Change Management System (CMS) Evaluation: A Case Study in a Multinational Manufacturing Company in Malaysia

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Abstract

Changes can be defined as modification of the form, fit or function of an object such as a process or a product. Changes can be positive or negative but in general, making changes show that a company is progressing and improving. A company can choose to take initiative to change or just wait for external forces depending on its necessity or requirement. In some cases, change is not favourable unless it is really necessary as it involves time and money as well as other resources. Due to this, a good change management is necessary so that changes can be monitored effectively. A dynamic and timely change management is important in order to ensure that the company does not fall behind in being competitive in the industry. This study focuses on the evaluation of the change management system in a manufacturing company. Focus is given to the measurement of the change process which has been agreed to be due to cycle time in which an ideal cycle time for the change process is simulated. Based on Monte Carlo simulation, it is figured that the overall cycle time can be improved by 35%. At the same time, other
effectiveness measure is also identified to improve the management system of the company.

**Keywords:** Change management analysis, ideal cycle time, Monte Carlo simulation.

1 Introduction

The manufacturing process is a complex one as it depends merely on supplies, equipment, factory overhead, the need for special parts, and the number of people who work at all points in the whole process. The more variables there are, the greater the possibility of disruption to the smooth operations of a factory. Management styles can also have a positive or negative impact on this process. In general, change can be defined as variation, modification, or transformation of an item. [1] defined competitiveness as “the ability to react and adapt to changes in close and wider environment” and when a company is able to react to the environment and reactions, ahead of their competitors. [2, 3] mentioned that manufacturing changes are subject to frequent changes due to technology, product innovation, variation of demand, product mix, continuous improvement, or change due to equipment and machines thus, a manufacturing companies have to be able to handle change with quick response at low cost in order to be competitive.

Changes in work process are required everywhere and are no longer a choice. Figure 1 depicts a need for change in organization in order for it to stay competitive. Several companies have been identified to be successful due to changes made in their work process. For example, not long ago, Apple was on the brink of fizzling out. From about 1993–1997, Apple found itself struggling to find a consistently profitable source of revenue, trying and failing to market everything from digital cameras to portable CD players to TV appliances. With Steve Jobs ousted due to internal squabbles, the company attempted to right ship with a revolving door of stopgap CEOs (including one former head of Pepsi-Cola.) Finally, in 1997, Jobs returned as CEO and instituted a bold change of direction. Instead of continuing to aimlessly follow marginal product ideas, Apple changes its production and began to focus once more on creating beautiful consumer electronics, starting with the iMac in 1998 [4]. This happen due to its ability to change its business process models as necessary.

Changes or modifications need to be managed, monitored and reviewed systematically. Uncontrolled changes can cause unnecessary quality issues,
operation hiccups, complication in productivity, problems in delivery, or customers’ dissatisfaction while ineffective changes can result in the waste of resources and caused the company to reduce its value to customers where finally, the company will lose its competitiveness to other companies. Modification or alteration of product, process, method, tools, equipment requires good process management since changes involve the use of resources such as time, material and man power as well as achieving the objective of the change such as improvement in productivity, improvement in quality, increase in profit, reduction in cost and many more. Systematic method to manage the change is therefore very crucial so that the change is not wasting any of these resources and the objective of the change is achieved.

This study is to evaluate the change management request process in a manufacturing company. The findings of this study are expected to be of help to the company in identifying the needs of improvement in current change request process. In addition, it will also provide better overview on the impact of the changes made.

Figure 2 shows a generic model of a change management process. The process starts with a request of change, a review of objective, an approval from the top management, the implementation of change and finally a review of the results of change.

In ensuring that the process is effective and efficient, time and costs of managing the process of the change request have to be constantly monitored.
and evaluated. Long cycle time of change will lead to high risk, high cost, high rework and will affect the product time to market and shorter cycle time can minimize resource consumption \[5\]. Hence, in this study, details analysis on the cycle time and reasons for change are done.

Delay in processing a change, can cause time, money, waste of resources, and potential of losing customer’s trust. \[6, 7, 8\] indicates that changes that are not managed properly can impact productivity and causing delays in schedule and resulted in cost overruns. In order to change, the characteristics of the change item should be clearly evaluated. This is to ensure that the change is necessary and the history of the object of the change is clearly understood. \[9\] included the evaluation of history of the characteristic of the item that needed to change and also the evaluation of the effect of the change is to be done prior to actual change. In managing a change, the main attribute that need to be analysed is the change item, then all the other attributes that

![Figure 2](image2.png)

**Figure 2** Generic Change Management Model.

![Figure 3](image3.png)

**Figure 3** The input and output factor of a change process.
came in around the item such as the change inputs and the change outputs as shown in Figure 3. Change Inputs are mainly information on the reason of change, which are based on a few questions such as (i) what is the change, (ii) why change is needed, (iii) what are the change required, iv) what drives the item to change, v) what attributes needed to realize the change, and so forth.

