Innovative Manufacturing Activities in Fujitsu Group Plants

● Toshihiko Sugano ● Tomohiko Maeda

(Manuscript received June 6, 2006)

Fujitsu initiated innovative manufacturing activities company-wide in 2003, and is now promoting innovative activities at each plant under the guidance of a consultant for the Toyota Production System (TPS). This paper describes the innovative manufacturing activities undertaken at Fujitsu Component Limited (FCL), and then introduces Fujitsu IT Products Limited (FJIT) and the Fujitsu Nasu Plant (mobile system manufacturing), which are promoting innovative activities that began in April 2004 at their facilities under TPS consultant guidance. Finally, this paper examines related activities under way at Shimane Fujitsu Limited (SFJ), which has received guidance from a TPS consultant since April 2005.

1. Introduction

The Fujitsu Group initiated innovative manufacturing activities company-wide starting from September 2003. Two years prior, Fujitsu Component Limited (FCL) undertook the development of innovative manufacturing activities. The introduction and results of these activities have become the driving force for the innovative manufacturing activities company-wide. Currently, the innovative manufacturing activities of the Fujitsu Group are being promoted at 14 plants[note 1)] of the Products Groups under the guidance of a consultant for the Toyota Production System (TPS).

This paper describes the innovative manufacturing activities first undertaken at FCL, and then introduces, as examples from among the Products Groups facilities, Fujitsu IT Products Limited (FJIT) and the Fujitsu Nasu Plant (mobile system manufacturing), which are promoting innovative activities that began in April 2004 at their facilities under TPS consultant guidance. Finally, this paper examines related activities under way at Shimane Fujitsu Limited (SFJ), which has received guidance from the TPS consultant since April 2005.

note 1) 14 plants including network, server, and personal-related plants.

2. FCL innovative manufacturing activities

FCL is involved with the development, manufacture, and sales of relays, connectors, keyboards, touch panels, pointing devices, and thermal printers. FCL consists of five domestic manufacturing subsidiaries such as Shinano Fujitsu Limited (SFCL) and four overseas manufacturing sites. Following the collapse of the IT bubble, FCL initiated innovative manufacturing activities and, as a result, has realized improvements in losses and gains. This section outlines the progress of the innovative manufacturing activities and describes their contents.

2.1 Outline of progress of innovative manufacturing activities

When the balance of supply and demand was lost due to the collapse of the IT bubble, overpro-

duction became a factor in applying pressure on management. Therefore, guidance under a TPS consultant to overcome this financial crisis was introduced with innovative manufacturing activities being initiated first for SFCL from May 2001. From 2002, the results of these activities for SFCL were then expanded to include all of the manufacturing activities of FCL. The innovative manufacturing activities were initiated with the aim of increasing productivity threefold and reducing the percent of inventory and percent defective by half for the entire company. Within one and a half to two years after these activities were initiated, the targets have been reached achieving improvements in losses and gains.

2.2 Contents of innovative manufacturing activities

To switch over from a conventional production system to the TPS, efforts were made to eliminate waste activities, shorten processes and not create delays as well as to create a continuous workflow (repetition of work) without depending on a system or spending money. Specifically, the following initiatives were taken for the line:

1) Work standing up, tightening up of work intervals,[note 2)] and sharing of multiple processes (reduction of space)
2) Changing offline to inline (shortening of processes and reduction of goods in process)
3) Using *mizusumashi* (fixed-course pick-up)[note 3)] (creation of Takt time)
4) Reduction of arrangement time (reduction of goods in process)

In addition, the following initiatives were taken at each plant and company-wide:

1) Integration of plants, handling of outside orders, reduction of warehouses, and storing[note 4)]
2) Arrangement of distribution (procurement and finished products) network (route deliveries)

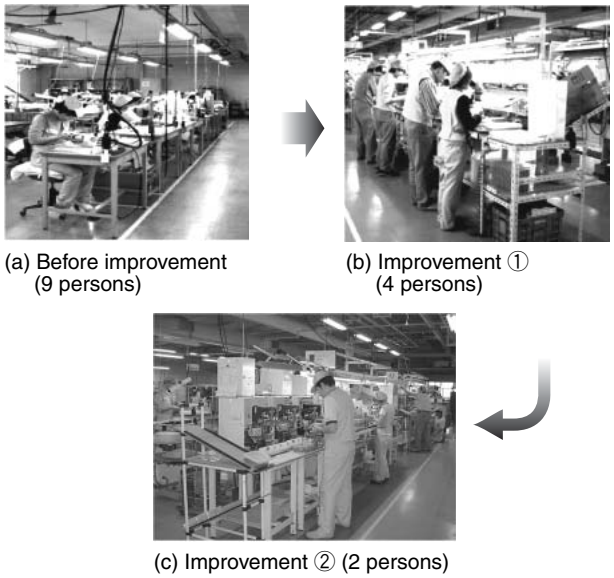


Figure 1
Example of improving production line at FCL.

