Management Case *describes a situation faced, a decision or action taken by an individual manager or by an organization at the strategic, functional or operational levels.*

Lucas-TVS Limited: A Journey towards Manufacturing Excellence

Kannan Sethuraman and Devanath Tirupati

" We decided we didn't need a crisis to change" -Mr T K Balaji, Chief Executive and MD of Lucas-TVS.

The case featured in this issue of ***Vikalpa*** discusses the journey embarked on by the top management of Lucas-TVS Limited in 1985 to make their firm a world-class manufacturing organization. The company's oldest plant at Padi, Chennai acted as a test bed for several of their initiatives. The case describes the steps that Lucas-TVS management took to implement this change process in manufacturing at their Padi plant during the period 1985-1998. The case concludes at an interesting stage where the company needs to decide on a future course of direction that would address a number of critical issues identified by Mr T K Balaji, the Chief Executive and MD of Lucas-TVS.

Readers are invited to send their responses on the case to ***Vikalpa*** Office.

Kannan Sethuraman and Devanath Tirupati are members of the faculty in the Production and Quantitative Methods Area of the Indian Institute of Management, Ahmedabad.

In mid-November 1998, Mr Balaji was reflecting on the changes that had taken place in the Indian auto ancillary market after the entry of Maruti Udyog in 1983, and on the initiatives that had been taken by his company to combat the new challenges.

> "In the same plant today, we are producing three times as much as we did about ten years ago, with marginal additional investment. During this period, in spite of stiff competition from both domestic and global component suppliers, we have managed to find newer opportunities to grow and prosper. Although I am quite pleased with the progress we have made thus far, I must say we are far from achieving the elusive goal of becoming world-class in our operations. In today's fierce market conditions in the auto industry, all of the major firms are required to compete on their ability to cut costs and prices while maintaining and upgrading quality. The implication of these developments for auto component suppliers like us is equally clear — our survival is critically dependent on our ability to reduce costs and raise product quality levels, apart from our ability to introduce new products to meet the changing needs of new vehicle manufacturers. The pace of change has been quite exciting and I am currently working on my priorities as I steer the company into the next millennium."

Preparation of this case was gready facilitated by Mr T K Balaji, Chief Executive and MD and Mr N Ravichandran, Executive Vice President, Lucas-TVS Limited, Padi, Chennai. Thanks are due to many others at the Padi plant. This study was sponsored by the Research and Publications Committee of IIMA. This draft has immensely benefited through invaluable comments from several of our colleagues here at IIMA. We are grateful to them for their generous support We also thank Dr John Pamaby for his extensive comments on our earlier draft.

Background

Lucas-TVS Ltd.

Lucas-TVS was set up in 1961 as a joint venture of Lucas Industries pic., UK (now Lucas Varity) and T V Sundaram lyengar & Sons (TVS), India, to manufacture Automotive Electrical Systems.

Lucas Industries of the UK and the Varity Corporation of the US merged in September 1996 to form a new UK holding company called Lucas Varity plc.[1] Lucas Varity designs, manufactures, and supplies advanced technology systems, products, and services to the world's automotive and aerospace industries. In 1998, it had annual revenues of 7.5 billion US dollars. Within the automotive sector, Lucas Varity is one of the world's largest suppliers of state-of-the-art braking, diesel fuel injection, and electrical and electronic systems and is a leading provider of after market[2] products and services. Its systems are installed as original equipment (OE) on vehicles made by Volvo, Mercedes-Benz, Volkswagen, Audi, Ford, Fiat, Peugeot, and Alfa Romeo.

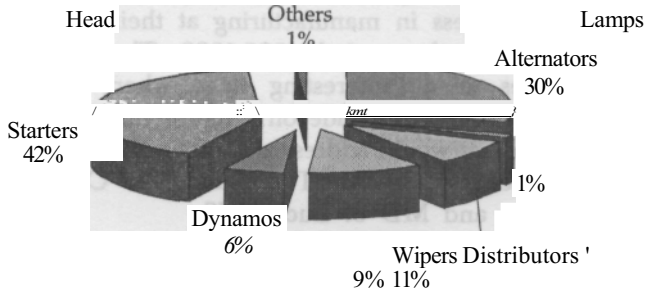
TVS is India's largest automotive components manufacturer, with a product range that includes auto electricals, braking systems, automotive wheels and axle fasteners, diesel fuel injection equipment, powder metal components, and two-wheelers. TVS is also the country's largest automotive marketing group, selling and servicing a wide variety of vehicles and spares. TVS is one of India's 20 large industrial houses, and has 25 manufacturing companies and a turnover in excess of Rs 8600 crore. Backed by five service and distribution companies with an extensive network across the country, the group has the largest distribution network for automotive products in India.

Lucas-TVS has emerged as one of India's largest independent suppliers of automotive components and it reaches out to all segments of the automotive industry such as passenger cars, commercial vehicles, tractors, jeeps, two-wheelers, and off-highway vehicles, and also caters to stationary and marine applications.

In 1998, Lucas-TVS had a sales turnover of Rs 457.73 crore (net of excise duty) (Exhibits 1 and 2). Lucas-TVS has two divisions - the auto electrical division and the fuel injection equipment division.

- *Auto Electrical Division:* The auto electrical division manufactures a complete range of auto electrical products from starters to wipers (Chart 1 and Exhibit 3). It has production facilities at Padi (Chennai), Eripakkam (Pondicherry), and Rewari (Haryana). The Padi plant has already been certified under ISO 9001 and has obtained the QS 9000 certification in 1997. The Pondicherry plant has also received the QS 9000 certification in 1999.
- *Fuel Injection Equipment Division:* In 1990, Lucas-TVS, in collaboration with the Lucas group, set up a factory on a 33 acre site at Mannur near Chennai to manufacture diesel fuel injection equipment for both direct and indirect diesel engines. The di vision, which is already certified with ISO 9001, received its QS 9000 certification in 1999.

Chart 1: Lucas-TVS Auto Electrical Division: Business Profile (1996-97) by Products



Lucas-TVS Limited also fully owns Lucas Indian Service that is engaged in the sales and service of auto electricals and fuel injection equipment manufactured by Lucas-TVS. Lucas Indian Service, established in 1930, has four regional offices located in the metros and 22 branch offices covering every major state. This is the fourth largest auto component distribution company in India after India Motor Parts & Accessories Ltd., Madras Auto Service Ltd., and Premier Auto-Electric Ltd.

A joint venture of Lucas Indian Service and Kokusan Denki Co. Ltd., Japan, India Nippon Electricals Limited (INEL) was established in 1985 to manufacture electronic ignition systems for two

[1] On May 10, 1999, TRW Inc. acquired Lucas Varity pic., resulting in the creation of a global supplier of high technology systems and services with nearly $19 billion in revenue.

[2] After market at Lucas-TVS refers to the demand generated for spare parts.

wheelers and portable gensets. INEL, an ISO 9001 certified company, is located at Hosur near Bangalore.

A 50/50 joint venture between Lucas-TVS, India and Koito Manufacturing Company Limited, Japan, India Japan" Lighting Limited (IJL) was incorporated in December 1996. IJL manufactures a range of headlamps, rear combination lamps, and various other signal lamps for automotive and two-wheeler applications. Its factory is located in Puduchatram village near Thiruvallur, about 25 km from the Padi site. Commercial production commenced in September 1997.

