Two types of top management support roles have been associated with systems implementation projects: the project sponsor and the project champion roles (Martin et al. 1999 [94]). The project sponsor is responsible for budgetary support and ensuring that key business representatives play a role on the project team. The project champion may or may not be a formal member of the project team, but can play a key role in change management efforts. In some organizations, the sponsor also serves as the business champion for the project; in other situations, a champion emerges from among the key business leaders.
The composition and leadership of the project team have also been recognized as important variables in systems implementation. Shaft and Vessey (1995)[95] have argued that both business (application) and technical knowledge improve the quality of traditional information systems analysis and design. These findings support the notion that R/3 implementations require not only package knowledge, but also business process knowledge (Seip and Sprengel 1998)[96]. In addition, since R/3 package implementations typically involve cross-functional process integration, key project team roles will be played by representatives from multiple business units who may be assigned full-time to the project (Norris et al. 1998[97]). According to the trade literature, it is also not uncommon for an ERP project to be business-led (Norris et al. 1998).

The trade literature suggests that attention to change management will be a critical success factor, given the large-scale process and system changes associated with enterprise-wide ERP implementations. The change management literature, which argues for the importance of not only pre-planned communications and training, but also the need to improve solutions (Mintzberg 1987[98]; appears to be relevant here, given the amount of organizational learning typically associated with ERP implementations.

The fact that third-party consultants are most often used as implementation partners, at two to 10 times the cost of the ERP software for the initial implementation, also supports the notion that ERP implementations are complex and that new project management skills will be needed to manage the complexity (Ryan 1999[22]). Implementation choices reported in the trade press that appear to be related to project complexity include the extent of process innovation, the degree of package customization, and the conversion strategy: phased, “big bang,” or pilot, or some combination of these strategies.
The figure 4 below incorporates these potentially important ERP implementation variables this study. First, the author begins the study with an assumption that characteristics of the organization, including industry and competitive strategy, will influence the ERP package capabilities that are sought by the organization. The only published cross-organizational report known to the authors (Davenport 1998[6]) draws considerable attention to the need to think through the business implications of implementing an ERP system. After first calling attention to the “enormous technical challenges,” Davenport concludes that disaster can result if a company fails to reconcile the technological imperatives with the business needs of the enterprise itself. Second, preliminary findings from the authors’ own field survey of ERP adoption decisions suggest that the ERP package capabilities sought can be summarized in terms of seven factors: new ways of doing business, IT cost reduction, data integration, flexibility/agility, IT purchasing, global capabilities, and Year 2000 compliance (Brown and Vessey 1999 [99]).

![Contingency Framework for ERP Implementation Approach](diagram)

Figure 3: Contingency Framework for ERP Implementation Approach
Third, the organizational characteristics and ERP package capabilities sought are assumed to influence the ERP package choice and project scope (modules, business units, geographies). The scope of implementation is a distinction not well addressed in the earlier literature. ERP implementations typically addressed in the literature include ERP modules for *value-chain activities*, materials management, production and operations, sales and distribution. However, many other companies purchase so-called ERP packages for functions that *support* the value chain only: human resources (HR) and/or financial/accounting modules. When no value-chain modules are involved, we refer to such implementations as “support” implementations (vs. “value-chain” implementations). Further, some firms are implementing ERP modules with the expectation of enterprise-wide solutions, while in other cases the solutions are implemented at the division level (or business unit level) only.

Finally, some enterprise-wide solutions are also global solutions. Some subset of variables for all three of these factors (organizational characteristics, ERP package capabilities, and package choice and scope of implementation) is then expected to influence the key ERP implementation choices identified from the literature. To demonstrate the potential utility of
the framework, the figure 5 above maps a published teaching case on a global SAP R/3 implementation into the framework (Martin et al. 1999 [94]).

Today, the integration of companies’ business processes is, if not a necessity, a requirement linked to the reactivity imperative. Organizations’ zeal to adopt integrated ERP systems is thus highly justified because these systems are believed to dramatically improve competitiveness. SAP R/3 has emerged as the dominant leader in ERP systems, and is now one of the most widely used tools for optimizing and re-engineering business processes (Cooke and Peterson, 1998 [100]; Al-Mashari, Al-Mudimigh, 2003[55]). Siemens and Lucent Technologies (W Francesconi, 1998[101]) for instance, have implemented SAP R/3 to improve the integrity of their supply chain. Nonetheless, even under ideal circumstances, ERP implementation is fraught with formidable challenges (Motwani et al., 2002[61]). For one, the company must successfully transform its organization within the specified time frame and within budget (Weston, 2001[101]). Until recently, the implementation process associated with such systems has been particularly long. Standish Group found that 90% of ERP implementations end up late or over budget (Umble et al., 2003[102]). In some cases, the implementation time is extended indefinitely, which has negative consequences for both the companies and the morale of their employees (Gupta, 2000 [70]; Mabert et al., 2001[74]). Note that this endeavour represents much more than a simple technological implementation in the traditional sense of the term (Mandal and Gunasekaran 2002[76]). The organizational change and process re-engineering in ERP projects, the enterprise- wide implications, the high resource commitment, high potential business benefits and risks associated with ERP systems make their implementation a much more complex exercise in innovation and change management than any other advanced manufacturing technology (Kumar et al., 2003[38]). Putting in place an ERP necessitates a transformation that is simultaneously strategic, technological, structural, organizational and social. It is therefore not surprising that many
ERP implementations fail (Soh et al., 2000[39]). Mabert et al. (2003[74]) found that even with significant investments in time and resources, a successful outcome is not guaranteed. Radding (1999)[103] argues that when an organization channels millions of dollars into a core business application and re-engineers its business processes around it, the exercise invariably becomes much more than a systems development project. Implementing ERP systems successfully requires an implementation strategy. Cooke and Peterson, 1998[100] observed that organizations that had no strategic plan for SAP implementation performed poorly 90% of the time compared with those that had a plan. A strategy and a plan, however, should follow systematic consideration of the company’s requirements and its ability to manage changes that would be required under the new situation. Companies must carefully define why the ERP system is being implemented and what critical business needs the ERP system will address (Umble et al., 2003[102]). As Mandal and Gunasekaran (2003)[76] affirm: “Such a strategy, either step-to-step or Big Bang, will determine how the related changes can be successfully absorbed at various parts of the organization”. While practitioners and academic scholars (articles and cases studies) provide valuable insights into ERP implementation process issues and key factors that lead to a successful implementation, a more systematic empirical analysis of ERP implementations is essential for understanding the ingredients of successful system implementation, as measured by on-time and on/under-budget performance.

Andre et al chose to analyze the implementation of SAP R/3 at Pratt & Whitney Canada (P&WC), a large aeronautics company, because this initiative reconciles both the requirements of a large scale project and the capacity of an organization to successfully carry out the organizational transformation required by the implementation of such a system. The project began in June 1996 and ended in January 1999 (two and a half years) and is recognized as a success story. All data taken from the main sources were consolidated and
linked to create a full picture of the entire implementation process. This article describes the approach followed by P&WC, as well as tactics and techniques used to operationalise its change plan. It provides evidence of the lessons related to this successful implementation of an ERP. The fundamental objective of the implementation of an ERP system at P&WC was to put in place an information infrastructure (called the Total Enterprise System (TES)), that would foster greater transparency vis-a-vis its customers worldwide, along with greater agility. In particular, P&WC wanted to improve customer response time, reduce work-in-process, and increase inventory turnover and increase visibility of inventory and operating costs. SAP R/3 provided P&WC with a global information system, TES that covers all of the company functions that process customers’ orders.

Implementation of the new system would affect more than 3000 employees in all company departments. P&WC adopted a ‘‘Big bang’’ approach to TES implementation. This approach was quite risky because it encompassed all processes simultaneously (Davenport, 2000). It called for considerable rigor because it took into consideration the entire P&WC environment, characterized by multi-site activities.1 On this topic, Davenport (2000, p. 176) notes: ‘‘It’s simply too difficult to anticipate all of the problems and changes involved in an implementation when everything is changing at once’’.

The concrete benefits anticipated from the implementation of TES, along with the minimization of associated risks, largely depended on the strategies and implementation practices chosen by P&WC, as suggested by Aladwani (2001)[44]. Below we will describe the highlights of the implementation approach. Major phases of TES implementation the project duration, i.e. 32 months (from June 1996 to January 1999), was unevenly distributed over five major implementation phases:

<table>
<thead>
<tr>
<th>Planning</th>
<th>System Planning, Benefit Analysis</th>
</tr>
</thead>
</table>

52
In departments across the organization, significant resources were mobilized to manage change and knowledge transfer. In particular, during phases III to V, many resource persons were deployed within several well-structured teams named Project Team, Training Development Team, Change Champions and Power Users. The planning approach adopted by P&WC was similar to those observed in many other organizations, as reported by Kumar et al. (2003)[38], who investigated critical management issues in ERP implementation projects at 20 organizations. Critical management issues considered were: Constitution of project team; project planning, training, infrastructure development, ongoing project management; quality assurance and stabilization of ERP. Some of these organizations adopted ASAP methodology proposed by SAP. Most ERP implementation projects are structured around phases. Models containing roughly six stages have emerged in the literature As Kumar et al. 2002,[104] noted, “All the stage models reported could be clubbed into four broad phases of planning, configuration, testing, and implementation”

Aside from the project phases, a particular feature of the methodology adopted by P&WC is that it proposed that five project threads “be woven into a cohesive fabric through its five work plans”. On reviewing the five phases we come to the following conclusions.

Phase I: Scoping and planning From June to December 1996, the P&W executives focused on defining the scope of activities and planning their implementation. They took into
consideration the strategic objectives, requirements of P&WC customers and best practices (identified through competitive analysis). The processes in place were evaluated to determine those that needed improvement. These considerations helped Management define the scope of the project and resulted in the initial decision to implement SAP R/3 as is, with minimal reengineering. They thus determined the scope of the project both in terms of the necessary resources and the systems to replace.

Phase II: Determining the level of previous reengineering

From January to March 1997, i.e. a three-month period, the P&WC executives defined their vision of the major business processes of the company in line with the targets set (Visioning & Targeting). They decided to perform very little process re-engineering during TES implementation.

Phase III: Process redesign

Running from April to September 1997, the third phase was mainly dedicated to redesigning processes in keeping with the executives’ vision and with the targets set. Ten processes were affected, which included 47 sub-processes, corresponding to 600 activities. The relatively short duration of this phase (7 months) reflected the P&WC executives’ deliberate decision to minimize re-engineering as part of the implementation process.

Phase IV: Configuration

The fourth phase, the longest at 10 months, was dedicated to configuration of the new system. It was during this phase that the main parameters of each SAP module were determined, and that the choice of parameter options related to the new system was clarified.
Phase V: Testing and delivery

The test phase ran from August to December 1998, and included three integration test cycles: An initial cycle related to master file data, a second to static data and a third to dynamic data. During each cycle, the key information technology programs were also tested. The successful test results were then formally accepted by the process managers. The cutover from the old systems to the TES took place on January 4, 1999. Planned from spring 1998 by the start-up committee, this operation constituted a “moment of truth” that was instrumental to the project’s success.

SAP’s methodology specifies five threads to ensure the consideration of five key factors throughout the project: Project Management, Technology Architecture, Process and Systems Integrity, Change Management, and Knowledge Transfer. Without these threads, a lack of attention to some aspects of these factors might have hampered the project, notably during integration of all of the business processes or during the adjustment of other company software to the ERP software.

