Advanced Technologies for Low Cost Safe and Reliable Automobiles for Indian Conditions

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Abstract - **The opening of Indian economy for global competition has forced Indian Automobile companies to utilize advanced technologies for productivity enhancement, so that they are not forced to shut down their enterprises. There are many aspects of engineering integrity which require careful consideration during design, manufacture, operation and maintenance of the complex systems such as automobile. The ultimate realization of the "goals of design" implies successful service during the entire life of the product. There is tremendous pressure to utilize light materials which results in fuel saving. Assessing the engineering integrity of components and systems under service conditions can be extremely complex and prognostic situation at design stage is often more difficult than the diagnostic one once failure has occurred. In this paper the advanced methodologies, utilized by Indian Automobile manufacturers for production of low cost, safe and reliable vehicle, have been explained so that the customers are not only satisfied but delighted and astonished to get such good product and services.**

I. Introduction

The opening of Indian economy for global competition has forced the Indian Entrepreneurs to strive for excellence through the use of various advanced technologies. This quest for excellence is imperative for survival and has led to numerous creative, useful and economic innovations and has also improved the quality of life.

Now, the Indian consumers have a variety of cars to choose as per one's liking and taste. Gone are the days when there were only two or three car manufacturers in the country. The market researchers have shown that consumers are looking beyond the first costs (i.e. the acquisition costs) and are considering the other costs which appertain throughout its life. Besides the first costs, the customers also consider the likely operating, maintenance/ repair costs coupled with the inconvenience caused by its partial or complete breakdown due to unreliability.

The earlier common attitude of Indian manufacturers, viz. "let the customer find the defective product and we will replace it free of charge" is now shifting to guaranteeing that customer's needs and desires are anticipated and met. The nature of current competition is forcing Indian companies to develop and sharpen following abilities (by acquiring advanced technologies from the global market and to modify these to suit local requirements):

(A) To understand the customer requirements and to provide these to the customer at the earliest possible (commensurate with techno-commercial and managerial ability of the company) at the lowest price.
(B) To market product and services of high quality and reliability consistently.
(C) To take care of fast changing technological, political and social scenario, and,
(D) To predict what the customer will demand one year or ten year from now (i.e. futuristic approach) and plan the strategy accordingly.

II. The Systems Approach for Safety and Dependability Analysis of Automobiles

The automobiles consist of a large number of interacting systems and subsystems such as engine, suspension, steering, brake, chassis, etc., together with various electromechanical control systems. Broadly speaking there are five types of engineered systems in an automobile, which are interacting in real time mode[1]. These are:

i) Active Electro-Mechanical Items such as power train subassemblies, brakes, power steering hydraulic circuit etc.
ii) Passive Mechanical Items such as chassis, body, exhaust pipe, supporting systems etc.
iii) Electrical Items such as storage battery, starter, ignition equipments etc.
iv) Electronic Items such as diodes, transistors, sensors, integrated circuits etc.
v) Microprocessors i.e. the central circuit element of the automobile electronic control unit (ECU)

The generic hierarchy of elements within a system is called TOP to BOTTOM approach, i.e. from system to product to subsystem to assemblies to components. This hierarchy of the system is a key concept in system engineering because it ties the physical and system architectures, specification and drawing trees, system breakdown structure, technical reviews, and configuration baselines.

The fundamental challenge in a system approach is to understand the boundary of the system which is the focus of development and how does that system relate to and interface with the other systems and the higher-level systems. The systems approach helps in identifying the dependency of various major items on other items and also how they interact with each other. The system itself is typically composed of several related elements and their interfaces; each element may be composed of hardware, software, data facilities, material services and techniques [2]. The distinction between a component and system is required to be clearly understood because the same

physical item can be treated as either a component or a system depending upon analyst's viewpoint. An automobile engineer may view the engine, gearbox, rear axle etc. as components and the complete vehicle as a drive train system. However, the engine manufacturer treats the engine as a system having piston, piston rings, cylinders, crankshafts etc. as its components. Thus the same item engine can be regarded as a component or a system depending upon analyst's viewpoint.

