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Enhancement of Production through Strategic Decision Making: A Case Study of Diesel Locomotive Works (DLW)

Ashutosh Mohan* Lakshmi Raman*

ABSTRACT

This paper aims to summarize the strategic decisions taken to double the production level of DLW in four years of time. The paper enumerates the possibilities up to which strategic and radical decisions can be taken in a government-owned industrial setup in India. Diesel Locomotive Works (DLW) manufactures diesel electric locomotives primarily for Indian Railways. To increase the output, strategic decisions are taken to purchase/outsource large number of items which used to be manufactured in-house. Achievement of loco production targets is the result of concerted efforts by all departments. Each department improved their working to dovetail their efforts to the loco production targets. Staff and unions of DLW are very supportive in implementing strategic decisions. The strategic decisions have transformed DLW, from an integrated locomotive manufacturer, to more of an assembler of locomotives.

KEYWORDS: Outsourcing, Strategic Decisions, Productivity, Staff Utilization, Multi-Skilling.

JEL CLASSIFICATION: M11, M110

BIOGRAPHICAL NOTE: **Ashutosh Mohan** is presently Assistant Professor at Faculty of Management Studies (FMS), Banaras Hindu University (BHU), Varanasi, He is a recipient of AICTE's Career Award for Young Teachers (CAYT).He is also a recipient of CAPS Fellowship, University of Arizona, USA. He is also a Member of Editorial Board of Journal of Supply Chain Management, USA and is serving as Associate Editor of BHU Management Review. E-mail: ashutoshmohan@rediffmail.com
Lakshmi Raman is presently Chief Mechanical Engineer/Planning in East Central Railway of Indian Railways. He has got vast experience in manpower management, productivity improvement, internal supply chain management and resource management in diesel locomotive production. E-mail: lakshmirita@rediffmail.com

INTRODUCTION

Diesel Locomotive Works (DLW) is a production unit under the Ministry of Railways, India. It manufactures diesel electric locomotives primarily for the requirements of Indian Railways. Every year a few locomotives are manufactured for non-railway customers and export commitments. Presently, locos manufactured are working in wide horse power range from 1350 horse power (hp) to 4500 hp.

The unit was established in 1963, as an integrated locomotive manufacturing unit, to manufacture diesel electric locomotives of ALCO (American Locomotive Company) design in the horse power range of 1350 to 2600 hp. It had the capability of manufacturing diesel generating sets of similar capacities. The installed capacity of the plant progressively increased to 140 locos (102 WDM2, 20 YDM4, and 18 WDS6 types of locos) in 1989/90 (Ref. MW/09/044/aug. project/New project). In 2001, the Railway Board gave demand projections of 85 locos /year only, for the next five years. Hence, DLW reduced its capacity to 125 locos of WDM2 type in 2001 (Reference for production capacity- Manpower review at DLW for year 2000-01).

In 1995, DLW went for transfer of technology agreement with General Motors, USA for upgrading the technology of diesel electric locos in India. From 1997/98, manufacturing activities of 4000 hp WDG4 and WDP4 locos were started. The new design of locos resulted in doubling of the inventory level as practically all components of new locos were uncommon from the earlier ALCO type of locos.

The production level of the DLW slowly increased from 4 locos in 1963/64 to 164 in 1997/98. It gradually reduced to 121 in 2004/05 due to reduction in demand and then again peaked to 222 in 2007/08 and to 224 in 2008/09. Additionally, 33 locos were manufactured from Parel workshop in 2008/09, the manufacturing partner of DLW. As an integrated loco manufacturer, DLW basically required steel plates, sheets, bars, billets, structural steel sections, casting, and forgings. The remaining job of conversion from raw material to finished product was done internally. Under such conditions, infrastructure, manpower, and technology (available within DLW only) were used. To manufacture numerous finished product from raw material, Large manpower used to work for giving output of 150 locos only . Time and efforts were concentrated on non-core operations, like manufacture of low-value items and associated criss-cross movement of material.

With the targets pegged at 250 locos /year, capacity constraints in manufacturing were envisaged. To overcome the shortage of capacity, strategic decisions were taken to outsource many activities. Vendor development exercises were undertaken to develop supply sources of large number of items in bulk quantities. Design of many items was changed to improve productivity of items manufactured in-house. Shops contributed to enhancement of production by improving productivity of in-house manufactured items and by flexibile deployment of staff and infrastructural resources. Finance, stores, and other departments improved their working by removing the bottle-necks in their systems.

DIESEL ELECTRIC LOCOMOTIVE

Diesel Electric Locomotive consists of diesel engine which generates the motive power. Diesel engine drives the alternator. The mechanical power is first converted to electrical energy by the alternator. The electricity generated is used to drive the traction motors, which in turn drive the wheels. To control and operate the engine and the alternator, various equipments are mounted on the loco chasis called underframe. The equipments are then covered by superstructure. The engine primarily consists of cast/forged and then machined items. The underframe and the superstructures are basically fabricated assemblies of steel plates and sheets of various sizes.

DLW has various departments like design, finance, stores, personnel, and production. The production department is responsible for loco production. The loco consists of three major assemblies: block, engine, and loco chassis with under-truck and superstructures. The various assemblies are manufactured in different shops and then assembled in the loco assembly area. The production shops are divided into block, engine, and loco division.

RESEARCH METHODOLOGY

The case study methodology is a common feature in Supply Chain Management (SCM) research (Bhattacharya *et al*. 1995, 1996; Hines, 1993; Goffin *et al*., 1997) and it can be used to review both intra- and inter-organisational interactions and relations. Typically, the case study employs a combination of research methods—and these may be qualitative, quantitative or both. Further, Yin (2003), identifies three types of case studies: exploratory, explanatory, and descriptive. The case study method has resulted in a holistic, in-depth investigation of the interacting issues of enhancement of production through strategic decision making. Tellis (1997), notes that case study research is not sampling research but that the selection of cases should maximize what can be learned within a specific time-frame. The unit of analysis is a system of action rather than an individual or group of individuals. The researcher considers not only the voice and perspective of the actors, but also of the relevant groups of actors and the interaction between them.

The research paper is a case study. It depicts how strategic and growth-oriented operational decisions are taken by practicing managers in the government sector. The government departments in India, in general, and DLW, in particular, are governed by the policies and rules framed by the government. The money is allocated and public procurement policies for expenditure are framed by the Parliament of India. In nut shell, there is little room to violate or circumvent the rules. Only the self motivation

of the decision maker, to succeed in achieving the targets can drive them to excel.

DLW is administratively divided into various departments and each department is headed by senior officers called head of the departments and supported by deputy heads, the in-charges of respective divisions. Strategic and innovative decision making in purchasing, finance, production, and so on is done by these officers. The methods of data collection employed included interviews, direct observation, and company's documentary sources. Yin (1994),notes the importance of using multiple sources of evidence within case study research. Observational evidence was gathered during formal events such as meetings and supplier development programmes and, less formally, during visits or interviews. These opportunities provided details of the research subjects' surroundings as well as the relevant interaction and behavioural and environmental conditions (Remenyi *et a*., 1998). To understand the decision-making process and the circumstances leading to these decisions in each department, methodology of interview was used.

Interviewing the multiple participants involved in the thinking–doing under study not only are particularly useful steps, but they also become mandatory if we really want to achieve deep understanding in research on thinking–doing processes (Arch g Woodside *et al.* 2003). Individual depth interviews were conducted with the relevant executives/officers who are in-charge for outsourcing/ purchasing activities and decision making to understand the dynamics of decision making. Officers were asked to relate their personal experiences and feelings related to the landmark achievement of the high production targets by DLW and the decisions/actions taken. The outcome of the actions were discussed with respect to data available from files/reports and then views noted down. The interviews lasted for 60 to 90 minutes. Many-a-time interviews were supplemented with a round of the division and interview of the dealing staff.

Relevant files of the purchase, planning, accounts, and other departments were studied. DLW publishes various reports on accounting, safety, and so on . These reports and files were studied and quantitative data was extracted.

During interviews, data was discussed with the officers, so that their subjective views could be associated with the actual information. These in-depth interviews and study of relevant files form the basis of the case study.

To understand the staff's perspective, members of the staff council (the staff union in DLW) and few senior supervisors and staff were interviewed with the same methodology.

TRACING THE HISTORY: DLW's PRODUCTION PLANNING

The installed capacity of DLW was 140 locos upto 2000/ 01. It then reduced to 125 locos. In the 1980s and 1990s, DLW's production level fluctuated in the range of 100 to 150 locos. Variation of production level, from DLW's premises, from 1997/98 to 2008/09 is traced in Figure 1. Additional 33 locos were assembled in Parel workshop in 2008/09. The locos built by Parel are not shown in the figure as these have been assembled by another unit. The paper revolves around the decisions taken at DLW.