Monte Carlo simulation has been used to estimate the cycle in a typical batch production system such as supply chain, where a variety of products is scheduled for production at determined periods of time [10]. It uses the delivery time as the maximum lead time in the method. The product’s final assembly cycle and delivery time, which were obtained via the production schedule and supply chain simulation, respectively, were both considered to estimate the demand distribution of product based on total duration. Efficient random variates generators were applied to model the lead time of the supply chain’s stages [11].

2 Research Methodology

In this study, an appropriate Quality tool, Supplier, Input, Process, Output, and Customer process (SIPOC) is used as part of the method of analysis. There are 6 steps used in the methodology of this study as shown in Figure 4, 5 and 6.

First, the company’s change management process was drawn out in order to understand the process steps. Suppliers are the people who provide information or material to the process, Input is the information or material

![SIPOC Diagram](image-url)  
**Figure 4** The SIPOC Diagram for Change Management Process.
| Customer Needs | Quality Drivers | Performance Requirement (Critical To Quality) |
|----------------|-----------------|-----------------------------------------------|
| Efficient Change Request | On Time Change Completion | * # of approval days |
| Number of Change Completion | * # of change requests in a month |

**Figure 5** The Critical to Quality (CTQ) tree for Change Management Process.

| FACTORS                  | VARIABLES                           | PROCESS FLOW                                      |
|--------------------------|-------------------------------------|--------------------------------------------------|
| Reason of Change         |                                     | Step 1: Request to change                        |
| The Products             |                                     | Step 2: Review change request content            |
| Internal/External factors|                                     | Step 3: SME Qualification Approval               |
| Change Requirements      |                                     | Step 4: CRB Qualification Approval               |
|                          | Critical to Quality Number of Approval Days | Step 5: Run Qualification                        |
|                          |                                     | Step 6: SME review qualification results        |
|                          |                                     | Step 7: CRB review qualification results        |
|                          |                                     | Step 8: Change Released                         |

**Figure 6** The Theoretical Schematic Diagram.
provided. Process is the steps required to do work, Output is the product, service, information obtained from the process that will provide to the customer and Customer is the next step of the business process or external customer. In this SIPOC diagram, the high-level process is drawn out identifying who are the supplier, the input variables, the detail process, the output variables and the customer of the Change Management process. Figure 4 summarised this step.

Next, the Critical to Quality (CTQ) of the process were determined. In order to build a CTQ tree, three attributes are used which are Need, Quality Driver and Performance Requirement. The needs of the change management process were obtained from brainstorming and interviewing the stakeholders of the change management process which are the Subject Matter Experts (SMEs), the Change Review Board (CRBs), the requestors, the document controller and the change management coordinator. A CTQ tree was plotted as shown in Figure 5. Based on the CTQ tree, two main variables are identified as the critical to quality variables which are the number of approval days and number of change requests in a month.

This study focuses on the critical to quality factor of number of approval days and therefore, in the next step, the factors that has relationship with the number of approvals are determined. The factors as available in the database, which are:
(a) the Reason of Change
(b) the Product
(c) the Internal/ External factors
(d) the Change Requirement

Figure 6 summarized the relationship between the number of approvals, its potential factors and the process involves. It also highlights the Change Approval Request Process (CARP).

2.1 Data Collection

This study used primary data that is obtained from the company database for the year 2017. The analysis will be divided into two phases. Phase 1 is the on-time change completion based on the approval days and deviation from the ideal time. Phase 2 is the reasonable quantity of change completion based on the number of change request in a month.

Phase 1

*Calculate the number of approval days for selected products*
After the top 20% products are selected, the cycle time of the change requests from the top 20% products are calculated. The number of approval days are calculated by adding up the cycle time of each process steps for each change requests. Analysis of the cycle time was carried out to identify which process contributes longer cycle time for each of the product. In this study, the number of days to complete a change of request were plotted against the reasons and factors of change using descriptive analysis and correlation analysis.