The systems engineering process begins with the capture of customer/market requirements which are analyzed and translated into functional or engineering requirements. For this a novel technique used by Japanese companies called, "Quality Function Deployment (QFD)" is been used by many Indian companies also.

The six basic steps of QFD with description for building a house of quality for product development are given in table 1.

Table 1
QFD System Design Summary

	Step	Description
1	Voice of Customer	Qualifying the needs & wants of customers
2	Competitive Analysis	Opinion of the customers regarding performance of your company with respect to your competitor
3	Voice of Engineer	Quantification of the technical measures to satisfy the customer's needs
4	Correlation	To establish the relationship between the voice of customers & the voice of engineers
5	Technical comparison	Comparison of your company product performance with that of your competitor, using competitor's technical specification literature & if required, testing both at simulated conditon.
6	Trade-offs	To find potential trade-offs for cost reduction & product quality/reliability enhancement for customer acceptance using concurrent engineering techniques

Based on these requirements the functional, architecture is developed and finally the physical architecture is synthesized. The IEEE std. 1220-1994 defines the systems engineering process as a generic problem solving process that provides the mechanisms for identifying and evolving the product and process definitions of a system. The process provides a structured approach for considering alternative design and configurations in the development of a system or product. The elements of the systems engineering process and how they iterate to produce a consistent set of requirements, functional arrangements, and physical solutions is shown in fig. 1. Here it may be noted that the validation of the requirements takes place at each stage of the process and concurrent trade-off analysis are performed iteratively to close the loop on requirements. This is achieved through setting up a dedicated team of representatives from all concerned departments at the very start of the design effort. The team works together from the beginning i.e. from concept stage all the way through initial production and strives to eliminate the " over-the-wall" mentality and "error feed-back" loops that characterize the sequential developmental process. Because marketing stays involved all the way into production, it can ensure that the critical features are not compromised along the way. Because manufacturing is involved in the early project stages, it can influence the design for ease of manufacture before it is locked in. Also because a dedicated team is working from beginning it can provide a valid project planning as well as an effective schedule and budget control for getting the product in least cost and time.

III. Effective Supply Chain Management for Productivity Enhancement

An entirely new industrial structure is emerging, thanks to the impact of electronic commerce on supply chain management (SCM) system of an enterprise [3]. The continuing trends in mass customization and globalization are driving manufacturers to refocus on core competencies. The most vital business imperative of an organization in the present highly competitive era is to manage its business as an extended enterprise, not just as integrated functions limited to within the framework of the organization. Information Technology (IT) enabled management practices allow companies to deploy business processes that can sense and respond to a broader range of competitive values in ever-finer increments. For competitive reasons, it is likely that one tightly aligned and coordinated network of companies – a group of suppliers, distributors, retailers, manufacturers and other support providers – will compete against other network of companies. The company which has the highly coordinated logistic support system of customer service, warehousing, inventory control, transportation, material handling, forecasting, purchasing and strategic planning etc. (so that the right product in right quantity and condition is delivered to the customer at the right place, time and cost) will become the eventual winner. Fig. 2 shows the Supply Chain Management Framework.

In order that the customer is not only satisfied but also delighted and astonished with the product and or service in the present uncertain business environment it is highly recommended to utilize sophisticated forecasting techniques so that cost of operation is minimum. Markov analysis is one of the most versatile techniques used in business management for forecasting.

IV. Agility Versus Mass Production

In mass production companies produce large quantities of standardized products. However, over the years, in mass production the technology has been refined to allow for minor variations in the product. But in Agile Manufacturing the products are customized [4]. This form

of production is called "Mass Customization", which means large quantities of products having unique individual features that have been specified by and/or customized for their respective customers.
In mass production, products are produced based on sales forecasts. If the forecast is wrong, this can sometimes result in large inventories of finished goods that are slow in selling. Agile Manufacturing companies produce to order: customized products for individual customers and thus inventories of finished products are minimized.