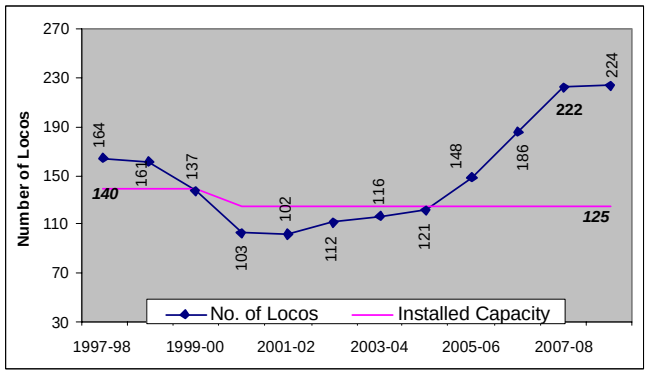

Figure 1 Variation in Production Level of DLW

As evident from Figure 1, loco production varied widely vis-à-vis the installed capacity. Loco production stood at 164 in 1997/98, but dropped to 102 in 2001/02 due to lack of demand. Initially, production targets given by the Railway Board, on yearly basis, were 112 for 2000/01, 125 for 2001/02, and 125 for 2002/03. Subsequently in December 2001, targets for 2002/03 were reduced to 90. In December 2001, the Railway board gave targets of only 80/85 locos for 2003/04 to 2006/07, (Rly Board's letter M(PU)/2001/New Tech. dtd 12/12/01). (File ref for production targets DLW/M/105/ part XXVII onwards)

Things became favorable in industries as gross domestic product (GDP) growth rate picked up from 4.3% in 2003 to 8.4% in 2006. The demand for locos also started picking up. In September 2006, the Railway board revised its targets of 80 locos for 2006/07 to 150 locos. In June 2006, targets given for 2007/08 were 200 and 250 locos for 2008/09. In February 2008, targets for 2007/08 were revised upward to 220 locos. In view of good economy, the Railway board has projected the requirement of locos at 250 in the coming years.

The DLW produced 121 locos in the year 2004/05. It seemed hard to increas the production by 82% from 121 to 220 in just three years duration. While DLW was grappling with targets of 220 locos, demand increased to 250 locos for 2008/09. During 2005—07, DLW also got orders and manufactured 12 DG sets for Nuclear Power Corporation. The order was prestigious in that the project was undertaken from design stage to commissioning stage while meeting very stringent safety and operational requirements of a nuclear power plant.

Though, on paper, DLW's machinery and plant capacity was still 125 locos, it was already 40 years old. Nearly 30% of the manpower involved in direct or indirect production was lost due to retirement and meager intake of fresh faces. The strength of production staff was 3034 in 1997/98, which reduced to 2151 in 2004/05 (file MPLO/MPU/25 for staff strength).

OVERTIME AS A MANAGEMENT PHILOSOPHY

Production level higher than the installed capacity was managed by limited outsourcing and widespread use of overtime. Giving overtime to staff was a regular measure for about 20 years. From the late 1970s to 1990s, overtime was a regular additional source of workers' income. Overtime has been used as an alternative staffing option that improves performance parameters. Considerable savings are also achieved if hourly rates of overtime are near to the normal rates (Easton F F *et al.,* 1997).

The peak of 164 locos in 1997/98 was managed by increasing the capacity of the shop by giving overtime to production related direct and indirect staff as no long-term demand was seen in the horizon. The Railway Board used to issue loco production targets on an yearly basis rather than rolling plan for 3 to 5 years (Ref files No. DLW/M/105/Pt XXVII 1998-99 to Pt 30, 2002-03). Hence, a short-term solution of giving overtime to staff was resorted to.

In 1997/98 amount equivalent to 11,68,606 work hours was paid to the production staff as overtime for producing 164 locos, which in turn came as 7125 overtime hours per unit production of loco. In 1992/93, 151 locos were produced and 7,39,276 hours of overtime were given, averaging to only 4896 overtime hours per unit of production. Overtime increased by 31% in 1997/98, in comparison to 1992/93, whereas during the same period production staff reduced by only 2.7%, from 3120 to 3034. (File No. ref MPLO/I&L/OT/24 for over time figures, file MPLO/MPU/25 for staff strength). This indicates that control and reasoning in giving overtime was lost. As workers get more money in working overtime than in normal time, all the inefficiencies/ problems arise in the normal working hours and the staff tries to solve problems in those extra hours. Thus, quality and discipline takes a beating due to loose managerial control by supervisors. In some extreme cases, in DLW, overtime business led to unrest in industrial relations leading to skirmishes between staff and supervisors. Researchers (King Stephen P, 1997) have also confirmed that unions tend to establish and maintain overtime. This aspect is confirmed from the increased overtime hours/loco in 1997/98 in comparison to 1992/93. Overtime working jeopardizes the safety of workers due to working under stress (Goldenhar Linda M. *et al.*, 2003*).* Productivity, in case of DLW quality, also reduces.

Overtime is considered as undesired practice in the industries particularly in government sector as staff gets habituated to it. Hence, in October 1999, it was decided to get rid of overtime. It was an opportune time also since the demand of the locos was decreasing. Overtime was reduced to zero. Hence, the locos were manufactured as per the capacity only. Only 137 locos could be produced in 1999/2000, against truncated target

of 138, primarily due to slow working by staff, as a repercussion of withdrawal of overtime (file DLW/M/105/Part XXVIII 1999-2000).

STRATEGIC INITIATIVES

Target was 'doubling the outturn in four years'. Such type of targets are herculean tasks in industrial setups where volumes are low and items are specialized, made to order and not 'off-the-shelf' types, big in size, and technologically intensive. Moreover, such targets are even more difficult to achieve in a government setup where decision making is tied up with rules and regulations and where there is always a danger of three Cs: Chief Vigilance Officer (CVC), (Comptroller and Auditor General)CAG, (Central Bureau of Intelligence) CBI, ,), lurking on the head of decision maker.

DLW as an organization responded very positively to the challenge thrown to it by the Railway Board, by not only achieving the target but also exceeding it, through various strategic initiatives. Increase in the production targets to 220 locos from existing capacity of 125 locos necessitated the need for more machines, infrastructure, and manpower. Production of 121 locos of 2004/05 was done with fixed assets of Rs 144 crores (Ref. Annual Report 2004-05). Achieving an outturn of 220 in 2007/08 required almost doubling of fixed assets to Rs 288 crores. Availability of funds was a big problem. Moreover, even if the funds were available construction of facilities, procurement, and installation of machines and their commissioning was not possible to be completed within a few months. These capital-intensive activities take a very long time to complete—anywhere from two to four years—due to complexity of government budgeting/sanctions and public procurement procedures.

At the same time, the government decided to go for overall reduction of staff strength and it became impossible to go for increase in staff to the level required for 250 locos. Recruitment of staff is done through Railway Recruitment Boards and this involves long-drawn procedure of compiling indents of nearby railways, advertising vacancies, written test and other formalities, which usually takes about two years to complete. New staff needs job orientation and training. Hence, even if staff was somehow made available, sufficient to fill vacancies, it could not have been put into productive use.

Owing to the perils associated with overtime, increasing capacity and production with overtime was not envisaged. By outsourcing, companies can not only lower their short-term direct costs but also their long-term capital investments, thus leveraging core competencies *(Quinn and Hilmer, 1994)*. Outsourcing provides for possibilities to expand output with limited capital investments and increased flexibility with reduced risk of exposure *(Christian Berggren et al. 2004,; Jussi Hatonen, 2009)*. Having ruled out capacity increase by increasing machines and manpower, DLW management thought of outsourcing, using available capacity of Central Railway Parel workshop, and improving staff availability for production by productivity improvement measures/resorting to multi-skilling of staff. These decisions were in line with the strategies contemplated by other industries.

OUTSOURCING/BALANCING INPUT: PRACTICING THE THEORIES

The core competency of DLW was in manufacturing engine block, underframe, and superstructures, under trucks, cylinder heads, connecting rod and camshaft. DLW has got special-purpose machines, technical know-how and highly skilled manpower required for manufacturing these items as core activities. In 2005/06, as a capacity-enhancement measure, the management decided to keep core competency items as shop-manufactured and, to purchase the non-core assemblies and sub-assemblies. Outsourcing of non-core activities has been widely accepted by the industries and has been recognized and recorded by the researchers alike *(Julia A Smith et al. 2005,; Morgan Swink et al., 2007)*. Outsourcing, commonly defined as the transfer of activities and processes previously conducted internally to an external party *(Ellram and Billington, 2001)*, is one of the most sustained trends of concurrent business *(Fill and Visser, 2000) (Julia A Smith et al., 2005; Morgan Swink et al., 2007)*.

The production programme given by Railway Board is on year to year basis. The production programme varies in both volume and product mix. Higher targets for production are no guarantee that targets for next five years will be at higher level than the installed capacity i.e. there was uncertainty of continued high production levels in coming years. Empirical study has indicated that volume flexibility and product flexibility are key responses to meet uncertainty *(Vickery et al., 1999)*. Hence, product and volume flexibility concepts were utilized to outsource activities. Product flexibility is a value-adding attribute that is immediately visible to the customer, Railways in our case, and requires the effective collaboration of the internal and external functional players. Volume flexibility directly impacts customer's perceptions by preventing out-of-stock conditions, shortage in locomotive availability of a particular specification in the case study, for products that are suddenly in high demand *(Ndubisi Nelson Oly et al., 2005)*. Hence, DLW opted for balancing input activities. Balancing input is another name of outsourcing. 'Balancing input' is the input given to the production activities in the form of purchased items from trade, in full or part quantities of yearly requirement. These are the items which were otherwise being manufactured in-house. These items, in part quantities, were purchased from trade and rest made in house. Some of the items were fully off loaded to trade. The balancing input option is exercised in such a manner that items can be in-sourced, if production level decreases or supplies from trade stop due to reasons beyond the control of DLW. Table 2 details Outsourcing resorted to in different divisions during 2003/2009.

With increase of production targets, number of items purchased and quantity of each item purchased increased over the years. The extent of outsourcing done during the period 2004-05 to 2008-09 is as shown in the Figure2, which clearly depicts that DLW was able to generate workforce of 285 men in 07-08 and 463 men in 08-09.