Phase 2

Simulating completion time using Monte Carlo Simulation model

Monte Carlo simulation is used to estimate or simulate future output of a process or an event. In general, it can be formulated as below.

\[
\text{Tomorrow's value} = \text{Today's value} \times e^r
\]

Where \( r \) = periodic daily return

In the change management system that is under study, there are variety of products involved. However, the processing time of each change request are expected to be the same for different products as well as different factors of change reason. Assume \( X \) is one of the products in the change requests list which comes directly from the change requester. \( X_i \) is then with \( i = 1, 2, 3 \ldots n \) where \( n \) is the \( i \)th product. The product \( X_i \) can generally involve different process stages regardless of the reason of change. The different staged of product, \( i \) can be defined as number of process staged \( j = 1, 2 \ldots , m_i \) where \( m_i \) is the complete stages of the change request process. The cycle time for product \( X_i \) on process \( j \) is denoted as \( t_{ij} \); \( i = 1, 2, \ldots, n \) & \( j = 1, 2, \ldots, m_i \). In this study, the completion time or the total time to complete the whole change request process is called total completion time.

3 Result and Analysis

The number of change requests by product was extracted out from the company database. There is a total of 14 products that had undergone change requests for the period of the study. Table 1 shows the number of change request for the 14 products for the whole year in descending order.

Product 1 contributes to the highest percentage of total change, which is 15.03%, and the lowest contribution goes for Product 14 with 0.52%. Since the process for each change request is the same, it is reasonable to just select a few products as the main focus for the next analysis of this study. A common method used is the Pareto analysis which is based on Pareto’s 80:20 rules, the top 20 percent of a population influence or represent the other 80% of the
### Table 1
Total number of change requests by product for year 2017

| Product | Jan-17 | Feb-17 | Mar-17 | Apr-17 | May-17 | Jun-17 | Jul-17 | Aug-17 | Sep-17 | Oct-17 | Nov-17 | Dec-17 | Grand Total |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------|
| 1       | 3      | 2      | 5      | 1      | 4      | 2      | 3      | 1      | 4      | 2      | 2      | 29     | 15.03%     |
| 2       | 4      | 2      | 2      | 2      | 5      | 1      | 1      | 1      | 2      | 1      | 1      | 24     | 13.47%     |
| 3       | 5      | 3      | 3      | 2      | 7      | 3      | 2      | 2      | 2      | 5      | 1      | 26     | 13.47%     |
| 4       | 4      | 4      | 3      | 2      | 3      | 1      | 3      | 2      | 5      | 1      | 1      | 25     | 12.95%     |
| 5       | 3      | 3      | 3      | 1      | 2      | 2      | 2      | 1      | 2      | 3      | 1      | 17     | 8.81%      |
| 6       | 2      | 2      | 2      | 1      | 2      | 3      | 3      | 2      | 2      | 2      | 1      | 16     | 8.81%      |
| 7       | 1      | 1      | 1      | 2      | 3      | 1      | 2      | 1      | 1      | 2      | 1      | 15     | 7.70%      |
| 8       | 1      | 2      | 2      | 1      | 1      | 1      | 1      | 2      | 1      | 1      | 1      | 15     | 7.70%      |
| 9       | 1      | 1      | 3      | 1      | 2      | 2      | 2      | 1      | 1      | 2      | 1      | 11     | 5.65%      |
| 10      | 1      | 1      | 1      | 1      | 1      | 2      | 2      | 1      | 1      | 2      | 1      | 7      | 3.61%      |
| 11      | 2      | 1      | 1      | 1      | 1      | 1      | 1      | 2      | 1      | 2      | 1      | 4      | 2.10%      |
| 12      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 2      | 1      | 2      | 1      | 4      | 2.10%      |
| 13      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 2      | 1      | 2      | 1      | 4      | 2.10%      |
| 14      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 2      | 1      | 2      | 1      | 4      | 2.10%      |
| 15      | 1      | 1      | 1      | 1      | 1      | 1      | 1      | 2      | 1      | 2      | 1      | 4      | 2.10%      |
| **Total** | **15** | **14** | **20** | **19** | **20** | **15** | **19** | **20** | **15** | **19** | **15** | **105** | **56.52%** |
The Pareto chart for Product population. Before the 20 percent of the items are selected, Pareto chart of chart of change requests for all 14 products were plotted as shown in Figure 7. Based on the cumulative percentage, we can see from Figure 7 that Product 1 and Product 2 accumulate to 28.5 percent of the overall number of changes where Product 1 with 29 change requests contributes 15% and Product 2 with 26 change requests contributes 13.5% from the overall number of change requests. These two products were then selected as the focus products in this study.

3.1 Performance Requirement (Critical to Quality)
As mentioned earlier, the performance is measured in two phases as below.