Then, the activities were promoted under the scenario of switching over to the *kanban* operation referred to by TPS.

As examples of improving the production line, workers stand up to work instead of sitting down and processes have been changed to a worker handling only a single process to multiple processes. Moreover, improving the equipment and jigs has enabled a reduction in persons on the production line. (**Figure 1**)

Further improvements include initiation of outside arrangement and one-touch operation to reduce the time needed to change arrangements of the mounting equipment, presses, molding devices and others. As a result, the high target of reducing the time by more than half has been achieved. Initiations have also been undertaken to increase the number of arrangements to promote the creation of smaller lots[note 5)] and One-Piece-At-a-Time production.[note 6)]

note 2) Reduction of the interval between processes.
note 3) Workers who supply the parts between processes.
note 4) Location for placing items assorted by type.
note 5) Reduction of the number of components of work lots.
note 6) Passing of each finished product to the next process.

As shown in **Figure 2**, the results of promoting plant integration, handling of outside orders, reduction of warehouses, and storing as improvements for the production system have reduced the percentage of outside orders by 40%. Tightening up of work intervals to reduce the space has also had a great effect in creating room within the plants (53% reduction), reducing the outside warehouses that originally numbered 10, and in terms of costs.

The effect of these improvement activities has also been beneficial in improving the morale of the workers. The goals and progress of individuals have been posted and training activities such as walking to experience the speed have been undertaken to encourage all of the employees in a plant to be more committed to manufacturing.

As a start to creating a continuous flow at a production site, One-Piece-At-a-Time production has been thoroughly emphasized and a mechanism prepared so that workers can differentiate between what is acceptable and what is not (enabling workers to check visually). Innovative manufacturing activities have then been initiated with the aim of thoroughly eliminating wastefulness. In addition, reforms have been continued in FCL overall by starting quality innovation activities, design innovation activities, and new product development promotion sessions.

3. FJIT innovative manufacturing activities

FJIT is a manufacturing company that was established in April 2002 through the integration of the manufacturing departments of Fujitsu's Numazu Plant (large-scale server manufacturer), Nagano Plant (storage system manufacturer), Kumagaya Plant (printed circuit board [PCB] unit manufacturer), and PFU Limited (small-scale server and peripheral device manufacturer). FJIT handles a wide variety of products from core devices such as large-scale and small-scale servers to peripheral devices such as scanners and printers. FJIT handles continual manufacturing of items ranging from PCB units to devices. Because FJIT manufactures various types of devices that require much time and processes to complete, FJIT has taken on the problems of reducing the number of inventories and work in process.

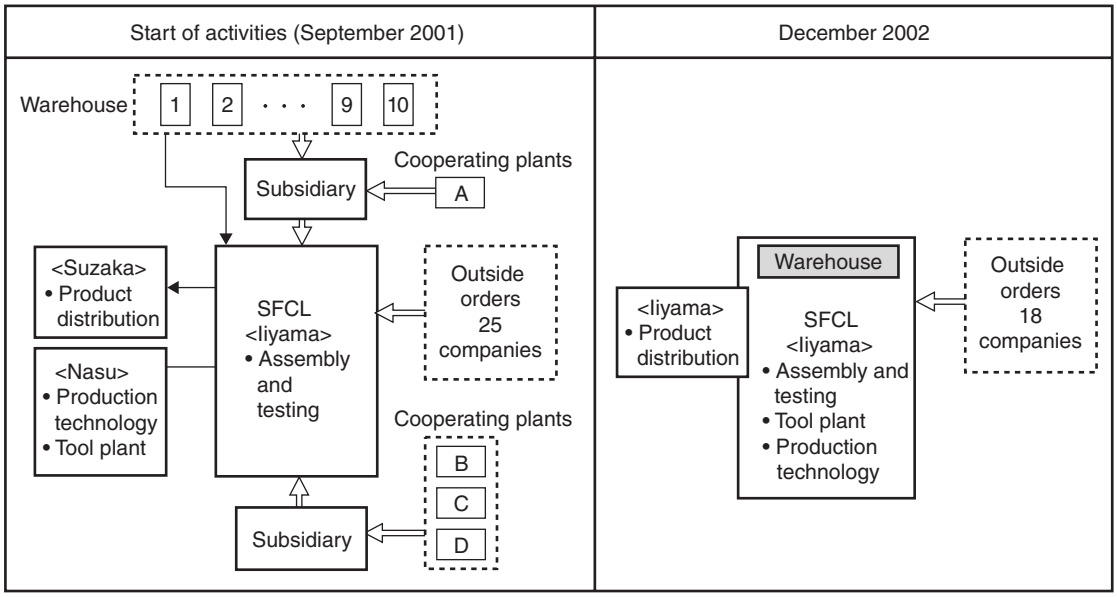


Figure 2
Arrangement of warehouse at factory at FCL.