While outsourcing, care was taken to outsource many of these items to small suppliers in the vicinity of DLW. Hence, cost reduction was achieved at one end and social obligation was also fulfilled by providing work to small industries. Closely located suppliers also ensured that we were able to keep tab on the progress of production and quality/process problems of supplier. Cost of supplier development and time was also brought down.

Table 1: Man hours equivalent Input planned as Outsourcing (Balancing Input)

Division	03-04	04-05	05-06	06-07	07-08	08-09
Engine	0	1584	39449	148087	164483	213878
Block	24633	48696	66328	70223	116047	94543
Loco	113496	221404	249144	363083	633675	1173763
Total BI Hrs	138129	271684	354921	581393	914205	1482184
Equated Men	43	85	111	181	285	463

Source: Files of TA/DyCME/Plg/BI (Balancing input) of 2003 to 2009

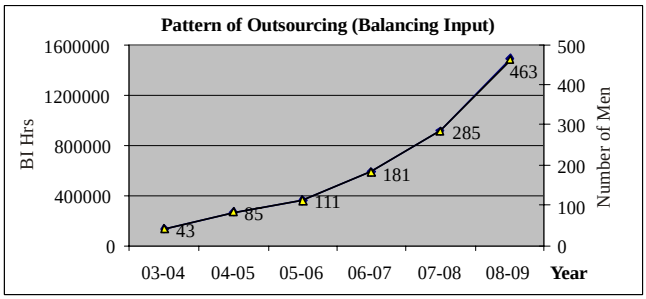

Figure 2: Pattern of Outsourcing in DLW
Source: Files of TA/DyCME/Plg/BI (Balancing input) of 2003 to 2009

STRATEGIC DECISIONS IN OUTSOURCING

Traditionally, DLW used to resort to outsourcing simple, non core activities in fabrication as well as fabrication\machining. This trend was followed till 06-07. But as the target burgeoned, shops were not able to find small items to outsource. Whether to perform specific activities within the boundaries or outside of the boundaries is an issue of ongoing concern to firms *(Rajan Vardrajan, 2009)*. Outsourcing by an organization is triggered by external environment. The triggers can be cost reduction, to increase production/quality levels, focus investment etc *(Canez L E et al., 2000)*. In fact outsourcing is a dynamic process in the sense that the related decisions and actions must continuously be adapted to changes in the strategic direction of the company *(Jesper Momme et al., 2002)*. Decisions were

required to be taken to make or buy an item to achieve the results. Top management reviewed the policy of outsourcing and decided to outsource new items. For 07-08 onwards, items covered hitherto under core activity category, like underframe, engine block, main base; camshafts etc. were included in outsourcing list. Each of the core activity items was labour intensive, e.g. an underframe consumes 4500 hrs. Hence by outsourcing these items, large capacity could be created in one go. But at the same time extensive vendor development efforts were required and planned.

Parel workshop started helping DLW in 05-06, by supplying a few machining and fabrication items. Management then saw a greater role for Parel workshop as a supplier of underframe. In 07-08, Parel's role was expanded as engine and loco assembler and strategic partner of DLW for supply of locos to railways and non railway customers.

Parel workshop had limited capacity to assemble diesel engine. Due to stiff targets DLW also did not have capacity to supply engines to Parel for assembly in locos. At this point, another strategic decision was taken. DMW, Patiala, was entrusted to supply assembled engines to Parel at the rate of two per month. These decisions were crucial in increasing the outturn of DLW, by creating huge capacity and availability of complete locos. By 08-09, contribution of Parel increased to 33 locos, about 15% what DLW produced.

Outsourcing to Parel Workshop

Parel workshop's primary job was to undertake periodic overhauling of diesel locos. As periodicity of overhauling of locos increased from 6 years to 8 years, surplus capacity got generated in complete range of activities required for locomotive overhauling which included engine assembly, loco assembly, and electrical equipment assembly sections. Consequently, capacity in machining, fabrication and forging activities also became surplus.

In 05-06, plans were made to utilize this capacity to support DLW, by off loading fabrication and machining of small items to Parel. By 07-08, this offloading increased to complete manufacture of underframe and assembly of engine and locomotive.

MANUFACTURING TO PURCHASE

In order to generate more capacity, 30 odd items were removed from 'manufacturing' list and made 'purchase' items. These items were small value items to fabricate or machine, but required lot of efforts to fabricate. Components or subassemblies of these items had to be moved to number of load centers. By converting these items from manufacturing to purchase, shop was able to reduce resources and efforts consumed in internal shop movement. For example, bumper support assembly consists of many flame-cut components, which needs to be formed and welded after passing through six different stations. Each assembly has got manpower input of only 3 hrs. Hence, effort was basically in movement of components. By purchasing similar low manpower-high effort type of items, DLW was able to generate about 63000 hrs in 2007-08, equivalent to 20 men's work.

IMPROVING STAFF UTILIZATION

Staff can be generated by improving the utilization of available staff. Various ingenious productivity improvement and wastage reduction methods were planned by production shops. By better management, it was ensured that the staffs were fully loaded. To take care of staff, welfare measures, such as redressal of grievances, availability of safety equipment, fast payment of dues etc. were efficiently managed. Deserving staff were awarded suitably from time to time.

PLAN IMPLEMENTATION

The rules framed by government are such that financial decision making requires many departments. In other words decisions are taken by a team representing diverse departments like purchase, finance, design etc., a suitable cocktail for conflict. A diverse group in an organization which emphasizes the values of respect for people and team orientation will be more likely to generate positive affect, and be low in relationship conflict *(Chuang You-Ta et al. ,2004)*. Need of a visionary leadership have been emphasized by many authors for acceptance of the

targets, subsequent planning and working towards realization of the targets. Leadership in strategic sourcing planning is crucial not only in setting and communication clear objectives and targets but also in motivating and rewarding employees to improve performance *(Chan, Tony C.T. et al., 2007)*. DLW was fortunate to have a leader with a vision to make the organization capable of meeting stiff targets. All the departments of the organization were reinvigorated with energy so that steps were taken by each of them to reach new highs. Every one took initiative to maximize utilization of available resources like man power, material and machines.

Production division is the core activity area where the actual loco production activities are undertaken. There was always resource constraint of material and manpower. By assimilating all the constraints, production division manufactured the locos as per the enhanced targets.

The Top Leadership

'Where there is a will there is a way', acceptance of target was the first move, which started with the belief of General Manager, the CEO of DLW, of achieving the targets. In turn he convinced top management, consisting of Chief Mechanical Engineer, Financial Advisor, and Controller of Stores that the targets were achievable. Each department was to be revitalized to rise to the occasion. Organizational value congruence reduce conflict by increasing the degree to which members identify with each other *(Chuang You-Ta et al., 2004)*. GM, DLW was able to imbibe the organizational values and objectives in his team so that all the departmental heads were able to dovetail their efforts to the common cause of targets.

Heads of the various departments, like production, personnel, stores, design, finance, accounts, civil and electrical started action in their respective departments. Charismatic leader assesses the environment for growth opportunities for his/her respective organization, criticizes the status quo and proposes radical changes in order to achieve organizational goals. *(Jens Rowold et al., 2007)*. GM/DLW led the team from front by demonstrating the charismatic leadership qualities. He was able to sense the environment of growth for DLW and its employees He formulated a strategic vision for the organization by increasing the production through strategic decision making and vitalizing operational decision making.

Leadership processes that are most likely to add significant value at higher organizational levels involve indirect and systems-wide influence. This type of leadership provides direction and influences managers both in upwards and downwards *(Stephen J Zaccaro et al., 2003)*. GM provided system-wide direction and influence. His ability to lead from front led to involvement of staff and supervisors alike. He was able to get the project sanctioned form Railway Board at a very fast pace.

GM made his agenda of increasing production by improving productivity, cost cutting, outsourcing, developing vendors, resolving quality problems and exercising his powers for smooth sailing of all. The dimensions of lateral trust (trust between employees) are positively related to the dimensions of organizational innovativeness. People are more likely to make efforts to innovate (by generating ideas and helping to implement them) when they have experiences of reasonable and positive responses from others. This is related to trust among employees *(Clegg et al., 2002)*. GM used to spend daily 2 hrs on the production shop floor and another 2 hrs in other departments. During Shop floor visits, he used to meet officers and supervisors and most importantly the staff who, were actually working on the locomotive or its subassemblies. He used to discuss on methods of production, simplification of processes, devising alternate processes, design simplification, usage of alternate material etc. with the staff. Production staff is the best person to comment on the processes and design, from the point of view of manufacturability, alternative processes, maintainability and very important, accessibility of parts for maintenance after assembly on the locos. The staff also got motivated as they felt that their suggestions were being valued. Mutual trust amongst staff was reinforced by the style of cooperative working of the leader.

The GM ensured that, subsequent to shop visits, in next 2 hrs the problem and solution discussed on shop floor got implemented in design office or procurement cell. Then next day GM himself informed the staff that actions initiated on one's suggestions. The speed of the leader is the speed of the team *(Patra Pradeep, 2009)*. The result oriented approach of GM set the ball of improvement rolling. The ball was set rolling. The inertia of any system is greatest at the starting point when the process of change begins to implement. In fact 'zero date' is very important. People think that one particular activity takes six months, pretty long time. Hence, they do not start the activity, may be for months all together.