![Figure 5: Five key factors for consideration](image-url)
2.8 **Drawbacks of ERP systems**

There is a large amount of literature available on the drawbacks of ERP systems. Although ERP systems have certain advantages such as low operating cost and improving customer service, they have some disadvantages due to the tight integration of application modules and data. Huge storage needs, networking requirements and training overheads are frequently mentioned ERP problems. However, the scale of business process re-engineering (BPR) and customisation tasks involved in the software implementation process are the major reasons for ERP dissatisfaction. Baan, PeopleSoft, as well as SAP calculate that customers spend between three and seven times more money on ERP implementation and associated services compared to the purchase of the software license (Scheer and Habermann, 2000[31]). This means that ERP projects are large, costly and difficult and that they require large investment in capital and staff and management time (Adam and O’doherty, 2000[34]) identified the disadvantages of ERP: its high cost prevents small businesses from setting up an ERP system, the privacy concern within an ERP system and lack of trained people may affect ERP’s efficiency. Implementation of an ERP project is painful, and customisation is costly and time-consuming. The various shortcomings of the ERP systems such as functionality and technicality and other shortcomings have been discussed by O’Connor and Dodd (2000)[105].

The different types of ERP system misfits (the gaps between the functionality offered by the package and that required by the adopting organisation), based on Asian organisations, have been presented by Soh et al. (2000)[39]. The observed misfits
Figure 6: Drawbacks of ERP systems

were clustered into three broad categories: data, process and output, in line with a traditional software application perspective. Data misfits arise from incompatibilities between organizational requirements and the ERP package in terms of data format, or the relationships among entities as represented in the underlying data model. Functional misfits arise from incompatibilities between organizational requirements and ERP packages in terms of the processing procedures required. Output misfits arise from incompatibilities between organizational requirements and the ERP package in terms of the presentation format and the information content of the output. Their findings suggest that the “misfit” issue may be worse in Asia because the business models underlying most ERP packages reflect European or US industry practices. ERP systems are complex, and implementing one can be a difficult, time-
consuming and expensive project for a company. For instance, the ERP adoption time, typically, takes from a few months for firms accepting all default settings, to years for firms needing to make major modifications. It costs tens of millions of dollars for a medium sized company and $300-500 million for large international corporations Mabert et al., 2001[93].

Along with obvious costs of an ERP implementation, there are also some possible hidden costs that may include losing some very intelligent employees after the initial implementation is done, continual implementation and training, waiting for return on investment (ROI) and post-ERP depression. Moreover, even with significant investments in time and money, there is no guarantee of the outcome. Although most ERP systems have business practice processes in their repository, not all of them are necessarily best in class applications for a specific firm. The firm still needs to select those applications available from software vendors for its specific requirements, and integrate both applications and ERP system into the firm’s IT backbone. Because ERP has made it easy to integrate other competing best in class applications, most firms either face the high cost of modifying the ERP modules to meet their requirements or simply do not install the applications. Indicative of the problems, some retailers were reported to face difficulties, when they implement ERP applications that were developed with manufacturers in mind Chung and Snyder, 2000[73]. One of the aims of implementing ERP systems is to uphold the highest quality standards of the business process. However, when the business condition has been changed, the system may not guarantee that the process embedded in ERP is still best. Hence, for example, a multi-agent system for adaptive inventory control in an ERP system maintenance has been proposed by Kwon and Lee (2001)[106].

Themistocleous et al. (2001)[80] proposed a model to identify, analyse and present the problems of ERP systems, as well as to examine new approaches to application integration (AI). They claimed that ERP systems amplified the need for integration, as existing systems
have to be incorporated with ERP applications. AI securely incorporates functionality from disparate applications and leads to the development of new strategic business solutions for enterprises. The results of the research confirm AI as a new means of system integration that adds value by placing business logic in the applications network, thus creating a more dynamic information system infrastructure. Additionally, organisations face many problems when customising ERP packages. Thus, customisation problems did not allow companies to make serious changes on the ERP package. IT and business managers also argue that ERP suites tend only to have one best in class application. For instance, PeopleSoft is linked with a good human resources module and Oracle with financials. Furthermore, organisations may be left waiting for the next upgrade from their ERP software vendor when they require further functionality.

Literature of the selection criteria for choosing the right ERP package is discussed in succeeding paragraphs. The normal symptoms that would suggest the need for ERP would be high levels of inventory, mismatched stock, lack of coordinated activity, excessive need for reconciliation, flouting of controls, poor customer response levels and operations falling short of industry benchmarks in terms of cost controls and general efficiency. The tangible benefits due to ERP adoption include: reduction of lead time by 60 per cent, 99 per cent on-time shipments, increased business, increase of inventory turnover by 30 per cent, reduction in cycle time by 80 per cent and work in progress reduced to 70 per cent. The intangible benefits include: better customer satisfaction, improved vendor performance, increased flexibility, reduced quality costs, improved resource utility, improved information accuracy and improved decision-making capability Siriginidi, 2000[72].

The deployment of ERP has two issues, viz., selection and implementation. The system selection process is deceptively difficult. While most ERP packages have similarities, they
also have fundamental design differences. The selection involves listening to the views of various people whose involvement would be essential and the criteria to go beyond technical issues such as proven experience of the supplier in the desired industry, along with support infrastructure. Selecting a system that is simple offers smart tools for system administration, a consistent interface and supports graphical and character interfaces that could reduce the implementation time. The various selection criteria of ERP systems are well documented (Bernroider and Koch, 2001[57]; Chen, 2001[71]; Everdingen et al., 2000[58]; Rao, 2000[25]; Siriginidi, 2000[72]; Sprott, 2000[33]; Verville and Halingten, 2002[141]). From the clients’ view point, the selection factors to be considered, as addressed by Siriginidi (2000)[72], include the stability and history of the ERP supplier, last 12-month track record of ERP sales, implementation support from suppliers and improvement in ERP packages.

In another study, Bernroider and Koch (2001)[57] discussed the results from an empirical study of Austrian companies concerning differences in the characteristics of the ERP system selection process between small or medium and large sized organisations. In particular, they addressed the fields of software packages considered and chosen, the weights assigned to different selection criteria, the size and structure of the team responsible for the decision, the methods employed and the effort expended.

The analysis conducted showed that there is a significant influence of organizational size on the software package selected. SAP R/3 systems are selected more often by large organisations, while small or medium sized companies often choose software supplied by Baan. A total of 29 different ERP selection criteria have been identified; the adaptability and flexibility of the software is more highly valued by smaller organisations, as these advantages may be unique business processes that need to be preserved. A short implementation time and therefore, lower costs are also given more importance, as resources are a bigger issue. The
high importance attributed to fit with current business procedures, flexibility, costs, user-friendliness of the system and short implementation has also been found in another empirical study of European midsize companies conducted by Everdingen et al. (2000)[58]. With regard to evaluating ERP suppliers, they also reported that all the European mid-markets tend to focus on product characteristics such as the functionality and quality of the products and services, rather than on characteristics of the ERP supplier of the product. At the same time, the speed of implementation, the possibilities of the product for interfacing with other applications and the price of products and services are also important supplier selection criteria. Sprott (2000)[33] identified four incremental selection criteria that organisations should use to choose the supplier of an enterprise applications. These are applicability, integration, adaptability and upgradability.

In his paper, Chen (2001)[71] analysed several critical planning issues prior to the ERP adoption decision, including needs assessment and choosing a right ERP system, matching business process with ERP system, understanding the organizational requirements, and economic and strategic justification. He reported that competitive strategy, targeted market segments, customer requirements, manufacturing environment, characteristics of the manufacturing process, supply chain strategy and available resources all enter into the decision of ERP adoption.

Verville and Halingten (2002)[107] investigated the decision process for selecting an ERP system through a case study. They reported that the three distinct types of an ERP system evaluation were vendor, functional and technical. Criteria such as vendor reputation, financial stability, long term viability and the vendor’s vision/corporate direction were factors that were considered during the vendor evaluation. In recent years, most ERP system suppliers have increased their focus on small or medium sized organisations, especially as the total
European midsize market for IT products and services surpasses US $50 billion per year
Everdingen et al., 2000[58]. There are some reasons for this trend, including a saturation of the market, as most large organisations have already implemented an ERP solution, increasing possibilities and need for the integration of systems between organisations and the availability of relatively inexpensive hardware. (Rao (2000)[25] identified the criteria for the selection of an ERP system for SMEs. These criteria are affordability, domain knowledge of suppliers, local support, technical upgradability and incorporation of latest technologies.

Frequently, references are made to factors proposed within a framework that identifies four main dimensions of the specificity of small to medium sized organisations: organizational, decisional, psycho sociological and information systems. In their study of ERP migrations, Kremers and van Dissel(2000)[108] suggested that migrations have a bad reputation with the users of ERP systems. They consider such projects as time-consuming and expensive. As a result, many organisations do not migrate the moment a new version becomes available. In addition, migrations are usually motivated by technical reasons rather than by business opportunities. These findings suggest that many organisations may have problems leveraging their (often large) investments in ERP systems. In addition, new improved versions of ERP systems regularly become available at the same time for all users. Therefore, at best, organisations may try to compete on the basis of the capability to migrate to a new version quickly.

An ERP “solution” can be put together in a number of ways. At one end, an organisation can install a single vendor package. At the other end, it can integrate different modules from different vendors and/or custom software for a BoB solution. Both approaches are undoubtedly complex due to their scale, scope and BPR requirements. The trade-offs of these two approaches are fairly simple. A multi-vendor solution can provide the best functionality
for each module, but implementing it becomes more complex because of the interfaces that need to be established. A single vendor solution may not have all the functionality required, but it will be easier to implement (Mabert et al., 2001)[93].

Until recently, most vendors (SAP, PeopleSoft, Oracle, etc.) have promoted a “one size fits all” solution built on “industry best practices”. This approach forced organisations to either conform to the “best practices” and configurations suggested by vendors and implementation consultants or embark on extremely costly reconfiguration of their ERP package.

Light et al. (2001)[109] highlight BoB as an alternative approach to enterprise IT infrastructure development. In their paper, the differences between BoB and single vendor ERP approaches are discussed and the issues organisations need to consider when deciding on a strategy are shown to centre on the complexity of implementation, required levels of business process alignment and associated maintenance. ERP requires a clean slate approach, whereas BoB offers the chance for organisations to recognise the existing ways of work and make trade-offs with stakeholders. This is an important distinction, as the BPR associated with BoB can facilitate implementation and the management of complexity. Another important difference is that ERP systems do not offer the same levels of flexibility, and potentially, the responsiveness associated with BoB. However, the trade-off is likely to be concerned with the future maintenance requirements. BoB approaches have the potential to require higher degrees of maintenance due to the complex connections made between different components, whereas maintenance of components and connections between components, of single vendor ERP systems is largely outsourced to the vendor. However, the paper presented a comparative analysis between ERP and BoB approaches, particularly with respect to the impact on business process and BPR implementation. Other issues such as
technology and cost require more research effort. 6. Implementation of an ERP system A tremendous effort has been made in discussing the implementations of ERP systems. Al-Mashari and Zairi (2006)[75] proposed an integrative framework for SAP R/3 implementation. Their framework was based on the premise that effective deployment of SAP R/3 is greatly determined by the extent to which certain key elements such as the business case, implementation strategy, change management and BPR, are comprehensively considered and fully integrated. The successful implementation of an ERP system increases competitiveness by increasing quality, reducing redundancy, speeding up processes, reducing lead times and inventory levels and increasing customer satisfaction (Gupta, 2000[70]). It has become increasingly clear that implementing an ERP system requires extensive efforts to transform the organisation’s processes. ERP systems are supposedly based on best practice generic business processes. Therefore, when purchasing an off-the-shelf ERP system, organisations obtain these practices and subsequently are pushed into the direction of implementing them (Kremers and van Dissel, 2000)[108].