Indian Automotive Industry: An Overview

> *"The Indian auto market will experience among the strongest market growth in all of Asia over the next decade," —* in *Asian Automotive Industry Forecast Report* released by DRI/McGraw-Hill.[3]

The evolution of the Indian auto industry during the post-independence period is characterized by three distinct phases. The first phase was prior to the advent of Maruti Udyog Limited (MUL) in 1983, when the industry never quite matched up to the performance of its counterparts in other parts of the world. A recent report on Indian Automobile Industry[4] partly attributed this situation to the all-pervasive atmosphere created by government's license raj. According to this report, the various layers of acts sheltered the industry from external competition and resulted in the curtailment of the development of the Indian automotive industry. Considerable inertia existed in the industry during this phase and as a result very little innovation took place. The second phase was the ten years from 1983 during which Maruti won its no-contest battle against Hindustan Motors and Premier Automobiles and emerged as a formidable competitor with a staggering 83 per cent share of the Rs 10,000 crore a year market. During this phase, the industry slowly started responding to the changing needs of customers. The last phase began with the advent of liberalization in 1993.

After the deregulation of the Indian passenger car industry in 1993, several international automobile giants like GM, Ford, Honda, Mitsubishi, Mercedez-Benz, Hyundai, Daewoo, and Fiat launched their passenger car models in India. Virtually every major vehicle manufacturer in the US, Japan, Korea, and Europe has announced or is poised to announce significant investments in India. The elimination of restrictions on majority joint venture ownership by foreign corporations in India has also provided a more attractive climate for foreign auto-makers than the climate that exists in other countries in Asia. The passenger car industry has notched impressive growth rates of about 19.5 per cent in the period between 1993 and 1997. After four years of good growth, the automotive industry has recently experienced a decline in sales in 1998 due to economic slowdown and excess capacity in the industry (Exhibit 4). TELCO's launch of Tata Indica in late 1998 has again spurred intense competition in India's small car industry.

A recent report by McKinsey[5] forecasts a four-fold growth in two-wheeler production, from the current 3.5 million units to 14 million units by 2010. Similarly, production in the passenger car segment is predicted to rise to 3.5 million by 2010, from the current level of 0.45 million cars. However, according to the R&D/JD Power report on Asian Automotive Industry,[6] the greatest impediment to this predicted growth may be the lack of infrastructure. The report wonders how India can have a million-vehicle market with the current state of its roads.

Emerging Trends in the Indian Automotive Component Industry[7]

> *"The international players are looking at India not just as a market but as a possible sourcing base for both vehicles and components to meet much of their global needs and this linkage to the international market will also ensure that the technology and products brought in for the Indian market will be truly world class," — Economic Times,* April 29, 1996.

The Rs 30,000 crore[8] automotive component industry in India can be broadly segmented under five major

[3] "India Represents One of the Strongest Growth Opportunities of All Asian Auto Markets," *Business Wire,* August 7, 1997.

[4] "Automobile Industry," A Report by Investment Information and Credit Rating Agency of India Ltd., *ICRA Industry Perspective,* September 22, 1998.

[3] "Industrial Downturn may Hit Auto Parts Sector," *Business Line,* November, 25, 1998.

[6] "R&D/JD Power Reports on India's Growth Potential: Pavement and Potholes on the Road to 1 Million Vehicles," *PR Newswire,* May 15, 1996.

[7] For further details on the auto component industry in India, please refer to Basant, R; Chandra, P and Sastry, T (1999). "Ancillarization of Auto Component Sector in India: Strategies for Capability Building and Integration in Global Markets of Small Scale Firms," IIM, Ahmedabad, Report.

[8] The size of the Indian auto component industry is derived from the article "Industry Report: An Imminent Shakeout," *Business India,* May 2, 1999.

heads: Engine parts (accounting for 35% of the total components produced in the country), transmission and steering parts (21%), suspension and braking parts (19%), electrical parts (7%), and other equipment (18%).

The auto component industry is relatively small and is highly fragmented in comparison to the size and scale of the industry in the world market. This fragmentation results in poor scale economies, which in turn adversely impacts the cost structure.[9] A 1995 survey of the automotive component industry by McKinsey India[10] indicates that the number of firms in the component industry in 1993-94 was around 6,350 of which 94 per cent were in the small scale. This fragmentation is partly attributable to the regulatory environment of the past and partly to the policy of vehicle manufacturers to have more than one vendor for the same component. The report also mentions that in 1992, the production shares of the top three players were in excess of 75 per cent for all product categories except transmission gears.

In response to the economic reforms initiated in 1993 and to the entry of the major auto manufacturers into the passenger car industry, major investments in capacity were made in the component sector. However, the mid-size car segment, which all the global auto manufacturers had driven into, simply failed to take off. The net result is that the component industry is currently suffering from excess capacity (expected to be as much as 40%) created in anticipation of increased demand. However, most auto-ancillary units fare better than the automotive sector due to the fact that they are less affected by recession because of the continuing demand for spare parts. The industry also seeks solace in the international markets during recession periods.

Two of the major charges levelled against the domestic component manufacturers are that they lack *quality consistency* and *delivery reliability.* According to a study done by McKinsey[11] for Automotive Component Manufacturers Association (ACMA), the rejection rate[12] for Indian auto components is 2,900 parts per million (PPM), which is more than ten times the world level of 240 PPM. The same study estimated the sub-suppliers' rejection rate to be 31,500 PPM, unacceptable by world standards.

The entry of global vehicle manufacturers in the industry has been followed by the entry of global component manufacturers. For example, Ford is setting up a 100 per cent subsidiary to manufacture a million starters and alternators per year. With many new entrants and with Denso and Mico Bosch already present, the competition in the auto electrical component industry has become very intense.

The increasing shift towards reduction in vendor base for an automobile company is putting enormous pressure on the chosen suppliers to make substantial financial investments in their operations so that they are capable of delivering high quality products at low costs with greater delivery reliability.

Padi Plant

> *"'Being our oldest plant, Padi plant acted as a test bed for several of our initiatives launched since early 7985 to become a world-class manufacturing organization,"* - Mr T K Balaji.

The first plant of Lucas-TVS was constructed at Padi in the state of Tamil Nadu in 1961. Initially there were about 25 employees. The work-force became unionized within five years of the plant's operations and the union has been in existence since 1965-66. During its early years (1960-71), the firm primarily focused on assembling kits that were procured from abroad. From 1973, indigenization was emphasized and slowly the range of products that were offered to customers was expanded. After 1978, Lucas-TVS started devoting more energy to absorption of technology and initiated new product designs. Since 1983, the management has been stressing the importance of indigenous designs. This strategic shift proved to be a turning point for the entire organization.

In 1999, the Padi plant with about 2,850 employees is in operation on a 55-acre site. At present, the plant produces a variety of alternators, starters, dynamos, distributors, head lamps, and wipers that are shipped to over 40 different manufacturers in all segments of the automotive industry such as

[9] This sentiment is decisively expressed by Mr K Mahesh, President, Automotive Component Manufacturer's Association (ACMA) in one of his recent interviews: "By not restricting the number of assemblers, as has been done by China, we are fragmenting capacities and, consequently, the entire economics of manufacture," *The Big Gamble on the Small Car, Business Today,* February 7-21, 1998.