GM's listening to staff's suggestions was a great change agent and motivator. Similarly, CME and other senior officers led their teams. Motivated staff solved and overcame the nagging problems during production activities on their own and greatly contributed by removing the hindrances and speed brakers to the manufacturing activity. When a complex locomotive consisting of more than 7000 parts is getting manufactured with an arrangement where, large number of these parts machined/fabricated at different places, there is always a chance some thing or other will not fit. Staff's attitude of doing the work correctly with available resources was the greatest single pro-production factor.

Involvement of top management increased the speed of decision making. Inter-departmental decision making became very fast, bureaucratic delays were drastically reduced. The leadership's faith in acceptance of targets and their ability to motivate & invigorate the organization was one of the most important factors for the success of DLW.

Unions and Staff

Before year 2000 the unions were of the view that everything should be made in-house, so that staffs' incentive is safe. Unions had a very narrow view, that we would make only that much for which we had capacity. Overtime was also prevalent in that era, which constrained the minds of staffs and unions to work to rule. Reduction in targets from customer, i.e. Railway Board, resulted in change in attitude. Stoppage of overtime further cleansed the mind of unions and staffs. Now, the management had upper hand. The option was clear to the unions either to work for upliftment of DLW, be part of development of the nation or lag behind, lose orders and jobs to private parties in coming years.

Period from the year 2000 to 2004 was having bundles of uncertainty. With increase in targets and general pro-privatisation scenario in the government sector, perception of unions changed. The change in perception was very positive. Unions became target-production oriented. They never objected to policies of outsourcing while ensuring that the present staff does not lose incentives. During their speeches, the union leaders spoke of saving DLW from falling production levels. They exhorted staff to work hard and increase production.

In nut shell, the union had been very positive and progressive towards the policies and became change agents to the progress and achievements made by DLW.

Human Resource Initiatives

Due to heavy retirement, the reduction in staff strength was sharp in the period of 2000 to 2005 when it reduced from 7481 to 5858. Since, government was showing unwillingness to increase the staff corresponding to higher targets and induct large scale manpower; only trickle manpower could be arranged. From calendar year 2005 to 2008, 1166 staff of DLW retired. During this period only 1057 staffs were inducted. (Ref-for Recruitment data DLW/P/Recruitment data, for Retirement-Retirement register from DLW data base).

In 2004-2005, 2151 staffs were employed in direct production. During the period 2005-2008, larger proportion of staff was posted in production shops than non-production areas. Staffs of helper category were redeployed from non production area to production area. Hence, the staff strength of production shops increased to 2343 in 2008-09.

Staff management in a production unit is a complete subject in itself. Large number of labour is concentrated at one place; about 40% of the total, 6000 staff, is available

in the production area. Due to lot of outsourcing redeployment of staff became necessary. The productivity of staffs was also increased to some extent through various ingenious steps were taken.

Stores

Purchasing should perform a number of activities to satisfy the operational requirements of internal customers, efficiently and effectively. Purchasing need to develop integrated purchasing strategies that support organizational strategies *(Monczka et al., 2007)*. Purchasing is a significant aspect of total cycle time of material procurement. Supplier selection, procurement transaction process, and nature of firm's relationships with supplier affect the total cycle time *(Billy N et al., 1997)*.

In DLW, the purchase function is performed by Stores department. The demands are generated based on the locomotive production plan, tenders floated and evaluated and purchased orders are placed. As evident, stores department's role is very critical in availability of material and has direct contribution to production

More number of locos to be produced meant larger amount of material to be procured, at a faster rate. Stores department functions under strict regime of rules and policies made by Railway Board. By way of reduction in 'wastage of time' in processing the cases, the stores department speeded up the purchase process, while following the rules. The systems were tightened to reduce delays and increase the speed of the procurement process. . Purchasing in its broadest sense is increasingly recognized as a strategic issue, since in-sourcing and outsourcing decisions have a crucial influence on an organization's success *(Car and Pearson, 2002)*. DLW's purchase department recognized the strategic importance of its function and took steps to increase its efficiency.

Previously, tenders used to be floated about a year before the requirement. Floating of tenders was advanced, by six months. Tenders were floated one and a half years before the requirement. Priority of opening of the tenders was fixed based on the time required for receipt of material against the tenders from the date of tendering. Global tenders were given top priority, followed by long-lead & bulky items and then came the turn of low value items. Minimum ordering quantity was increased to three to five years, for low valued items. Previously the time period for quantity calculations was one year only. Batching/bundling the requirement of three to five years led to increase in value of the tender and attracted the bigger players. It facilitated the better quality of the supplied items by bigger suppliers having better manufacturing facilities. Condition of phased delivery of products was included in the tender documents itself, which ensured that there was no excessive supply of material to DLW to choke the stocking wards.

Increase in steel prices during last two years resulted in non-supply of material by suppliers. Particularly, superstructures and under frames, which are having largest content of the steel were badly affected. The suppliers who bagged the orders at lower rates were not able to supply the material due to sharp increase in the steel prices. The suppliers were incurring heavy losses in each supply. Hence, suppliers' working capital itself was washed out and refused to supply the material. As an emergency measure, fresh tenders were opened quickly and suppliers were asked to supply material in both new and old tenders. Suppliers were then able to supply the material by averaging their costs and balancing their losses in old tenders with margins of the new tenders. Through understanding between suppliers and purchaser, it was ensured that material was available.

Normally, the output of the office staff is not objectively measurable; hence they tend to forget the files pending at their tables. Using the existing information available in the computer center, a monitoring system for the procurement process was established. In the system, purchase cases right from the demand stage to purchase order stage could be monitored, with a fortnightly review at senior officers' level. Summary of files available with the dealers was now available with the officers. Monitoring ensured that files were constantly on move to speed up the decision making.

As a time saving device, in exceptional cases, repeat orders were placed on the suppliers to meet urgent requirements which arose due to failure of supplies from other suppliers. DLW purchases many items from General Motors on single tender. The purchasing of goods required lengthy global tendering system, which used to take long time. DLW finalized a rate contract with General Motors covering 496 items for two years for immediate procurement.

As a vendor delight measure, the material was received and accounted for fast, reducing the time of bill payment within one month. It was ensured that after the material was accounted for and inspected; payment was made against clear bills within three days.

Design

Design division played crucial role in identification and development of sources for the items which were planned for outsourcing, at the same time simplifying the design and standardization of components used on different locos to reduce inventory. (Reference- 'Soochna' technical report of design office, Annual Reports of DLW)

Introduction of microprocessor control on locomotives was a strategic decision. WDG3 locos used to be manufactured with E-type excitation system. In the E-type excitation locos, shop had to make control panel and had to do lot of electrical wiring in the loco. From 06-07, the design of these locos was changed to microprocessor control from E-type control system. Microprocessor controlled locos' control panel was designated as trade item. Hence, lot of electrical and sheet metal shops' capacity was released for doing other work. Another advantage of these locos was that the wiring had less work content.

Each loco is tested in loco test shop. The testing involves running of the loco in simulated and actual running condition. During testing, with older control system the wire testing used to take lot of time. Testing became even easier with the up-gradation of the system with fault data pack up-gradation. With microprocessor control system, testing time reduced from earlier 6 days to 4 days, in-turn increased the capacity of test shop.

Previously, for electrics like switches, contactors, traction motors etc. only one source, BHEL- a government undertaking, was considered. Supplies from BHEL always gave sleepless nights to management. With increase in production it was felt that BHEL may not be able to supply material at the required rate. Then decision was taken to develop few sources in private sector, which required extensive designing and collaboration with the vendors.

There had been supply problems for wheels of GM type of locos, as these used to be imported. Design of these wheels was modified to 'S' shaped wheel, which ensured that the wheels were manufactured indigenously from Durgapur steel plant and available in time for production.

Outsourcing requires extensive search and development of vendors. Design teams undertook visits of likely suppliers, short listed the good ones and worked with the suppliers to develop items at the suppliers' premises. Development of vendors for superstructures, underframe, engine block, main base etc. was the major contribution.

Switching over to stiffer camshafts simplified manufacturing. Suppliers were available in the market for supplying stiffer camshafts, adding new sources. Various types of gears used to be manufactured in house. Sources were developed for proof-machined and finished machined gears. Design of many items was modified to improve manufacturability at shop floor e.g. design of pipes was modified to reduce welding process. Design changes also resulted in development of vendors and absorption of technology available in the market such as fiber reinforced plastic panels for control desk, alternate material/process for gears. Underframes and trucks of WDG3 and WDM3d locos were redesigned in such a way that same truck could be fitted in either of the loco. The postponement feature of truck design gave flexibility to truck frame suppliers and to shops, as they could delay the truck differentiation.

Low value hardware and pipe fittings were bulked under one part number so that reputed manufacturers were made interested to quote, so as to improve the quality of the items and reduce number of tenders, hence time to purchase items.

Finance and Accounts Department

In public purchasing activity, finance and accounts department plays very important role. An indenter views the role of finance and accounts department as negative, just a department to create road blocks in the path of progress. At the same time finance and accounts have to see that public money is well spent. Hence finance has to make the balancing act. Previously, finance department did not appreciate their role and responsibility in meeting the production targets. Attitudinal change was required, which could be brought about by the senior managers, by way of counseling the staff and officers. A simple act of compiling all the check points in a check list reduced the cycle time of dealing with proposals from months to a few weeks. Proposals for procurement or works contract were sent to finance for financial concurrence. Previously as a routine files used to be returned to the proposing department many times, always with new set of queries. Hence crucial time was lost in to and fro movement of files resulting in delays in implementing decisions leading to delayed implementation of projects. The check lists ensured that proposals were made correctly at first place and checked in one go by finance. It also instilled sense of responsibility on the staff of finance department.