This section describes the promotion of the innovation manufacturing activities for solving these problems and the actual innovations taken.

3.1 Promotion of innovative manufacturing activities

Starting from December 2003, FJIT established five WGs: the device manufacturing, PCB unit manufacturing, peripheral device manufacturing, product flow, and common WGs. As company-wide activities of FJIT, innovative manufacturing activities aiming to double within two years the quality, productivity, lead time, remaining inventories, and space reduction were initiated. The first step for the promotion of TPS was to promote the reforms in the employees' current understanding and awareness as described below under guidance of the TPS consultant from April 2004:

1) Studying the real situations of FJIT such as what is the basis of the essential problems of FJIT, what the employees are thinking, and what are their concerns.
2) Holding meetings to exchange opinions between management and general employees in arranging the environment of FJIT in regards to personnel, items, and money, implementing 2S (Sort, Straighten) activities, and promoting the company president and executives' periodic visits to the plants.

3.2 Innovation details

3.2.1 Reduction of outside warehouses

When FJIT was first established in 2002, there were 12 outside warehouses where the items from the suppliers were stored. These supplies were then sent from the warehouses to the plants in the amounts required for that day's manufacturing requirements. With the implementation of 2Ss, reduction of space within the warehouses, review of the supply cycle from the suppliers, and tightening up of work intervals within the plants, one warehouse was eliminated in the fourth quarter of 2003 and nine warehouses were eliminated in the fourth quarter of 2004. As of September 2006, there is now only one outside warehouse.

3.2.2 Production line innovations

The following activities were initiated on the production line, placing emphasis on rectification and One-Piece-At-a-Time production:

1) Eliminate branching and merging of the production flows (rectification).
2) Arrange equipment in order of processes.
3) Supply items one at a time (One-Piece-At-a-Time production).
4) Realize the pull system.

The following describes the activities that were initiated to promote innovative manufacturing activities on the production line by product group:

1) Manufacturing of peripheral devices such as printers and scanners

In the manufacturing of peripheral devices such as printers and scanners, based on the improvement activities that have been initiated so far, we have constructed the pull system[note 7] within the plants quickly and entered the phase for increasing the level of improvement within the plants and promoting the connection between supplying the materials from the suppliers and forwarding the materials.

2) Manufacturing of devices such as servers

In the manufacturing of devices such as servers, the conventional system for achieving a short lead time was like this. First, half-finished products referred to as the basics were sent to the warehouse. Then, when a build-to-order (BTO) order was received from a customer, the product was assembled based on the customer's specifications, tested, and shipped. Under this system, however, the intermediate stock could not often be controlled satisfactorily because the basics were

note 7) System where the post-process pulls as a few items as needed out of the prior process when needed, and the prior process manufactures the items for the amount that has been pulled out.

manufactured while the orders had not been guaranteed. Currently, therefore, initiatives have been taken to reduce the manufacturing lead time from assembly to testing, realize BTO consistent manufacturing from the beginning without carrying half-finished products (basics), and realize a system where the materials can be supplied to the production line in a timely manner.

Conversion to the pull system is scheduled for future implementation. However, from June 2005, progress has been made in converting to this system for some of the device types and activities are currently being undertaken to increase the number of device types.

3) Manufacturing of PCB units

Efforts are being made to realize mixed One-Piece-At-a-Time production[note 8)] in the manufacturing of PCB units. For ROM write at preprocessing, the components are being set on the production line synchronized with the production sequence units. For surface mount technology (SMT) manufacturing, small-lot flow[note 9)] is being implemented using single arrangement.[note 10)] For the insert mount technology (IMT) process, the process course and work time for each process are being reorganized. In particular, activities are being undertaken to construct a rectified production line and achieve mixed One-Piece-At-a-Time production by reducing the time and number of patterns when changing the arrangement of the solder flow equipment that is a restraining factor in terms of equipment.

From the rectification and One-Piece-At-a-Time production within a process, we have currently entered the phase of constructing a system that rectifies the lines connecting all processes and realizes the pull system in the entire plant. As shown in the top half of **Figure 3**, conventionally there is a load of work in process between each process and intermediate warehouse. However, activities are currently being undertaken to abolish intermediate warehouses and work in process by creating production lines, which matches the format aimed at in the bottom half of Figure 3 to meet the initial plan.

note 8) To circulate various products of different processes on a single production line to achieve One-Piece-At-a-Time production.

note 9) To flow the parts in lots as small as possible so as to be able to meet the needs of the customers.

note 10) To complete arrangement within 10 minutes at the time when much time is needed to change the arrangement.

4. Nasu Plant innovative manufacturing activities

The Nasu Plant is involved in the manufacture of wireless terrestrial station equipment, network controllers, signal processors, and so on. For the Nasu Plant, the problem is flexible handling of the required changes.

This section outlines the progress of the innovative manufacturing activities for solving this problem and describes their contents.