[10] Kumar, A; Mercer, G; Narashimhan, L and Turcq, D (1995). "Emergent Component Industries and the Way Ahead: The Example of India," *McKinsey Project,* The Economic Intelligence Unit.

[11] "Auto Components - Getting Past the Potholes," *Business Line,* June 15, 1997.

[12] The rejection rate refers to the number of units rejected by OEMs (Original Equipment Manufacturers) from the vendor's supplies.

passenger cars, commercial vehicles, tractors, jeeps, and two-wheelers. The Padi plant manufactures more than 400 different end products across the different product units and it is Lucas-TVS's largest manufacturing plant, in terms of both volume and sales, in 1999, more than 60 per cent of their sales are from products that are internally designed by Lucas-TVS.

Journey towards World-Class Manufacturing

Status of Manufacturing before 1985

> *"During those days, activity itself was considered an achievement,"* — recalls Mr N Ravichandran, Executive Vice President of Operations, commenting on the old paradigm that prevailed in Lucas-TVS prior to 1985.

The Padi plant was initially organized by processes (Exhibit 5 displays the layout of the plant in 1985) and all the machinery and operators for the individual processes were located together. The plant had equipment of varying vintage and capabilities and the average age of the machinery in the plant was about 15 years. A process capability study in 1985 revealed that roughly 30 per cent of the processes were not capable of meeting the product specifications. The frequent breakdown of machinery resulted in considerable amounts of downtime. The resulting scrap levels were as high as 3 per cent.

Referring to the old style of operations at Lucas-TVS prior to 1985, Mr Ravichandran comments:

> "In those days, if you mark a shaft in -the morning, it would take more than a month to travel through the plant. Since the plant was organized by process, there was a lot of criss-crossing of material across the factory and parts were moved from process to process. Also, the utilization of machines and operators was critical to us. It was no wonder that our managers here at Padi plant were actually encouraging our workers to keep producing and accumulate high inventory levels of both work in progress and finished goods to increase utilization of machines. We were averaging annually 4.2 turns of our inventory while our counterparts elsewhere in the world were achieving as much as 10-20 inventory turns in 1985. As an organization, before 1985, we placed very little emphasis on timely deliveries and schedule adherence. We experienced considerable delays in every aspect of our operations."

Recognizing the Need for Change

> *"The credit that you can give to the TVS management is that we listened to Dr Parnaby's advice that we don't need a trauma for initiating a change,"*
> • Mr T K Balaji.

Mr Balaji, Mr R D Flint (the then Joint Managing Director of Lucas-TVS Ltd.) and the senior management of Lucas-TVS realized that the entry of Maruti Udyog Ltd. in 1983 was the beginning of a notable change in the Indian auto market characterized by numerous opportunities as well as challenges. While the future promised a wide variety of product mixes and relatively high growth potential, these opportunities had serious implications for Lucas-TVS in terms of its capability for frequent introduction of new, high quality products. At the same time, the entry of world-class manufacturers such as Bosch and Nippondenso put pressure on Lucas-TVS to remain competitive along dimensions such as price, quality, and response times. It was also clear that, to compete successfully in this new environment, it no longer could afford the inefficiencies in its operations that prevailed prior to 1985.

Dr John Parnaby, who was the Group Director, Manufacturing Technology, Lucas Industries Pic. and a visiting professor of Manufacturing Systems Engineering at Universities of Bradford and Birmingham, acted as the prime catalyst for the changes at Lucas-TVS. In his capacity' as the Group Director, Dr Parnaby regularly visited many of the organizations that had joint ventures with Lucas. During one such visit to Lucas-TVS in early 1985, he stressed the need for Lucas-TVS to look beyond India and aspire to compete with global players through world-class manufacturing practices.

Dr Parnaby observed that the top competitors in the world at that time were capable of:

- Operating with less inventory.
- Coping economically with higher product variety.
- Operating economically with small batch sizes.
- Rapidly changing between products.
- Having a shorter manufacturing lead time.
- Guaranteeing delivery with high quality.

A firm believer in the Toyota Production System[13] (TPS), Dr Parnaby advised the top management of Lucas-TVS to take a "systems approach towards manufacturing" which would require several new manufacturing principles to be introduced at Lucas-TVS, such as simplification of the flow of material through the plant by reorganizing the machines and equipment, introduction of cellular manufacturing, creation of team structures, and provision of cross training to the work-force. He also advocated the importance of setting up a world-class product introduction process and designing their own products instead of licensing designs and drawings from others, in order to move up the value chain.

Mr Balaji and Mr Flint realized the need for this paradigm shift in order to remain competitive visa-vis the new entrants from the global arena. However, they also realized the need to convince everyone in their organization about the importance of becoming leaner and more efficient. The general feeling was that while these techniques were effective in foreign soil, they would not work as well in the Indian environment. Specifically, the concerns were about the lack of infrastructure in India, uncertainties with respect to procurement, arms length relationship with suppliers, and lack of quality and delivery consciousness within many organizations. Also there was doubt in the minds of the people as to whether Lucas-TVS had the ability to achieve these quantum improvements in performance as suggested by Dr Parnaby. Mr Balaji was certain that the transition period for his organization would not be an easy one.

Task Force Formation and its Role in the Implementation of the Change Process

After prolonged deliberations stretching over a period of six months, the Lucas-TVS management decided to go ahead and, in 1985, set up a task force to study the issue in greater detail and prepare a feasibility report for adoption of the change process at the Padi plant. A three-member task force comprising Mr C K R Murugan, Mr N Ravichandran, and Mr Mohan Rao was formed.[14] All three had excellent track records and were well regarded for their contributions at Lucas-TVS. In 1985, Mr Murugan was a deputy manager in the Purchase Division and he was chosen to bring in a non-manufacturing perspective to the task force. He had already completed 22 years of service at Lucas-TVS. Mr Ravichandran was a Chief Methods Engineer and had over 17 years of service at Lucas-TVS. He was selected, according to Mr Balaji, because he was "people sensitive." Mr Mohan Rao, a Chief Work-study Engineer, had completed more than 15 years in the organization. He was chosen to provide analytical strength to the taskforce. According to Mr Balaji, these three formed a good team and complemented each other well in terms of their skills and abilities.

The three members of the task force spent the first six months visiting a number of innovative plants in the UK and received extensive training in the implementation of these modern production methods. On returning to India, they spent another six months collecting and analysing company-specific data to assess the potential impact of the change process. In particular, they analysed the market, product, quality, and flow within their plants. They also benchmarked their performance with the best in the industry both within and outside the country.

At the end of the study, the task force came out with a clear recommendation to go ahead with the project and identified several tangible/meausrable performance targets. It targeted raising productivity levels and reducing inventory, rejections, scrap levels, and warranty losses by 50 per cent in a span of three years while simultaneously aiming at maximizing customer satisfaction.

Further, the task force recommended that Lucas-TVS should focus initially on maximizing the potential of current resources. Accordingly, the emphasis was on harnessing the full potential of the human resources, on changing the mind-set of the work-force at all levels, and on improving the layout to facilitate a smooth flow with the processes and manufacturing equipment already in place. The task force accorded lower priority to investments in new technology and automation, but decided to concentrate on these hard investments later.