Railways being an old and established organization have developed detailed rules for each occasion with constant updating. Whenever a proposal came to the finance department, the staff searched for rules. Time was lost in searches. Finance department compiled the rules on each subject and gave copies to concerned staff so that they could correctly see the proposal in the context of current rules.

Before placement of purchase orders, finance and accounts had to ensure that the rates are reasonable. Since there was fluctuation in prices of steel and petroleum products, hence in many cases prices rose many fold. Large number of new outsourced items did not have last purchase prices. In public purchasing it is very difficult to certify a price as reasonable, more so in industrial goods. As a policy matter, finance decided that based on the merit and urgency of the case, orders for three months requirement would be placed even if the prices seem to be on higher side. In the mean time, indenter and production would get time to design new strategy.

Purchase activities are based on production programs. Production program saw wide fluctuations due to changes in targets or changes necessitated due to non availability of material for some type of locos with manufacturing department. To cover these fluctuations, production program from Railway Board was not available readily. Hence, stores department was not able to generate indents for purchasing the material. To overcome the problem, a policy was evolved where senior finance, production and stores officers jointly issued a production program. Based on the program, indents were generated and purchase orders placed. At a later date, whenever there was change in the program, quantity changes were done during servicing of contracts, by using option of increasing or decreasing quantity, upto 30% in current orders.

Role of Quality Assurance

Quality assurance department is responsible for keeping a check on the quality of items received from trade or manufactured in house. The department played a crucial role in ensuring the availability of right quality of material, through increased number of suppliers.

The quality assurance department was hitherto known as inspection department. To infuse the ideals of assuring the quality of the processes at shop and at vendors' premises level, inspection department was reorganized and renamed as quality assurance department. Officers and supervisors were re-designated as quality assurance managers.

The sincerity of vendors in India is poor, particularly when they supply to government departments. It is the tender system by which supplier are tempted to quote very low and then try to cut on quality front. Suppliers do not do what we expect, they do what we inspect. With increased outsourced items and reduced inspection staff, it was a challenge to inspect all the items supplied by vendors. To ensure quality of all the vendor supplied items, a system of check list was evolved. Based on the customer and

shop feedback, quality points were included in the check list. These check lists were continually updated to cover the quality issues based on the new problems encountered during inspection or shop usage. The check lists were made available to the suppliers so that they themselves could check the items produced and only then offer the material for inspection or supply on their own certificate. In short, suppliers were told about our quality requirements objectively.

It was the initiative of quality assurance department which induced the habit of quality among the vendors and helped them in evolving truly as 'partners in progress' of DLW.

Tooling Division

Tooling items like hand tools and cutting inserts are used in large quantities in DLW. A good quality tool costs higher but gives consistent quality for years. Tooling vendor directory, originally prepared in 2002, was thoroughly revised to weed out poor suppliers based on quality and responsiveness. Further, it limited the number of vendors for each product to few reputed brands of world class quality. For example, vendors for pneumatic tools were limited to only two brands, i.e. Chicago Pneumatic and Ingersol Rand, only. Decision resulted in better quality and easy maintainability of pneumatic tools, by using fewer varieties of spares. Further repair kit concept was implemented. The assets could be kept in good fettle.

Similarly, vendors for cutting inserts were rationalized to a few vendors in each category. Machine operator's preference about the inserts was kept in mind. Cutting tools were now stocked as a set of tool holder, inserts, shims etc. so as to ensure the availability of spares for the special tool holders. Rationalization of inserts and stocking in kits resulted in cost saving as volume of each insert/tool increased to achieve economies of scale.

Though computers were installed in tooling division in 2003-04, however maturity in usage arrived in 05-06, when all tooling designing were switched to Autocad for efficient and accurate designing of tools. Tooling/Jigs designing is a complex process and manufacturing them is even more complex. Output of operators working on manufacture of jigs is difficult to be measured. Hence the productivity could not be monitored. A system of grading the jigs, based upon the complexity was developed. Weightage was assigned to different operations such as drilling, milling, hand lapping, grinding etc. based on difficulty, skill and time required to perform the operation. By new system, each jig was given 'complexity number' (written as unit count on the drawing) during design stage itself and it became the basis of measurement of the output given by the staff. Effective monitoring resulted in efficient tool and jig manufacturing.

MANAGEMENT BY PRODUCTION DIVISION

Production division is the front line organization where production activities are undertaken and managed. Production division ensured that the resources are fully utilized, productivity improved, process simplification resorted to and most suitable items identified for outsourcing. Researchers have also emphasized the need of viewing sourcing strategy as bottom-up redesign of underlying processes rather than a top-down management tool to ensure strategic direction and employee commitment *(Jesper Momme 2002)*. Identification of items for outsourcing is a strategic decision which requires in depth knowledge of manufacturing technology and associated processes available internal and external to the organization. Production team is equipped with the required knowledge. Moreover realignment of resources of shops is required once the outsourcing materializes. Hence bottom-up approach is preferable.

Staff management incorporated productivity improvement measures, waste reduction and superior man management methods like multi-skilling, rotation, floating staff etc.

Reduction in 'Overhead Staff'

The shop staff is categorized as direct worker (dw), essentially indirect workers (eiw) and non –incentive (ni) staff. Direct workers are those involved in direct production work, essentially indirect workers are those who help the direct worker in giving production by monitoring supply chain within DLW, machine and plant

maintenance, tooling etc and non –incentive staff are the one's who do sundry jobs.

For doubling the production large numbers of staffs were required. To generate staff, efficient staff management was resorted to, by reducing the number of eiw and ni. It was done by zero base assessment of the staff required for other than production work. The productivity of eiw and ni was increased by better tooling, protective equipment, material handling equipment, environment, measuring and test equipments and off course loading the staff to full of their capacity. Due to these efforts eiw reduced by 165 (14%) and ni by 93(66%) in 08-09 with respect to 01-02. Reduction in dw was only 6.7% during this period. In 01-02, only 102 locos were produced and in 08-09, 224 locos were produced. Hence it is apparent that manpower was so managed that dw were reduced least where as overhead causing eiw and ni were reduced to greater extent.

Productivity Improvement Measures

To increase capacity of a plant, productivity improvement is also one of the important methods. Though most of the processes in DLW were quite old and established leaving meager leeway for improving productivity, yet shops were able to reduce 275 hrs/loco, equivalent to 13 men /year, during 04-05, in existing processes, working out minor changes only.

From 04-05 onwards, major contributor of productivity improvement measures was the time study of new processes. Time study was resorted to whenever there was change of design/technology/machine. Job timings were allotted on tighter side. The time study was done with the premise that staff would have to work at least 6 hrs for hard jobs like welding and 6.5 hrs for less hard jobs like fitting/machining jobs. The shop staff had been very cooperative and supportive to take up the responsibility in improving productivity. A new axle turning lathe was commissioned in Nov'07. The commissioning activity was completed very fast and the machine was put into production in Dec'07 itself. The rate of production with the new machine was benchmarked at 2.2 axles per shift compared to 1.5 axles with older machine, resulting shooting up of 50% on productivity. Commissioning of axle turning lathe increased the production of axles and eliminated dependence on Parel workshop for the axles. Similarly the productivity of new wheel turning machine was kept at 25% higher than the old machines. These machines broke the legacy of inefficiency in the commissioning and time study of new machines.

Policy of strict time study is evident from the allotted time for new activities. For example, allotted time for similar activities of underframe manufacture, loco assembly, truck assembly, testing, painting etc. for WDG3 loco is 19600 hrs and that for WDG4 is 12400 hrs. Discounting for more purchase items of WDG4 locos, an improvement in productivity is almost 15%.

Waste Reduction Measures

Waste eats up lot of effort, manpower, machine capacity and material. Wastage of capacity in production is broadly categorized as - replacement hours and idle time. A 'replacement hour' is the time required to correct or repair a defective component. 'Idle time' is the time for which staff wait for work due to non availability of raw material, machine, power etc. So a replacement hour is the indicator of poor quality and idle time is the indicator of labour wastage. Both wastages consume manpower, the asset already in short supply. According to *K. Kirsten Schliephake et.al., (2009)*, - many businesses are able to reduce the waste disposal requirements and associated waste costs through a combination of various schemes such as: cleaner production initiatives; source management of waste streams and; supply chain partnerships.

Reduction in defined wastages required tremendous efforts at shop floor level and to some extent at supplier end. Close monitoring of these indices and study of the processes contributing these wastages was the key to success. Quality problems requiring rework were recorded in shop supervisors' register. The problem was studied by officers and staffs. Epidemic and critical problems were discussed in the morning production meeting chaired by senior officers.

Staff and supervisors were motivated to control the process, modify the methods to enhance the quality of the product. "Do it right, the first time" motto was explained and engrained in the minds of staff. Reduction in replacement hours by 27% over 04-05 in 08-09 was achieved (from 43633 hrs to 31686 hrs, file ref MPLO/I&L/05). If one considers the production level, resultant reduction amounts to 64% in terms of replacement hrs per loco.

Idle time could be reduced by optimal utilization of manpower. It required both reduction in the failure of machines and flexibility of manpower. Supervisor and staff were alert. Whenever there was a failure on account of machine, staff was shifted to another machine or to similar machines. On several occasions, the staff was booked in third shift that too at short notice. Idea was to never let the staff wait for work. Idle time was reduced by 38% from 98908 hrs in 2004-05 to 60637 hrs in 2008-09 (file ref MPLO/I&L/04).