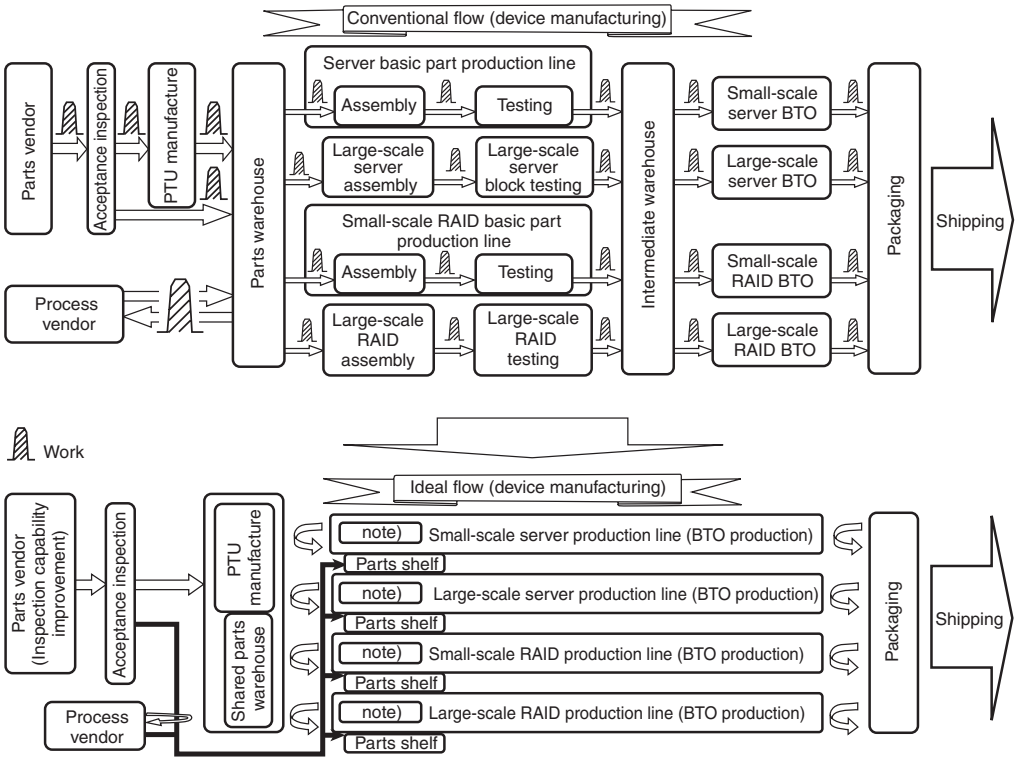
4.1 Outline of plant improvement and innovative manufacturing activities

Figure 4 shows the schedule of the plant improvement and innovative manufacturing activities for the Nasu Plant.

Even before now, separate activities have been continuously undertaken for improving the Nasu Plant. From construction innovations after the collapse of the telecommunications bubble, implementation of a cell production system and steady improvement activities such as the promotion of multi-skill development have been promoted to strengthen the production capability to enable the flexible handling of the required changes. Moreover, in December 2003, innovative manufacturing activities (PI2004 activities) were started with the aim of doubling productivity within two years.

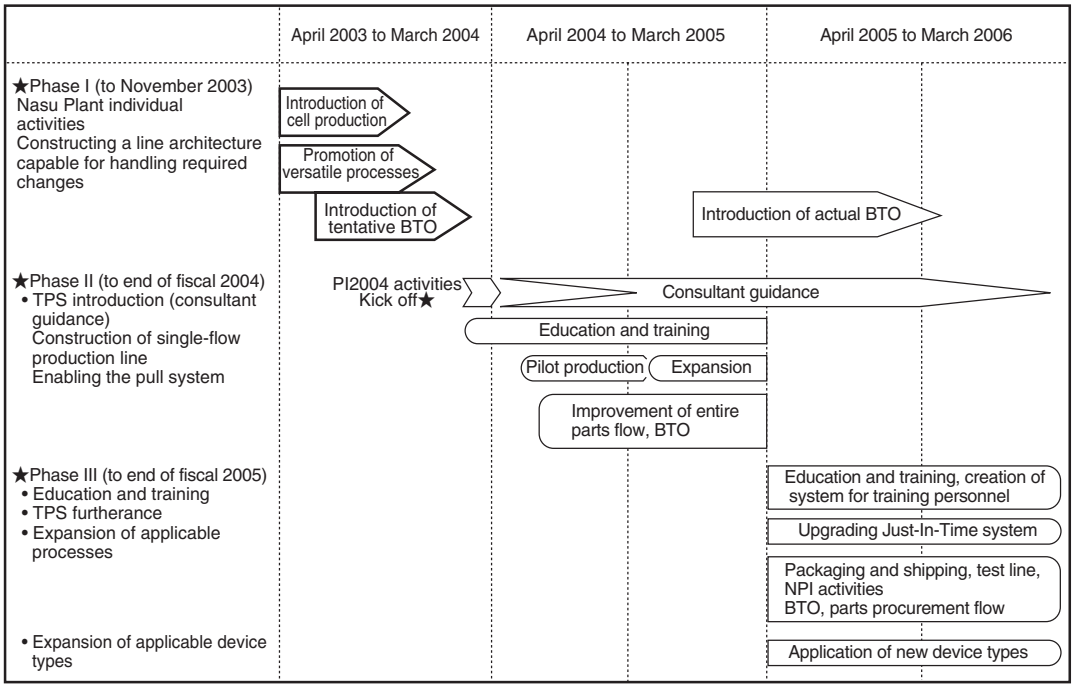
4.2 Details of innovative manufacturing activities (PI2004 activities)