[13] Toyota Production System (TPS) is aimed at enabling a manufacturer to produce the right products in the right quantity and deliver them to their customers at the right time in the right place with the desired quality and price. The primary purpose of this production system, developed by Toyota, is to eliminate all kinds of waste through improvement activities. Several companies around the world have embraced the TPS philosophy and have demonstrated the value and effectiveness of this philosophy in diverse business environments. It is important to note that the effectiveness of this strategy relies heavily on two basic requirements: 1) Commitment and direction from top management, and 2) Participation and involvement of all employees.

[14] In 1999, at the time of writing this case, Mr Murugan is the President of Operations and Mr Ravichandran is the Executive Vice President of Operations at the Padi plant. Mr Mohan Rao has retired from the organization.

Top Management Initiative to Get Worker Buy-in

> *"This change that we need to undertake is not an option. This is something that is becoming inevitable, "* — Mr Balaji's address to his work-force in 1985.

First and foremost, Mr Balaji recognized the importance of worker involvement and worker commitment to success and made every effort to ensure the participation of the workers and their whole-hearted acceptance of the proposed changes. Essentially, he envisioned an organization where the creative talents of all his employees would be directed to the general well being of the plant. He addressed employees at all levels in batches of 50 to align their minds to the new objectives. He anchored about 50 such meetings within a span of a year (1985-86) and articulated the need to transform the company into a lean and flexible organization, able to deliver better, more timely products with better use of resources. He helped them understand the changing market scenarios and the need to look at effectiveness in operations as a source of long-term competitive advantage. At that time, he promised his workers that if the mission were to be successful, he would ensure rightful recognition to all his workers.

Evaluating the difficulties he faced while convincing his work-force about the change process, Mr Balaji comments:

> "I still firmly believe it to be one of the most challenging tasks that I faced during the change process at Lucas-TVS. Changing their mind-set was critical for the success of this task that we were undertaking. Fortunately, we have always had a very healthy relationship between the management and the work-force here at Lucas-TVS. We have not had a single day lost due to industrial relation problems in the last twenty years. The employee turnover also has been minimal and there is trust amongst the employees that the management lives up to its words."

Layout Changes and Employee Empowerment (1986-91)

> *"This Padi facility at that time looked nothing like it looks today. We had a plant that was built in the early 60s. We knew that it had to be considerably modified to transform it into a world-class facility. However, in 1985, there were not many firms in India that had gone through this kind of massive transformation. This posed considerable challenges to us,"* - recalls Mr T K Balaji about the layout changes at the Padi plant in 1986.

After getting the work-force's support for the proposed initiatives towards making Lucas-TVS a world-class organization, the major tasks that were undertaken were reorganization of the plant and changing the layout of the facility to streamline the product flow. As a part of the change process, all employees were provided special training on a variety of new techniques to manage manufacturing processes effectively. Also, workers were trained to perform multiple tasks to offer higher flexibility to the organization.

One of the basic precepts behind TPS is elimination of all non-value-added activities such as waiting time between processes. In the old process layout, the shop-floor was organized according to activities (Exhibit 5) and this resulted in parts traveling in a jumbled fashion through the shop-floor. Based on the processing needs and flow within the plant, the task force decided to classify Lucas-TVS's products into six product units (alternators, axial starters, dynamos, pre-engaged starters, wipers and distributors, and headlamps, regulators, and process services). The team also advised a team of engineers to relocate equipment and machinery to create focused factories, each capable of handling a single product type. This product focus was confined primarily to assembly and a few immediate upstream operations. Processes further upstream such as heat treatment and painting were still organized by process and represented resources common to all products. This strategy was dictated mainly by the nature of the process, lack of divisibility, scale economies in investment and operations, and constraints on space.

In 1986, Lucas-TVS began modifying the layout from a process layout to a product-based layout. The effort was first pilot tested in the alternator unit since alternators were one of the key products. Moreover, it was considered strategically important to improve efficiencies with respect to the production of alternators for obtaining business from Maruti. This was a massive effort requiring rationalization of machines and equipment, movement and relocation of heavy machinery with corresponding changes in the building structure.

Mr Ravichandran recounts some of the key hurdles faced during the implementation of these layout changes:

"It was definitely not an easy task given the complexity involved in making changes to the layout without halting production. Since we desired no interruptions of the deliveries scheduled for our customers, we had decided to perform all layout changes during the weekends to avoid stoppage of production. It required a phenomenal level of planning at the operating level focusing on individual process flow, availability of alternative machines, and alternative possible routings for production and organizing special tooling where and when they were needed.

We were changing the relative positions of as many as 120 machines/workstations between an early morning of a Sunday and the following morning on Monday. A battery of maintenance technicians, electricians, electronic engineers, and tool engineers were working round the clock on Sundays so that on the following Mondays, there were no disruptions to our scheduled production. It also involved relocating some of these machines to as many as four new locations before finally shifting them to their desired locations for the simple reason of creating space."

It took five years to complete the layout changes in the entire plant, almost two years more than the targeted time period. Mr Ravichandran attributed the delay to their lack of experience in such massive transformations. The layout of the plant in 1999 is shown in Exhibit 6. Except for the evolution of the line due to formation of modules and cells, the layout reflects the changes implemented in the plant during the period 1986-91.

The task force team also identified areas where the operators required training to facilitate the transformation. The workers were sent in batches of 30 to Taramani Training Centre and were given training and exposure for five days on a variety of new techniques to manage the change process effectively. They were given exposure to change management, Statistical Process Control (SPC) techniques, preventive maintenance, flow production concepts, usage of Kanbans,[15] and the new roles that they would have to play in the envisioned organization. This training programme was also designed to provide the basics of Toyota's 5Ss[16] *(Seiri, Seiton, Seison, Seiketsu, and Shitsuke]* to the workers.

Dr Parnaby recalled the key role that training played in the whole transformation process:

"In 1985, I had facilitated the transfer of open learning training materials on topics such as flow charting, kaizen[17], kanban, quick changeover, design for manufacturability, statistical process control (SPC), quality function deployment (QFD), failure mode effect analysis (FMEA), etc. developed in the UK by my team to Lucas-TVS and a new training centre for all levels was built at Padi. A team of supporting Manufacturing Systems Engineers, trained in world's best practices, was created at Padi. This, in my opinion, was of critical importance to education led innovation."

Initially, when all these changes were proposed, there was considerable skepticism about the suitability of these techniques for the Indian environment and their effectiveness at the Padi plant. One of the mechanisms by which the management obtained the support of their work-force was through the initiation of small group activities (SGA). Once a week, these groups met to take up a specific problem and came up with an improved solution. A number of such Kaizen suggestions[18] at the operational level, spanning the entire plant, was primarily responsible for the productivity gains achieved during this period. The number of Kaizen suggestions received increased ten-fold during this period (Exhibit 7) and these activities, still continuing today, have fostered a culture of continuous learning and improvement among the employees.

Also, once in every three months, the SGA organizers publish a newsletter in Tamil called "Siru Kuzhu Cheythi Malar" (Small Group Newsletter). This newsletter publishes many useful concepts in

[5] Kanban is a tag-like card on which the type and quantity of units are written and it is sent from workers of one process to workers of the preceding process.

[6] 5S is a method used to diminish the slack hidden in plants. 5S represents the Japanese words *Seiri* (Sort), *Seiton* (Segregate), *Seiso* (Shine), *Sieketsu* (Standards), and *Shitsuke* (Strengthen Discipline) which collectively translate to a cleanup activity at the work place.

[7] "Kaizen furnishes the dynamism of continuing improvement and the very human motivation of encouraging individuals to take part in designing and managing their own jobs," *The Toyota Production System Handbook,* Toyota Motor Corporation.