Reduction in replacement hours and idle time was equivalent to generation of 24 staffs. Bad effects of both replacement hrs and idle time are not just limited to loss of manpower, but biggest ill is that these activities hold up the production as production line is stopped to take corrective action. Hence reduction of these roadblocks in production was stressed.

Innovative Measures

The productivity improvement is a never-ending journey. By carefully planning and execution, the painstaking investment in the initial cost, effort, and people may be rewarded by overwhelming results. The dimensions of vertical trust (trust between employees and leaders) are positively related to the dimensions of organizational innovativeness *(Ellonen Riikka et al., 2008)*. Change must involve people and must not be imposed, plan the actions, establish communication channels are some of the process commandments for improving the productivity *(Patra Pradeep et al., 2009)*. Production division, followed these commandments, designed and executed innovative measures, resulting in increased production.

J. E. Ettlie and E.M. Reza (1992), suggested that successful organizations use integrating mechanisms of two types to capture the value from process innovations, making process innovation a unique occasion for significant restructuring and; creating effective new patterns from the many alternative ways of accomplishing these changes. Although shops had constraints of limited manpower resources and irregular supply of items from trade yet they utilized the staff completely by devising innovative measures, improved the processes and production, hitherto unknown in railway's governmental parlance. Some of the measures are as follows

- Availability of material was not always uniform. There were always shortages of material in first few months of a year in the assembly area, due to consumption of material at a higher rate, towards the end of the previous year. Material problem also occurred due to shortage of items supplied by new vendors as these suppliers were passing through development phase. It resulted in excess capacity or idling of staff on one occasion and manpower capacity constraints at the other.

- In 05-06, a new method of staff utilization was implemented in sheet metal shop. For first six months full strength of staff was deployed in Sheet Metal Shop, to advance manufacturing of superstructures. When material position in assembly area improved, 30 sheet metal shop staffs were transferred to underframe and assembly area to increase production. Temporary shifting of staff became the norm to tide over the manpower constraints in the localized area of shops.

- Similarly, few artisans of Truck machine shop were made flexible and floating in the sense that they were transferred to assembly or underframe area where ever capacity constraint was noticed.

- As more and more outsourced material started trickling in, production level of sheet metal shop, which used to produce superstructures of the order of 15 locos/month, was truncated to produced only 2 locos/month of outturn. The man power so saved was transferred and utilized in underframe shop and loco assembly area. Closure of Sheet Metal Shop was a strategic decision. About 60

men were generated by this decision. Now the shop makes items just sufficient to keep the CNC machines operational and to avoid complete wipeout of skill of fabrication of superstructures.

- Though large numbers of items were outsourced from Sheet Metal Shop and Underframe shop, but outsourcing did not guarantee availability of material. Suppliers had their hands full with outsourced items. Sharp increase in prices of steel added to supplier's perils. Hence many a times in spite of continuous monitoring and chasing, material was not available. Shops used to make lot of hue and cry for the material, but at the same time dexterously used the flexible capacity developed to fabricate items in the shop itself as a stop gap arrangement. Floating gangs of fitter and welders were developed by withdrawing few staffs from different sections for specific periods. Hence DLW was able to navigate through dry spells caused by material shortages.

- In each shop section a few staff were motivated and trained to work as fitter and welder. The move was very helpful, in particular, in fitting jobs where welder was required for 'tacking' purpose only for a while. For remaining time the welder used to wait for work. Now only fitter could do the job.

- Similarly machinist of general purpose CNC machines and that of conventional machines were trained in operation of at least three machines. It ensured flexibility in operation of machines, clearing load centers, reduction in idle time. Idle time, which was due to break down of machines, was reduced, utilization of manpower was optimised and continuous incentive to staff and production to organization was ensured. Though staffs were initially hesitant to follow flexibility, but realised the importance of multi-skilling for DLW and for themselves

- DLW's Technical Training Center trains act-apprentices for 2 years. These apprentices are not railway employees. Usually these trainees are given training in laboratory conditions. As an unconventional method 80 trainees were booked to work on locos, as on the job training for one year. These trainees worked as regular employees and gave production. As per documentation procedures trainees' outturn could not be taken on books, and all the work done by them went unaccounted for. However, this deployment removed the bottlenecks occurring due to staff shortage. Normal working of shops envisages group working by two to three staffs. If one or more staff was on leave or absent, the remaining staffs' become idle or their efficiency went down drastically. The Shop used these trainees to strengthen the existing gangs, where they helped regular staff in material handling, fitting and welding type of jobs. By utilising trainees, shops were able to maintain the production all time of the year by drastically reducing the impact of leave or low attendance of regular staffs.

- Practically in all manufacturing systems problem of unbalanced production line exists. To balance the production line, more staff was employed at the point of constraints. Many a times it resulted in overstaffing at bottleneck point and finally resulted in loss of manpower due to lack of working space.

Such points were identified and staffs were booked in 3rd shift, e.g. in block, underframe, truck machine shop, CNC machines and light machine shop. It ensured that infrastructure and manpower were utilized completely. It ensured that no staff was waiting for work, thus reducing idle time and increasing production. Introduction of 3rd shift required additional staff. Gang strength of the working gang was critically analyzed. Optimisation of gang strength was achieved by introduction of fixtures; change of assembly process or simply by breaking large gangs into small ones. Then staff could be spared for 3rd shift operation. Reduction in gang strength resulted in shortage of staff at some points. The depleted gangs were strengthened by providing trainees. Another practice of unifying the gang members, on day to day basis, with other depleted assembly gangs was resorted to, which could be achieved by better management and flexible utilization of staff.

- The processes can be improved to reduce the rejections. The effective improvement procedure involves selection of the problem process, understand it, measure it, execute the improvement and review the improved process *(Lee K T et al., 2001).*

Increase in capacity was also achieved by improving processes, there by reducing rejections. Shops truly fulfilled its responsibility by improving the quality of manufacturing process. For example, detailed study of camshaft manufacturing processes resulted in reduction of rejections from 11% in 2005-06 to 6.5% in 2008-09. Similarly, rejection and/or rectification of machined and fabricated items were reduced resulting in overall reduction in rectification hours. The reduced rejections increased shop's capacity and smoothen the production belt.

- Shops assisted management in selection of items for outsourcing. Cylinder head for engines are complex castings. Quality of casting has got great bearing on the quality of machined product. Each head passes through 15 different stages. Rejection at any of the stage causes complete rejection of the head losing up to two months of work. Cylinder head machining was considered as core activity. The rejection rate at machining itself was more than 5%. Another 5% heads used to get rejected during hydraulic testing. Hence, a lot of effort was being wasted. A strategic decision advised by shops was to outsource cylinder heads to casting suppliers, so that defects are controlled at suppliers end. By outsourcing, large numbers of machinists were now available for production at other machines.

- Similarly shop identified items which were low in manpower content and criticality and could be outsourced without jeopardizing the product quality. For example, control shaft consists of 35 small items; each item goes to many load centers. For manufacturing, each item was to be moved within the shop every shift. If one of the items hits a bottleneck then engine assembly used to wait for the control shaft.

Production Control and Communication Meetings

Communication plays critical role in an organization whether it is vertical or horizontal. Downward vertical communication can stimulate employee commitment. Further, it is much more effective to build on freedom and motivation of employees *(D Charvatova et al., 2006)*. DLW as an organization has matured to communicate in all directions at operational level. The seamless flow of information was made possible by the General Manager. Direct contact of General Manager with officers, staff and supervisors, as detailed in leadership paragraph resulted in excellent flow of information. The freedom to staff and supervisors to communicate and propose changes in manufacturing processes energized the production team.

At shop floor level, daily meetings were conducted in the morning on production issues. These meeting were modified to deal the extended issues concerning quality, safety, environment and process development. Efforts were put in to foster team working. Fighting supervisors were persuaded to settle issues bilaterally before start of the meeting. It resulted in competition among supervisors that they should not get a bad point in the meeting. Stress was on the completion of the job on requests of one another without the intervention of higher officers. The culture of cooperative working gave rise to sense of ownership of the shop to the supervisors. Cooperation and ownership resulted in automatic removal of production problems in-situ and helped production enormously. 'Ownership as a motivator' has been studied by many authors. Researchers have concluded that ownership improves productivity *(Jonathan Michie et al., 2002)*. Though in government industry's context, ownership stands for giving certain degree of freedom to decide and work.

Communication gap between supervisors is dangerous as it results in lack of focus on priority. Supervisors and their team of staffs tend to fall apart. There is always a suspicion about manager's decision, lack of clear direction, results in lack of ownership in decision and interest at shop floor.

Wal-Mart encourages some forms of organizational citizenship behavior such as keeping coworkers informed and suggesting organizational improvements *(Saporito, 1992)*. One such step was introduced consisting of a system of conducting short meeting amongst supervisors, headed by the senior most supervisor, just after lunch in each shop resulted in removal of all communication gaps

between supervisors. It gave further impetus to theory of ownership to supervisors. They served as process drivers. Problem solving was done at the shop floor level. Decision making became fast. Critical time was saved. The efforts of all the staff and supervisors then became focused to achieve production targets. Hourly rather minute to minute monitoring by supervisors was emphasized resulting in optimal utilization of staff and assets.