Products today have higher information content than products of yesterday. This is made possible by computer technology. IC chips control many consumer appliances. Modern automobiles use engine controllers that are based on microprocessors.

Single times sales was the expectation of the merchandisers before the advent of the Age of Agility. Today, companies want to have continuing relationships with their customers. Automobile companies want their customers to have their new cars serviced at the dealer where the car was purchased. This provides continuing service business for the dealer, and when the customer finally decides that the time is right to purchase a new car, the first logical place to look for that new car is at the same dealer. Now many customers are ready to pay more, if it is customized for them. In present age the marketplace allows different pricing structures for different customers if various special features required by them are provided. The below mentioned case study illustrates how a reputed Indian automobile company has utilized various enabling technologies and management practices of Agile Manufacturing for providing the enterprise wide control of information flow using the latest technique of Virtual Private Network for giving not only satisfaction to the customers, but for exciting them with their prompt services.

Case Study (Implementation of VPNs in one of the reputed automobile company):

A crucial link in the supply chain link of M/s A company, one of the reputed automobile companies in the country, is its ability to forecast demand accurately, which helps the vendor plan the production schedule in advance, thus lowering costs. Its "value chain management strategy" identifies the linkages and interdependencies between suppliers, intermediaries and customers. To ensure that information flowed quickly along the value chain, M/s A Co. linked them to the plant through an extranet VPN.

A VPN is a private network that uses a public network (usually the Internet) to connect remote sites or users together. Instead of using a dedicated, real-world connection such as leased line, a VPN uses "virtual" connections routed through the Internet from the company's private network to the remote sites or employees.

VPNs are fast and easy to configure and reconfigure, and are highly scalable, with solid relationships between cost and functionality.

The main objective of M/s A Co. supply chain concept was to synchronize the service requirements of the customer with the flow of materials from suppliers in such a way that the apparent contradictory situation of conflicting goals of high customer service, low inventory investment and low operating costs may be optimized.

The development of an integrated supply chain required the management of material and information flows to be viewed from three perspectives:

(A) Strategic,
(B) Tactical, and
(C) Operational.

At each level the use of facilities, people, finance and systems had to be coordinated and harmonized utilizing a secure and efficient information management system.

The strategic perspective had the usual finance and marketing focus, but in addition the focus was on excellent information management so that supply can be obtained as and when desired. The focus at strategic level developed was:

(i) Objectives and policies for the supply chain in order to achieve competitive superiority against predominantly the market leader,

(ii) An organizational structure capable of bridging the functional barriers and thereby ensuring an integrated value delivery based supply chain utilizing the VPN for efficient and secure information management system.

(iii) The physical components of the supply chain, viz., vendor locations, warehouse locations and appropriate transport system to suit the delivery schedules.

The tactical perspective focused on the means by which the strategic objectives would be realized. This identified the necessary resources for achieving balance within the supply chain viz. Just In Time, Kanban, etc.

However, it is the operational perspective, which actually nurtures efficiency within M/s A Co.'s supply chain. Its focus is on costs: costs of logistics, procurement costs, operational costs and even marketing costs, the objective being to achieve a trade-off between costs and customer service. If M/s A Co. could cut down on costs, it could maintain its margins and at the same time provide quality customer service, thus in turn providing "Value" to the customer in the price sensitive automobile sector. This has helped M/s A Co. become a customer-focused company.

Information Sharing & Collaborative Partnership: Vendors are given access to M/s A Co.'s production schedules while M/s A Co. monitors stock levels with its geographically distant vendors over the VPN. Based on agreed schedules, vendors manage raw materials, manufactured components in synchronized schedules and deliver them Just-in-Time. Best management practices and

benchmarking techniques encouraged by M/s A Co. have significantly reduced lead times and inventory costs while improving delivery reliability.

By proper use of encryption and tunneling protocols designed for extranet-based VPNs, third-party organizations are locked out of the VPN, and hence they do not have access to sensitive enterprise data.

The costs involved in installing and operation of the VPN have been offset by tremendous gains, which are given below. The direct costs involved one time investment cost in setting up the information systems of M/s A Co. based on VPN, and training to be given to M/s A Co.'s staff and to its vendors.