According to a recent study, more than 70 per cent of Fortune 1000 companies have either begun the implementation of an ERP system or plan to do so in the next few years. Another positive aspect is that smaller firms that are very dependent on large companies, are going to be forced into ERP packages to stay compliant with larger organisations’ ERP systems. Enterprise preparedness for embarking an ERP system has been discussed by Siriginidi (2000)[72]. For instance, infrastructure resource planning, education about ERP, human resource planning, top management’s commitment, training facilities and commitment to release the right people are among the factors that should be considered before implementing an ERP package. Chen (2001)[71] claimed that economic and strategic justifications for an ERP project prior to installation are very necessary, not only because of the enormous investments and risks involved; the justification process helps to identify all the potential
benefits that can be accrued with ERP implementation, which later become yardsticks for performance evaluation. Reductionism and complex thinking in the realm of ERP implementations have been discussed by Wood and Caldas (2001)[110].

Failures of ERP system implementation projects have been known to lead to organizational bankruptcy (Davenport, 1998 [6]; Markus et al., 2000[10]). A methodological framework for dealing with the complex problem of evaluating ERP projects has been proposed by Teltumbde (2000)[43]. A study of problems and outcomes in ERP projects has been conducted by Markus et al. (2000)[10]. Two basic research questions were addressed. First, how successful are companies at different points in time in their ERP experiences, and how are different measures of success related? Second, what problems do ERP adopters encounter as they implement and deploy ERP, and how are these problems related to outcomes? Markus et al. (2000)[10] developed a four-phase model of ERP implementation: chartering, project, shake-down and onwards and upwards. The findings showed that the success of ERP systems depends on when it is measured and that success at one point of time may only be loosely related to success at another point of time. Companies experience problems at all phases of the ERP system life cycle and many of the problems experienced in later phases originated earlier, but remained unnoticed or uncorrected. These findings suggest that researchers and companies will do well to adopt broad definitions and multiple measures of success and pay particular attention to the early identification and correction of problems.

2.9 Current ERP research (Approach and Implementation)

Current ERP research has focused on the ERP implementation stage, post-implementation and other organizational issues, the issue of acquisition process for ERP software is, for the most part, being ignored. Further research work in this area should be aimed to detail the difference in the ERP implementation between SMEs and large organisations. Most ERP
systems contain best practice models. Current studies have not focused on the knowledge transfer practices involved in an ERP implementation including the various types of knowledge transferred and factors affecting this transfer. Nah et al. (2011)[82] discuss various factors to be considered while implementing from organisation point of view as well as from employees point of view.

There are different approaches to ERP strategy, ranging from skeleton implementations to full functionality. There are also important differences in how organisations manage the gap between their legacy systems and the ERP business processes. It appears easier to mould the organisation to the ERP software rather than vice versa.

There are many possible approaches to implement ERP systems. ERP systems are now the most common IT strategy for all organisations. From a management perspective, the nature of the ERP implementation problem includes strategic, organisation and technical dimensions. Therefore, ERP implementation involves a mix of business process change (BPC) and software configuration to align the software with the business processes.

There are two different strategic approaches to ERP software implementation. In the first approach, an organisation has to re-engineer the business process to accommodate the functionality of the ERP system, which means deep changes in long-established ways of doing business and a shakeup of important peoples’ roles and responsibilities. This technique will take advantage of future ERP releases, benefit from the improved processes, and avoid costly irreparable errors. The other approach is customisation of the software to fit the existing process, which will slow down the project, introduce dangerous bugs into the system and make upgrading the software to the ERP vendor’s next release excruciatingly difficult, because the customisations will need to be torn apart and rewritten to fit with the new version. However, the former approach has proven to be more logical and effective; historically,
ERP implementations have had to deal with the critical issue of changing the business process or modifying the software (Boykin, 2001[79]). Since each alternative has drawbacks, the solution can be a compromise between complete process redesign and massive software modification. However, many companies tend to take the advice of their ERP software vendor and focus more on process changes.

The current generation of ERP systems also provides reference models or process templates that embody the current best business practices (Kumar and Hillegersberg, 2000)[12]. When improving business processes, reference models can be included. Reference models provided by ERP software vendors or consultant companies benefit the customer by utilising business process knowledge and best practices, providing the opportunity to compare business software solutions or pinpointing positive or negative implementation issues (Scheer and Habermann, 2000)[31].

An ERP implementation often entails transferring the business knowledge incorporated in the basic architecture of the software package into the adopting organisation. In their paper, Lee and Lee (2000) proposed a new approach to analysing ERP implementations from a knowledge transfer perspective. First, the types of knowledge transferred during an ERP implementation and the factors affecting this transfer were identified. Then they investigated how conflicts between the business knowledge transferred from the ERP package and the existing organizational knowledge are resolved. Their results indicated that the business processes which are incorporated in an ERP package are transferred into an organisation along with the business rules inherent in the processes due to process automation, the limited flexibility of such packages and the cross-functional nature of an ERP package. The results also suggested that an organisation’s adaptive capability concerning the role and responsibility redistribution, the development of new types of required knowledge and the
introduction of a different knowledge structure influences an organisation’s ability to internalise these standardised processes into business routines that provide a competitive advantage.

ERP projects are complex and require reliance on many different types of expertise often sourced outside the organisation. Consultants often advise managers to undertake some degree of re-engineering of key processes before acquiring ERP systems (Bancroft et al., 1998); this adds to the complexity and political character of the projects (Adam and O’doherty, 2000). These difficulties have led some researchers to take a negative view on ERP systems. Wood and Caldas (2010) characterised the goals of ERP systems and questioned whether the current interest in ERP in the business community is justified more by political reasons than by sound managerial reasoning. Indeed, these authors found low levels of satisfaction in their survey of firms having implemented ERP systems with 45 per cent of firms perceiving no improvements whatever from implementation and 43 per cent claiming that no cycle reduction had been obtained.

ERP implementation should involve the analysis of current business processes and the chance of re-engineering, rather than designing an application system that makes only the best of bad processes. Therefore, ERP implementation and BPR activities should be closely connected. In principle, it would be always better to carry out BPR in advance of ERP. Pragmatically, it may not be easy to do so because BPR is effort intensive and costs money and time. Also, carrying out BPR in advance of ERP implies that the enterprises need to put resources into two successive projects. In addition, it would be worth implementing the ERP package in its vanilla form. ERP packages offer many best business practices that might be worth including as a part of BPR (Gulla and Brasethvik, 2002). After the ERP implementation, one could get into continuous process re-engineering. Several enterprises may have different
primary objectives in implementing ERP. They would probably fall in one of the following: standardisation of objectives, BPR, elimination of organizational and technical bottlenecks, improvement in quality of information, replacement of out-of-date procedures and systems, integration of business processes, reduction in standalone systems and interfaces, and covering areas previously neglected. The objectives and the corresponding expectations should be clearly documented (Siriginidi, 2000).[72].

In an exploratory survey, Wood and Caldas (2010)[110] found that most of the companies in the survey (71 per cent) admitted that implementation followed re-engineering or was conducted simultaneously with re-engineering. However, 24 per cent of the firms affirmed that the implementation process was focused on its human side and its transformational dimension, while 36 per cent of companies confirmed that the implantation process was more heavily focused on IT.

An empirical investigation of the reality of ERP system implementations in Irish organisations has been carried out by Adam and O’doherty (2012)[34]. They focused specifically on the profiles and sizes of the organisations implementing ERP and on the key parameters in their relationship with their suppliers of ERP software. They found that the ERP implementations in Irish organisations are different to the projects that have been reported elsewhere in two key respects. First, the organisations interested in ERP software were, on average, far smaller than the case studies reported in the literature and the majority of the cases they reviewed were SMEs. Second, the duration of implementation was far shorter than that reported elsewhere. These results are not surprising if one considers the smaller average size of Irish organisations, but they indicated that the ERP movement is truly ready for an extension towards the SME market. They also indicated that the duration of the implementation of ERP software may be related to the size and complexity of the client
organisation and that SMEs can expect to have better time implementing ERPs that the current literature suggests.

They also found that software implementers play a key role, not only in technical terms but also in managerial and political terms, because they can help their clients in correcting their expectations and perceptions of ERP systems and implementations. Chen (2001)[71] identified the essential knowledge required for ERP software implementation in SMEs. Furthermore, he proposed a framework for interrelating the various areas of knowledge. The framework comprises three dimensions: the project management, the issues and the technical knowledge dimensions.

The difficulties of ERP implementations have been widely cited in the literature (Davenport, 1998 [6]). Although companies spend millions on ERP packages and the implementation process, there is extensive evidence that they experience considerable problems, particularly during the actual implementation project. In response to these problems, there has been a developing body of academic literature (Markus et al., 2000[10]; Motwani et al., 2011[61]; Nah et al., 2001[81]; Parr and Shanks, 2000[112]) which addresses the difficulties of ERP implementation by proposing critical success factors (CSFs) and process models of the implementation. Both are aimed at better planning and hence, more successful ERP implementation.

Bancroft et al. (1998) [75] provided CSFs for ERP implementation, including top management support, the presence of a champion, good communication with stakeholders and effective project management. The factors specific to ERP implementation include re-engineering business processes, understanding corporate cultural change and using business analysts on the project team. In another study a CSFs framework has been developed to help managers successfully plan and implement an ERP project. Their CSFs model includes
strategic factors, such as the overall implementation strategy, and tactical factors such as technical software configuration and project management variables. The approach has been illustrated by two case studies. The case analysis highlighted the critical impact of legacy systems upon the implementation process and the importance of selecting an appropriate ERP strategy.

Research on the critical factors for initial and ongoing ERP implementation success has been discussed by Nah et al. (2001)[82]. In their paper, 11 factors were identified to be critical to ERP implementation success: ERP teamwork and composition; change management program and culture; top management support; business plan and vision; BPR with minimum customisation; project management; monitoring and evaluation of performance; effective communication; software development, testing and troubleshooting; project champion; appropriate business and IT legacy systems. In their study of the complexity of multi site ERP implementation, Markus et al. (2000[10]) claimed that implementing ERP systems can be quite straightforward when organisations are simply structured and operate in one or a few locations. But when organisations are structurally complex and geographically dispersed, implementing ERP systems involves difficult, possibly unique, technical and managerial choices and challenges.

In her study to describe and identify the risk factors associated with enterprise-wide/ERP projects, Sumner (2000)[42] concluded that some of the unique challenges in managing enterprise-wide projects included the challenge of re-engineering business processes to “fit” the process which the ERP software supports, investment in recruiting and deskilling technology professionals, the challenge of using external consultants and integrating their application-specific knowledge and technical expertise with the existing teams, the risk of
technological bottlenecks through client/server implementation and the challenge of recruiting and retaining business analysts who combine technology and business skills.

In a study aimed at determining the factors for success or failure in the implementation of ERP systems in SMEs, Marsh in 2012 suggested that key success factors include cross-functional team approaches, organizational experience of similar scale IT or organizational change projects, and deep understanding of the key issues relating to ERP implementations. Marsh also identified the failure factors including top-down or consultant-driven implementations, IT department-driven implementations, or implementations where the ERP is seen as a quick technological fix to problems within the operation of the firm, rather than as a strategic investment. Typically, ERP initiatives in organisations are motivated by senior executives other than the chief information systems officer (CIO).