[8] Lucas-TVS provides cash rewards to workers whose kaizen suggestions have been accepted and implemented. The award amount depends on the annual savings from the implemented suggestion.

a simple and readable form and enables local workers to read and appreciate them in their mother tongue.

Results Achieved

The layout changes and worker training together involved an investment of Rs 1.7 crore. The benefits of these changes to the Padi plant were immediate. In six years, the networth and sales per employee of the company doubled with almost negligible change in the work-force size. The product layout eliminated criss-crossing of material across the factory and resulted in smoother flow of products through the factory. The changes led to considerable reductions in floor space requirements and resulted in improved inventory turns. Exhibit 7 displays the improvements realized with respect to some key performance indicators from 1985 to 1991.

Dormant Period (1991-92) and Impending Challenges

> *"In 1991, after finishing the layout changes, we felt as if we had achieved nirvana. Since we were one of the first few companies to have gone through this change process, there was a state of complacency within the organization about the improvements achieved in our performance,"* - Mr Balaji recalls the mood that prevailed in 1991-92.

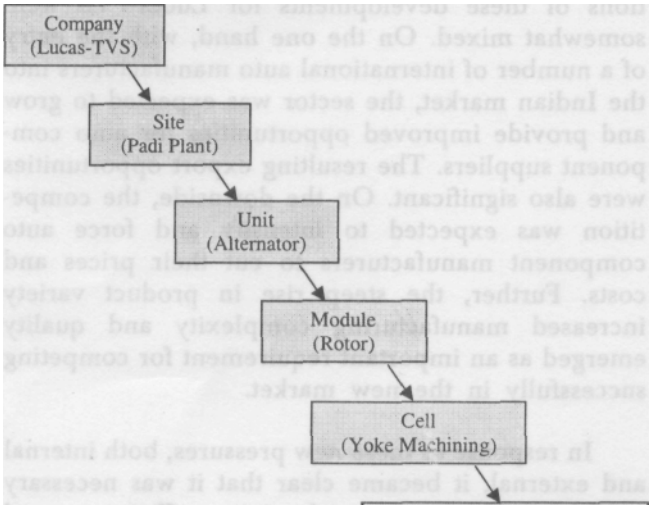
The major reorganization involving plant layout changes was followed by a lull in 1991-92. The pace of improvements had slowed down considerably during this period and this was most apparent in the 'suggestion scheme' that witnessed a steep drop in the number of suggestions received: from 4534 in 1990-91 to 2830 in 1991-92. The resulting savings for the company and the award amounts were correspondingly lower. Other performance measures such as inventory turns and sales per employee also reflected a similar trend. The period also witnessed a severe recession in the Indian economy and Lucas-TVS's sales growth in 1992 was far below the management's expectations. In response to the economic downturn and the foreign exchange crisis, the Indian government went in for economic liberalization and adopted several reform policies that eased many of the restrictions and opened up the economy to foreign competition and investors. The implications of these developments for Lucas-TVS were somewhat mixed. On the one hand, with the entry of a number of international auto manufacturers into the Indian market, the sector was expected to grow and provide improved opportunities for auto component suppliers. The resulting export opportunities were also significant. On the downside, the competition was expected to intensify and force auto component manufacturers to cut their prices and costs. Further, the steep rise in product variety increased manufacturing complexity and quality emerged as an important requirement for competing successfully in the new market.

In response to these new pressures, both internal and external, it became clear that it was necessary to achieve gains in productivity, efficiency, and operational flexibility. Further, in order to maintain the momentum generated through earlier efforts, it was important to seek opportunities continuously. Accordingly, the task force proposed a hierarchical, modular approach as described in Figure 1. This approach builds on the product focus resulting from the plant reorganization. A unit in Figure 1 corresponds to a focused factory in the plant dedicated to production of a subset of product families. Modules within each unit comprise of subassemblies whose operations are typically performed in sequence. A cell is a subset of sequential activities within a module that could be assigned, when necessary, to a single worker. While the classification of modules within each unit was relatively straightforward and followed the manufacturing/assembly sequence, the redesign of the line to form cells required thorough analyses of individual processes within each module and flow of material through them to simultaneously achieve productivity gains and operational flexibility. The Manufacturing Systems Engineering group[19] (MSE) which evolved out of the task force, played a key role at this stage and was instrumental in identifying opportunities, designing the cells, and finally implementing the scheme. The MSE department was influenced significantly by Mr Miles, an engineer from Lucas, in its adoption of flexible cells or "Nagare"[M] cells to achieve these twin objectives.

[19] The Manufacturing Systems Engineering Methodology, initially introduced by Dr John Parnaby, aimed at increasing the effectiveness of the core business processes at Lucas-TVS, i.e., the manufacturing operations process, the supply chain management process, and the product introduction process.

[20] The Nagare system aims to facilitate single piece flow in mixed model production environments. It has three significant features: Firstly, in this environment, the briefest increment of time is utilized. Secondly, while designing these systems, synchronization is given more importance and emphasis than speed. Delivering what is needed when it is needed is vital. Lastly, product-based layouts are emphasized than process-based layouts.

Figure 1: Hierarchical Approach for Modularization



Nagare Cell Formation

> *"Nagare derives from a Japanese expression that indicates the simultaneity of two actions."*— Shigeo Shingo, A Study of the Toyota Production System, 1989.

Creation of a flexible work-force with each worker trained to perform multiple tasks was one of the key elements of the new paradigm to permit "lean" operations in the face of growing variety and demand uncertainty. The first set of "cell" operators with responsibility for multiple tasks was trained in 1992. The first Nagare cell was designed by the MSE for the Yoke Machining operation in the starter unit (see Exhibit 8 for comparison before and after cell formation). Prior to the formation of the cell, three operators were jointly producing 160 units per day. After the formation of the cell, the daily productivity increased to 240 units and the tasks were now performed by a single operator.

Apart from worker acceptance, the cell formation required union approval and changes in the contract terms. A monetary incentive, the "cell allowance," was created. Initially, there were apprehensions in the minds of workers about increased work load as a result of the creation of these cells and about the downsizing of the work-force that may result due to the productivity gains achieved through the adoption of these new manufacturing techniques. However, as pointed out by Mr Ravichandran, Lucas-TVS has used the efficiency achieved to serve the growing market for its products and has managed to avoid laying off any of its workers.

Essentially, as shown in Exhibit 8, Nagare cells comprise equipment and machines required for processing an appropriately chosen sequence of operations within a module. The cell is designed in such a way that it permits line operation with varying levels of work-force, thereby providing great flexibility for changing production rates in a dynamic manner by altering the number of workers assigned to the cells. The scheme is based on the availability of multi-skilled workers capable of performing all the cell operations. The U-shaped layout shown in Exhibit 8 is typical of this approach since it provides the operators easy access to all the machines in the cell and facilitates production, during low demand periods, with minimum number of workers. This is in contrast to the arrangement before cell formation, which required fixed number of workers.

Usually, creation of Nagare cells was in consonance with process improvements and safety. The resulting improvements in productivity and other manufacturing performance measures were quite substantial. By January 1999, Lucas-TVS had more than 84 Nagare cells in operation.

