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Quality Quandaries: Reducing Work in Process at an Emergency Assistance Center

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INTRODUCTION

An important principle of *lean* manufacturing (cf. Womack and Jones 2003) is that it strives for low levels of work in process (WIP). Work in process or in-process inventory consists of all unfinished jobs or parts in a process at a particular moment in time. Disadvantages of high amounts of WIP include inventory costs, increased throughput times, and other kinds of nuisance. On the other hand, WIP makes a process less vulnerable to disruptions, because it provides a buffer of jobs to work on.

The ideal of a small amount of WIP was key to the successes of Toyota in the second half of the 20th century and is well appreciated in the manufacturing industry. For manufacturing processes it is clear that WIP costs money, because of the cost of capital not available for investment, the cost of storage space, and the risk of obsolescence and damages. In the service industry, on the other hand, where inventory costs are relatively small, the advantages of low WIP are less obvious. Nevertheless, the benefits of reducing WIP may be substantial for organizations in the service industry as well, because it leads to shorter throughput times and less nuisance created by jobs being processed simultaneously.

This article describes a case study of an improvement project at an emergency assistance center. The next section briefly explains why and how to control WIP in non-manufacturing processes. In the subsequent sections the case study on the emergency assistance center is introduced and described.

CONTROL OF WORK IN PROCESS

Advantages of smaller amounts of WIP in the service industry include shorter throughput times and less nuisance by multiple jobs being done at the same time. That more WIP leads to longer throughput times can be seen from Little's law:

$$\text{Average throughput time} = \frac{\text{Average amountof WIP}}{\text{Average throughput rate}}. \qquad [1]$$

Little's law is intuitive: if there is a lot of work in the pipeline, it will take a long time for each job to be finished. Note, however, that through Little's law, WIP affects throughput time; that is, time that a job spends in the process but not (necessarily) total lead time as experienced by the customer.

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This is because, in reducing WIP, the gain in throughput time in the process may be transferred to additional queue time before the job is released into the process.

Another potential advantage of low WIP levels to services processes is that it reduces the problems associated with jobs being processed simultaneously: the jobs in the pipeline must be managed and this creates extra work, such as planning, changes in the planning, and discussions about the planning. The complexity of multiple jobs being done simultaneously may result in a higher probability of mistakes and in additional setup times consisting of searching files and of reading and rereading them multiple times.

In a lean operation, the amount of WIP is controlled, usually by setting a maximum for it, called a *WIP cap*. This is in contrast with a so-called push system as depicted in Figure 1.

In a push system, new jobs are immediately added to the WIP, and therefore the amount of WIP is determined by the number of job requests that arrive. In a pull system, on the other hand, as shown in Figure 2, new jobs do not immediately enter the process but wait in a buffer to be released into the process when the amount of WIP is below the WIP cap.

In this job release, jobs can be prioritized by using sequencing rules, such as earliest due date first (EDD), first in–first out (FIFO), or first in process–first out (FIPFO). For an excellent treatment of WIP control in the context of manufacturing, we refer to Hopp and Spearman (2008).

An objection that can be made against pull systems is that pull systems avoid safety buffers and latitude because these increase WIP. This makes lean processes vulnerable to disruptions. In some processes this is a valid objection. On the other hand, it could also be seen as an advantage: safety buffers

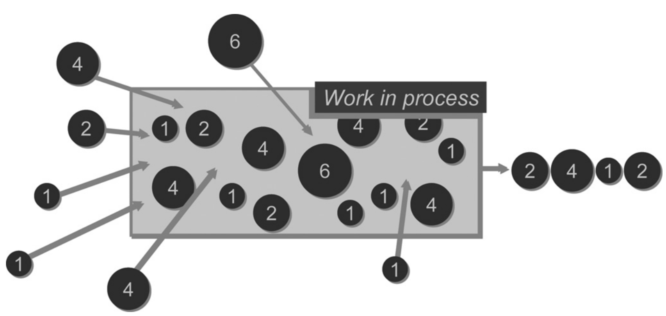

FIGURE 1 Push system.