Willcock and Sykes (2000)[113] tackle the issue of ERP implementation from the perspective of the IT managers of a company. They observed that most CIOs and their IS/IT departments seem to have been “asleep at the wheel” in understanding and dealing with the ERP phenomenon. They suggest how the CIO and the IS department can transform themselves in dealing with the challenges of adopting, implementing, and if necessary, adapting enterprise-wide systems to the specific needs of their organisation. The technical and organizational complexities of projects represent conceptually general rivers of implementation effort. Francalanci (2001)[114] investigated the impact of the technical size and organizational complexity of SAP R/3 projects on implementation effort. Specifically, project size was measured in terms of the number of SAP modules and sub-modules that were implemented, while complexity is defined as the organizational scope of the project in terms of users involved and the overall company size. His findings suggested that both technical size and organizational complexity of projects are relevant drivers of
implementation effort. The results indicated that implementation effort not only grows with the number of modules and sub-modules that were selected for implementation, but that SAP was found to require increasing resources to be implemented in larger companies and for a higher number of users, thus indicating that, while there was a technical component of effort that was independent of the organizational breadth of the project, each user added an organizational component of costs.

Sarker and Lee (2000)[115] examined through a case study the role of three key social enablers, strong and committed leadership, open and honest communication, and a balanced and empowered implementation team, that are necessary conditions/precursors for successful ERP implementation. They claimed that, while all three enablers may contribute to ERP implementation success, only strong and committed leadership can be empirically established as a necessary condition.

In summary, one of the most widely-cited variables critical to the successful implementation of a large customised system, as shown in Table III, is top management support. Given the cross-functional nature and large budget of a typical ERP implementation, the extent of top management support appears to be an important characteristic. Two types of top management support roles have been associated with systems implementation projects: the project sponsor and the project champion roles. The project sponsor is responsible for budgetary support and ensuring that key business representatives play a role on the project team. The project champion may or may not be a formal member of the project team, but can play a key role in change management efforts. In some organisations, the sponsor also serves as the business champion for the project; in other situations, a champion emerges from among the key business leaders (Brown and Vessey 1999 [99]).
Al-Mudimigh et al. (2001)[47], Markus et al. (2000)[54] and Parr and Shanks (2000)[112] have all proposed models of ERP implementation in order to gain a deeper understanding of the process and hence, provide guidelines for successful implementation. They presented a view of the implementation process which was derived from discussions with 20 practitioners and from studies of three multinational corporation implementation projects. The Bancroft model has five phases: focus, as is, to be, construction and testing and actual implementation. The focus phase is essentially a planning phase in which the key activities are the set-up of the steering committee, selection and structuring of the project team, development of the project’s guiding principles and creation of a project plan. The as is phase involves analysis of current business processes, installation of the ERP, mapping of the business processes on to the ERP functions and training of the project team. The ‘to-be’ phase entails high-level design and then detailed design subject to user acceptance followed by interactive prototyping accompanied by constant communication with users. The key activities of the construction and testing phase are the development of a comprehensive configuration, the population of the test instance with real data, building and testing interfaces, writing and testing reports and finally, system and user testing. Finally, the actual implementation phase covers building networks, installing desktops and managing user training and support. In summary, the model of implementation extends from the beginning (focus) of the project proper to the cut-over of the live system.

Parr and Shanks (2000)[112] presented a project phase model (PPM) of ERP implementation project that is a synthesis of the existing ERP implementation process model and focuses on the implementation project. Two case studies of ERP implementation within the same organisation, one unsuccessful and later a successful one were reported and analysed in order to determine which CSFs are necessary within each phase of the PPM. The PPM has three major phases: planning, project and enhancement. In addition, because the focus of the model
was on the implementation project itself, the project phase was divided into five sub-phases: set-up, re-engineering, design, configuration and testing and installation. Parr and Shanks claimed that the PPM, together with associated CSFs, provides guidance for practitioners when planning ERP implementation projects and also provides researchers with a foundation for further empirical research.

An integrative framework for ERP implementation has been proposed by Al-Mudimigh et al. (2001)[47]. The framework was based on an extensive review of the factors and the essential elements that contribute to success in the context of ERP implementation. Although ERP packages provide generic off-the-shelf business and software solutions for customers, there is growing evidence that failure to adapt ERP packages that are implemented in companies with different corporate and national cultures, to fit these cultures, leads to projects that are expensive and overdue.

Krumbholz et al. (2012)[116] presented a research which synthesises social science theories of culture, in order to be able to model and predict the impact of culture on ERP package implementation. The results provided evidence for an association between corporate culture and ERP implementation problems, but no direct evidence for an association between national culture and implementation problems. Furthermore, the results demonstrated that these diverse implementation problems can be caused by a mismatch between a small set of core values which are indicative of a customer’s corporate culture. Huang and Palvia (2001)[59] proposed a framework for examining ERP implementation in selected advanced and developing countries. Their research showed that ERP technology faces additional challenges in developing countries related to economic, cultural and basic infrastructure issues. No validation of the proposed framework was presented. Also, additional research
work is required to investigate the relationships between the various components of their framework.

Daily operations, planning and decision-making functions in organisations are increasingly dependent on transaction data. Vosburg and Kumar (2001) [117] discussed issues related to the origin of dirty data, associated problems and costs of using dirty data in an organisation, the process of dealing with dirty data then migrating to a new system (ERP) and the benefits of an ERP in managing dirty data. They explored these issues using the experiences of a company, which implemented an ERP system in their organisation. The guidelines for companies planning to implement ERP solutions to overcome dirty data problems have been presented in Vosburg and Kumar’s [117] paper. Stijn and Wensley discussed the issues relating to the representation of process knowledge during the implementation and in-use phase of ERP systems. They suggested that ERP may, very well, embed some of the process knowledge that is resident in organisations. Based on the extensive literature survey, which was aimed at learning about the basic concepts of ERP, how it evolved over the years, what are the factors that influence organisations to resort to ERP systems as solutions, how ERP acts as a multi dimensional key to solving problems of a large enterprise, how ERP effects organisations like the Armed Forces, what are the factors that influence the decision to choose a particular ERP package, what are the likely impediments in the implementation of ERP, what are the critical success factors for successful implementation of ERP, the researcher has been able to pin point the factors that are most crucial for ERP implementation such as Inadequate definition of requirements, Resistance to Change, Inadequate Resources, Inadequate Training and Education, Lack of Top Management support, Unrealistic expectations of benefits and ROI, Miscalculation of time and effort, Poor communications, Software business process incompatibility, Poor project design and management, Poor ERP package selection irrespective of the size
and type of organisation. Also, many new facets have come to fore regarding the ERP implementation process in large organisations like the Armed Forces. It is quite evident from the literature survey that the benefits accrued by implementing ERP far outweigh the cost incumbent on it. Some of the prime benefits by implementing ERP systems in any organisation are enumerated below: -

1. Integrated processes and information systems.
2. Consolidation of current system in the logistics system.
3. Reduced complexity of application of technology for logistics system.
4. Reduced reliance on programmers to make software changes.
5. Authoritative data source and information visibility at all levels.
6. Reduced date redundancy and duplicative data entry.
7. More effective and efficient business processes.

Several studies have showed that it is essential to have people with right set of business and IT skills to assure the success of a project (Skok and Legge 2002[118]; Wateridge 1997[119]). Hawa et al (2002)[120] pointed out that the improvement of an enterprise relies on the success of software engineering projects, which respectively depends on the human resources. The paper analysed the basic human requirements for the successful project concentrating on the know-how, profiles and roles of the project team members, and the ways of improving those. Focusing on the human competences has a direct impact on the outcome of the project.
Authors emphasised that enterprise wide projects require the coordination, comprehension and mutual acceptance of the multidisciplinary teams, which contain management, technical personnel, end-users, consultants, vendors and others. This posed the human factor as a key point in any enterprise improvement projects.

None of these approaches fulfils all the expectations of re-engineering projects. The use of external consultants creates a dependency toward them. The use of in-house technical personnel brings limited results.

The following HR requirements are considered to be important for a successful project: it is essential to have sufficient human resources **available** for the project. These should have sufficient **Expertise**. The success of the project depends largely on the **quality** of the project members. The project management should have authority and control over all the aspects of the project, to be able to act quickly, effectively and independently. The **composition of project teams** with competent and skilful project team members and external consultants influences directly the output of the project. The team must work in **Trust**. The study of Wateridge (1997)[119] indicated that project managers play a key role in developing and implementing successful IS/IT project and by acquiring and applying certain skills they can make these projects successful.

Furthermore, these skills are often mentioned in the critical success factors lists. People have seen by many authors as key contributors to the success and failure of the projects. Very often, projects managers need to lead, manage and communicate with the large number of stakeholders, technicians, sponsors and users, and it is important to satisfy all these interested parties and deliver benefits to the client and organisation (Wateridge, 1997)[119]. The article also brought out that the means to become better project manager is not only learning through
experience, instead, skills can be learned by reading, seminars, schooling and workshops. Learning only through experience will take a long time.

2.10 Observed Impediments in success of ERP implementation

It is important to discuss what constitutes an ERP implementation failure? There are degrees of failure with ERP projects. The most obvious failure is never actually implementing the ERP system. But a project can be considered failed if the new system is not fully utilized. Apparently, no single point of failure can be attributed to unsuccessful ERP implementations. Some of the causes that have been identified as the causes of failed ERP projects include:

(a) Inherent complexity of ERP implementation
(b) Unrealistic expectations
(c) Outside consultant issues
(d) Over-customization of software
(e) Inadequate training
(f) Using IT to solve the problem
(g) Process risk and process barriers
(h) Timeline flexibility
(i) Infrastructure issues

For any ERP implementation there are certain universal factors which have been identified through this literature survey, these are:

(1) Business Process Re-engineering.
(2) Planning and foresight.
(3) Change management.
(4) User training on IT solutions.
(5) Management of risk.
(6) Top management support.
(7) Effective communication.
(8) Team work and composition.
(9) User involvement.
(10) Use of private consultants.

The order of importance for the above factors differs for each organisation depending on its functional applicability. Based on these important inputs the researcher has chalked a systematic plan which includes surveys by means of interviews, case studies, questionnaires etc to validate the critical success factors and impediments which the Corps of EME is likely to encounter on its ERP implementation path.

2.11 **ERP Related Technologies and Their Applications**

ERP vendors, realised the limitations of the old legacy information systems used the 1980s and 1990s. These old systems were developed in-house using several different database management systems, languages and packages, creating islands of non-compatible solutions unfit for seamless data flow between them. It was difficult to increase the capacity or to upgrade them with the organization’s business changes, strategic goals and new information technologies. It was realised that an ideal system should have the following characteristics:
• Modular design comprising many distinct business modules using centralized common database management system (DBMS).

• The modules are integrated and provide seamless data flow increasing operational transparency through standard interfaces and batch processing capabilities.

• Flexible to offer best business practices, work in real time and Internet-enabled

Different ERP vendors provide ERP systems with some degree of specialty but they are generally complex systems involving high cost and require time-consuming tailoring and configuration. The core modules are almost the same for all of them. Some of the core ERP modules found in the successful ERP systems are:

• Project management and Risk management

• Financial management

• Inventory Management

• Production management

• Human resources management

• Supply chain Management

• Customer relationship management

The modules of an ERP system can either work as stand-alone units or several modules can be combined together to form an integrated system.
2.11.1 Project Management and Risk Management

The selection, procurement, and deployment of an Enterprise Resource Planning system is fraught with risk in exchange for significant business and financial rewards. In many cases the packaged ERP product does not provide the entire solution for the business process. These gaps can be closed with third party products or by customizing existing products. Management of this customization of the core ERP system has traditionally been addressed through science–based, project management methods. Well–publicized failures using this approach create the need for new methods for managing ERP projects.