Several low cost automation projects were initiated after 1992 which were motivated by the MSE's desire to improve the flow within the Nagare cells and to facilitate cell operation with minimum number of workers (in most cases one). In some instances, the objective was to reduce the cycle time and increase worker productivity. For example, until recently, the armature core driving operation was performed manually. One worker suggested that this core driving operation could be automated with rotary index table. By doing this, a 100 per cent increase in productivity was achieved and the changeover time was reduced by 90 per cent.

Explaining the approach that Lucas-TVS adopts for undertaking these automation projects, Mr Gopalakrishnan, Manager, MSE, mentions:

> "Here at Lucas-TVS, automation projects are never adopted for the sake of automation. Each project that we undertake requires compelling justification, not necessarily translatable into monetary benefits. For projects that are approved and implemented, the benefits have been quite diverse and have included fatigue reduction, reduction in cycle time, quality, and productivity improvements."

Quality Initiatives since 1992

The introduction of quality control at each work centre was a sharp departure from past practices, according to Mr Balaji:

> "Prior to 1985, we were operating with the notion that the person who produced can't be trusted with the task of ensuring quality. In those days, the size of the quality assurance department was considered to be indicative of the importance a firm gave to the quality of its products. Since 1992, we witnessed the entry of global vehicle manufacturers in the industry. We realized that without ISO 9000 certification, we would not be able to participate in global tenders. This made us take a careful look at our quality assurance systems."

Since 1992, considerable attention was devoted to streamlining quality assurance systems, resulting in the award of ISO 9001 in 1993. This process involved educating the work-force in the following areas:

- Stressing the importance of quality systems.
- Maintaining quality control charts.
- Using visual displays.
- Following work instructions and procedures.

Subsequently, Lucas-TVS also received the QS 9000[21] certification in October 1997. It achieved this distinction through development and implementation of fundamental quality management systems that provide for structured control and continuous improvement, enabling defect prevention and reduction of process variation and waste.

Recent Developments

Since 1995, the company has been focusing on developing capabilities and flexibility to implement single piece flow within the plant while simultaneously achieving just-in-time (JIT) deliveries to customers. By 1995, as a result of liberalization, the environment had changed significantly and the company was facing external pressures, particularly from the OEMs who demanded quick responses, JIT deliveries in small lots, and reduction in prices. For example, in 1998, MUL's plant in Delhi/Faridabad would only accept daily deliveries in accordance with their production schedule. The implications of these developments were two-fold: (a) Lucas-TVS needed to maintain sufficient finished goods inventories in their warehouse in Delhi in order to service MUL and (b) Reduce inventory levels to cut costs. This in turn implied frequent shipments from the plant in small lots. By late 1998, the company had streamlined the distribution system and was following a bi-weekly shipment schedule from the Padi plant to the warehouse in Delhi.

Implementation of the above was facilitated by building additional capabilities in manufacturing, planning, scheduling, and operations. For example, quick change tooling schemes at several processes permitted reduction of process batch sizes. Similarly, smoother flows with Nagare cells allowed transfer batches of size one within each cell. This single piece flow concept was tested initially in 1995 on an experimental basis in two cells. By 1998, the scheme was successfully implemented in 164 cells in the plant. Efforts in this regard are continuing and the ultimate objective is to achieve lot sizes of one (single piece flow) in both process and transfer batches. The cell formation in assembly module enabled the organization to respond more quickly to the changing needs of the customers.

Currently, worker assignments are done on a weekly basis, and production rates are determined daily in response to changing customer demands. Customer demands determine the *"takf"*[22] time which is the rate at which the cell would have to operate. The *takt* time would dictate the staffing of the workstations within the cell. This is in sharp contrast to the earlier practice in which the rates and worker assignments were done on a monthly basis. While the resulting gains in productivity are significant, the company's target is to achieve complete flexibility by changing the worker assignments daily in response to demand changes.

[21] The goal of QS 9000 certification is to improve the quality, reliability, maintainability, and durability of products supplied to Chrysler Corporation, Ford Motor Company, and General Motors Corporation. The big three auto-makers of the US automobile industry had conveyed to all their suppliers that they should acquire the quality certification before the end of 1997.

[n] *Takt* is the German word for metre, as in musical metre. In Toyota Production System, *takt* characterizes the pace ofsales in the marketplace. It is computed as the quotient of daily working hours divided by the number of product orders that one requires to fulfil each day.

Worker Reactions

Mr Ramalingam, one of the senior-most operators at the Padi plant, comments on the overall transformation:

> "Definitely, there is a greater sense of ownership today than ever before. The satisfaction results due to our contribution towards the manufacturing of a complete part unlike before when we were responsible for just a single operation. Also, in this environment, due to the empowerment of the workers, the problem gets identified right away and a remedy is sought. We are able to see the impact of our work on output quality. Today, the cellular concept is so popular among the workers that those who are not designated as cell workers are constantly pressurizing the management to give them the opportunity to be cell workers."

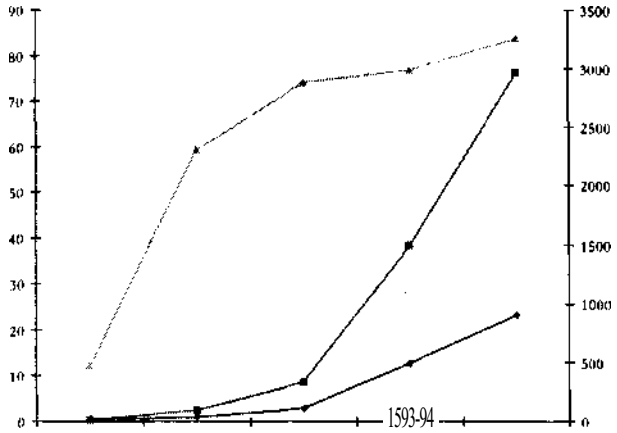
Looking to the Future

> *"All these improvements in performance have been achieved only through the dedicated and tireless efforts of our managers from top to bottom. The contribution by engineers in developing new products and processes has been phenomenal. Without the whole-hearted commitment from every single employee at Lucas-TVS, none of these changes would have been possible. Excellence is a moving target and we can't afford to remain satisfied with our current achievements. We need to continuously seek higher levels of excellence. For the challenges that we face ahead, we once again require unequivocal support from all our constituencies,"* — states Mr Balaji in January 1999.

At the company strategy meeting in January 1999, Mr Balaji, while acknowledging the accomplishments that his managers and workers have achieved in the last 12 years (see Exhibit 7 for the performance figures in 1998, Exhibit 9 for the various milestones achieved during the journey and Chart 2 for sales-manpower trend in the auto electrical division), outlined the new challenges facing his company:

> "I see at least six areas that require immediate attention as we strive to match the world-class competitors in terms of our performance. First and foremost, we are still not showing world-class results with respect to our quality. Though we have gotten QS 9000/ISO 9001 certifications, we have to do lot of homework to match world-class standards. To be amongst the best in the world, our defects would have to come down to 150 PPM. It is extremely important to get the product right the very first time. At present, we have filters to get the product right by the time it leaves our factory. However, quality defects should be eliminated from arising in the first place and this requires capable machinery and systems. As we move into the next millennium, our next challenge will be to match the technological capabilities of our competitors.
>
> Since the early 1990s, due to the increase in the number of OEMs, we are experiencing tremendous proliferation of parts and products. We have not thoroughly understood the costs arising as a result of this product variety and complexity. I see this as an important challenge as we strive to match the product offerings of our world-class competitors. We would have to enhance our new product development capabilities and more efforts need to be devoted towards modularization of our products.
>
> Supplier alignment with our initiatives has not made much progress so far. Only about 10 per cent of our suppliers have developed capabilities to match our requirements. I feel this is another important area that warrants our attention. In the next decade, supply chains are going to compete with one another and

Chart 2: Sales-Manpower Trend
Auto Electrical Division
(Padi+Pondy+Rewari)



without ironing out wrinkles in our supply chain, I do not envision Lucas-TVS emerging as victors.

