The Factory Succeeded in Cutting Downtime by 25% through the Introduction of IoT

The factory production line demands constant process improvement and streamlining. Each factory has its own history of innovation and employees may find it hard to make further improvement. However, operations can be made even more efficient through the introduction of a new method, namely IoT. By using IoT to visualize data that usually remains hidden (such as the operational status of production lines or the frequency of errors), factories can speedily deal with unforeseen stoppages or switchovers. This report will introduce a case where a factory managed to substantially improve efficiency through the introduction of IoT.

Fujitsu I-Network Systems' Yamanashi factory in Minami Alps city, Yamanashi prefecture

Hiroto Nakamura

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When the IoT (Internet of Things) is introduced to factories, this can cause considerable consternation. This is because employees feel proud of raising productivity and maintaining safety on a daily basis through their own initiatives to improve workplace operations. A company's ICT division or ICT venders may seem like outsiders to workers on the factory floor, so it is perhaps only natural for workers to feel some resistance to proposals to 'visualize and streamline factory operations using IoT.'

Some companies have already achieved huge efficiencies by introducing IoT at their factories, but a surprisingly large number of these firms also struggled to get factory workers on board during the initial phase. These include Fujitsu I-Network Systems (hereinafter FINET; Yamanashi factory in Minami Alps city, Yamanashi Prefecture), a member of the Fujitsu Group and a provider of product manufacturing and service solutions for enterprise networks.

As a Fujitsu Group in-house initiative, IoT was introduced to printed circuit board (PCB) mounting lines at FINET's Yamanashi factory. This succeeded in cutting the duration of line stoppages by 25%. However, according to Hiroto Nakamura, President of FINET, "when we first introduced IoT to our factory lines, we were unsure whether it would produce results or instead just add to our workload." Before commencing operations, President Nakamura and his team first clarified exactly what IoT could do and what kind of data it would yield. Fujitsu's IoT Division and the FINET team jointly determined the purpose and the goals for introducing IoT. They worked together to verify data and confirm the effectiveness of the program.

Masaharu Kano is Solution Director at the IoT Business Division, located at Fujitsu Network Servise Business Unit. He had this to say about approaching FINET with the idea for the project.

"It is becoming more utilised in a variety of scenarios. In particular, we expect the IoT data lying dormant within factories to have a substantial economic impact through the streamlining of operations. By visualizing and analyzing data, IoT-era factories will be able to optimize production and this will lead to total automization in the future. We approached FINET with the idea of jointly carrying out an in-house project as a way to verify the potential of factory IoT and to provide solutions."

When talks with FINET actually began, though, those on the factory floor had difficulties setting targets for IoT beforehand. There was also some confusion about the method of introducing IoT while also assessing it. "It seems they wanted us to clarify as much as possible what needed to be assessed, based on an understand of their field. There were also communication difficulties between ICT-related departments and the factory floor, so it was hard to reach an agreement on exactly what to assess," says Kano. There were also concerns at the factory that the introduction of IoT would add unnecessarily to their workload. Mr. Kano and his team explained how the initiative would not be a burden and how it would be possible to verify developments with minimal effort.

The proposal was received by Naoya Takei, Director of FINET's Business Solutions Department. "We were quite proud of our own initiatives to improve operations at the factory." he says, "but after several talks with Fujitsu, we also came to realize that IoT would be an effective way to uncover issues in real time and improve them in a timely manner." The proposal seemed to be based on an awareness of the issues faced at the factory, so Takei and his team decided to accept the challenge of introducing IoT.

The project tackled line problems in three phases

The planning and design stage of the FINET IoT project began at the start of fiscal 2015, with the project launching in eariest in July 2015. The initiative was rolled out in three phases, as outlined below (Figure 1).

Phase 1 was 'visualizing the manufacturing line data.' This involved gathering digital data about the lines and presenting them in visual form to yield new insights that would lead to improvements. "We had no major goals initially; we just focused on making improvements based on minor observations,' says Mr. Takei.