ERP provides the means to coordinate and manage this information, by integrating enterprise information and business processes. The ERP environment faces constant change and reassessment of organizational processes and technology. The project management method used with ERP deployments must provide adaptability and agility to support these evolutionary processes and technologies.

The management of an ERP deployment involves requirements gathering, vendor selection, product acquisition, system integration and software development, and system deployment and operation. It involves risk management, stakeholder politics, financial support, and other intangible roles and activities that impact project success. By applying the values and principles of project management along with risk management, defined critical success factors, architecture driven design, people management, the agile team can deliver real value in the presence of uncertainty while maximizing the return on assets and minimizing risk.

2.11.2 Financial Management

In an ever-changing financial services environment, ERP and financial systems must adapt to mergers, acquisitions, divestitures, and other changes in business or organizational models.
Executives overseeing these systems must be able to understand available options for ERP and financial management systems and how they can best support their organization’s strategies and business objectives.

- Streamline financial management processes and align it with organisation.
- Capture operating efficiencies through improved and standardized organization-wide business policies and processes.
- Enhance financial management controls.
- Obtain better information to manage business
- Enhance system capabilities for changing business needs and changing technologies

2.11.3 Inventory Management

Inventory management module of ERP software offers a complete set of inventory management, manufacturing, and purchasing capabilities that improves supply chain management and delivers an end-to-end procure-to-pay process and should be able to get an in-depth, real-time view into key supplier, inventory and procurement indicators and self-service capabilities for partners, vendors and customers. The efficient inventory management module:

- Gives complete real-time visibility into demand, supply and costs with a clear view into inventory costs, turn rates and inventory profitability.
- Eliminates manual inventory management processes and improves vendor satisfaction integrating all functions and providing self-service and real-time visibility.
- Reduces inventory costs, increases operational efficiencies and eliminates inefficiencies throughout an organization.
- Streamlines requisition processes and improves collaboration with vendors.
- Helps track costs and eliminates errors by creating a complete business process.
- Leads to optimized manufacturing processes wherein it streamlines the assembly process.

2.11.4 Production management

In the era of shorter production cycles, more demand for new products and heightened competition, the manufacturing industry finds help in a trusted friend like “ERP software.” After perfecting the CRM, sales, supply chain management, etc., it is necessary to integrate the missing link and that is the production floor. In a manufacturing company, typically, it is the ‘operations’ or ‘production’ that is the biggest cost centre. The whole success of a product could hinge on how fast and efficiently the production is managed. ERP answers the question, ‘what to make’ and ‘when to make’. Production Module is designed for specific needs of manufacture industries include core capabilities. It facilitates production planning, Taking orders and delivering products to customers. This includes Bill of Material, Material Requirement, Planning Production Order Management, Resource scheduling, Production Reporting.

2.11.5 Human Resource Management

The Main Objective of Human resource Management module is to streamline the HR processes in the Organization and thereby increase the efficiency of the procedures. The other objectives of the Human Resource Module are faster HR processes with real time information
for quick decision making and ensure a competence based approach to put the best people in the right job. The HR module are to manage Workforce, Recruitment, Induction, Training & skills, Personnel Administration, Travel, Time & Attendance, Performance, HR Reports. Training is essential to accelerate the learning process. In addition, professional development programs need to be in place and project managers must develop their skills and competences throughout their career.

2.11.6 Supply Chain Management

An ERP software solution seeks to streamline and integrate operations, processes and information flows in an enterprise, to synergize the resources of an organization namely men, material, money and machine. In other words, ERP systems integrate all data and processes of an organization into a unified system. Increased globalisation and competition has made supply chain management (SCM) a very important and critical issue for any company. SCM is all about getting the right things to the right places at the right time.

An SCM ERP module is used throughout a manufacturer’s production process like Planning, Execution, Inventory, Forecasting, Demand Planning, Asset Management, Reporting, Logistics, Delivery, Raw Material Management and Returns Processing.

2.11.7 Customer Relationship Management

For accomplishing desired success, organizations continuously strive for increased sales performance, superior customer service and enhanced customer relationship management. To achieve these objectives one needs solutions that provide rapid access to centralized customer information. Customer relationship management module of ERP offers consistent and readily available customer data, allowing managing pre-sales activities, perform automated sales
processes, deliver consistent customer service, evaluate sales and service successes and identify trends, problems and opportunities.

The benefits accrued by using this module are :-

(a) Interaction with other areas of the system, gives 'clear' view of the customer

(b) Maximising opportunities and retaining high value customers enhances revenue and profit.

(c) Provides value-added services to stay ahead of your competitors.

(d) Improves product development and service delivery processes

(e) Provides in-depth knowledge of the customer's needs

(f) Organizes the customer experience through quick problem resolution

(g) Successful customer interaction

As we have seen that the various modules of ERP packages offer different solutions. The modules required for any organisation depends on its own typical needs and it has to be custom made for that organisation. It is very important to understand that the needs of any organisation have to be clearly defined and the areas which need ERP solutions have to be earmarked before deciding on the module to address the concerns of these areas.

An organisation as large and as complex as Army have its own typical needs which need to be understood well before embarking on a ERP project. Before proceeding we shall discuss its various aspects to get an in-depth understanding of the various functions of Army logistics.
2.12 The Indian Army’s Strategic and Tactical Interface With Logistics System

To understand the complexities of the logistics network of the Indian Army it will be worthwhile to first understand the structure of the Indian Army Logistics System as enunciated in the official documents of the Army.

The three major responsibilities of a military high command in any country are to create, support and employ combat forces to achieve the national aspirations. Therefore all major military decisions need a blend of strategy and logistics which are inseparable. The relationship between the three can be explained as The Strategy determines the required level of military capability The Logistics sustain the military capability and The Operational plans exploit military and logistic capability.

The Strategic level logistics activities encompasses the industrial base, mobilisation, strategic lift (air and sea), capabilities, procurement, material readiness, strategic stockpiles and re-generation; while the operational level encompasses reception, staging, sustainment, re-deployment, theatre distribution, intermediate intra-theatre airlift and reconstitution and finally the Tactical level involves arming, manning, feeding, transporting and sustaining the soldiers.

The Army’s maintenance (maint) system is typical to its organisation as it generally illustrates a different philosophy. The Army system of maintenance is based on a network of static, base & forward installations which perform basic warehousing, bulk & retail issue functions. Forward linkages to field army are established through mobile & organic logistics units orbited to various formations. Disposal is organised through rearward move of unserviceable or surplus to requirement stores. Maintenance & repair actions follow an
echeloned system of base, intermediate and forward repairs. Figure 7 depicts the maintenance system in place.

It is important that to cater for the requirements of the present day Indian Army which has to operate over varied terrain and climatic conditions a responsive logistics system should have the following:

(a) A streamlined chain with lean organisations to eliminate multiplicity and repeated handling to increase the velocity of logistic support.
(b) A “sense and respond” system working on the “push” model to increase user satisfaction.

(c) An efficient inventory management system to reduce excessive stocks.

(d) Rapid recovery and re-deployment of scarce logistic resources during various phases of operations.

(e) Specially tailored units for theatre-specific logistic requirements.

The maintenance philosophy lays out the vision for the future is to develop a logistic system which is highly effective, responsive and provides the operational commander the freedom and ability to execute his mission successfully. The “footprint” of logistics for the Army should ensure a seamless and fully networked system that provides information and situation awareness to enable asset visibility and enhanced velocity of logistic support. Concurrently, there is a need to reduce inventories significantly and rely on predictive and real-time information, coupled with rapid transportation, to meet user demands. Harnessing advanced information technology, use of sensors and reliance on decision support systems will improve logistic efficiency and enhance operational readiness and, thus, reduce the number of personnel involved in the supply chain management. These advancements will significantly impact our operational and logistic philosophy for which future commanders must prepare and ensure a smooth change in logistic management.

The present logistics system is a legacy of the British as obtained at the time of independence. Logistics system at that time was designed on theatre basis. This concept is detached from the environmental realities of our nation today. The main features of our existing logistics system will be Discussed as Hierarchy of Indian Army Logistics System and Functioning of Indian Army Logistics System.
2.12.1 **Hierarchy of Indian Army Logistics System**

The existing Indian Army Logistics system functions at three main levels which are National/Central Government Level, Services Headquarters Level and Field Army level. Let us have a look at each of these in the following paragraphs.

2.12.2 **National/Central Government Level**

The Indian Defence set up has the Cabinet Committee on Security (CCS) with prime minister as its chairman at its apex. This committee lays down country’s political aims, which forms the basis of formulating the military aims. The Ministry of Defence (MoD) comes under it and is primarily responsible for the defence of the country. It comprises of the three services namely Indian Army, Indian Air Force and India Navy each of which has their own logistics set up. The logistics functioning under the MoD is undertaken by Raksha Mantri’s Production and Supply Committee, Defence Procurement Board, Defence Research and Development Organisation (DRDO), and Ministry of Defence (Finance).
2.12.3  **IHQ of MoD (Army)**

Overall co-ordination and control of logistics activity at IHQ of MoD (Army) level is done by a multitude of functionaries. Logistics for Indian Army are catered for by six different services which are controlled by Principle Staff Officers (PSOs). The functioning of the various directorates along with the services for which they are responsible are as under:-
(a) **Director General of Military Operations (DGMO).** It lays down operational policy, composition of forces, stocking and reserves.

(b) **Adjutant General.** It is responsible for HR, discipline and welfare and looks after the medical aspects of logistics.

(c) **Directorate General Weapons and Equipment.** It is responsible for equipment policy and procurement.

(d) **Master General Ordnance (MGO).** It is responsible for material support and equipment Maintenance support which it undertakes through:-

   (i) **Directorate General of Ordnance Services.** It is responsible for provisioning, stocking and replenishing

   (ii) **Directorate General of Electronics and Mechanical Engineers.** It is responsible for maintenance and repair of all military equipment.

(e) **Director General of Operational Logistics (DGOL).** This directorate deals with all aspects of operational logistics policy, implementation and monitoring.

(f) **Quarter Master General (QMG).** All other aspects of Logistics are dealt with by this branch like supplies, transport and movement under **Directorate General of Supplies and Transport (DGST).** Who is responsible for provisioning, stocking and replenishing of Supplies.

(g) **Engineer in Chief’s Branch.** Engineer support for creation and maintenance of infrastructure.
2.12.4 Functioning of Indian Army Logistics System

The functioning of the Indian Army Logistics system broadly comprise of maintenance system which hinges on moving the men and materials of war from the base, over a communications zone, to a series of maintenance areas of the field force. The exact organisation depends on the distance of the field force from the base. The logistics support to the Field Armies in a theatre is provided by a multi echeloned logistics support system.

It is quite evident from the present system that the logistics response of tomorrow has to continually focus on the rapidly changing needs of the users with speed and focused delivery of materials and services. It has to transgress traditional inter service boundaries for which
there is need to decongest the supply chain, eliminate legacy structures and improve asset visibility. The Indian Army needs to operate on real-time information flow by adopting integrated practices. While analyzing the existing logistics support system it becomes increasingly clear that there are a vast number of horizontal and vertical functions involved and integration of these functions will be the key for future warfare.