I want to bring to your attention a notable statistic from the recently released report on worker training.[23] Our total training expenditures per employee ranks among the lowest in the industry. It is quite clear in my mind that we have not devoted much attention to training our employees. The competition in the world today revolves around developing knowledge workers and retaining them. We would be severely handicapped if we do not concentrate on providing adequate training to our employees on a continuous basis. We must strive hard to provide an environment that is highly conducive for continuous learning.

Last, but not the least, developments in the area of information technology are bound to influence all major companies in the coming decade. IT in many organizations has become an end rather than a means for achieving goals. It is imperative for us to investigate how IT can enhance the effectiveness of our operations, quality assurance, new product development, and the linkage with our suppliers.

In short, what we need is another major initiative similar to the one that we undertook 15 years back to achieve these goals. I have requested Mr N Ravichandran to head a task force to craft the plan of action for this initiative."

Returning from the strategy meeting, Mr Ravichandran is pondering about his new role and the nature of leadership and vision that he must provide as Lucas-TVS steps into yet another challenging phase of transformation.

[23] American Society for Training and Development (ASTD) conducts the survey and provides this benchmarking report to participating organizations.

Exhibit 1: Selected Financial Statistics of Lucas-TVS Ltd.*

Rs in Million

Year End: July 31	*1985*	*1991*	*1996*	*1997*	*1998*
Sales (Net of Excise Duty)	609.8	1,557.9	4,582.8	5,202.9	4,577.3
Capital Employed	284.4	658.9	2,111.3	2,677.9	2,958.3
Net Worth	227.5	410.8	1,842.7	2,368.4	2,799.3
Gross Fixed Assets •	285.9	593.1	1,957.9	2,439.0	2,633.2

*Selected financial statistics for the entire Lucas-TVS Ltd. that includes all its divisions and operations.

Exhibit 2: Lucas-TVS Ltd. and its Divisions, Subsidiaries, and Joint Ventures (1997-98)

Division	*Year of Starting*	*Sales (in Millions of Rupees)*	*Size of Work-force*	*Factory Location*	*Business*
1. Auto Electricals (1997-98)		3683.7			Complete range of auto electrical products from starters to horns
• Padi Plant	1961		2871	Padi, Chennai	
• Pondy	1991		196	Pondicherry	
• Rewari	1995		12	Rewari, Haryana	
2. Fuel Injection Equipment (1997-98)	1990	890	298	Mannur, Sriperumpudhur	Manufactures diesel fuel injection equipment
3. Lucas Indian Service (1997-98)	1930	1200	475	4 regional offices in metres and 22 branch offices covering all major states	Engaged in the sales and services of auto electricals and fuel injection equipment
4. India Nippon Electricals Ltd. (1997-98)	1986	602.1	295	Hosur	Manufactures electronic ignition systems for two-wheelers and portable gensets
5. India Japan Lighting Ltd. (1998-99)	1996-97	137	74	Puduchatram village near Thiruvallur	A range of headlamps, rear combination lamps, and various other signal lamps for automotive and two-wheeler applications

Exhibit 3: Product Portfolio of Lucas-TVS

Exhibit 4: Sales Figures for Various Segments in the Auto Industry for 1998-99

	Sales in 1998-99	*Percentage Change from Previous Year*
Passenger Cars (Domestic)	409,966	-2
Exports	25,464	-14
Two-wheelers	3,400,427	+12
Three-wheelers	210,220	-10
Commercial Vehicles	139,565	-12

Source: *Economic Times*, April 29, 1999.

