The Lean Enterprise

Carole Jones, Nick Medlen, Clifford Merlo, Michael Robertson and John Shepherdson

Abstract

The Japanese automotive industry is based around principles of "lean thinking", and attaches great importance to reducing waste and focusing on those activities which add value for the customer. There has recently been interest in applying similar principles in service industry environments, including communications providers. This paper discusses the application of lean principles to BT, and describes some of the lean tools and techniques that are being used to transform BT. These include value stream analysis, a tool for exposing waste, and root cause analysis, which is a method for pursuing perfection. The use of new technologies as enablers for lean practice is also discussed.

1. Introduction

The success of the Japanese automotive industry after the second world war is largely attributable to the development of the Toyota Production System (TPS). The TPS is based around principles of "lean thinking", and has subsequently been emulated by numerous manufacturers in many industries throughout the world. Toyota devised their lean manufacturing system as an alternative to the mass production systems which had evolved in the West, and which Toyota perceived to be extremely wasteful of time, human effort, space, material and human potential.

Lean thinking consists of a body of best practice whose primary aim is to reduce waste and focus only on those activities which add value for the customer. This best practice can be summarised in five key principles [1]:

- Define each product such that it precisely meets customer requirements.
- Identify the value stream for each product (the complete set of actions required to prepare a product or service and deliver it to the customer).
- Allow value to flow through the value stream without delays or barriers.
- Allow the customer to pull value, rather than the manufacturer producing to forecasts. This is sometimes referred to as Just-in-Time (JIT).
- Pursue perfection and practice continuous improvement.

The key to achieving all of these principles is the existence of a culture of trust and empowerment, rather than command and control. Thus, in a lean system, continuous improvement is achieved by allowing front-line staff the time and freedom to devise improvements and remove waste. Policy formulation happens through a "catch-ball" process, where the opinions and experiences of people at all levels are solicited, and alternative options are debated. The focus for managers is on optimising the system on which the front-line people work, rather than using stick and/or carrot approaches to try to make the people work harder within a poor system.

Recently, an interest has arisen in applying similar principles in service industry environments. This trend has been driven by increasing globalisation and competition. Some adaptation of lean principles is necessary to make them relevant to service industries; this will be discussed further in section 3. However, the key principles of reducing waste, empowering people and focusing on adding value for the customer are universally applicable and can bring a competitive advantage to any industry. This paper discusses some actual and potential applications of lean principles within BT and other communications providers.

2. Lean Thinking in Manufacturing Industry

A traditional non-lean manufacturing organisation is characterised by a functional organisation and disconnected processes, with products moving from one functional department to another. There are high levels of inventory, long delays between departments, and products are processed in large batches using big machines. Goods are made to a forecast, which may be inaccurate due to the long cycle time. The culture is one of command and control, backed up by financial incentives and threats to encourage the achievement of targets. These targets are not customer focused, but are based around cost reduction and increasing productivity. The command and control culture is reflected in relationships with suppliers, which are contractual, with only the minimum possible amount of information being exchanged. The organisation is very hierarchical, and decisions are made by managers who are isolated from day-to-day production. The opinions of operations people are not considered, and they do not have the opportunity to contribute to improvement activities, since 100% of their time is scheduled on production activities. Any improvement activities that do take place are based on optimising individual functional areas, with the result that the overall process is often sub-optimised. Morale and job satisfaction are low, since most people carry out repetitive jobs and cannot see how their contribution relates to the whole process.

By contrast, in a lean manufacturer, the functional organisation is replaced by a process-based one, and there is a culture of trust, with operations people involved in decision-making. The culture gives rise to a sense of pride in a job well done, which acts as an intrinsic motivator. Levels of inventory are low, and batch processing has been replaced by single piece flow. Cycle times are short, enabling goods to be produced to order, rather than to forecast, using right-sized machines in each process area. Rather than using cost and productivity targets, the focus is always on doing that which adds value in the eyes of the customer. Instead of scheduling each person's time 100% on production activities, time is allowed for everyone to participate in continuous improvement (*kaizen*) activities. Suppliers are viewed as partners, with whom information is openly exchanged.

3. Lean Thinking in a Communications Provider

In their publication "The Lean Communications Provider" [2]. Adams and Willetts describe the contribution that service management can make towards reducing costs and focusing on customer value. However, the broader application of lean principles

to all of the activities of a communications provider has not, to date, been discussed in the literature. This paper aims to close that gap, and to discuss the translation of lean principles from a manufacturing to a service context.