The goal for phase 2 was "improving the manufacturing lead time." During this phase, the analysis from phase 1 was used to gain an understanding of the reasons behind stoppages, with improvements then implemented accordingly. "Our goal was to raise operation rates and boost productivity by cutting the amount of short-term stoppages," explains Mr. Takei.

The goal for phase 3 was 'preventing stoppages.' Event information from line equipment would be analyzed for signs of damage or to determine where maintenance was needed, with measures then taken to ensure there were no stoppages.

The results of phase 1 and 2 were verified over a one-year period. The process of line visualization and streamlining continued thereafter and the project is now at the practical use stage. With regards to phase 3's goal of preventing stoppages, knowledge is now being accumulated in order to enhance analysis from the verification stage onward. "We are building up the knowhow to determine signs of damage from IoT data analysis. I am convinced we will achieve results going forward," says Mr. Takei.

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IoT was introduced with minimal effort through the utilization of maintenance log data

IoT was introduced to three lines at the FINET Yamaguchi factory: the 'C3 Line,' which produces PCBs for PBX (private branch exchanges); and the C4 and C5 Lines,' which produce PCBs for smart meter telecommunications units. The C3 Line produces various products in small quantities while the C4/C5 lines are used for mass production, but all three are basically PCB mounting lines. Solder paste is printed over raw circuit boards and the components are installed on the boards using multiple surface mounting machines. The solder is then melted and the PCBs are passed through a reflow oven to fix the components in place. The finished product in then inspected. The phase one visualization process first utilized log data from equipment like the solder printers and surface mounting machines. "This is data recorded by equipment manufacturers for maintenance purposes. In the past it wasn't available to the actual factories. It took a great effort to analyze the log data ourselves to extract event information about the commencement and end of operations or errors, etc.," explains Mr. Takei.

Though data analysis took a lot of time and effort, the idea was to use IoT to utilize data generated by the equipment in an effective manner without having to attach new sensors and so on. Data not automatically extracted from the equipment could be gathered using tablets or barcode readers. Furthermore, web cameras were attached to the PCB mounting lines to enable the actual movements of workers to be checked at the same time. This was implemented with the minimum level of hardware investment and without altering line operations.

The equipment log data was collected on the FUJITSU Cloud Service K5 IoT Platform, an IoT data utilization platform service (*1). This was then checked on a display screen using FUJITSU Manufacturing Industry Solution VisuaLine, an IoT solution developed by Fujitsu to visualize the operational status of manufacturing processes (hereinafter 'Visua-