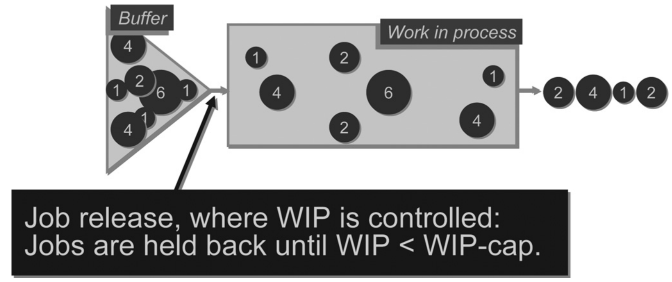

FIGURE 2 WIP control.

and latitude hide problems in the process, whereas the tight way of working in lean processes reveals problems so they can be tackled. In general, the choice for a pull system entails the choice for related efforts, such as mistake proofing, variability reduction, and good relations with suppliers.

An example of a pull system is the famous kanban system employed by Toyota. In a kanban system there is a WIP cap for every step. Process steps use cards that signal to the previous step that a new part is required. This ensures that the amount of WIP in a certain step never exceeds the total number of cards. A kanban system requires a smooth, even, and predictable workflow, because it does not allow any safety buffers in the process. Therefore, it is only advised for processes that are highly repetitive (Hall, 1983).

Another pull system, that is less stringent and easier to implement than kanban, is constant work in process (CONWIP). In a CONWIP system there is a WIP cap for the whole process. New jobs are not allowed to be released into the process until the amount of WIP is below the WIP cap, as shown in Figure 2. There is no explicit control over where in the process the WIP will accumulate. Typically, WIP will accumulate before the bottleneck, thus ensuring that the bottleneck always has a buffer of work and is never idle. Therefore, a CONWIP system is generally more robust to variability than a kanban system.

CASE STUDY

In 2009 and 2010, a project aimed at reducing WIP took place at Eurocross Assistance, an emergency assistance center in The Netherlands. We will discuss this project in the remainder of this article, because it is a nice example of the application of WIP control in the service industry.

Eurocross Assistance has provided emergency assistance to Dutch people throughout the world since 1982. It has around 300 employees, who coordinate emergency assistance services such as medical help; breakdown services; assistance in case of fire, storm, or water damage; and personal emergency services. Since 2009, Eurocross Assistance has had a Lean Six Sigma program organizing improvement projects using Lean Six Sigma's define–measure–analyze–improve–control (DMAIC) method. The project to be discussed here was part of this program. For an introduction to Lean Six Sigma in services and health care see De Mast et al. (2012).

The project was executed by two black belts (i.e., project leaders) certified by the University of Amsterdam, who reported to the Lean Six Sigma program manager (acting as champion) and were coached by external consultants of the Institute for Business and Industrial Statistics of the University of Amsterdam (acting as master black belts, experts in the Lean Six Sigma methodology). The project took place in the department International Assistance, which provides assistance to people traveling abroad. The objective of the project was to reduce the work in process, the number of open appointments of assistance coordinators, by at least 10%, maintaining the same level of customer satisfaction. In the following sections the project is described following the five DMAIC phases.

DEFINE

In the define phase, the black belts described the process to be improved and formulated the project objectives and their potential benefits. The project aimed to improve the process of providing assistance to clients abroad by the department International Assistance. After a client calls for assistance, the following steps are executed in this process. First, a file is prepared. After that, the insurance coverage is determined. Then, actions are performed by assistance coordinators to fulfill the client request and the client is informed. Finally, the file is closed. While processing client requests, the assistance coordinators see a list on their computer screen of all open appointments and actions that need to be performed: the work in process.

Before the start of the project, this list was estimated to contain actions related to 80 client files on average. The objective of the project was to reduce the work in process—the number of jobs visible on this action list—aiming to reduce throughput times and processing times. This would have several potential benefits. The most important benefit was that client satisfaction would improve, because client requests would be handled on time. Another benefit to the organization was that the service coordinators would become more efficient and would be able to handle more client files per year. Financially, this would result in a reduction in personnel cost through reducing the number of full-time equivalents (FTEs) working in the process.

MEASURE

In the measure phase, the black belts operationalized the project objectives as requirements on quantifiable and measurable quality characteristics and established a procedure to measure these characteristics. In Lean Six Sigma, these quality characteristics are often called *critical to quality* (CTQs) characteristics.

The three CTQs in this project are work in process, timeliness, and time spent searching and reading. Timeliness is an important aspect of the service quality perceived by clients who are in need of emergency assistance in a foreign country. Time spent searching and reading files is part of the total processing time and determines the number of assistance coordinators needed in the process. The amount of work in process, defined here as the number of open appointments at the start of the day, has an effect on both of the other CTQs. It determines the throughput time through Little's law and thereby influences timeliness. Many open appointments cause employees to spend time scrolling through the appointments on their computer and reading files multiple times, and therefore the work in process also affects the time spent searching and reading. Therefore, the requirements on the CTQs were to minimize work in process, minimize searching and reading time, and maximize the timeliness of actions. The way the CTQs relate to the project objectives and the strategic goals of the company can be schematically displayed in a so-called CTQ flowdown (cf. De Koning and De Mast 2007). The CTQ flowdown for this project is shown in Figure 3.