A non-lean communications company, shown in Figure 1, consists of several functional departments. Jobs, such as a request for provision of service, are passed sequentially from one department to another, with no end-to-end ownership and poor communication between departments. Each time the job is passed on to another department, a long delay is incurred whilst the job sits in a queue awaiting attention. The functional organisation and lack of multi-skilling mean that complex management structures are needed to supervise the workforce. As with the non-lean manufacturer, there is a command and control culture and decisions are made by managers in isolation. There is little attempt to match supply of network capacity with demand in individual areas. This results in there being unused capacity in some geographic areas whilst in other areas there is insufficient capacity to meet the demand for provision of service. Furthermore, sales people are unaware of the status of network capacity, and may encourage customers to buy products which there is insufficient capacity to provide. The products offered tend to be highly uniform and standardised. Field engineers have 100% of their time scheduled to install telephones, and there is a focus on increasing productivity. Call Centre advisors similarly spend all of their time answering calls, and have strict targets regarding call handling times. Financial incentives and threats are used to back up these targets, and there is no time available for these people to participate in improvement activities.

Figure 2 illustrates some features of a lean, process-based communications provider. The organisation is based around customer focused teams, consisting of all the people needed to see a job through end-to-end. A job will typically be owned first by a call centre advisor and then by a field engineer, with these people pulling in any other specialist functions required to progress the job, yet maintaining ownership. This helps to achieve a short cycle time for fulfilling the customer’s order. Through dialogue with customers and the use of information such as demographic profiles, there is a good understanding of the likely demand for network capacity. The consequence is that a level of network capacity just adequate to meet demand is maintained at all times. This is complemented by a network build process with a sufficiently short cycle time that additional capacity can be installed rapidly in response to an increase in demand. Service is customised to the individual needs of each customer, and the focus is always on doing whatever adds value in the eyes of individual customers, rather than focusing on artificial cost and productivity targets and other non-customer-centric measures. Communication between the various units (*e.g.* Call Centre and field) is excellent, and sales people are fully informed of the status of network capacity and workforce availability. As with the lean manufacturing organisation, there is a culture of trust and everyone is involved in decision-making and continuous improvement activities. This leads to pride of ownership, which acts as a motivator.

Although there are many parallels between manufacturing and service organisations, there are also a number of key differences, which must be taken into account when seeking to apply lean principles to a communications provider. These include the following:

- The ability to obtain service is not a physical product, but is a combination of customer premises equipment (CPE), access to network capacity and a package of different services. Much of the network infrastructure is shared between many customers, and the network capacity is effectively "rented" to the customer for the duration of a call. All of these aspects must be considered when determining how to optimise the flow of value to the customer.
- It is difficult to relate some of the terminology of lean production to a communications provider, and it is important to appreciate that there is not always a simple one-to-one correspondence between manufacturing and communications terminology. For example, should network capacity which is installed but unassigned be viewed as excess inventory or as a service factory which is not operating at its full potential? The authors believe that both metaphors provide valuable insights into operating BT in a leaner fashion.
- The very nature of communications products means that the product itself is distributed over a vast geographic area, and it is therefore not possible to collocate all of the functions needed to produce that product. Some of the principles of continuous flow production can therefore not be directly applied to a communications provider, and must be replaced by the use of virtual teams with excellent internal communications mechanisms.
- The concept of matching supply with demand is more complex, since it is necessary to know both the volume of demand and where it will arise.

Over the past few years BT has undertaken a vast programme of change, resulting in an organisation that is more closely aligned to lean thinking. Customer service advisors and field engineers now reside within the same organisational unit, rather than being in separate functional silos. Customers are served by local customer service teams, which were established to encourage empowerment and teamwork. However, BT, in common with many organisations, recognises that lean thinking with, its pursuit of perfection, is a never-ending quest, and is continually seeking new techniques to bring about greater leanness. The following sections describe some of the initiatives that are helping to bring about the lean transformation of BT.