This section describes the PI2004 activities in regards to the innovative manufacturing



note) In-plant outside order
PTU: Printed Circuit Board Unit
RAID: Redundant Array of Inexpensive Disk (storage system)
BTO:Build To Order (received order production system)

Figure 3
Conventional and ideal production lines at FJIT.



PI2004:Product Innovation 2004

Figure 4
Innovation activity schedule at Nasu Plant.

activities for the production line of the Nasu Plant.

4.2.1 Improvements of production line

The production line of the Nasu Plant consists of various processes. These processes include assembling PCB units referred to as plug-in units (PIUs) into SMT units, testing the units and then installing them into shelves, installing the shelves on shelf racks, testing the devices, packaging, and finally shipping.

Under the guidance of the TPS consultant, the production flow has been rectified and a Takt-time concept where the products can be constructed even as fast as they can be sold introduced. For the Nasu Plant members also, the activities have been expanded with the following concepts emphasized:

1) Work honestly adhering to the TPS concept.
2) Think of ways to improve without giving any reason why it cannot be done.

Before the improvements, each process had a buffer where components could be added to any production line utilizing this buffer. Moreover, a flexible production system had been constructed by arranging intermediate warehouses to prevent any loss of balance. However, there was a lot of branching and merging and congestion between the processes [**Figure 5 (a)**]. Introduction of the innovative manufacturing activities enabled the promotion of rectification by device type and the construction of a mixed flow production line. After flow rectification, the production flow was changed to the pull system for all production lines and processes for SMTs, PIUs, device assembly, device testing, and packaging [**Figure 5 (b)**].

4.2.2 Result of production line improvements

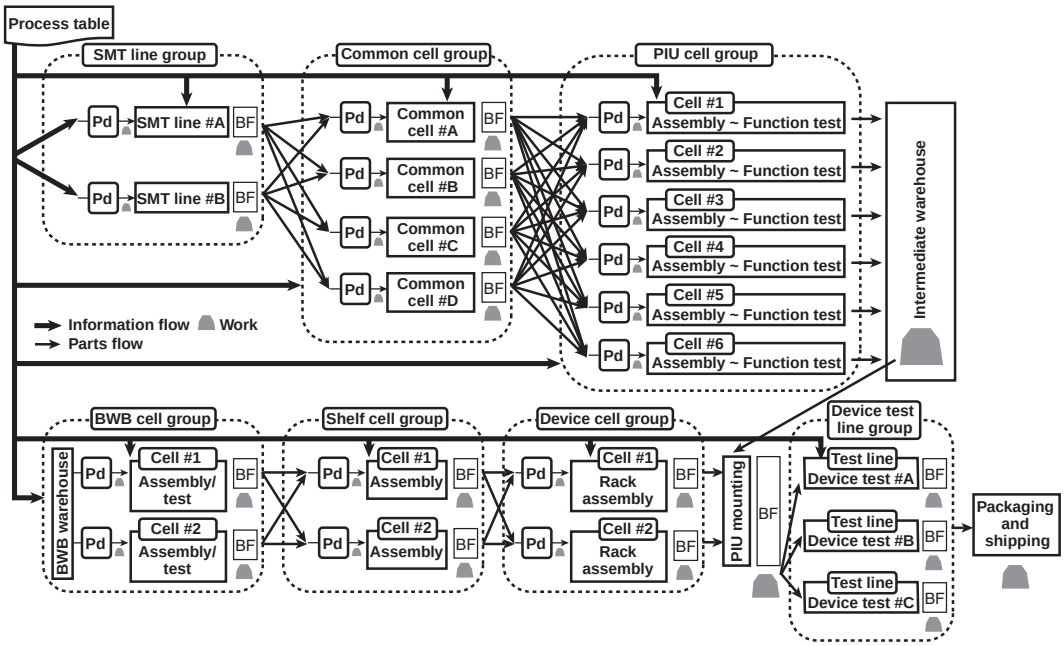
As described above, a single-flow production line without any branching and merging between the processes has been created, the test types have been integrated, and mixed flow of different device types has been created. This has initially enabled a production format where products could be manufactured taking into account estimated amounts because the production lead time of 14 days was longer than the customer's supply lead time of 13 days to be improved as shown in **Figure 6**. The supply lead time to the customer could also be reduced significantly by three days. Excellent results in regards to space, number of retention days, and cost reductions were also obtained as listed in **Table 1**. Moreover, the target of doubling the quality, cost, and delivery (QCD) within two years was achieved within one year.