FIGURE 3 CTQ flowdown.

The amount of work in process was determined based on the number of open actions visible to assistance coordinators in their workload overview at the start of each day and was measured for a sample of days and employees. The timeliness of actions was measured by taking a sample of actions and registering whether they met the time that was promised to the client and also by calculating the difference between the time it was first possible to perform the action and the time it was actually performed. The time spent searching and reading was measured in the following way: Assistance coordinators filled in time sheets during periods of 2 hours, measuring the amount of time they spent on each of a number of activities. Two of these activities were reading files and scrolling through the workload searching for the next action to take. The time spent on different activities was registered during 46 hours total.

ANALYZE

In the analyze phase the black belts determined the current performance of the CTQs, based on the data collected. A thorough analysis led to a diagnosis of the problem and a list of potential influence factors.

An analysis of the timeliness of actions showed that 53% of the actions were not taken within the time agreed to. In 38% of the cases this was because the previous step had not been completed yet, but in 62% of the cases the time could have been met if the action had been given more priority. For those actions in the sample that were performed late, the measurements showed that, on average, actions could have been performed almost 8 hours earlier. The black belts set as a project objective that 100% of the actions should be on time.

The time spent on different activities by the assistance coordinators is displayed in a pie chart in Figure 4. This figure shows that 9% of the time was spent searching, and 19% of the time was spent reading. This can largely be seen as non-value-added work; that is, work that does not add value for the customer. The assistance coordinators also spent 32% of their time on the telephone (either calling or being called), 34% of their time entering data, and 5% of their time on consultation and gathering information. Based on these data and a diagnosis of the current situation, the time spent reading files was targeted to decrease to only 10% of the time, and the time spent searching was to be avoided altogether.

Figure 5 shows a histogram of the number of open actions that an assistance coordinator sees on his workload overview per day, based on a sample of 40 observations. It shows that the average WIP per employee per day was 63 actions. Over the previous half year, the average throughput rate had been 54 completed actions per employee per day. Based on these figures, it follows from Little's law that that the

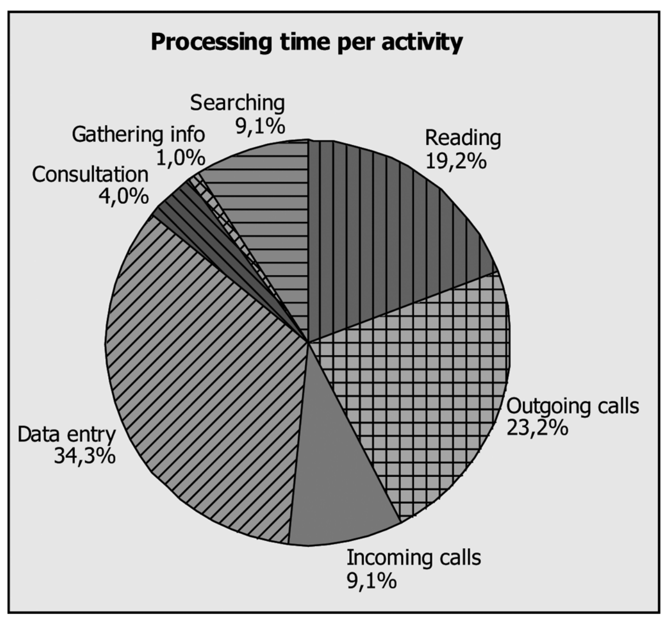

FIGURE 4 Pie chart showing processing time per activity.

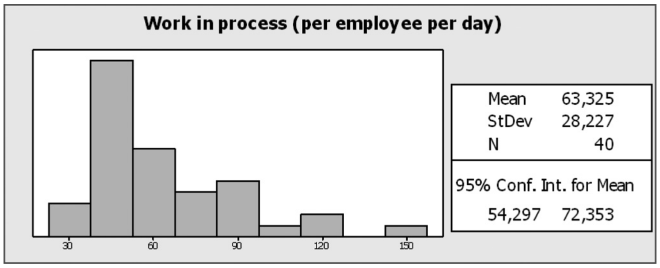

FIGURE 5 Histogram of work in process per employee per day.

average throughput time of tasks is slightly more than a day. The objective was set to reduce the WIP to 15 by using a new software system, largely reducing the time spent searching and reading and reducing the average throughput time to only a third of a day.