The above costs however were offset by the following gains:

1. Reduction in lead-time by 70%, thus further reducing inventory by 25%.
2. Reduction in working capital and improved cash flow.
3. Improved logistic strategy due to availability of online information.
4. Improved vendor relationship.

Thus, it is clear that the setup of such a VPN provided fast turn on return on investment (ROI). Additionally, in the dynamic environment, as some suppliers part ways, their access to the VPN is blocked and as new suppliers become partners in the enterprise, VPN scalability feature ensures that the system reconfiguration is trouble-free.

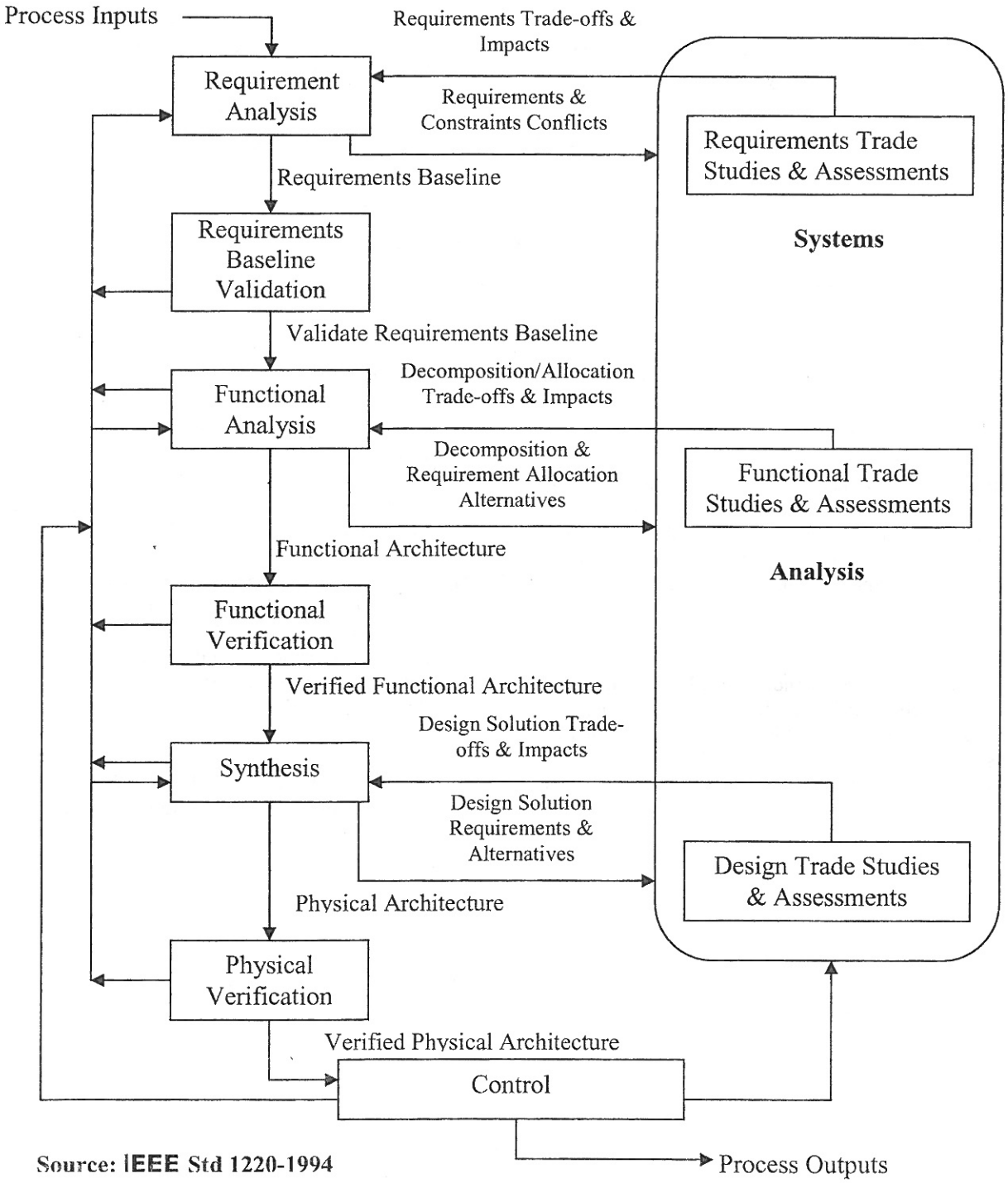

Fig.1. The system engineering process

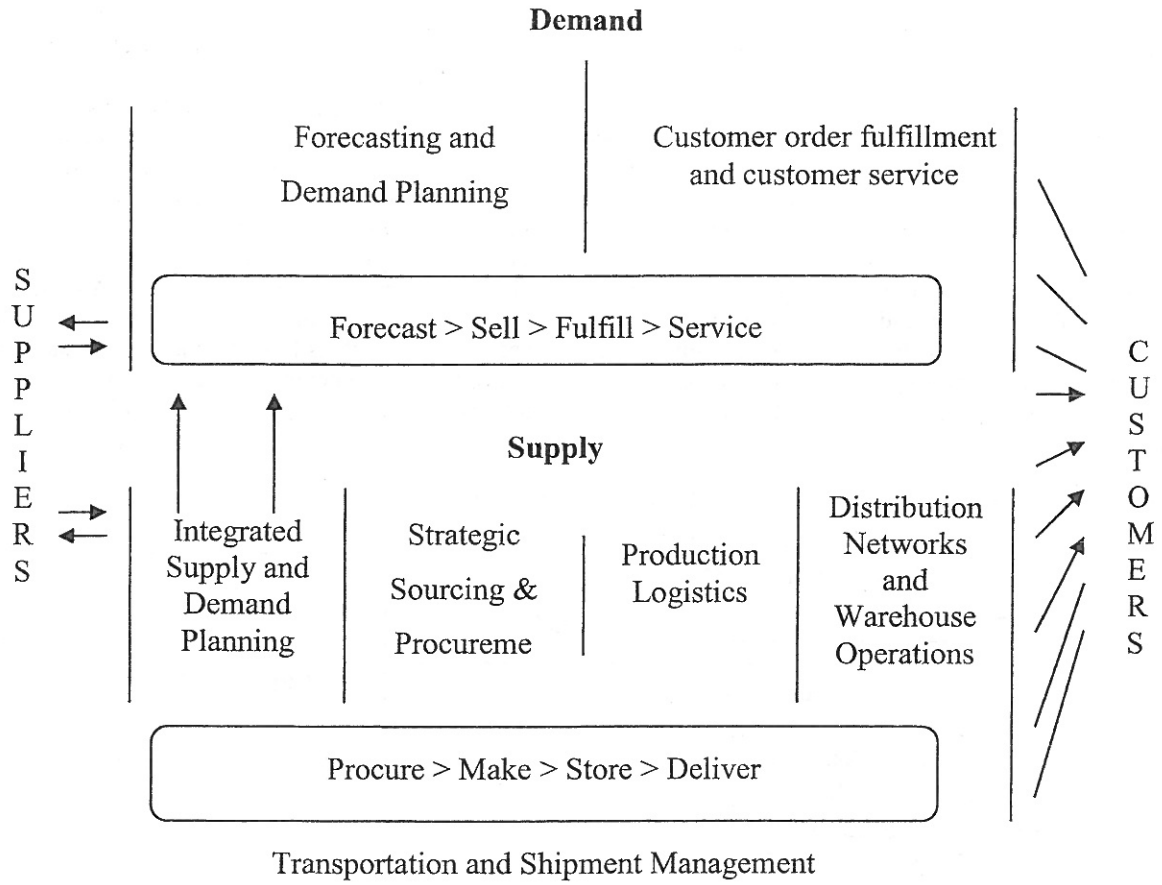

Fig. 2. SUPPLY CHAIN MANAGEMENT FRAMEWORK

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VI. REFERENCES

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