Quality of Consumables and Hand tools

Quality of consumables such as electrodes, paints, tool inserts etc has great bearing on quality and productivity of workers. Similarly, quality of hand tools determines productivity, working conditions and quality of the product. Many strategic decisions were taken by shop which resulted in sourcing of quality consumables leading to quantum jump in production and quality of product. Electrodes, paints and tools were the major contributors.

Vendor directory published by railway's research organization, RDSO, lists numerous suppliers and includes few suppliers having world class quality of electrodes. By utilizing its own experience of electrodes of different brands, DLW developed an independent vendor directory in 2005, so as to limit the number of suppliers to only three-four suppliers per electrode with consistent quality.

DLW had been living with problems, like rework in block, for the last many years. Rework had become part of production activity in many processes. Solution to block problem also gave impetus to the idea of reviewing the processes even though they may have been in use for many years. Each shop checked the processes where high rework was being done.

Engine block fabrication involves usage of 6.3 mm electrodes to AWS 6020. Prior to 2005, shop was using different brands of electrodes to the specification. To check the quality of the weld, block is radio-graphed three times. About 80% of the blocks fabricated using these electrodes had high rework content. In many cases block had to be repaired and radio graphed two/three times. For doing rectification, block had to be moved to different bay, reworked and then again brought to first bay for radiography. The process was repeated until defects were eliminated. Rework cycle used to take three days for each rework, resulting in huge work in progress inventory, blockage of fixtures, loss of production to rework and poor quality. The low quality electrode used to cost about Rs. 9 per electrode. The rework used to involve about three days per block plus man hours used in rework. Decision was taken to purchase the electrode as proprietary item from one manufacturer directly. After that only 3% blocks need rework, instead of previous figure of 80%. Though the cost of the electrode increased to Rs. 17 per electrode, but the reworking time of block reduced to almost zero; the reduction in intra-shop movement of block, release of fixtures, space and manpower for block production has much greater value. The reduction in rework in block manufacture was a major contributor in doubling the outturn.

Paint shop used to take lot of time for painting of locos, even then loco painting quality was poor. In winter and rainy seasons, due to slow drying of paints, quality further deteriorated. The prices of paint in DLW were about Rs. 80 per litre in late nineties and still more or less same in 2006-07 even though the prices of petroleum products had at least doubled. What happened was that, local manufacturers entered the supply system. At the cost of quality, they reduced the prices. Poor quality paint was oily, low in weight/volume, poor in consistency, took lot of time in drying, and gave non uniform surface finish. Net result was poor finish and bad name for locos and DLW. In 2007, management took a decision to purchase only branded paints from leading manufactures that were listed in stock exchange. It reduced the painting cycle time to 3.5 days, with quality surface finish.

STAFF WELFARE AND GRIEVANCE REDRESSAL MECHANISM

Like every organization, DLW had detailed staff welfare and grievance redressal mechanism. Over the years these mechanisms were confined to books only, as it happens in practically all industries and particularly government departments. Business faces a set of critical human problems salvation lies in the hands of human resource

specialists themselves, who must switch from being administrators and huggers to value-generating partners. Human resource departments must start by re-engineering their own staff *(Jac Fitz, 1997)*.

Under the leadership of CME/production, the officers and staff of personnel department cleaned the system and developed it into a well oiled system. Staff promotions, transfer and seniority issues were efficiently dealt. Disbursal of loans for motorcycle and house were made transparent and fast. The motto of personnel department was that staff should not come to chase their personnel matters; rather they should concentrate on their production activities only. A new system was introduced by which passes, the authority to travel free in trains, were delivered to the staff at their work place itself, instead of personnel office. This saved lot of time and irritation to the staff.

Similarly, grievance registers were maintained at the shop floor level. Welfare inspectors and personnel officers used to go to the shop, collect the grievances, which also included all pay matters like increments, incentive payments, allowance payments etc., redress it and gave feed back to the staff. Problems pertaining to personnel department affect payment aspects of the staff. Hence, payment problems were likely to demoralize staff and their families. Removing these problems all together gave peace of mind to the staff and acted as a great motivator. Family support also increased. "The feel good" factor lifted the enthusiasm and production.

OUTSOURCING AS CAPACITY ENHANCING ACTIVITY

Capacity of the DLW was increased by outsourcing large quantity of items. Increased outsourcing resulted in increased dependence on the suppliers/vendors. Effective sourcing requires organizations to coordinate sourcing requirements, activities and decisions across the enterprises in order to maximize buying leverage and supply performance. *(Minahan T.A., 2003)*. Simply placing purchase order on some supplier does not ensure that material will be received in time. Vendors need to be assisted, developed and looked after. Vendor development effort in superstructures, underframe and block machining were elaborate owing to the complexity of components. Close coordination with Parel workshop, which acted as a vendor to DLW, was ensured to utilize their capacity to the advantage of DLW. Integration of corporate strategy and sourcing strategy is positively associated with manufacturing capabilities of supplier *(Morgan Swink et al., 2007)*. Hence, all outsourcing decisions were linked to the available or developable manufacturing capabilities of the suppliers. The purchase process consists of five phases; identification of needs, formulation of decision criteria, supplier identification, supplier selection and contract, management & monitoring of contract. Outsourcing should be viewed as transition of responsibility from user organization to contractor *(Kakouris P. Andreas et al., 2006)*. The transition phase of the outsourcing methodology is characterized by transition planning, organizational planning and transition of service. Outsourcing and purchase related decision making was structured according to these phases to ensure smooth transition of responsibility from DLW to suppliers.

Vendor Development Activities of Critical Outsourced Items

Supplier development was pioneered in the automotive industry. Companies such as Toyota and Honda are masters at supplier development initiatives *(Liker and Wu,2000)*. They have long since recognised that the supply chain is only as strong as its weakest link and therefore invest time and money into developing suppliers' skills and capabilities. Supplier development is anchored firmly in both the customer's and supplier's organization, leading to joint team structures *(Hartely and Choi, 1996)*. To this end the buyer must become involved with the supplier in training and education in order to address skills gaps. This requires a fundamental shift involving behavioural changes in the customer-supplier relationship *(Dale et al., 1994; St John and Heriot, 1993)*. Expected outcomes of supplier development programmes include, improved efficiency and reduced costs through information sharing, communication, joint-problem solving and risk-sharing *(Quayle, 2000; Handfield et al., 2000)*,

as well enhanced supplier performance in terms of technical, quality, delivery *(Watts and Hahn, 1993)*. Success or failure may be determined by the degree to which the organizations display a co-operative culture, the quality of the relationship and the strategic importance attached to supplier development by both the customer and the supplier.

As detailed in balancing input paragraph, management decided to outsource items which were hitherto considered as core competency area. These items required special manufacturing processes involving special purpose machines, extensive fixtures and skilled labour. None of the vendors in India had facilities and technology for producing these items in their factories. Most of the vendors had capability to manufacture similar items, using general purpose machines and fixtures which were not sufficient to develop & supply the items to DLW in a series production environment. These vendors were not inclined to invest heavily in infrastructure and tooling. Hence, concerted efforts were required to develop the source by imparting the technical know-how and controlling the processes of the vendors.

Processes involving some of the critical items are listed below.

SUPERSTRUCTURES

Outsourcing of superstructure started with purchase of small quantities of long hood and cab, in 04-05. From 06-07 about 50% of requirement of each item was outsourced as balancing input. With increase in targets, the balancing input quantity was subsequently increased to 100%, in 07-08 and sheet metal shop was almost closed.

Outsourcing required tremendous supplier development efforts. The detailed manufacturing drawings of the superstructures were given to the supplier. Supplier's leading skilled persons were given training in the fabrication process at DLW. The fixtures and tooling used were shown to supplier. When actual production started at suppliers' site, design and shop supervisors were deputed to supplier's works. The final products were thoroughly inspected by inspection and design /shop supervisors. The products were used on locos in controlled conditions, where user of the products noted the defects & deficiencies of the superstructures. These defects were informed to the supplier. Reduction in defects, in turn, reduced the time required for fitment of outsourced items during loco assembly.

UNDERFRAME

Under frames of WDM3D and WDG4 were outsourced to M/S TGS and M/S Technophobe. Under frames are the heaviest and complex items weighing about 20 tons. These are about 20m long and 4 m wide structures. An underframe takes up the load of diesel engine, alternator and other equipments. It transmits and absorbs practically all tractive, buffing and braking forces acting on the locomotive. Supplier development was the key issue in this item. Training of skilled staff and supervisors of supplier, both in DLW and in the supplier's workshop, was done by the DLW design and shop teams. Know-how of tooling, jigs and fixtures was imparted to the supplier. Supplier development activities were more rigorous than superstructures due to the complexity of the underframe. Frequent visits of suppliers' works were resorted to.

Under frames of WDG3 type were outsourced to Parel wokshop. Under frames of WDM3D were outsourced to trade. 19 WDM3D under frames were received in 07-08, which gave the much needed impetus to the production capacity. During 08-09, 30 WDM3D and 60 WDG4 underframe were outsourced, but DLW had limited success in WDG4 as trade could supply only 15 WDG4 under frames.

Though full quantity was not received from trade, even then this capacity generation gave much of the flip required for meeting the targets.

CYL-ENGINE BLOCK ALCO DESIGN

Engine block for 16 cylinder engines is a structural steel design component where pistons, cylinder liner, con rod assembly; crankshaft assembly and camshaft assembly are assembled to make a complete power pack. Block is a complex structure, weighing 5.5 tons, consists of saddle

forgings and micro alloyed steel plates up to 75 mm thickness. It involves X-ray quality welding. Fabrication calls for robust jigs and fixtures as well as heavy duty overhead cranes for transportation during different fabrication and machining stages. Fabrication also involves different stages of intermediate machining and radiography inspection of the weld joints and it takes approx. 1072 hours of fabrication and 636 hours of machining. Fabrication and partial machining had been out sourced in a view to develop alternate source as well as to save man & machine hours in DLW.