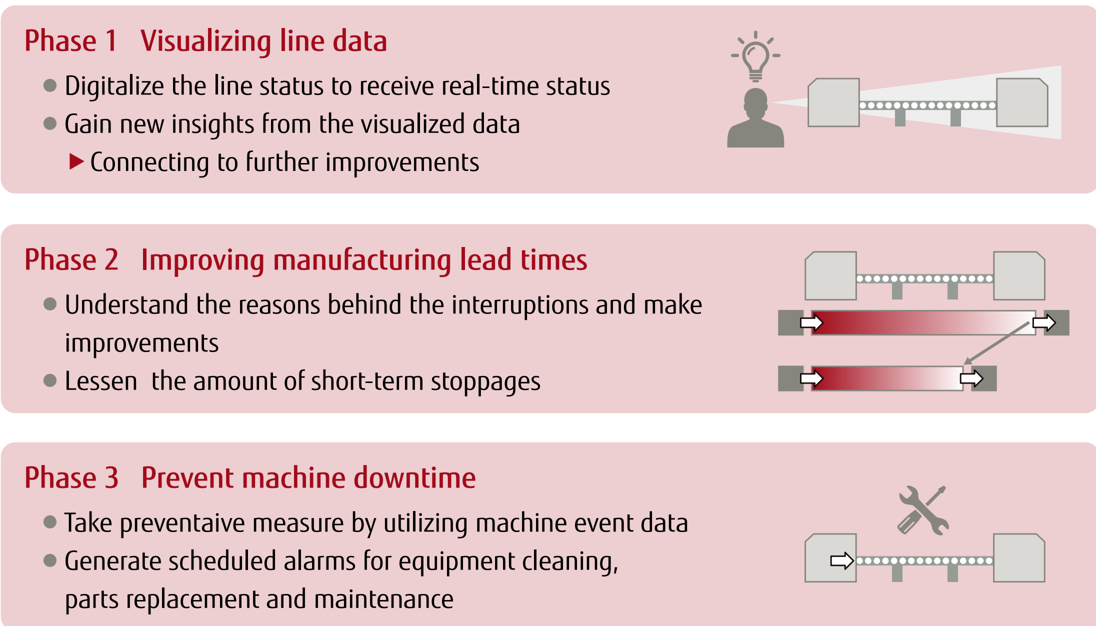

Figure 1: Fujitsu and FINET introduced IoT at the factory in three phases

Line') (*2). VisuaLine chronologically plots the start and end times of printed circuit board operations in each solder printer as well as the surface mounting machine process, with the time lines then displayed in the form of a line graph. Operational progress can be easily checked chronologically by superimposing data about errors or parts replacement over the time lines. If the manufacturing process goes smoothly, the time lines will be displayed at regular intervals, but if a delay occurs in the manufacturing process, it can be flagged by inserting a blank space between the time lines of the product involved in the delay and the next product to be manufactured. The idea is to present the delay in the visual form of out-of-sync timelines.

Furthermore, factory floor comments were recorded in an Excel sheet and displayed in VisuaLine alongside the log data gathered from the equipment. This enabled information about errors and delays to be shared (utilizing both 'equipment data' and 'human insights). By displaying all this together with video captured by webcam, it was possible to check in detail the machinery and human actions involved in any delays flagged in the time lines (Figure 2).

The printed circuit board (PCB) mounting lines at the Yamanashi factory, where IoT was introduced

IoT revealed problems relating to parts depletion and mask recognition errors

After the data was visualized in phase one, it was then analyzed in phase two in order to improve manufacturing lead times. Before IoT was introduced, there was a feeling that line stoppages were occurring because the surface mounting machines often ran out of parts. After viewing the data, it became clear that around 70% of surface mounting machine delays were due to this reason.

Naoya Takei

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First off, measures were taken to minimize the time needed to get replacement parts. At the time, the machine needed to be halted so the operator could get replacement parts, so it took a while to get things running again. To rectify this, a system was developed to estimate how many parts remained. When it looked like a surface mounting machine would soon run out, replacements were collected in advance and placed near the machine. This shortened the amount of stoppage time due to parts replacement.

However, line stoppages often occurred because feeder adhesion errors (when attaching the parts to the boards) were often mistakenly attributed to a machine running out of parts. This led to unnecessary line stoppages. "When we checked data related to 'minor errors' like adhesion errors, we discovered that errors often piled up before a line was stopped. By visualizing the data, we would get information about the locations where the minor errors were accruing. This enabled us to take action before the line was stopped," says Mr. Takei.

With solder printers, it was discovered that 94% of stoppages were due to recognition errors involving the metal masks used when printing the solder paste. Even when an error occurred, it could be fixed easily, so the workers did not pay much attention to stoppages caused by these errors. During the verification process, it was discovered that the solder printer program would automatically recognize only one of the two types of metal mask. By modifying the program so that it automatically recognized both types, the factory managed to cut the number of stoppages due to mask recognition errors. "Though the stoppages only occurred for a few seconds, this problem caused over 90% of stoppages, so it had to be dealt with. We managed to do away with the superfluous work needed to solve this problem and we raised the quality of the work carried out by our employees," says Koichiro Uehata, acting Director of FINET's Manufacturing Department.

The situation was different on the C3 Line, which produces various products in small quantities. When a different product needs to be manufactured, this involves a 'switchover' process. The switchover is to prepare the line for the next product. It involves switching the parts and tools, calibrating the tools and checking the operation before manufacturing commences, for instance.