Phase 1 - On time change completion based on the approval days and deviation from the ideal time.
Phase 2 - Reasonable change completion time based on the number of change request in a month.

Phase 1
The total completion days for each change request for the two products are calculated using formula 3.1. Table 2 summarized the average completion time for each process and category. On average, any change request for Product 1 takes about 23 days to be completed and Product 2 is 26 days.

Detail calculation on the average completion time for Product 1 is 25.5 days with minimum number of days required can be as low as 10 days only
Table 2  The average cycle time of change process for product 1 and product 2

| Product Name(s) | Create Request | Submit Request | Document Review | Subject Matter Expert (SME) Approval for Qualification | Change Review Board (CRB) Approval for Qualification | Execution of Qualification Plan | SME Result Review | CRB Approval to Release | Completion Days (Average) |
|-----------------|----------------|----------------|-----------------|-------------------------------------------------------|-----------------------------------------------------|--------------------------------|-----------------|--------------------------|--------------------------|
| Product 1       | 3.5            | 1.0            | 1.0             | 7.0                                                   | 3.7                                                  | 0.0                            | 4.1             | 2.6                      | 22.8                     |
| Product 2       | 4.1            | 1.0            | 1.0             | 8.1                                                   | 5.7                                                  | 0.0                            | 3.7             | 2.8                      | 26.3                     |
and the maximum number of days is 55 days. Hence, considering the average total completion time to be the ideal time, the total deviation from the ideal time is approximately 107.6.

The same detail analysis has been done for Product 2. The minimum number of total completion day is 10 days while the maximum number is also 55 days. The mean deviation from the average completion time is almost 111.2 point. Note that from Table 1, a total number of 193 changes are managed every year with an average of 16 changes in total per month. Hence, identifying the critical process that contributes to total completion time might be able to help the management to plan for a more efficient management of all the changes.

3.2 Identifying the Process that Contribute to Higher Completion Time

The average completion time for each process was plotted against each process time in Figure 8. Note that completion time for Step 6 is excluded and is not going to be evaluated in this study since the cycle time for step 6 is controlled and monitored separately for this Change Approval Request Process.

The process with the highest cycle time is identified to be at Step 4 process for both Product 1 and Product 2. Step 4 is the process where SMEs review the qualification plan of the change request. It also can be seen that average cycle time for change request is higher for Product 2 in critical process; Step 4 and 5, while for the rest of the process, the total completion time are almost similar.
the same for both products. This indicates further investigation needed for the two processes.

**Phase 2**

In this phase the ideal time for completing Step 4 is analysed by using simulation.

### 3.3 Simulating the Completion Time for Improvement

Based on the analysis done in Section 3.2, it is found that Step 4 (Subject Matter Expert Approval for Qualification) has the highest completion time. Further analysis on breakdown time for each process is displayed on Table 3. It is found out that Step 4 also has the highest variation in its overall time. The process time for Step 4 is the time taken by the subject matter expert (SME) approval for qualification with the highest variation can mean the instability in the process itself due to human capability and judgement. It can due to

| Step Number | Average Completion Time (days) | Variance | Std Deviation |
|-------------|-------------------------------|----------|---------------|
| 1           | 3.89                          | 2.02     | 1.42          |
| 4           | **8.03**                      | **33.18**| **5.76**      |
| 5           | 4.06                          | 3.57     | 1.89          |
| 7           | 4.62                          | 10.39    | 3.22          |
| 8           | 2.89                          | 2.45     | 1.57          |

### Table 3  Summary of variation in completion time for critical steps for both products

| Step Number | Average Completion Time (days) | Variance | Std Deviation |
|-------------|-------------------------------|----------|---------------|
| 1           | 3.89                          | 2.02     | 1.42          |
| 4           | **8.03**                      | **33.18**| **5.76**      |
| 5           | 4.06                          | 3.57     | 1.89          |
| 7           | 4.62                          | 10.39    | 3.22          |
| 8           | 2.89                          | 2.45     | 1.57          |