In addition, to accelerate the understanding of TPS and for education and training, improvement review meetings are being held every other week separate from the guidance meetings held by the consultant. At the improvement review meetings, confirmation and investigations are made in regards to such items as the aim and effectiveness of the execution method of the improvements. The leader of the production line also starts under his or her own initiative a mini-guidance meeting to promote the awareness of problems among all of the operators and the understanding of TPS.

4.3 Development of future innovations

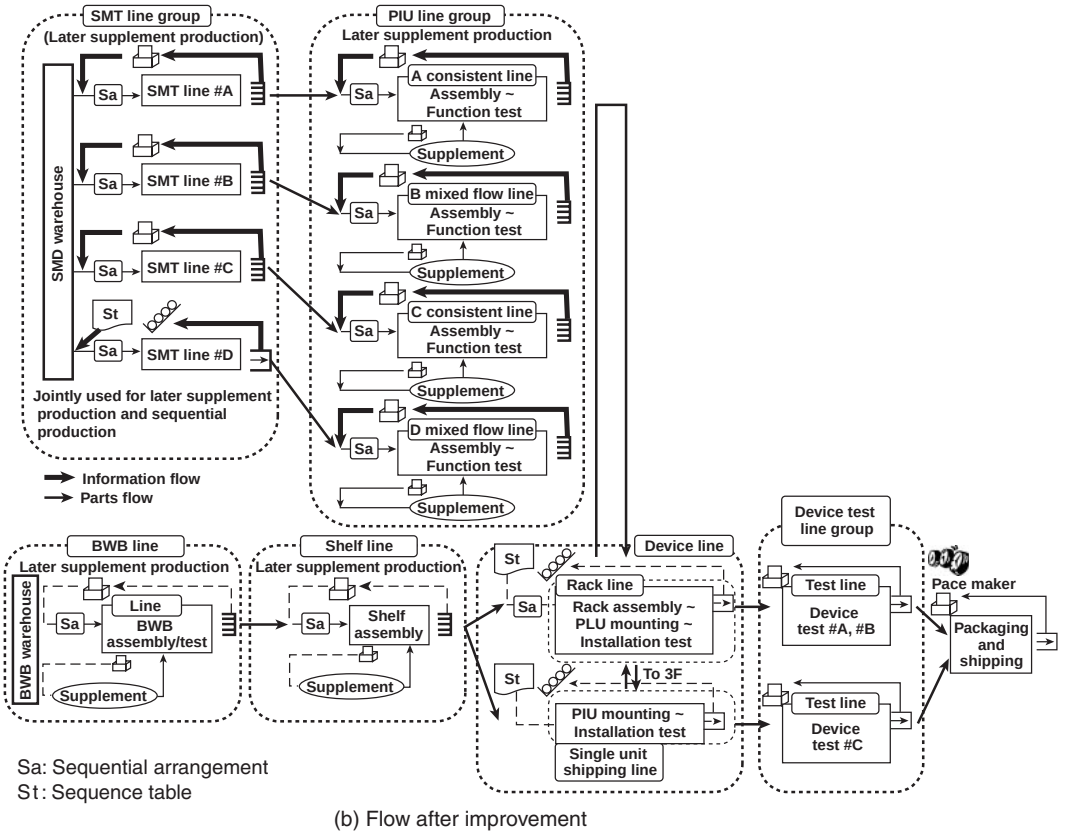
Currently, upgrading the improvement level within the Nasu Plant involves reviewing the appropriate work in process within the plant to reveal and remedy any problems as well as initiating automation such as stopping at specific points on individual production lines and utilization of *andon* indicators.[note 11] In addition, the existing production lines by device types are being reformed into a mixed-device type production line and special-purpose test equipment that has been a source of problems is being changed to general-purpose equipment. Activities are also being investigated and expanded to meet the introduction of the pull system from within the plant, between the plants, and with the suppliers.

note 11) Electric light board indicating whether a equipment or process is currently active or inactive.



Pd: Prior disbursement
SMT: Surface Mount Technology
PIU: Plug-in Unit
BF: Buffer
BWB: Back Wire Board

(a) Flow before improvement



Sa: Sequential arrangement
St: Sequence table

(b) Flow after improvement

Figure 5
Production line improvement at Nasu Plant.