Manufacturing of block was a core activity, involved heavy special purpose machines and skilled manpower. A developmental purchase order for 40 nos. 16 cylinder engine block (fabricated and envelop machined) was placed on M/s TGS/Jamshedpur for the first time in the history of DLW. To start the fabrication of 16 cylinder engine block in time, DLW had given raw materials of IS: 2062 Gr.C to M/s TGS as the material was not readily available in the market. All necessary drawings of jigs, fixtures and templates were also given to the firm to manufacture necessary jigs and fixtures for fabrication. During fabrication of 16 cylinder engine block, DLW officials visited the firm regularly and gave technical know-how to the supplier.

Block shop has capacity constraints in planner jobs. Block manufacturing requires extensive machining of subassemblies and that of fabricated block on planning machines e.g. topdeck, main base and spline. Spline used to be purchased in solid billet form and then it used to be machined in DLW. To remove the bottleneck, spline was converted to proof machined item. Main base, top deck, turbo support etc were outsourced. This activity helped in doubling the production of ALCO blocks.

EMD CRANK CASE MACHINING

Similar to Alco block, Crank case or engine block for 16 cylinder engine of EMD locomotive is also a complex structural steel design, consisting of main frame member forgings and micro alloyed steel plates up to 30 mm thickness. This complex structure is made up by Ultrasonic quality welding of these components. Fabrication and final machining also involves different stages of intermediate machining and ultrasonic & radiography inspection of the weld joints. To achieve the precise fabrication and machining, special processes and machines are used.

GM engine block machine could not be commissioned in time. Fabrication of block started in 06-07, but machining activity started in 07-08, even that at very slow rate of 1 block per month against requirement of 5 blocks. On the other hand shop had capacity to fabricate 3 to 4 GM engine block but did not have capacity to machine. To meet the production requirement, the machining of the block was outsourced. DLW provided fabricated crankcase to the firm and it supplied machined crankcase to DLW.

Initially, M/s HMT Hyderabad was the only single indigenous source for machining of the item. With changing fortunes of Indian economy, HMT's spare capacity for DLW dwindled to zero by May'06. Therefore, further developmental order for machining of 10 Nos. Crank Case was placed on M/s TGS, Jamshedpur. To start the machining of GM Crank Case in time, M/S TGS was assisted in development of required jigs & fixtures. DLW formulated detailed process plan for machining of crank case. DLW's technical team frequently visited the firm and discussed the problems & gave assistance to the firm.

Parel Workshop

Parel workshop is under administrative control of Central Railway and has vast experience of overhauling the locos and fabrication of small items. Although it is serving in very small numbers, narrow gauge locos have also been produced by this workshop. Parel workshop played a great saviour in 07-08 and helped in increasing the loco production capacity of DLW. It was a strategic decision to rope in Parel workshop to make items for DLW.

In 05-06, Parel workshop started manufacturing few locomotive components and supplied to DLW. The role of Parel was then limited as a back up supplier over and above whatever planned from shop manufacturing or outsourcing. The list included axles, wheels, equalizing

& compensating beams, battery boxes, camshafts, hardware type pins, spline and top deck machining, etc.

The capability of Parel was then assessed and it was entrusted to develop fabrication facilities for underframe. An underframe weighs about 18 to 20 tons and consumes about 4500 man hours. Hence, it was a big item for resource generation. As a trial measure, underframe for WDG3 were outsourced to Parel workshop, Mumbai. Soon Parel developed capacity to manufacture WDG3 underframe. 12 underframes were supplied in 06-07, which could be converted into loco by DLW. Manufacture of underframe picked up to 23 and 21 in subsequent years.

Development of underframe required frequent visits of staff and supervisors to Parel and vice versa. As Parel did not have facilities for flame cutting and shearing of plates and sheets, DLW provided cut sheets and plates to Parel. From 07-08 these cut items were outsourced as 'kit for underframe' and directly supplied to Parel. Kit consisted of 210 assorted items, each item weighing from few kg to 2000 kg. Such strategic decisions helped railways to develop another diesel locomotive manufacturer in Indian railways, which can now manufacture underframe, assemble engines and locomotives. All the material for manufacturing was purchased and supplied by DLW.

Owing to development of loco assembly capability at Parel, it manufactured 1 loco in 06-07, 12 in 07-08, and 33 in 08-09. Hence production targets set for DLW could be achieved. Parel manufactured WDG3 and WDS6 locos. All the WDS6 locos were manufactured at Parel workshop and supplied to non railway customers, for which commissioning and servicing back up was required to be provided by railways. The target for WDS6 was about one per month. If a loco was to be manufactured with the proposed speed, it would have been costly and cumbersome affair at DLW, because mind-set of manpower and systems were set for larger volumes. Strategic decision has relieved DLW of the pain of manufacturing, commissioning and servicing the loco at the customer site and saved high value commissioning and servicing staff.

Vendor Satisfaction

Vendors like to supply to those customers who makes the payment quickly. As a part of vendor satisfaction measure, monthly meetings by DLW departments like accounts, material control, inspection, stores and other concerned departments, were started to sort out interdepartmental issues. It ensured that no bills are pending more than one month from the date of receipt of material and submission of bill. Target for payment against clear bills was 3 days. It had a very big impact on the morale of the vendors and in turn availability of material from suppliers improved.

Literature promotes cooperative approach to outsourcing management *(Jussi Hatoen et al.. 2009)*. The cooperation involves good communication with the vendors to solve mutual issues effectively and efficiently. Apart from shop floor contact with the vendors, vendors meet were regularly organized for the vendors, who supply critical components and also for those whose response time was poor. In these meetings all the vendors of one or a group of similar items were invited to roundtable conference where their quality and supply related issues were discussed in front of all the vendors. It created a sort of competitive environment in the meetings, as none of the suppliers wanted to get exposed or termed as poor in front of others. They tried to take corrective steps before coming to the meetings.

IMPACT OF QUALITY MANAGEMENT SYSTEMS AND OHSAS

The empirical results suggest that the implementation of ISO was able to improve firm's productivity *(GodfreyYeung et al., 2008)*. This relationship was also visible in DLW. DLW went for ISO 9002:1994 certification in Jan'97 and ISO 14001:1996 in March'01. In Sept'05, OHSAS 18001:1997 was obtained. In Dec'05, quality systems, environmental systems and health & safety management system were integrated. With time and experience, procedures were simplified. Integration of quality assurance, environment management and health & safety systems achieved maturity. The maturity brought simplified user friendly documentation, simpler

procedures, processes, work instructions and quality plans which covered all practical quality assurance aspects rather than just paper work. Matured and simplified documentation resulted in easy to understand and implement documents. The quality of the products increased resulting in reduced rework, rejections. Preference to ISO certified suppliers resulted in improved quality of vendor supplied items.

In 2005, DLW went for OHSAS certification. Staffs were provided with latest and world class safety equipments available in the market. The equipments like helmet, gloves, aprons, goggles, ear plugs and ear muffs of different specifications were purchased to meet requirement of each individual e.g. hand gloves of machinist, fitter and welder are different from one another. Even each category has got two/three variants.

Implementation of OHSAS increased safety awareness of the staff and increased individuals' performance. Improved safety measures resulted in better safety parameters. Total man-days lost due to accident reduced from 1521 hrs in 2004 to 843 in 2008. Similarly incidence rate (Accident per thousand employees) reduced from 10.45 in 2005 to 6.92. (Ref Safety bulletin 2008 and 2009).

Healthy and safe staff is a motivated lot, rejuvenated with enthusiasm, having direct bearing on availability of manpower and their ability to work hard at optimal level to give quality production.

CONCLUSION

DLW was established about four decades ago to manufacture diesel electric locomotives. Till 04-05, its manufacturing philosophy was that of a truly integrated diesel locomotive manufacturing plant. The complete engine, underframe, superstructure fabricated bogies and over 2000 components were manufactured under one roof starting from such basic construction material as plates, sheets, bars and pipes. With increase in production targets DLW has transformed itself from an integrated locomotive manufacturer to a locomotive assembler. The management and staff has shown dexterity in both as an integrated manufacturer and as well as an assembler.

The success has been built on the outsourcing of manufacturing activities, bringing attitudinal changes in working by various departments, flexibility and multi-skilling of production staff. Ability to get the material out of vendors was the strong point of the organization. The cooperative, flexible, motivated and ownership driven staff is the inner strength of DLW. The paper has concentrated on production targets with respect to total number of locos and has not covered the shortfall in different types of locos. Though DLW has been able to manufacture the locos as per the targets in numbers, but could not meet the individual targets for each type of loco. Production lagged in high horse power locos of WDG4/WDP4 types of locos. Instead of high horse power locos, DLW manufactured 3100 hp locos to make up the shortages. Reasons for the shortfall in production need to be studied. DLW is working with high inventory level of about Rs 800 crores with yearly material consumption of about Rs 1900 crores. Reasons for high inventory and measures required to reduce the inventory level need to be studied. Purchase philosophy of DLW is of transactional type. The changes in production program were noticed due to non-availability of material even in presence of large inventory. Availability of structured supplier relationship management was not evident. Study is needed to go into the details of supplier relationship management encompassing supplier selection, performance evaluation and collaboration.

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