2.13 **Demerits of Existing Logistics System**

Our logistics system suffers from inadequacies which vary from theatre to theatre and are also terrain dependant. However the demerits are tackled as a whole to prevent confusion which arises from getting into unnecessary details. These are enumerated in succeeding sub-paragraphs:

**(a) Lack of Holistic Logistics Planning.** Integration and Implementation. At the apex level there is no overarching logistics organization which is all pervasive and is therefore able to holistically plan logistics support. Multiple organizations lead to logistics playing the catch up game by trying to fit logistics as per a plan rather than a plan being executed only if it is logistically feasible eg mobilisation resource demand due to its limited availability is always overbid by all..

**(b) Lack of Jointness/Integration.** Although this dissertation is limited in scope to the Indian Army, one of the major limitations of the existing logistics system is the lack of Integration of logistics functioning amongst the three services. It would be fair to say that logistics offers the maximum scope for integration as it is easily implementable due to a number of overlapping and common functions which have to be executed in the three services.
(c) **Absence of Asset Visibility.** Perhaps the most important drawback at present remains the lack of asset visibility. Although the three services are following/pursuing their own automation programmes, total asset visibility across the spectrum largely remains a distant end state. This is so due to lack of integration between the three services automation programmes. This leads to large quantum of reserves being held at all levels of all commodities.

(d) **No Infusion of Technology and Contemporary Logistics Practices.** One of the reasons for the existing drawback is the lack of infusion of technology ranging from database management to networking logistics functioning across the entire spectrum. As a result of this the present lack of asset visibility brings with it the drawbacks mentioned above. The lack of incorporation of contemporary logistics practices has led to decreasing logistic efficiency and that too at an alarmingly fast rate.

(e) **Poor Industrial Base** largely dependent on Defence sector, Lengthy Procurement Delays due to procedures prepared in a trust deficit environment, constrained Availability of finance and sub-optimal financial management

2.14 **Automation of Logistics Organisations in the Indian Army**

Automation is a major factor which would affect the implementation of the integrated logistics as it ensures asset visibility and transparency which leads to effective decision making. Unfortunately, the defence services as such were late starters as regards automation. Specifically as regards automation of logistics services in the Indian Army, the effort is lagging way behind of what it should be at present. However a number of automation initiatives are presently under way which will show an automated Indian Army. It will have a major impact on the integrated logistics implementation for the Indian Army. The logistics
automation projects currently underway in the Indian Army such as LOGINET, MOVNET, MEDNET, EMERALD, MISA and CICP.

**Logistics Network (LOGINET).** The network is planned to act as an interface between various logistics automation projects underway in the Indian Army to act as a platform which will provide collated data for informed and effective logistics based decision making. Its features and current status is as shown in figure 14

---

**Figure 10: Logistic Network : LOGINET**
The main features of LOGINET are as under:-

(a) Act as an interface with databases and integrate various logistics application under development.

(b) Extraction, transformation and loading of above data on a single database.

(c) Possibility of online manipulation using analytical tools.

(d) Logistics based scenario building and contingency planning.

(e) A repository of historical information is available for reference.

(f) Ability to provide logistics solutions to assist in logistics decision making.

Various other networks as part of LOGINET are:

- **Movement Network (MOVNET)**. To streamline the complete movement control.

- **Management of Information Systems for Army Service Corps (ASC) (MISA)**.

  Specific to the areas of supplies, Animal Transport, Fuel Oil and Lubricants and Mechanical Transport at all levels.

- **Electronic and Mechanical Repair and Logistics Delivery (EMERALD)**. EME specific aspects of equipment management.

- **Medical Network (MEDNET)**. To automate medical functioning.

- **Computerised Inventory Control Project (CICP)**. To integrate all echelons of stores and functioning of ordanance.
Having seen the Indian Army’s logistics system and its evolution and also its existing problems it is obvious that the solution lies in automation and integration of data by means of a custom made IT solution

2.15 ERP Technology in the COPRS of EME

The Corps of Electronics and Mechanical Engineers (EME) is the technical service of Indian Army for providing engineering support (primarily maintenance, repair and overhaul) to all equipment held by Indian Army ranging from light vehicles to tanks, guns, missiles, radars, computers, helicopters, communication equipment, night vision devices, simulators during war and peace. The major role of EME is to achieve and maintain the operational fitness of equipment of Indian Army. Corps of EME follows echelon based service delivery model where permissive repair schedules are carried out at every level. The echelons are divided as light, field, intermediate and base. The forward repair teams (light repairs) based on customized vehicles function within a battlefield, recovering equipment casualties from their point of collapse and provide in situ service support. At field level the support is provided by affiliated smaller workshop very close the designated operational area. These are tailor made to terrain, equipment and role. At intermediate or the zonal level major repairs beyond the capability of smaller field workshops eg repair to major assemblies is undertaken by bigger workshops. At base workshop, they dismantle and rebuild equipment. The equipment is given a new lease of life. In addition EME is also involved in designing selection, procurement, and discard of equipment. The corps has its own training establishments from basic to postgraduate level. The corps has philosophy to provide service support form womb to tomb.

2.15.1 Mission & Objectives of EME

The responsibility for maintenance of Indian Army equipment from inception to discard (womb to tomb) lies with EME. The contribution of EME for Equipment management is
indispensable. Indian Army is also expanding very fast in terms of equipment and technology relying completely on EME’s capabilities for full support to maintain their equipment till the discard stage at all times. Mission of EME is ‘To manage the complete Equipment Life Cycle from the time it is inducted to the time it is discarded’. In other words it is to achieve and maintain the operational fitness of equipment of Indian army’. Figure 17 depicts the core objectives and key responsibilities of EME.

![Figure 17: Objectives and responsibilities of EME](image)

**Figure 11:** Objectives and responsibilities of EME

### 2.15.2 Expectations of Indian Army

Today Indian Army is expanding and modernizing very fast in terms of equipment and technology. The nature of war has also changed drastically. In today’s war scenario, It emerges at very short notice and is for short period but with very high intensity and pace. These changed conditions demand not only higher amount of synergy but also very high reliability of information system, surveillance system and all time availability of equipment.
In today scenario, in addition to maintenance and repair of equipment, Indian Army is also demanding faster response and availability of accurate information on the status of repair and availability of equipment.

**Changing Indian Army Expectations**

![Diagram showing changing expectations of Indian Army]

Figure 12: Changing expectations of Indian Army

### 2.15.3 EME - Project EMERALD

Indian Army expectation for all time availability of equipment, availability of repair information, status of equipment under repair/overhaul and support at all times necessitate the need of bringing in system at EME that shall increase the efficiency and better management of resources. In addition EME needs to address various internal challenges as discussed earlier. The onus is on the Corps of EME to proactively position itself to meet the challenges and expectations. It is necessary that the Corps prepares itself for focused engineering support management challenges that it would face in future battlefield milieu where equipment & technology would play a predominant role for the war winning strategies.
of the nation. The changed perception is brought about by the ubiquitous presence of networks and the demonstrated power of information technology.

As part of the overall modernization plan, the Indian Army is in the process of automating its various logistics elements under the umbrella of project LOGINET (Logistics Net). The Project EMERALD (EME Reliability Availability Logistics Delivery) besides other components envisages a fully automated system of functioning for the Corps of EME so that it can provide the necessary real time information and intelligence to the decision makers.

To facilitate a faster and leaner implementation of the project, Phase-I of the project is envisaged in the select representative units for implementation of ERP for the Corps of EME’s automation across all functions and verticals in a seamlessly integrated environment. Phase-II of the project would involve rolling out of the application in the balance EME units after successful implementation of the Phase-I of the project.

Figure 13: Project EMERALD: Systems view
There have been many approaches in the last decade to automate many vertical functions, which may have improved the IT awareness levels, and has migrated sizeable portion of crucial data to the digital medium.

However, there is a need to integrate these efforts and bring about enterprise wide escalation to digital medium. The Corps of EME is on the verge of leveraging the power of Information Technology (IT) for its functions and preparing itself for future challenges in a net-centric equipment intensive environment where real time information would be of paramount importance for analysis and decision making.

While Project REPNET is for the complete Corps of EME, it is split in small projects for easy and faster implementation. In this effort Project Emerald was conceptualized as pilot project to implement Enterprise Resource Planning (ERP). Project EMERALD (EME Reliability Availability Logistics Delivery) is the planned pilot project for implementation of ERP for
the Corps of EME’s automation across all functions and verticals in a seamlessly integrated environment.

The primary objective of Project EMERALD is to provide integrated and efficient processes. Some of the main objectives of the implementation are:

1. Envisage a fully automated system of functioning for the Corps of EME so as to provide necessary real-time information to decision makers.

2. Create a better framework for efficient information flow between various levels of the organization.

3. Improve functions so as to reduce sub-optimal utilization of Asset, inventory and resource.

4. Timely dissemination of policies, technical literature, repair statistical data and analysis etc.

5. To turn the organization into a virtual office through necessary statistical and MIS tools for performance analysis.

6. Integrate the internal functions of organization.

2.16 Proposed System Overview

EME is organized into several functional entities such as Light repair detachments, Field workshops, Intermediate Repair workshops, and Base workshops. Based on study, EME structure, roles & responsibilities, the objectives of Project EMERALD, scope of ERP and urge to address key challenges, the enterprise system has been identified to form part of two global entities:-
This entity reflects the core function of EME by virtue of being the equipment managers for the Army. The responsibility of maintenance from inception to discard lies with EME which has been suitably quoted in the Vision for EME. This Global Entity can be further decomposed into the following blocks which in effect depict the various facets of equipment life cycle management.

(a) Equipment Induction: This block deals with the various functions of equipment induction are Trials i.e Maintainability Evaluation Trials (MET) and Policies by of formulation of Equipment Support Plan (ESP) including policy formulation all kinds of technical literatures, regulations, training etc.

(b) Equipment Exploitation: Deals with all the maintenance functions relating to the life cycle exploitation of equipment to include Preventive Maintenance, Inspections, Corrective Maintenance, Modifications and procedure of Reports and returns. Decision making and Policy formulation.

(c) Overhaul and equipment regeneration for enhancing the life of the equipment.

(d) Indigenisation, Discard, Provisioning and inventory management

(g) Financial Accounts & Grants Management for equipment life cycle management and the Human Resource Life Cycle Management to include functions such as payroll, public funds and regimental funds.
2.16.2 **Enterprise Human Resource Management**

The HR management in EME is very critical as it includes selection, enrolment, induction training, manage performance and promotions, pay and allowances and their retirement to include a few. The complexity is much more as there are 42 trades having different QRs for enrolment, training and career management. It also has to deal with training and placement of officers.

2.17 **Functional Scope of ERP in EME**

Based on the above proposed ERP Solution, Functional Scope of the proposed ERP system includes following modules/components:

(a) Maintenance, Repair and Overhaul (MRO)

(b) Materials Management

(c) Organizational Human Resources and Administration

(d) Finance & Accounts Management

(f) Campus Management

The current IT solution proposed for EME also includes two other key components:

(a) Knowledge Management

(b) Document Management
2.17.1 MRO (Maintain, Repair, Overhaul) Module

The Main Objective of MRO module is to streamline EME’s core process activities of Maintenance, Repair and Overhaul through an integrated solution and thereby achieve and maintain the operational fitness of equipment of the Army. The functional requirements of the MRO module are to manage Equipment Induction, execution of Preventive Maintenance, execution of Breakdown maintenance in Workshop, execution of all echelons of Repair, Overhaul of Vehicles / Equipments, execution of Work Order, Quality Control, execution of Modification of Equipment, Calibration of tools, gauges, Maintenance Reports & Meetings, Repair & Recovery.