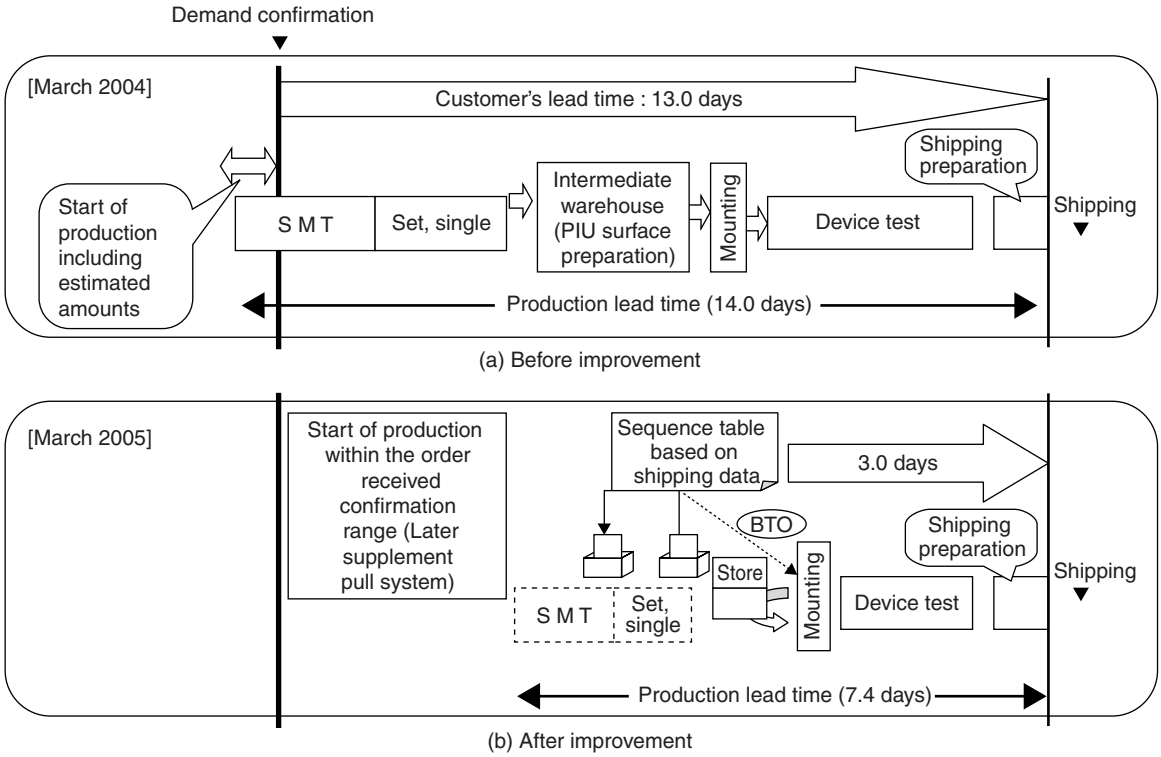


Figure 6
Improvement of lead time at Nasu Plant.

Table 1
Result of Nasu Plant activities.

Productivity	2.1 times
Lead time	14.0 days → 7.4 days (▲47%)
Retention days	18.7 days → 9.6 days (▲49%)
Parts boxes	5000 boxes → 1200 boxes (▲76%)
Space	6287 m^2 → 4163 m^2 (▲34%)
Amount of cost reduction	1.18 billion yen (3.8 times compared to fiscal 2003)

5. SFJ innovative manufacturing activities

SFJ is a domestic manufacturing plant that produces two million laptop computers a year. SFJ is fully involved with domestic manufacturing from the manufacture of PCB units to device assembly. SFJ has constructed a consistent production system that even extends to testing. To maintain QCD that is second to none, SFJ is actively involved in innovative manufacturing activities. This section describes the innovative manufacturing activities that SFJ has undertaken so far (**Figure 7**).

5.1 Outline of promotion of plant improvement activities and innovative manufacturing activities

In 1999, SFJ started cost reduction activities as the plant improvement activities. SFJ has undertaken activities to reduce the lead times and manufacturing costs company-wide.

The result of these activities is the establishment of a cell line production system (system that successfully combines the flexibility of cells that enable the workers' skills to be fully utilized with an automated production line that increases equipment efficiency) and the construction of a single-flow production line that encompasses all facets of production from assembly, running, and testing, to packaging.