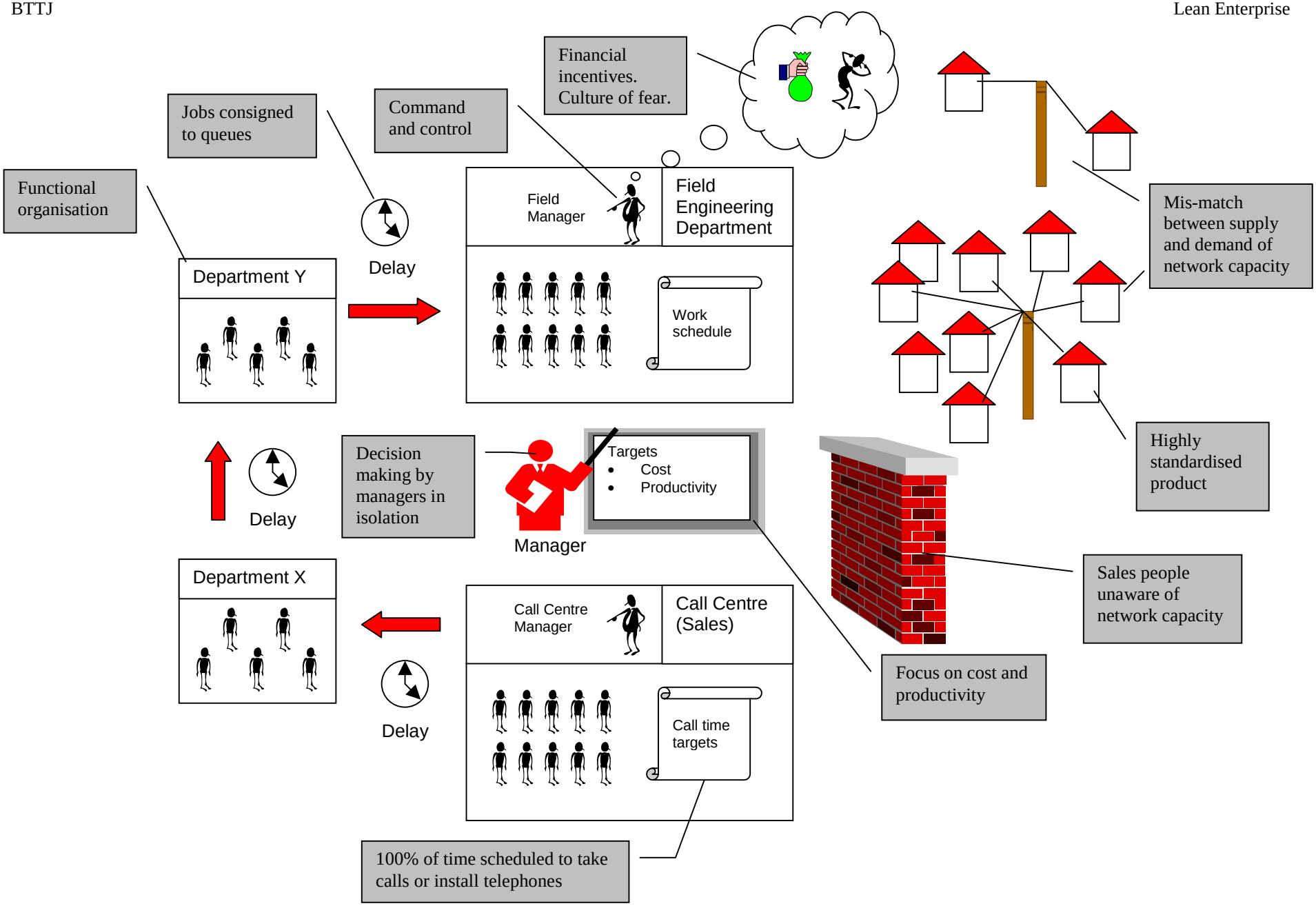

Figure 1 – Non-lean Communications Provider

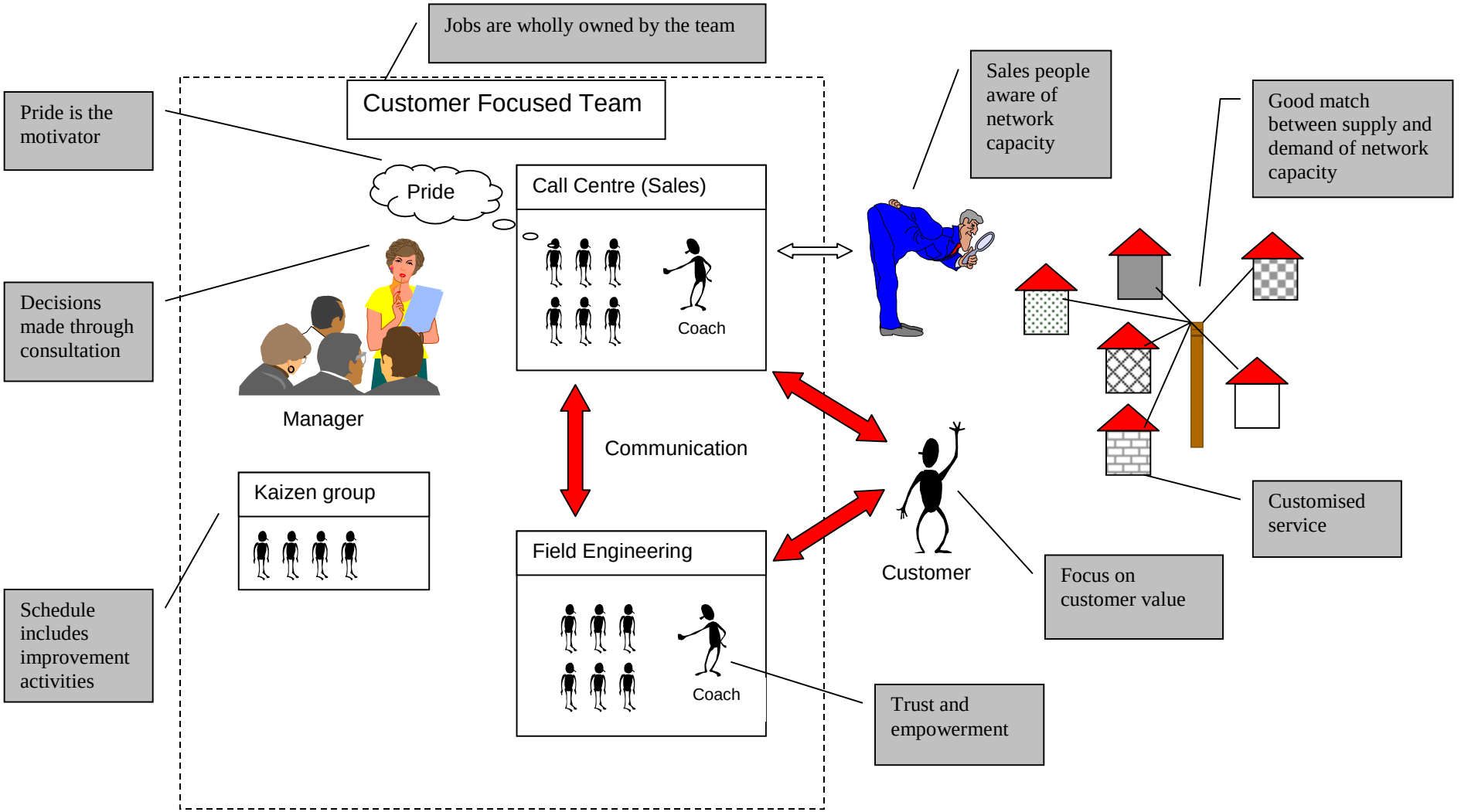

Figure 2 – Lean Communications Provider

4. Value Stream Analysis

Value Stream Analysis (VSA) is just one tool from the lean toolkit, which can help to implement the five lean principles described at the beginning of this paper. The primary focus of VSA is on identifying the value stream for a product. However, it also enables waste to be exposed and opportunities for making better use of flow and pull to be identified.

VSA entails examining all of the actions required to take a product or service through the flow of the production process and bring it into the hands of the customer. Each of these actions is analysed from the point of view of whether it adds value in the eyes of the customer. Non-value add activities are often referred to by the Japanese term *muda* (waste), and fall into two categories:

1. Those activities which create no value but are currently required and cannot be eliminated yet (type one *muda*).
2. Those activities which do not create value and can be eliminated immediately (type two *muda*).

Once the type two *muda* has been eliminated, opportunities should be sought to reduce the type one *muda* through the use of new practices or new technologies. Although VSA is a good method for eliminating waste at the local level, its main strength is in the improvement opportunities that can be identified at the more generic level, for example by improving communication and process flow between departments or by eliminating double-handling.

Within BT VSA has been used to analyse a number of processes. One example is the process for providing basic telephony to customers (the PSTN provision process). This process encompasses taking the customer order, allocating a number, allocating a copper pair (if capacity already exists), adding network capacity if necessary, configuring the exchange and carrying out the installation work. Planning and management of resource to cope with the workstack and allocation of jobs to people were also covered in the VSA exercise.