The objective of the project could now be restated as follows. After the project, all actions should be on time, which would have a large impact on client satisfaction. Furthermore, the WIP should decrease to 15 and the time spent searching and reading should decrease by 18%. This would create the opportunity to reduce the number of assistance coordinators by nine FTEs, which represents more than €500,000 of personnel costs.

Brainstorm sessions with a number of assistance coordinators led to a list of important influence factors affecting the CTQs. The most important influence factors are shown in Table 1.

The timeliness of actions was influenced by several factors. First of all, if there was less WIP, the throughput time would decrease and work could be more easily prioritized. Furthermore, the time when actions were due was currently not visible in the workload overview. Many actions were not planned at a certain time. Another cause of the poor timeliness was the lack of protocols and working procedures. This was the cause of mistakes and rework and therefore increased the throughput time of actions. A control variable that could be used to improve the timeliness was the capacity: the number of assistance coordinators at work.

TABLE 1 Important influence factors per CTQ

CTQ: Timeliness
Work in process Due time shown (yes/no) Standard working procedures Capacity (number of FTEs)
CTQ: Searching and reading time
Work in process Correctness and clarity of registrations Changing screens in software (yes/no) Standard organization of information
CTQ: Work in process
WIP cap Unnecessary and duplicative actions Actions not due yet Actions not performable yet

The most important reason why so much time was lost searching and reading was that there were so many open actions visible in the workload overview. A reduction in WIP would largely decrease the time spent searching and reading. The searching and reading time was also influenced by the correctness, clarity, and conciseness of registrations in the workload management system. Because information was often incorrect, unclear, or not concise, the assistance coordinators spent more time searching and reading, and the probability of mistakes increased. In addition, the setup and appearance of the workload management software were inefficient, because employees had to change screens frequently when searching for a file or an action to take. Moreover, information was hard to find, because it was not organized in a standardized way.

The amount of WIP was large due to many unnecessary appointments in the workload overview. For example, some unnecessary appointments were automatically generated, some appointments were entered with the wrong date, or duplicate appointments were added. In addition, the workload overview was used as a to-do list by some of the employees, in the sense that they created imaginary appointments as reminders. Furthermore, there were many actions in the workload that could not be performed yet, because the previous step had not been finished. The amount of WIP could be reduced by a new workload management system that follows the rule of CONWIP: only show an action in the workload overview if the WIP is less than a certain WIP cap.

IMPROVE

In the improve phase the black belts provided evidence of the effect of the most important influence factors. Based on these influence factors, the black belts designed a number of improvement actions that together would result in a large improvement in the CTQs.

First, the black belts analyzed the effect that the influence factors would have on the CTQs. Perhaps the most important influence factor was the height of the WIP cap in the intended CONWIP system, because this would determine the work in process and would consequently influence the other two CTQs as well. Setting a WIP cap to 15 would immediately reduce the number of actions in the workload to at most 15. It was easily shown that this was possible, because the majority of the jobs currently in the workload did not need to be released into the process yet: they were either unnecessary, duplicative, not due yet, or not performable yet. The black belts found that no less than 80% of the actions were not due yet and did not need to be shown in the workload. In addition, for 52.4% of the open appointments an immediate action was not possible because the previous process step had not been completed yet. Furthermore, 14% of the actions were duplicate entries saying "a fax was received" or "an e-mail was received," and 2.2% of the actions were appointments to call back customers who complained about earlier appointments that were not met.

The time spent searching and reading was strongly influenced by the WIP. Per day, an assistant coordinator spent 30 minutes scrolling through the workload searching for an action that needed to be performed. This searching time could be reduced to (almost) zero if the amount of WIP was kept low, changing screens in the software system was not necessary, and information was organized in a standardized way. The reading time was also affected by the amount of WIP. Much of the reading time was caused by unnecessary appointments in the workload overview: on average 30% of the 50 appointments that an assistance coordinator opened, read, and closed during a shift were not followed by an action. Reading an unnecessary action cost an assistance coordinator 3 minutes of additional processing time on average. In addition, the correctness and clarity of information affected the reading time. Of all files, 44% contained incorrect information, and 12% were considered unclear. An assistance provider spent 20 minutes per day reading and correcting files that were incorrect or unclear.