This switchover occurred seven or eight times a day on C3 Line, which each switchover taking 60 to 90 minutes. The switchover process was converted into digital data using a tablet. The worker switchover schedule was visualized and streamlined, while moves were taken to eliminate mistakes when parts were being switched. This boosted manufacturing efficiency.

"In the past we stopped the lines before dealing with any problems that occurred. With IoT, though, we can monitor things in real time and deal with any problems before they occur. By phase two, we had managed to cut stoppage times on PCB mounting lines by 25% while boosting productivity by 20%," says Fujitsu I-Network Systems executive Atsuya Murai. At first, FINET was also unsure about what benefits IoT could bring, but Murai says it has helped the company gain a concrete understanding about occurrences on the factory lines while also helping employees feel a higher sense of accomplishment and achievement with their jobs.

Data analysis helps to prevent stoppages

After achieving substantial results up to phase two, FINET is now implementing phase three with the aim of preventing stoppages. This includes preventing motor failure, for instance. Surface mounted machines use a number of motors, such as the motor used to move the tray that provides parts. If a motor fails, it can take ten hours to get lines running again. This has a big impact on productivity.

Phase three involves building up knowledge by checking log data after a motor failure occurs to see if there were any warning signs beforehand.

When investigating one motor failure, it was discovered that the motor had given a 'shaft error' warning two to three months before the failure.

The problem was solved by resetting the motor, but FINET realized this kind of warning could foreshadow serious trouble, so it would be best to use the warnings to develop measures to prevent failures that could lead to stoppages.

As a new factory IoT initiative, FINET is thinking about introducing a framework that uses Fujitsu's image processing software Imagepower TrackingEye (*3) to measure line operation times, with the results displayed together with worker movements using VisuaLine. The aim is to measure the time taken to replace depleted parts, for instance, or the precision of operational procedures. Even if these are not captured precisely by camera, they can be checked using time lines. This initiative will identify more potential areas for improvement by visualizing employee operations as data.