Data was collected by interviewing people carrying out each step involved in the PSTN provision process, and by observing people doing their jobs. Each step was broken down into a series of activities, the time taken for each activity was recorded, and each activity was given a designation to indicate whether it added value. Value-add activities were designated as “operation”, whilst non-value-add activities were categorised as “delay” (including queuing and re-work), “transport” (of material or information) or “inspection”. Supporting information was also collected, such as numbers of people involved, any discussion required, use of equipment and systems, and problems encountered. This analysis enabled improvement opportunities specific to each process area to be identified. Examples of these local improvement opportunities included:

- Replacing unreliable computer systems.
- Greater use of electronic data transfer.
- Improving training in some areas.

- Better communications between sales agents and field engineers.

The next stage in the analysis entailed combining all of the process steps to obtain a picture of the overall process. This enabled the more generic problems to be identified. Because individual provision jobs vary greatly in complexity, there is a large variation in the break-down of value-add and non-value-add activities between worst and best cases. Figure 3 shows this break-down for the best case, when a job passes smoothly through the system without any delays introduced due to failures or batching. In such cases, 37% of the total time is spent on value-add activities. This is a world class figure, since even those Japanese companies which have been employing lean principles for many years have only achieved values of around 50%. However, far too many jobs do not proceed down this route for a variety of reasons, including delays, poor internal communications and failure of automatic systems, requiring manual intervention or the need for re-work. The VSA data enabled the most common reasons for such failure to be diagnosed, so that the most significant improvement areas could be identified.

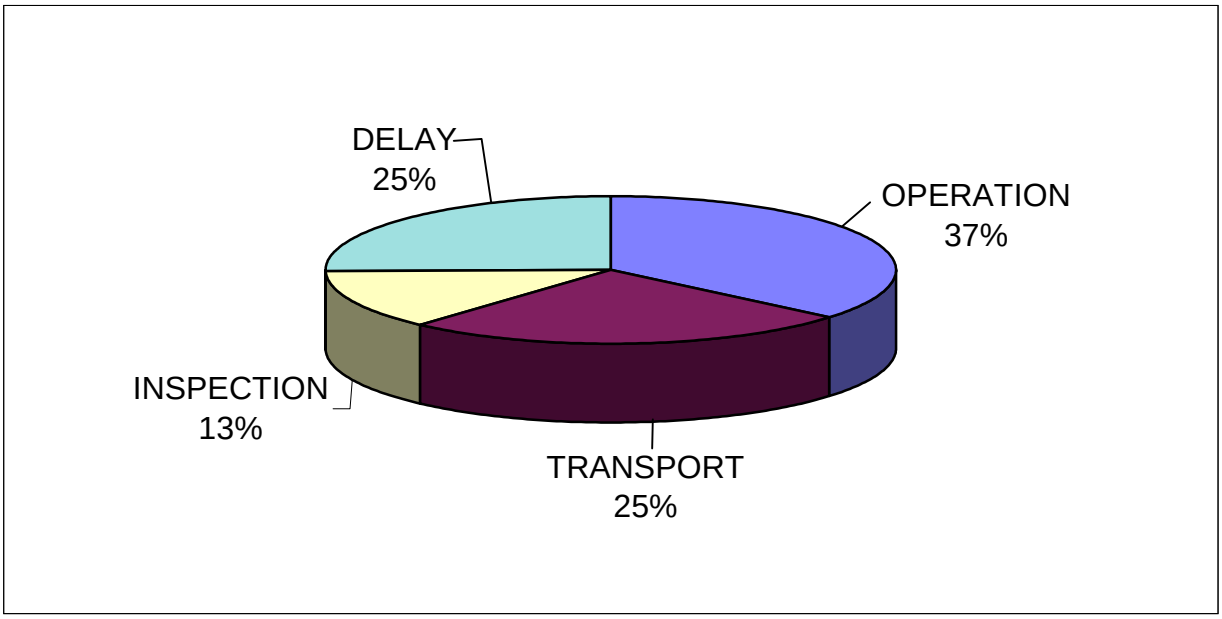

Figure 3 – Pie chart for VSA of PSTN provision process (best case)

Examples of some of the more generic and radical improvement opportunities which emerged from the VSA exercise were as follows:

- Introduce end-to-end process ownership and management of jobs.
- Reduce functional barriers by greater use of multi-skilling.
- Focus measures on the flow of value that processes are delivering to customers, and reduce the number of internal and functional measures.