Exhibit 5: Plant Layout at Padi in 1985

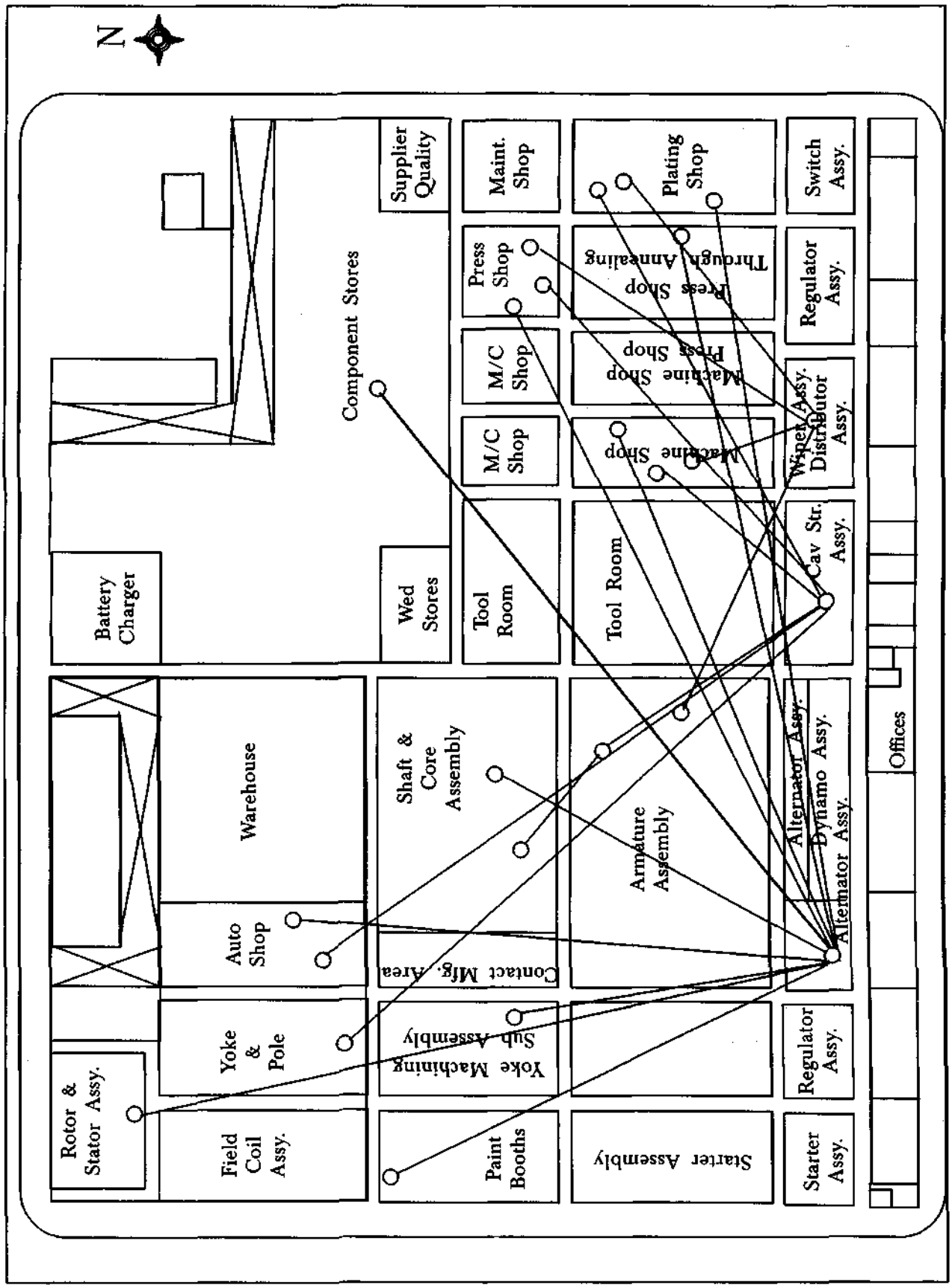


Exhibit 6: Plant Layout at Padi in 1999

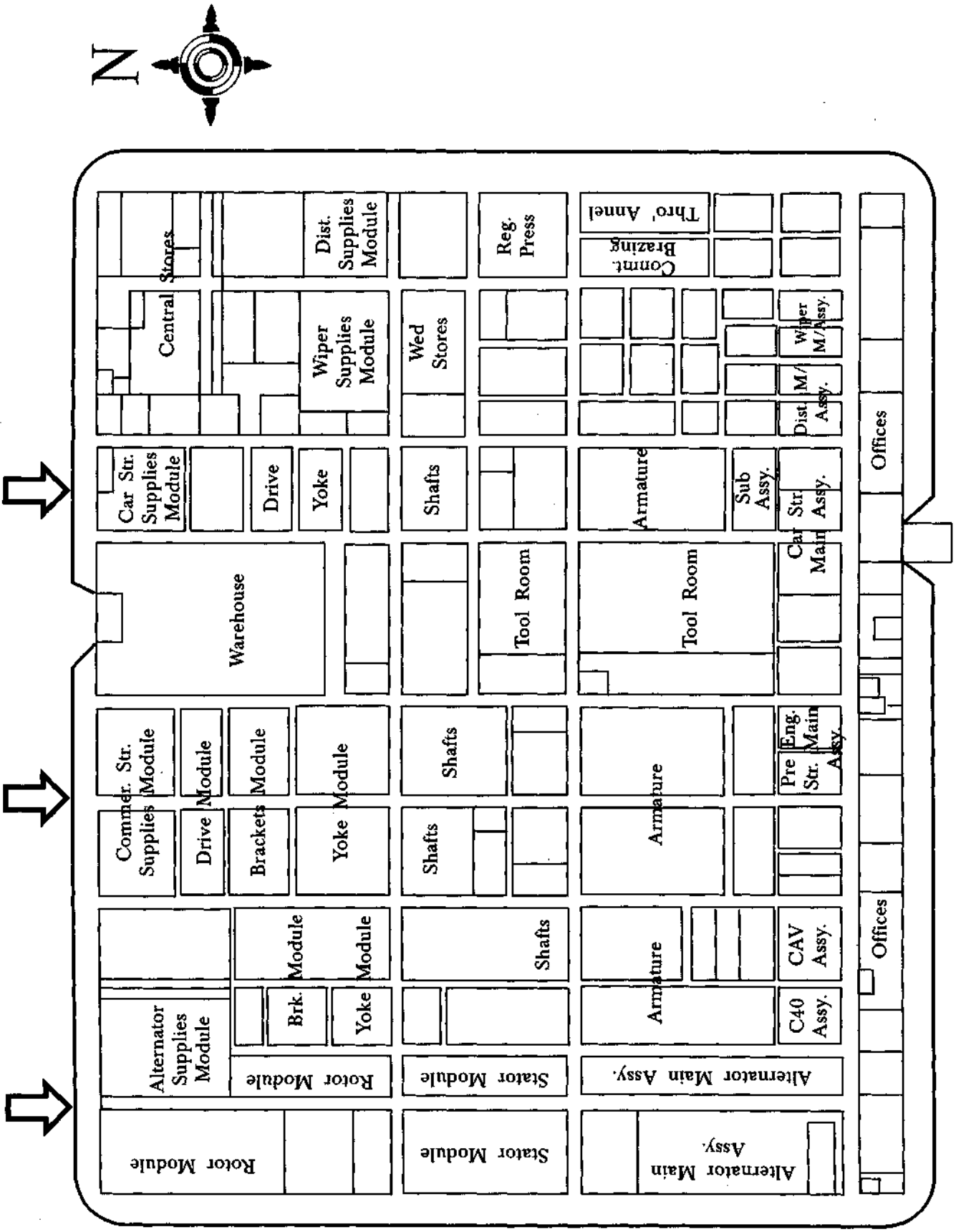
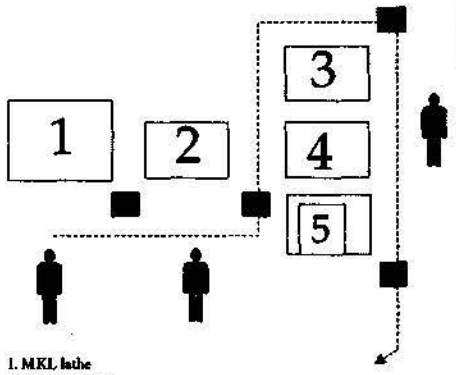


Exhibit 7: Transformation of the Padi Plant

	Unit	*1985*	*1991*	*1998*
Sales Value (Padi Plant)	Rs in Million	609.8	1,466.9	3,178.2
Annual Production –	Millions of units	0.43	0.77	1.40
Rotating Machines (Starters, Alternators and Generators)	Times	1	1.79	3.26
Total Employee Strength	Nos.	3105	3056	2871
Sales per Employee	Rs in Million	0.196	0.48	1.107
Average Worker Compensation (Index 1985)	Times	1	2.09	4.72
Lot Sizes	Nos.	4000	40	Within Cell–1 Across 40
Typical Setup Time (for Critical Machines)	Minute	540	120	10
Inventory Turns		4.2	7.2	14
Rejections	%	10	3.3	2.5
Scrap	%	2.97	1.5	1.5
Downtime	%	2.0	0.5	0.2
Floor Space Utilization	Sq.ft/ Rs Million Sales	515	254	119
Space Utilization Index (Base 1985)	Times	1	2.03	4.33
Capital Employed	Rs in Million	227.5	442.6	1,144.4
Sales per Capital Employed		2.68	3.31	2.78
Annual Savings from Suggestions	Rs in Million	0.201	10.723	1.816

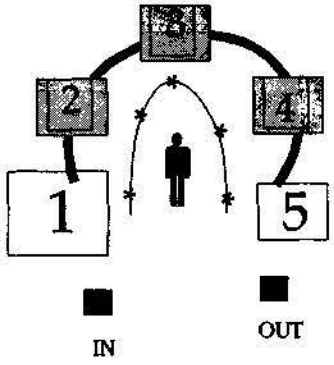
Exhibit 8: Formation of the First Nagare Cell in the Yoke Machining Operation

Status before Cell



1. MKL lathe
2. Gimping press
3. 4 way drill
4. Sa drill
5. Bench

Status after Cell



Features :
Low cost gimping press (inhouse manufacturing) operation established in hydro pneumatic press from mechanical press resulting in space reduction.

Benefits	From	To
Manufacturing leadtime	300 Mins	2 Mins
Manpower	5	2
Transfer batch size	150	1
Space in square feet	150	120

Exhibit 9: Lucas-TVS's Journey towards Manufacturing Excellence: Key Milestones