![MRO Module Diagram]

Figure 15: MRO module
2.17.2 **Material Management**

The ‘EME’ Material Management module is expected to cover the complete gamut of business processes related to the provisioning of all types & categories of materials and services including spare parts, tools, ammunition, perishable items, capital goods & revenue goods. This module is also expected to cover new supplier development & procurement directly from local suppliers & OEMs as per EME policies, internal procurement from army workshops for manufacturing components and spare parts and internal transfer of all categories of items to one workshop to other and also back to Ordnance.

The processes in the Material Management module would initiate with the determination of requirement of all categories of material for the generation of demand and end with the back loading of surplus/scrap to Ordnance and the subsequent integration/interface into the MRO & accounts payable process.

![Materials module diagram](image)

**Figure 16: Materials module**
2.17.3  **Financial Accounts and Grant Management**

Budget and Finance processes are one of the most common and dispersed functions among the organizational structure of EME. The proposed module of “Financial Accounts & Grants Management” is expected to incorporate real time integration between the various organizational units as well as across various modules and functions, for making appropriate changes in the financial books. The module will be based on a central Grant Management system at its core and the information feeding will take place through various other modules through auto linkage of the specific grant expenses with appropriate activities. Secondly there will be provision of Cash Ledgers with facility for updating them through sub registers, or manual entry. Further the linkage of a appropriate workflow design with the Finance module will take care of the auto routing of expense proposals for sanction procedure. Thus a consolidated Finance module which is integrated with all other functions across different module will be able to take care of the entire lifecycle of any financial transaction, irrespective of the initiating department/section, organizational unit or Grant head handled.

![Finance Module Diagram](image)

Figure 17: Finance module
2.17.4 **Human Resource Management**

The Main Objective of Human resource Management module is to streamline the HR processes in the Organization and thereby increase the efficiency of the procedures. The other objectives of the Human Resource Module are faster HR processes with real time information for quick decision making. It should Restrict the data access to users based need to know basis. It must Ensure a system of checks and balances on HR activities through transparency along with notifications and alerts and Ensure a competence based approach to put the best people in the right job.

The functional requirements of the HR module are to manage Workforce, Recruitment, Induction, Training & skills, Personnel Administration, Travel, Time & Attendance, Performance, HR Reports.

The envisaged HR module would be:

![HR: RELATIONSHIP](image)

Figure 18: HR module
Campus Management

The Main Objective of Campus Management module is to effectively plan, coordinate and deliver the training program(s) to the employees of EME at the training institutes. The proposed system for training lifecycle management would cover functions such as: Pre-admission including syllabus and training programs, Admission process, Course execution, Examination process, course feedback and cost calculations.

Knowledge Management

The Knowledge Management Portal envisioned for EME shall provide a platform for sharing information. Webpage and document management repositories will be used. Users will be able to upload/download and share documents, presentations, journals etc.

The requirements from the Knowledge Management System (KMS) are, Document and Record Management to include generation of ESP documents and Query Management.

2.18 Implementation Strategy

Phased and big bang are the two primary strategies used to implement ERP systems. This section describes in detail the properties of these two strategies and their advantages and disadvantages. This section also analyzes the choice of implementation methodology in light of organization size, complexity and structure and in terms of overall extent of implementation.

2.18.1 Phased Implementation Strategy

A phased approach is one where modules are implemented one at a time or in a group of modules, often a single location at a time. The risk of failure is low, even though new
interfaces need to be built between the existing and the new system. The advantages and disadvantages of this approach are as follows

**Advantages**

(a) Reduced complexity for coordinating, controlling and organizing the project and resources

(b) Costs are spread over a longer period of time

(c) Smoother changeover

**Disadvantages**

(a) Project time increases and Motivation declines

(c) Customized interfaces are required to maintain the data transfer for implemented modules transfer to the new ones.

### 2.18.2 Big Bang Implementation Strategy

In full big-bang implementation, an entire suite of ERP applications is implemented at all locations at same time. Using big bang, the system goes from being a test version to being the actual system in only a matter of days. The advantages and disadvantages of this approach are as follows

**Advantages**

(a) Shorter implementation time and high Motivation high

(b) No interfaces between the old and the new system are necessary
Disadvantages

(a) Implementation are complex and Risks of total failure
(b) Time between development and implementation may be longer

Comparing both the strategies From the comparison it clearly emerges that for a large organization which is wide spread, with multi level controls, multi level interactions and multiple functions phased approach will be more logical. This view is more strengthened due to the fact that it will be operated by personal with different levels of education and understanding from basics to highest levels. Hence phased plan has been selected for implementation. The comparison is :

<table>
<thead>
<tr>
<th>Phased Approach</th>
<th>Big Bang Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small groups of users converted at a time.</td>
<td>The application deployed as one; all users</td>
</tr>
<tr>
<td></td>
<td>simultaneously cut over to the new system.</td>
</tr>
<tr>
<td>Minimal disruption to the production environment.</td>
<td>Large-scale disruption to production</td>
</tr>
<tr>
<td></td>
<td>environment.</td>
</tr>
<tr>
<td>Any performance issues that occur can be quickly</td>
<td>Performance issues may result in large-scale</td>
</tr>
<tr>
<td>isolated and rectified without any large-scale</td>
<td>disruptions to user population.</td>
</tr>
<tr>
<td>disruption to the wider user population.</td>
<td></td>
</tr>
<tr>
<td>Allows for a staggered training, meaning that you</td>
<td>Requires mass training, resulting in large</td>
</tr>
<tr>
<td>potentially have fewer users out of the workforce</td>
<td>numbers out of the workforce at a time.</td>
</tr>
<tr>
<td>at any single time.</td>
<td></td>
</tr>
<tr>
<td>Potentially a need to keep two systems</td>
<td>Only single system running at one time, so</td>
</tr>
<tr>
<td>running, often incurring additional bandwidth and system requirements.</td>
<td>no additional bandwidth or system requirements.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Additional cost of having a help desk support two separate groups of users, including potential ongoing maintenance costs for maintaining two separate systems.</td>
<td>There is no need to support two concurrent systems.</td>
</tr>
<tr>
<td>Issue of data correlation, where there is a need to cross-reference data across two systems, may add unnecessary complexity into the system.</td>
<td>No need to implement temporary infrastructure and systems to facilitate support and data correlation between two relatively disparate systems.</td>
</tr>
<tr>
<td>More focused planning, allowing for variations to be implemented more easily and with more speed.</td>
<td>Requires comprehensive planning, a lot of which will have been ironed out during the pilot phase and coordinated in the contingency-planning process</td>
</tr>
</tbody>
</table>

### 2.19 Implementation Plan

Though phasing strategy shall be adopted for the implementation of modules, these modules shall be deployed at different locations based on dependency and ease of training.

The Implementation of ERP at Corps of EME for phase-I of the project Emerald shall be done under 2 steps. The necessary capacity building and change management programs should also be rolled out in this period. The phasing is determined based on the dependencies in implementation with other departments/modules.
Step 1 shall include implementation of HR, MM and MRO Module across identified entities. MRO module is recommended for phase 1 with the mere fact that it shall be dependent on MM and HRM module. Though Knowledge Management module shall be implemented in step 2, but the KM content related to MRO, HR and MM shall be implemented in step 1 itself.

Step 2 shall include Campus and Finance module for implementation along with left over

The implementation for Phase-I of the Project EMERALD is shown below:

![Phased Approach Diagram]

Figure 23: Implementation: Phased approach
The journey of ERP Roll out at all other locations after the completion of pilot Project Emerald is expected to be completed in 3 years. As this journey shall also be covered in phases and the key learning from pilot phase shall smoothen and fasten the process of implementation all these locations.

2.20 Change Management

Success of EMERALD project is imperative as it would lay down foundation for the overall automation plan of the entire organization. Establish an appropriate institutional framework to drive and implement change at operational level in EME. The framework is proposed at two levels- strategic (organizational) and tactical (unit) level. At strategic level, project implementation team led by identified senior leadership would be responsible to formulate change vision and take strategic decisions. Project management team comprising of technology, process and training teams at organizational level would be are responsible to formulate necessary operational strategies in their respective areas. At tactical level, change management teams in all the identified units would be accountable to successfully implement change at ground level by translating organization’s vision into key action elements, identifying localized impediments and managing stakeholders throughout the lifecycle of the project.

The second intervention area is Communication which is a critical success element of a change program. While the culture of military set up establishes top down information flow, the change program at operational level needs to encourage bottom-top information flow to identify operational issues so that change teams could constantly take corrective and preventive action steps.
The third intervention is in the area of capacity building of change skills of EME stakeholders to implement change and effectively perform within the new work system.

2.21 Reverse Logistics

One important aspect that Project EMERALD has not considered is the reverse logistics. Reverse logistics stands for all operations related to the reuse of products and materials. It is "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. More precisely, reverse logistics is the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal. Remanufacturing and refurbishing activities also may be included in the definition of reverse logistics." The reverse logistics process includes the management of surplus as well as returned equipment and machines from the hardware/inventory. Normally, logistics deal with events that bring the product towards the user. In the case of reverse logistics, the resource goes at least one step back in the supply chain. For instance, goods move from the customer to the distributor or to the manufacturer.

Reverse logistics is the timely and accurate movement of serviceable and unserviceable materiel from a user back through the supply pipeline to the appropriate activity. In the past, the Army has placed reverse logistics on the proverbial back burner for several reasons. Reverse logistics is not "glamorous" or "high tech." To the tactician, reverse logistics cannot be linked directly to readiness drivers. Few commands include reverse logistics as a component in their performance reviews or review and analysis briefings. In recent years, industry has placed greater emphasis on Reverse Logistics. Ten years ago, literature on
reverse logistics was uncommon. Today, entire textbooks are devoted to the subject. So why has industry moved reverse logistics to the front burner? The simple answer is buying power, or, more correctly, the avoidance of lost buying power; reverse logistics makes the greatest and most efficient use of existing resources. In order to maximize the Army's buying power, we too must adopt the same philosophy for the same reasons (though obviously in a different context).

In view of this there is a need to integrate this important aspect of reverse logistics as an important part of the supply module of Project EMERALD so as to accrue maximum benefits out of this concept.

Based on the detailed in-depth study of EME’s ERP project EMERALD it is evident that critical success factors and likely impediments have to be identified and addressed for the successful implementation of this project, In the next chapter various survey techniques have been used to identify all the factors

2.22 **Selection of vendors**

As we have seen in earlier that ERP is a challenging prospect to implement in any organisation. The high failure rate of ERP implementation calls for a better understanding of Identification and Selection of right package and right vendor.

The planning process for ERP implementation in EME is a complex one which often involves decision making with contradictory variables. It is very important to simplify the decision making process, especially when large number of input criterion are available, by using various analytical management tools. Analytical Hierarchical Process (AHP) is one such tool which systematically simplifies the decision making by making it more logical and quantifiable so that decision makers can arrive at an intelligent and objective decision.

ERP is not merely a computer package that is used for collection of data from sub-departments of an enterprise. It must have analytical and decision making tools. This aspect is
more critical in Defence Forces especially with respect to regular process so as to keep a Commander free to make important strategic decisions. One such decision making tool is required to ease the procurement process of military equipment. Purchase of military equipment is a complex process. The people in charge have to often walk a tight rope in order to acquire the best equipment at the lowest price. These two contradictory requirements confound the situation even further. In case of items that are available commercially off the shelf (COTS), the situation is more convoluted. Cost cannot be a sole factor to decide as the functionalities of the equipment may differ drastically from one another. Multiple criteria involved in the selection make the judgment subjective and open ended. This selection becomes a case of Multi Criteria Decision Making (MCDM). The methodology can easily be converted as a smart module that can be added to ERP to help decision makers take informed and intelligent decisions when confronted with the problems of choosing between a No. of equal seeming options. A methodology to use AHP for MCDM has been explained in succeeding paragraphs. The methodology has been used to make a decision to select best Global Positioning system (GPS) from amongst a number of available options. The same criteria can be applied to all procurements which are characteristics based.