This example shows how value stream analysis has been successfully used in BT to identify and prioritise improvement initiatives. It also highlights the importance of examining the complete end-to-end process, rather than a single functional area, since

many of the problems identified related to the interfaces between these different functions.

5. Root Cause Analysis

Root Cause Analysis (RCA) is another tool used by organisations that practice lean thinking. In this case the primary aim is to address the fifth lean principle of pursuing perfection and practising continuous improvement. This is achieved by identifying and tackling the root causes of recurrent and pernicious problems, rather than fixing their symptoms. RCA is a collection of techniques [3] to identify the crux of a problem, and includes both structured and unstructured techniques. Many of these techniques, such as tree and fishbone diagrams, are methods for displaying and analysing data, rather than capturing it. Perhaps the most widely used technique for gathering information is the "five whys" technique, devised by Toyota, in which the question "why?" is asked repeatedly, until the root cause is reached. The five whys technique lends itself more to simple problems than to complex ones, and must therefore be combined with other techniques when addressing complex problems, which may have several inter-dependent root causes.

Within BT, RCA has been applied to the issue of network faults. If fault rates could be reduced, there would be a direct reduction in the costs associated with repair, but more importantly it would result in better service for customers, leading to greater customer satisfaction and loyalty. Information on the factors that influence fault rates was captured through interviews with operational staff at various levels, using a combination of the five whys and other techniques. The data was then analysed using a fishbone diagram, shown in Figure 4. This indicates all of the factors which must be optimised in order to achieve a low fault rate.