5.2 Initiation of shape-up activities

As described in the previous section, the cost

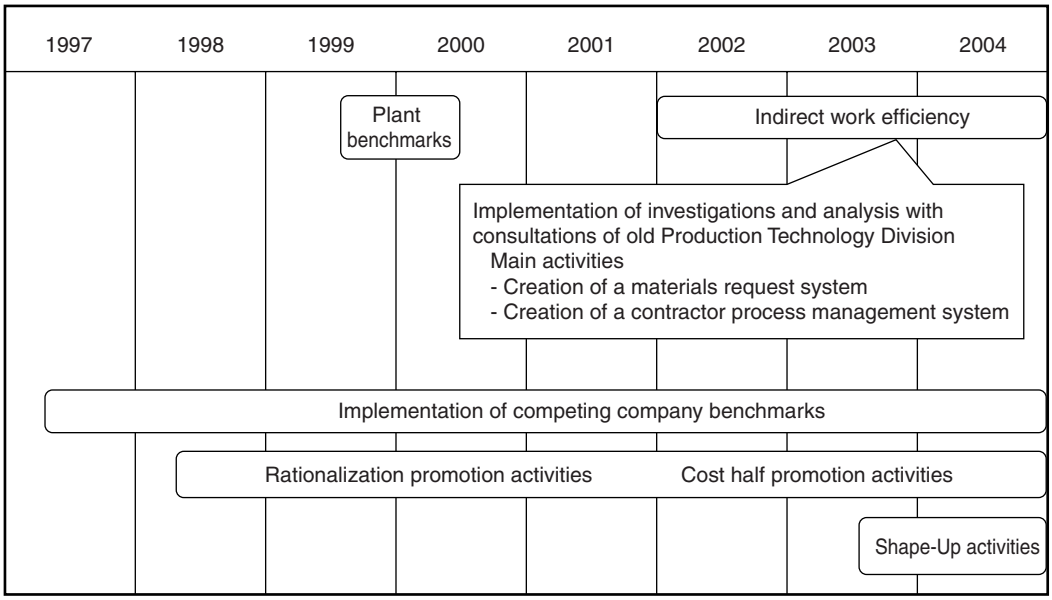


Figure 7
Innovation activity schedule at SFJ.

reduction activities of the plant improvement activities started in 1999 have resulted in reducing the manufacturing costs by 15% and the manufacturing lead time by 23% as listed in **Table 2**. To further promote the improvements, company-wide activities given the name of Shape-Up activities, with on-site guidance, have been initiated as innovative manufacturing activities starting from November 2003.

The weekly improvement activities and improvement study meetings that are held regularly each week have aimed at completing 2Ss, tightening the work intervals, and creating a material supply flow. These activities have reduced the production lead time by 25%, created space and free areas within the plant, and enabled the elimination of outside warehouses in December 2004.

The parts supply and work efficiency on the device assembly lines has been improved by changing the parts supply method from side supply [**Figure 8 (a)**] to front supply [**Figure 8 (b)**].

The plan has always been to construct a single-flow production line. However, with the introduction of the TPS consultant starting from 2005, initiatives have again been undertaken to rectify the production line, change to small lots, synchronize with the subassembly processes, and upgrade the Just-In-Time method of parts supply.

The analysis and investigations carried out based on this guidance have resulted in the elimination of branching and merging of the production flow, switching to a new production system (NPS) that adheres to a single-flow production line, and further reduction in lead time and costs.

5.3 Future innovations

Because orders received fluctuate greatly for personal products, how to promote level production and improve the supply method of materials in cooperation with the suppliers are signification problems.

In parallel with the innovations within the plant, innovations in propagating and making equal information including marketing divisions and innovations in the supply chain management (SCM) for the procurement of supplies including the flow of parts from overseas are being undertaken.

Table 2
Results of activities at SFJ.

Target	2002	2003		
	Second half	First half	Start of activities November	Second half
Manufacturing costs	100%	94%	93%	85%
Manufacturing lead time	100%	100%	93%	77%

(a) Supplying parts from the side (before improvement)

(b) Supplying parts from the front (after improvement)

Figure 8
Assembly line improvement at SFJ.

6. Conclusion

The environment of the Fujitsu Group's business has become increasingly severe due to various causes such as having to compete against lower production costs overseas and having to handle the manufacture of a variety of products of differing amounts to meet our customers' needs. To win out over this competition, it will be necessary to further promote the innovative manufacturing activities. The Fujitsu Group will therefore be rapidly undertaking from now on various initiatives including realizing the pull system of production within the plants, cooperating with the suppliers and between the plants, undertaking initiatives for innovations of the test process that carries more weight than the assembly process, realizing leveled orders and production in cooperation with the marketing divisions, reducing the information processing lead time, and constructing a system for training the personnel. The Fujitsu Group is therefore planning the construction of a system to promote the improvement spiral and is making renewed efforts to expand TPS within the Fujitsu Group so that daily improvement activities will become part of the daily work routine.

Toshihiko Sugano, *Fujitsu Ltd.*
Mr. Sugano received the B.E. and M.E. degrees in Mechanical Engineering from Kobe University, Hyogo, Japan in 1978 and 1980, respectively. He joined Fujitsu Ltd., Kanagawa, Japan in 1980, where he has been engaged in development of production systems.

Tomohiko Maeda, *Fujitsu Ltd.*
Mr. Maeda received the B.E. degree in Mechanical Engineering from the University of Electro-Communications, Tokyo, Japan in 1986. He joined Fujitsu Ltd., Kanagawa, Japan in 1986, where he has been engaged in development of production systems. He is a member of the Japan Society of Mechanical Engineers.