2.22.1 Use of AHP for selection of vendors for ERP in EME

AHP was developed by Thomas Saaty in the 70’s and elaborated through his book in the 90’s. It is a very helpful tool that provides assistance in complex decision making settings. The process has been successfully implemented in problems like supplier selection, resource allocation, etc. It can also be used in daily life decision making like buying a new car, prediction of which team will win a cricket match and so on. AHP consists of the following four steps:-

(a) Making hierarchy

(b) Pair wise comparisons
(c) Determining the priorities

(d) Evaluate the ratings of the alternatives

**Making hierarchy**: This would entail the use of experts. The three major criteria that can be selected in consultation with the experts for a GPS are technical, operational and economic.

The technical criteria evaluation needs to be done in two parts. First would be the general characteristics like compatibility, dimensions, weight, etc. This can either be done by a team consisting of representatives from users, designing agency and experts in the field of technology concerned. The second part would be the maintainability aspect of the equipment. The maintenance agency can be used for this. This part would also include the information regarding availability of spare parts and maintain facilities required an available.

The operational criteria need to be enumerated by the user. This will include the attributes like accuracy, quality of display, time taken for setting, etc. The economic criteria can be developed into second level hierarchy by the procurement agency or a rep of spares supplier. This can include the attributes like cost of spares, future upgrades cost, cost of maintenance, etc. Figure 20 below shows a suggested hierarchy for a GPS.
For the sake of brevity and considering this example only as a means to explain the underlying process, the hierarchy has not been enumerated to a great detail. AHP as a process can be used to solve MCDM problems, however complex they are.

**Pair wise Comparisons:** This step involves comparing of a pair of alternatives and deciding which one has more importance than the other. We also decide the extent to which one is better than the other. When deciding between options A and B, an objective grading of 1, 3, 5, 7 or 9 is given depending on whether A is equally, very weakly more, weakly more, strongly more or absolutely more important than B. A matrix is then made which has these pair wise comparisons. This matrix is called as the reciprocal matrix because if A is stronger
than B by say 3, B is stronger than A by 1/3. These comparisons are done at a per level basis which restricts the number of comparisons to be done. That means, from the tree, Characteristics and Maintainability will be compared. In the next stage, the fourth level attributes of Characteristics will be compared, which are data output, compatibility, weight, dimensions, reliability and no. of channels. Table below shows such a reciprocal matrix.

Table 2.1

<table>
<thead>
<tr>
<th></th>
<th>Data output</th>
<th>Compatibility</th>
<th>Weight</th>
<th>Dimensions</th>
<th>Reliability</th>
<th>No. of Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data output</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>1/3</td>
<td>5</td>
</tr>
<tr>
<td>Compatibility</td>
<td>1/5</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1/9</td>
<td>1</td>
</tr>
<tr>
<td>Weight</td>
<td>1/5</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1/5</td>
<td>1</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1/7</td>
<td>1/3</td>
<td>1/3</td>
<td>1</td>
<td>1/5</td>
<td>1</td>
</tr>
<tr>
<td>Reliability</td>
<td>3</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>No. of Channels</td>
<td>1/5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1/7</td>
<td>1</td>
</tr>
<tr>
<td>SUM</td>
<td>4.74</td>
<td>17.33</td>
<td>13.33</td>
<td>20</td>
<td>1.98</td>
<td>16</td>
</tr>
</tbody>
</table>

Determining the priorities  The next step is to find out the Normalised principle Eigen vector. This is a simple step of finding the geometric mean of the elements of all the columns of the reciprocal matrix. The step will be much clearer from the tables below.

Table 2.2

<table>
<thead>
<tr>
<th></th>
<th>Normalised Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data output</td>
<td>((1\times5\times5\times7\times1/3\times5)^{1/6} = 2.575)</td>
</tr>
<tr>
<td>Compatibility</td>
<td>((1/5\times1\times1\times3\times1/9\times1)^{1/6} = 0.636)</td>
</tr>
<tr>
<td>Weight</td>
<td>((1/5\times1\times1\times3\times1/5\times1)^{1/6} = 0.7)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>((1/7\times1/3\times1/3\times1\times1/5\times1)^{1/6} = 0.383)</td>
</tr>
</tbody>
</table>
### Table 2.3

The vector can now be normalised by dividing the sum by each element of the vector.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Normalised Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data output</td>
<td>0.285</td>
</tr>
<tr>
<td>Compatibility</td>
<td>0.075</td>
</tr>
<tr>
<td>Weight</td>
<td>0.08</td>
</tr>
<tr>
<td>Dimensions</td>
<td>0.05</td>
</tr>
<tr>
<td>Reliability</td>
<td>0.45</td>
</tr>
<tr>
<td>No. of Channels</td>
<td>0.06</td>
</tr>
<tr>
<td>SUM</td>
<td>1</td>
</tr>
</tbody>
</table>

**Normalised Principle Eigen Vector**: This vector is also called as the priority vector. It shows the relative weights among the attributes that we are comparing. It is clear that reliability is most important attribute with 45% priority followed by data output with 28.5%.

The next step is to check for consistency of the result. As these comparisons are subjective, there is a chance of inconsistency creeping into the choices. That means that there might have been a case where our selection indicates that A>B and B>C but C>A which is logically incorrect. For checking consistency, we calculate principle Eigen value which is equal to

\[ \lambda_{\text{max}} = \text{Each element of Eigen vector} \times \text{Sum of columns of reciprocal matrix} \]

\[ = 4.74 \times 0.285 + 17.33 \times 0.075 + 13.33 \times 0.08 + 20 \times 0.05 + 1.98 \times 0.45 + 16 \times 0.06 \]

\[ = 6.568 \]

Consistency Index, CI = \[ \frac{\lambda_{\text{max}} - n}{(n-1)} \]
where \( n \) is the number of attributes compared. In this case, \( n= 6 \)

Therefore \( CI = (6.568 – 6) / (6-1) = 0.11361 \)

Also, Consistency Ratio \( CR = CI/RI \), where \( RI \) is Random Index whose value depends on \( n \).

The \( RI \) value table is as shown below:

<table>
<thead>
<tr>
<th>( n )</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0.58</td>
<td>0.9</td>
<td>1.12</td>
<td>1.24</td>
<td>1.32</td>
<td>1.41</td>
<td>1.45</td>
<td>1.49</td>
</tr>
</tbody>
</table>

Hence, \( CR = 0.11361 / 1.24 = 0.0916 \)

The comparisons are considered as consistent as \( CR < 0.1 \), i.e., the inconsistency is less than 10%. In case we get \( CR \) above 0.1, the pair wise comparison is checked again for inconsistencies, and rectified.

Such an exercise of pair wise comparison is carried out for the complete hierarchical tree.

The effort will yield result similar to what is shown in figure 30 below:
Evaluating the ratings of the alternatives: After we have been able to get at the priority values of all the attributes in the hierarchy tree, it is now time to weigh our alternatives. Suppose we have to choose from three alternatives, A, B or C. We weigh each of our alternatives against the others on the basis of an attribute by making a reciprocal matrix. That means, as per table below, we see that which of the GPS has better data output than others and how much better it is.

<table>
<thead>
<tr>
<th>For Data Output</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>1/5</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Similar comparisons of the alternatives on various attributes will result as tables below:

<table>
<thead>
<tr>
<th>For Compatibility</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>3</td>
<td>1/5</td>
</tr>
<tr>
<td>B</td>
<td>1/3</td>
<td>1</td>
<td>1/7</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For Weight</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1/3</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>1/3</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For Dimensions</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>1/3</td>
<td>1</td>
<td>1/3</td>
</tr>
<tr>
<td>C</td>
<td>1/5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>For Reliability</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1/3</td>
<td>1/5</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>1</td>
<td>1/3</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Comparing compatibility, weight, dimensions, reliability and number of channels

Normalizing each of these reciprocal matrix, we get a new table as shown below:

<table>
<thead>
<tr>
<th>For Data output</th>
<th>Geometric Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>((1 \times 5 \times 3)^{1/3} = 2.46)</td>
</tr>
<tr>
<td>B</td>
<td>((1/5 \times 1 \times 3)^{1/3} = 0.84)</td>
</tr>
<tr>
<td>C</td>
<td>((1/3 \times 1/3 \times 1)^{1/3} = 0.48)</td>
</tr>
<tr>
<td>SUM</td>
<td>3.78</td>
</tr>
</tbody>
</table>

Normalised geometric means

We now normalise the vector by dividing each of the element by the sum and get the results:

<table>
<thead>
<tr>
<th>For Data output</th>
<th>Geometric Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>(2.46/3.78 = 0.65)</td>
</tr>
<tr>
<td>B</td>
<td>(0.84/3.78 = 0.22)</td>
</tr>
<tr>
<td>C</td>
<td>(0.48/3.78 = 0.13)</td>
</tr>
<tr>
<td>SUM</td>
<td>1</td>
</tr>
</tbody>
</table>

Normalised principle Eigen Vector

Repeating the same procedure for all the attributes will get us results:

<table>
<thead>
<tr>
<th>Data output</th>
<th>Compatibility</th>
<th>Weight</th>
<th>Dimensions</th>
<th>Reliability</th>
<th>No. of Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.65</td>
<td>0.19</td>
<td>0.2</td>
<td>0.65</td>
<td>0.10</td>
</tr>
</tbody>
</table>
The hierarchical tree will look like the one in figure 40 below:

The priority of each alternative is then calculated, based on the attribute characteristics.

Prioritized technical aspects
In the similar manner, preceding a step upwards will yield results as below

Fig 28: Technical, operational and economic aspects

A similar step upwards will lead us to the result as to which alternative is the best one. It will also tell us as to what are the strong attributes of each of the alternative and which are the areas in which it lacks.

\[ A = 0.1204 \times 0.3422 + 0.5972 \times 0.4714 + 0.2824 \times 0.2221 = 0.3854 \]
\[ B = 0.1204 \times 0.2711 + 0.5972 \times 0.3211 + 0.2824 \times 0.3816 = 0.3321 \]
\[ C = 0.1204 \times 0.3867 + 0.5972 \times 0.2075 + 0.2824 \times 0.3963 = 0.2825 \]

The results quite clearly suggest that option A is a far better choice than other two options. In case only cost was considered as a deciding criteria, option C would have been selected, which is the worst among these three options.

Multi Criteria Decision Making is a complex process and can often lead to a number of faults. Equipment procurement for defence application is a serious business where small mistakes can often have a catastrophic domino effect. AHP is a technique that can help obviate a number of problems by approaching them in a logical and systematic way. The technique can be used in a number of applications where there are more than one alternative, each with a number of attributes. Vendor selection for ERP implementation in a large enterprise is one of the applications of this technique wherein we can identify and select the
best available alternative keeping in consideration the typical requirements of an organisation such as the Defense Forces.

2.23 Use of various survey techniques for identifying key implementation factors

Various survey techniques were used in this study with the primary aim of identifying the key factors for implementation of ERP in the Corps of EME. The design of various survey techniques like questionnaires (for different strata), case studies and interviews was planned very carefully to ensure that both, cross-sectional and longitudinal data is collected and analysed. The main criteria while designing various questions and responses was to extract realistic and accurate data so that it can be converted into useful information for analysing it such that it clearly indicates the key factors that are going to impact the implementation of ERP.

The analysis of these questionnaires, case studies and interviews is covered in detail in subsequent chapters.