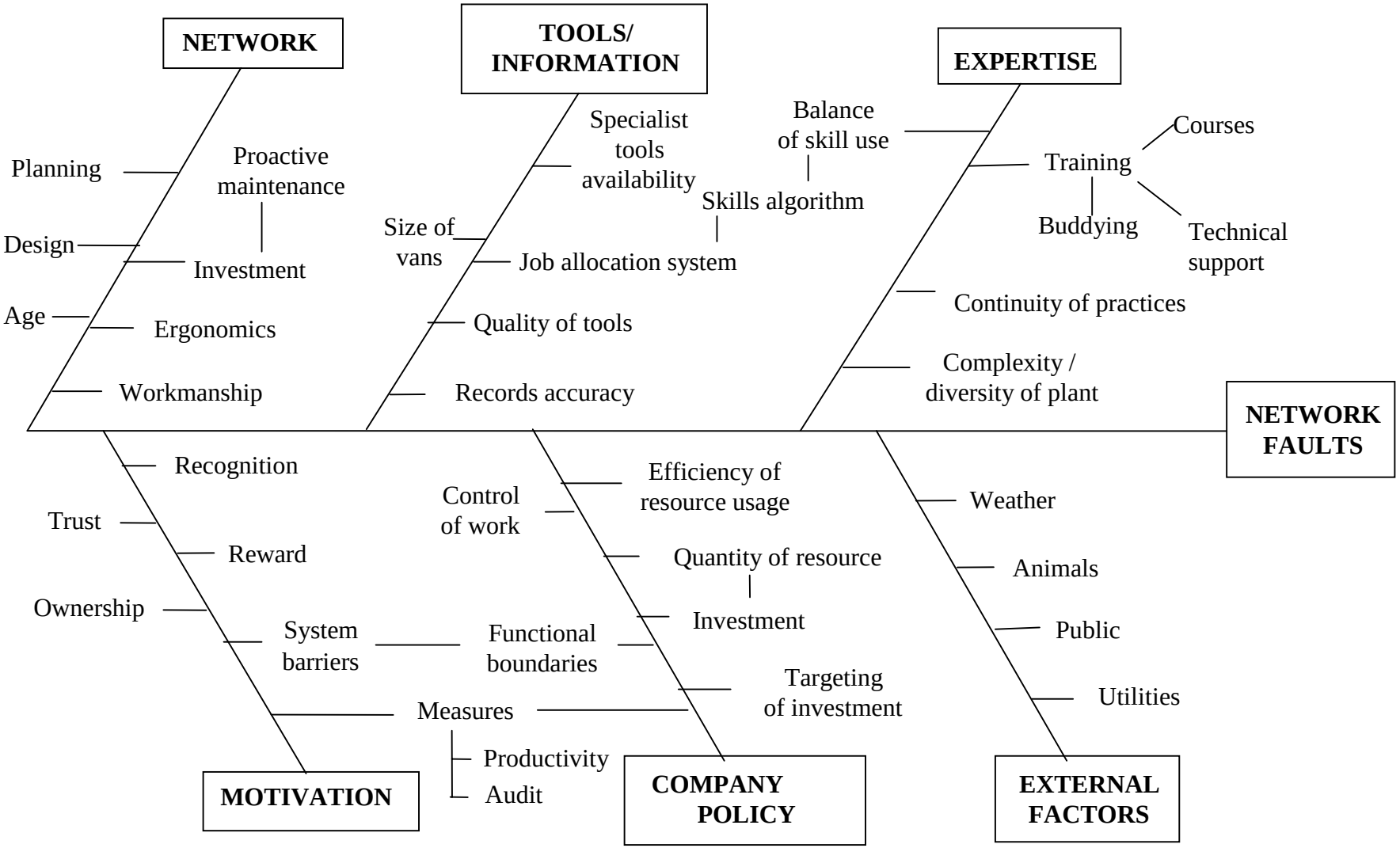

Figure 4 – Root cause analysis of network fault drivers

Further analysis was carried out to determine the weighting of each of the main fault rate drivers. This analysis concluded that company policy has by far the greatest potential to influence fault rates. This may be somewhat surprising at first sight, but is one example of the principles that cause and effect can be widely separated in space and time [4]. Examples of policies which can have a positive impact on reducing network faults include:

- Measures based on adding value for the customer (rather than those based on cost and productivity) ensure that engineers always do a quality job, and help to avoid further or repeated faults in the future.
- Organising the company according to end-to-end processes will lead to a focus on meeting customers' needs and excellent co-operation between all of the people involved.
- Judicious investment in new plant and in preventative maintenance of existing plant can prevent faults from occurring, and often cost less than reactive repair.

6. Future Opportunities

Although there is much scope for making BT's existing processes and systems leaner, some of the greatest opportunities arise from the use of new technologies. Two of the key attributes of a lean communications provider are the ability to match supply and demand for network capacity by deploying network on a JIT basis, and the ability to provide flexible and customisable services. In this section, some of the new technologies which may be enablers for these attributes will be discussed.

The access bearer network is currently predominantly based around copper pairs. However, there is interest in deploying alternative technologies within the access network [5], driven by the projected future demand for higher bandwidth services. High speed copper (*e.g.* ADSL), fibre and wireless technologies are all under consideration by communications providers. In general, there is a conflict between flexibility and high bandwidth on one hand, and rapid provision and low waste on the other hand. However, certain access bearer technologies can help to overcome this conflict. For example, wireless technologies are suitable for rapid provision, but are inflexible, whilst fibre is flexible, but has potential for high levels of waste (unused bandwidth) and cannot be provided rapidly. Perhaps the best solution lies in a hybrid solution, such as fibre to the cabinet with cellular radio used to reach the customer's premises. Such a solution provides good flexibility and also enables provision of service to new customers to occur rapidly, without the need for high levels of unused network inventory.

Internet Protocol (IP) networks would offer opportunities for greater leanness if they were deployed within the access network. As the cost of IP concentrators and routers falls, it is possible to envisage a situation where an IP concentrator was installed in the cabinet, combined with novel physical bearer technologies such as fibre or ADSL. All potential customer premises could be hard-wired into the network, with soft configuration being carried out when service was requested, allowing provision to occur much more rapidly. Because network infrastructure would be shared between many customers, waste would be reduced relative to a circuit switched network, where each customer's dedicated channel is unused for much of the time. This

solution would also provide a generic platform for the provision of new products, enabling customers to readily upgrade to new services as they become available.

The civil engineering works associated with cable installation are one of the main barriers to providing network connectivity on a JIT basis and maintaining low levels of inventory. A number of technological solutions are now available or under development to alleviate these problems. Blown fibre is a well established technique for quick and easy installation of fibre bundles into existing ducts, and has also been adapted for copper cables. Parasitic cabling within existing utility pipes (gas, water, sewerage *etc*.) is another alternative for fast and economic connection, and several companies have developed systems for quick and convenient upgrading from copper to fibre dropwires [6, 7].