### Table 4  Simulation of maximum time for Step 4 for both products

| Run | Product 1 | Product 2 |
|-----|-----------|-----------|
|     | Maximum Time for Step 4 =26 | Maximum Time for Step 4 =12 | Maximum Time for Step 4 =22 | Maximum Time for Step 4 =14 |
|     | Step 4 Total | Step 4 Total | Step 4 Total | Step 4 Total |
| 1   | 23.16 31.09 7.35 19.4 | 8.07 20.83 7.88 16.55 |
| 2   | 23.74 36.22 7.34 18.94 | 8.07 17.11 7.68 17.26 |
| 3   | 22.69 35.76 7.52 16.97 | 8.68 19.26 7.9 19.14 |
| 4   | 23.74 36.44 7.48 19.42 | 8.69 15.15 7.91 15.34 |
| 5   | 23.72 40.49 7.52 20.77 | 8.69 20.21 7.95 15.19 |
| 6   | 23.72 34.41 7.53 19.99 | 8.64 16.22 7.76 17.68 |
| 7   | 24.91 41.69 7.53 23.18 | 8.77 19.61 8.14 20.72 |
| 8   | 25.99 42.14 6.79 20.72 | 8.77 16.62 7.73 15.32 |
| 9   | 26 38.62 7.14 18.67 | 8.54 21.28 7.78 15.25 |
| 10  | 26 43.83 7.14 22.66 | 8.15 16.99 7.79 18 |
| Average | **24.37** | **38.07** | **20.07** | **18.33** |
| Std Dev | 1.25 | 3.98 | 1.86 | 0.29 | 2.15 | 0.13 | 1.89 |
less experience expert is judging as well as the nature of change itself that can be complicated. Hence, in order to detail the simulation, more data is needed [12].

In order to analyse the possible improvement in monitoring the critical steps in calculating the total completion time, separate analysis for both products will be done.

The critical step for Product 1 is Step 4 and the highest change request is from Customer Requirement. Hence, using the Monte Carlo Simulation method, the total completion time for the change management process is simulated with the process time for Step 4 is determined. The rest of the process time for the other steps are constrained within the minimum and its maximum total process time from Table 3. The simulation is run using Excel Solver for 100 times and the result is summarised in Table 4. It shows that the average total completion time (when the process time for Step 4 is limited to be less than the maximum 26 days) is proposed to be reduced to 38.07 days or improved by 30.9 percent with a minimal standard deviation at 3.98. Similarly, when the process time for Step 4 is limited to be less than the average time of 12 days, the average total completion time can further be reduced to only 20 days or 12.3 percent. Hence, it shows that by monitoring the total number of days in Step 4, the total completion days for managing the change process for the majority of requests for change can be improved.

For Product 2, the critical step is also Step 4 and the highest change request is from Cost Savings. Hence, using the Monte Carlo Simulation method, the total completion time for the change management process is simulated with the process time for Step 4. The simulation is run using Excel Solver for 100 times and the result is summarised in Table 4 as well. It shows that the average total completion time (when the process time for Step 4 is limited to be less than the maximum 22 days) is proposed to be reduced to 18.33 days or improved by 60.1 percent with a minimal standard deviation at 2.15. Similarly, when the process time for Step 4 is limited to be less than

| Table 5 Summary of simulation results on improvement |
|---------------------------------------------------|
| Product 1 | Product 2 |
| Maximum Total Completion Days | 55 | 46 |
| Proposed Maximum Total Completion Days | 38 | 18.33 |
| Percentage Improvement | 30.9 | 60.1 |
| Maximum Step 4 Completion Days | 22.8 | 26.3 |
| Proposed Maximum Step 4 Completion Days | 20.07 | 17.03 |
| Percentage Improvement | 12.3 | 35.0 |
the average time of 8.1 days, the average total completion time can further be reduced to 17.03 days or 35 percent improvement.

4 Conclusion and Recommendation

This main purpose of this study was to review the Change Management process of a multinational company in Malaysia. The study includes a review on measuring the effect of change in the company. The change requests of year 2017 were analysed on the cycle time and the reasons that contributed to the number of change requests. The first objective of this study is to describe the cycle time for completion of the change request in order to identify the cause of variation in the change request completion time. Further brainstorming and more data collection and analysis will be required in order to understand why these two contribute the most. The final objective is to evaluate the improvement if total completion time for critical process is monitored. Based on Monte Carlo Simulation, it is possible to improve the Step 4 cycle time up to 35%, thus improve the overall completion time.

Based on the limitation of this study, recommendation for improvement can only be done for the company under study and the results obtained are specific only to the company practices. The findings in the cycle time analysis give an idea on where the company needs to focus on in order to improve the change requests process which can also be used by other company in similar industries. Even though the results of this study are specific to this manufacturing company, it gives an overview to other companies of similar industry on what and where improvement can be done in relation to the cycle time study of the change management process. Finally, for future research the use of Data Envelopment Analysis can be explored to evaluate the efficiency of a Change Management System, especially in relation to time, since it is a non-parametric method where multiple outputs and multiple input parameters are compared in order to evaluate the relative level of performance efficiency [13].

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