The timeliness of actions would benefit from low WIP as well. The actions that were performed too late could have been performed almost 8 hours earlier on average, and 62% of them could have been performed on time if they had been given more priority. A large amount of WIP made it difficult to correctly prioritize actions. This was made even more difficult by the fact that due times were never shown in the workload overview. The timeliness was also affected by mistakes and rework caused by the lack of protocols and working procedures. A control variable that influenced timeliness was the number of assistance coordinators: if due times were not met, extra temporary capacity could be assigned to the process.

The improvement actions that the black belts designed were as follows. First of all, they decided to use a CONWIP system as displayed in Figure 2, with a WIP cap of 15. Actions were not released into the workload overview until the workload was below 15 actions. All actions would be given a due time by the assistance coordinator who put the action into its file. The order of the release of actions into the workload overview would be based on this due time according to an EDD prioritization, and the due time would be shown in the workload overview. Actions that were not performable yet or not due yet would not be shown in the workload overview. Assistance providers would only see a limited number of jobs in their workload and changing screens would not be necessary. In order to implement this, new software would be developed.

Secondly, protocols and working procedures for assistance coordinators would be improved, and assistance coordinators would be coached about the new procedures. They would be instructed about correct, clear, and concise registration in the client files and in the workload management software. Information in the files would be organized in a standardized way such that it would become easy to find. Redundant and duplicative actions were to be avoided.

Thirdly, in order to ensure that appointments with clients were met, the capacity management would be improved. The manager would receive a daily report showing how many appointments were open on a certain day. With this knowledge, the manager would better be able to decide the capacity that was necessary per task. In case of insufficient capacity for a certain task, the manager could assign additional temporary capacity.

An implementation plan was created for the improvement actions. The manager of the department International Assistance was accountable for implementing them by the beginning of 2011.

CONTROL

In the control phase, the black belts improved the process control system. They documented the improved process, created a control plan to deal with irregularities in the process, organized continuous improvement, and defined roles and responsibilities. Many irregularities such as mistakes and duplicative actions could be avoided by the new software system. The assistance coordinators were responsible for correcting any mistakes and resolving any irregularities they encountered. They would see only a small number of actions in their workload overview, including their due times. The manager would see a daily report of the total workload for that day and was to adapt the capacity to the workload. Quarterly reports would be made on client satisfaction, based on complaints and compliments from clients as well as on customer surveys. In addition, the performance of assistance coordinators would be reported on a regular basis by coaches, who provide coaching on the job and one-on-one training. The assistance coordinators would receive feedback on these reports and, if necessary, further improvements could be made based on these reports.

Finally, the benefits of the project were determined, follow-up actions were planned, and the black belts were discharged from the project. The benefits of the project were substantial. Since the improvement actions were implemented, almost all appointments with clients were met. Because of the reduction in the time spent searching and reading, the number of FTEs necessary in the process decreased by six. Currently, further improvements are underway. During 2012 the work in process will be further reduced to a single action per person. Assistance providers will only see the single action with the nearest due date in their workload overview. This is expected to further improve the timeliness of actions and to further reduce the time spent reading and searching by three FTEs. In addition to improved client satisfaction, the yearly financial benefits of the project were €540.000, the personnel costs related to nine FTEs.

CONCLUSION

The project of reducing work in process at an emergency assistance center is a nice example of the impact that WIP reduction can have in the service industry. By implementing CONWIP and by improving the workload management system, the time spent searching and reading was largely reduced, and the timeliness of actions was improved. This led to substantial benefits for both the business and the customer.

Though the advantages of WIP control for manufacturing processes are widely recognized, this project illustrates that WIP control can be beneficial to services as well. Even though in the service industry inventory costs are often small, the benefits in terms of throughput time and nuisance associated with WIP can be substantial.

REFERENCES

De Koning, H., De Mast, J. (2007). The CTQ flowdown as a conceptual model of project objectives. *Quality Management Journal*, 14(2): 19–28.

De Mast, J., Does, R. J. M. M., De Koning, H., Lokkerbol, J. (2012). *Lean Six Sigma for Services and Healthcare*. Alphen aan den Rijn. The Netherlands: Beaumont Quality Publications.

Hall, R. W. (1983). *Zero Inventories Homewood*. IL: Dow Jones-Irwin.

Hopp, W. J., Spearman, M. L. (2008). *Factory Physics*. New York: McGraw-Hill.

Womack, J. P., Jones, D. T. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation Florence*. MA: Free Press.