Novel process technologies may be enablers for introducing lean practices across the enterprise. Workflow systems are designed to automate business processes by passing documents, information or tasks from one participant to another for action, according to a set of procedural rules [8]. Standard workflow products are not intrinsically lean and are most applicable to high volume, low variety processes. However, they can be made more flexible by the addition of a layer of intelligent software agents, which automate various resource management and problem resolution tasks [9]. One possible application for this approach (known as agent-enhanced workflow) is to facilitate customer empowerment, such that customers can configure their own service. In such an environment, a customer might request provision of a new service, and software agents representing the customer and the provider would negotiate and agree a time and price for provision of that service. Next generation operational support systems (OSSs) are already addressing the trend for customer empowerment by incorporating workflow functionality.

Goal-based workflow, which is not yet commercially available, is predicated on the idea that the end justifies the means. Given a goal to install product A for customer B in time C, a business process would be generated on an *ad hoc* basis to best achieve that goal. A virtual team would be assembled to service the process, and the diary of each individual involved would be automatically updated to reflect their required involvement. Thus the business process is customised to meet the needs of each individual customer, taking account of the workstacks of those involved and any other constraints.

If all of these technology options were combined, it is possible to envisage a future scenario where a customer could request a new service via the Internet, and software agents would agree the details of the provision in real time. Novel access bearer technologies, IP networks and civil engineering technologies would then enable the provision to be carried out within minutes or hours of the request.

7. Conclusions

Manufacturing companies that have embraced lean practices have reaped the benefits of increased customer and employee satisfaction, shorter lead times, reduced inventories, fewer defects, shorter time to market and lower operating costs. Communications providers who adopt lean thinking have the potential to:

- Improve customer service by focusing on what the customer wants, rather than what is most convenient for the organisation.
- Reduce operating costs by reducing inventory and removing the need for re-work.
- Increase the degree of flexibility to provide new services through adaptable processes.

BT is continuing to make great strides along the route towards leanness, and this paper has described some practical ways in which lean principles can be applied to a communications provider. There is evidence from manufacturing industry that a major competitive advantage can be gained by adopting lean principles. Indeed, lean thinking may prove to be a pre-requisite for survival in a future market of rapid technological advance and rising customer expectations.

8. References

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10. Biographies

Carole Jones is a member of the Advanced Operational Solutions Unit within BT Advanced Communications Engineering. She graduated from Durham University in 1984 with a degree in Applied Physics and Chemistry, and obtained a Ph.D. from the same university in 1987. After a year's postdoctoral research at Cambridge University, Carole joined BT in 1988. She initially worked on non-linear optical devices, and subsequently on silicon micro-engineering. In 1996 Carole began working on process management, where her main interest has been a study of production management techniques and their application to BT.

Nick Medlen is a member of the Advanced Operational Solutions Unit within BT Advanced Communications Engineering. Nick joined BT Laboratories in 1987 with an honours degree in Applied Physics. Initially he specialised in optical fibre cable and plant design. Subsequently he led teams working on aspects of optical fibre network design and operations. He then took on the management of the access network metallic infrastructure planning and performance project for ADSL. Latterly he carried out technical consultancy on fibre network design for some of BT's joint ventures. Nick is now investigating state of the art process re-engineering techniques.

Clifford Merlo is a member of the Advanced Operational Solutions Unit within BT Advanced Communications Engineering. He joined BT in 1981, developing underwater tools for BT cable ships, and later joined the team developing TAT8 optical fibre receiver units. In 1987 he joined the team developing optical fibre access network technology, and was then involved in technical trials on the copper access network. In 1998 Clifford worked for Telfort in Holland for six months. On his return Clifford began working on process re-engineering techniques and specifically the methods used in Japan to increase the efficiency of factories.

Michael Robertson is a member of the Business Engineering Laboratory within BT Laboratories. He graduated from St. Andrews University with a B.Sc. in Physics in 1976 and Durham University with a Ph.D. in 1980. He joined BT Laboratories in 1979 to work on laser reliability. In 1987, he took over a group working on optoelectronic component design and fabrication. He was part of the team from BT that set up BT&D Technologies (now part of HP) to manufacture optoelectronic components. Since August 1997 he has led a new group on Process Engineering, analysing and developing solutions to operational process problems within BT.

John Shepherdson is a member of the Business Engineering Laboratory within BT Laboratories. He has an honours degree in Electronic and Communications Engineering, and an M.Sc. in Artificial Intelligence. He joined BT in 1987 and has

spent most of his career working in the field of advanced information processing. His current research interests are in the field of intelligent process management, with particular emphasis on the use of collaborative software agents to facilitate the management of decentralised business processes.