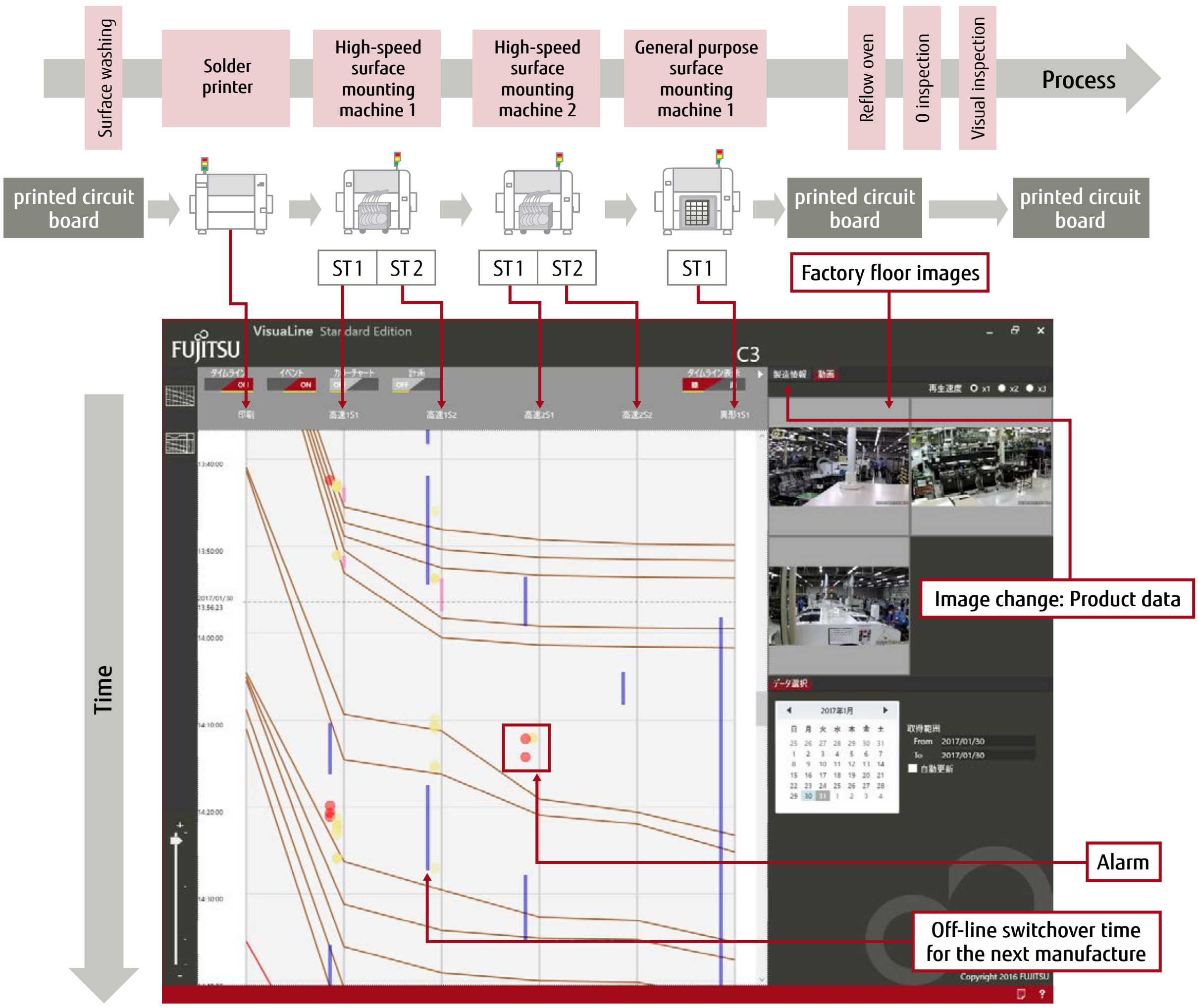

Figure 2: VisuaLine presents PCB mounting line data in visual form

The data visualized in VisuaLine can be checked at large displays attached to the lines

When it seemed like a line would run out of parts, replacements were placed by the surface mounting machine (the reels on the right-hand stand). This shortened the amount of stoppage time due to parts replacement

IoT has already reached the 'practical use' stage at the FINET factory

As outlined at the start, FINET was skeptical when first introducing IoT. However, the initiative steadily achieved results from the modest 'visualization' phase onwards, without the need for substantial investment, so FINET grew more cognizant of IoT's benefits. The initiative was initially implemented as a trial, but President Nakamura, says IoT has already boosted actual line productivity, with the technology now at the practical use stage.

If IoT is skillfully introduced at factories, like in this example, it can be used to boost efficiency and productivity. Of course, conditions differ substantially depending on the industry or company, so these differences will need to be taken into account when introducing IoT. That is to say, factory network integration is necessary to make effective use of IoT.

"Factory network integration involves developing the infrastructure needed to introduce IoT in an optimal manner," says Mr. Kano, adding "Fujitsu has accumulated know-how through factory IoT trials like the one at FINET and we feel we can provide optimal factory network integration."

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The VisuaLine solution provided by Fujitsu during the FINET project was honed through demonstration trials, with its functions adjusted based on the results of these trials. It was released on general sale in December 2016. Infrastructure development through factory network integration is a process that requires individual optimization on a case-by-case basis, whereas IoT solutions like VisuaLine are one-size-fits-all solutions, but by combining the two, factories are starting to achieve real results when introducing IoT.

1 FUJITSU Cloud Service K5 IoT Platform (an IoT data utilization platform service) http://jp.fujitsu.com/solutions/cloud/paas/iot-platform/
2 FUJITSU Manufacturing Industry Solution VisuaLine (a solution that supports factory-floor reform) http://www.fujitsu.com/jp/solutions/industry/manufacturing/monozukuri-total-support/services/kakushintai/visualine/
3 FUJITSU Software Imagepower TrackingEye (software that analyses behavior from video footage) http://www.fujitsu.com/jp/group/fqss/solutions/software/applications/image-monitoring/mizzo/

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