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# Six Sigma Approach in Safety Performance at Transport Logistics Industry

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**Abstract** – *This Company is one of the largest multipurpose port in Malaysia which provides facilities and services to handle variety of cargoes ranging from containers, cars, break bulk cargoes, dry bulk cargoes and liquid bulk cargoes. The company divided into three main core business divisions which are Container Division, Conventional and Logistics Services and Marine Divisions. Based on Pareto analysis, Conventional & Logistics Services has the highest number of accidents with 75% of total number of accidents in year 2014. In this company, the trend analysis of accident keep increasing month by month. In this study using DMAIC approach, the objectives of this study is to improve safety performance by decreasing the number of accident focused on Conventional & Logistics Division by using six sigma approach. Six sigma is a quality tools for process improvement. It involved five phases which using many quality tools to identify problem and improves the process. The data being analysed by using statistical method and graph. As conclusion, the average number of accident decrease from 7.33 to 7.25 and the trend analysis shows decline graph compared to before. Based on the hypothesis testing, using the p-value, it was found the shift pattern, safety culture (unsafe act unsafe condition report submission), accidents location, type of activity and contractors have significance impact to number of accident. Meanwhile, number of tonnage handled (productivity) and number of man-hour does not have significance impact to the number of accident. It was also found that there is no significance between numbers of accident happen at night shift, morning shift or afternoon shift. It can be concluded that, the six sigma approach are suitable method to analyse accident and can be a significance approach in determining the root cause of accident in the company.* 

**Keywords:** Six sigma; Safety, Injury, Chi-square, Transport and logistics industry, Safety performance

## 1.0 INTRODUCTION

As the company going through massive development, the concerns about the safety and health of employees arise. With all these developments over the years, managing a good safety performance thus becomes a true challenge to the company. Based on the statistics of incidents and trend of operators getting injured, there was a rather alarming rate of incident cases which is increasing year by year. It also reflected in man hour loss involving injured employees which effect company's productivity and performance. Based on the above scenario, the researcher took an initiative to conduct research on matters that related to the incident reduction and analysis in one of sea transport and logistics company located in Malaysia by implementing lean six sigma tools which consist of Define phase, Measure phase, Analyse phase, Improve

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phase and Control phase (DMAIC). The purpose of this study to be conducted is to improve accident rate performance for Conventional Logistics Services related accident by using six sigma approach. Many accident happen while handling the cargo especially if the activity involving manual handling as the employees directly exposed to hazard and risk [1].

## 2.0 LITERATURE REVIEW

### 2.1 Six Sigma

In order to achieve highest quality standards, many industries have implemented lean six sigma tools for process improvement especially in manufacturing industry. As many company struggles in improving product and service quality, improving process productivity and reducing operation cost, initiatives such total quality management(TQM), 5S, Kaizen and lean six sigma has been implemented to overcome this issue. Lean Six Sigma was introduced by Motorola in 1987. The purpose was to reduce the variation of process output in order to achieve six sigma standard. Six sigma standard means six standard deviation lie between the mean and the nearest specification limit. This technique's objective is to achieve and allow 3.4 defects in probability of one millions production (per million) or also known as defects per million opportunities (DPM) [2]. DMAIC tools proven to reduce accident cases by increasing safety level awareness and gave financial impact in reducing cost to the company [3]. In organizational mindset, six sigma was widely used in decision making which is based on data, identify root causes of problems, and priority the customer's request by finding the defects, identify and maintain the control variation, and continuous improved[4]. Similar to Edward Deming's 'Plan-Do-Check-Act' problem solving approach, the DMAIC is a significant methodology to improve process [5]. DMAIC methodology to be essential to Six Sigma programs and appropriate for delivering business improvements. In six sigma programs, there were many tools used for process improvement, which include Pareto Charts, Histograms, Fishbone diagram analysis, and Failure mode analysis, Statistical Process Control (SPC), Department of Environment and Shi-square [6].

### 2.2 Six Sigma in Safety

Six sigma tools are widely used to improve process and product quality. The tools derived from five methodology cycle which were define, measure, analyse, improve and control (DMAIC). This methodology can be implemented in improving safety performance. As safety performance become crucial and significance in an organization. The basic of continuous improvement (CI), to stimulate the safety cultural and learning organization to be achieved, management commitment was very important [7]. The data sets were analysed by using statistical method to provide accurate measurement and prove. Despite improving the safety performance, this methodology can reduce accident cost. In accident, based on iceberg theory, the indirect cost are hidden cost which usually higher than direct cost as shown in Figure 1[8].

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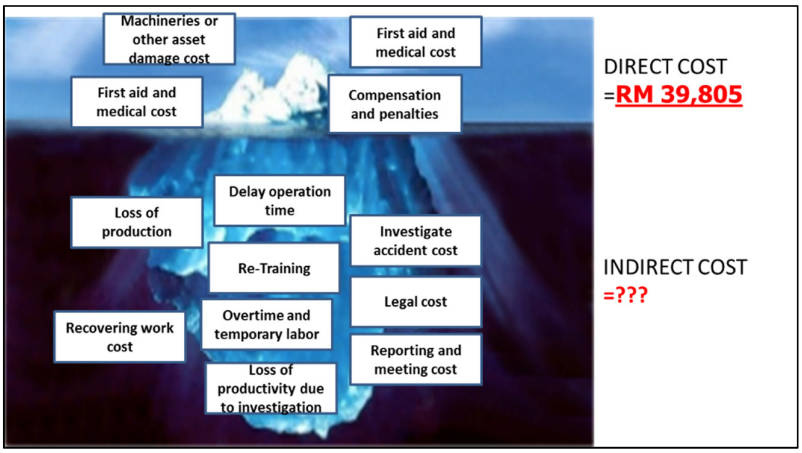


**Figure 1:** Iceberg theory of Accident Cost

Lean six sigma approach are successful implemented in improving safety in manufacturing industries [2]. Besides that, risk assessment also can be conducted by using one of six sigma tools which is failure mode effect analysis. The analysis will determine the highest rating as priority based on risk priority number (RPN) for each failure mode. The RPN can be calculate by simple mathematical equation which Severity(S) x Occurrence (O) x Detection (D). Severity(S), Occurrence (O), Detection (D) was number of scale usually 1-10 which can easily being determined from the lowest to the highest value [9].

## 3.0 METHODOLOGY

Six sigma comprises phases of DMAIC as shown in Figure 2. Firstly, in define phase, the objectives of the study, problem statement, scope of study and financial implication are determined. The voice of customer and the overall process was also determined by using CT-Tree (Critical to Quality, Critical to Cost and Critical to operation) and Supplier, Input, Process, Output and Customer (SIPOC). The project team formed and each roles and responsibilities are also explained. Secondly, in measure phase, the process mapping was conducted to choose focused area to be improved. Root cause analysis was conducted by using cause and effect analysis (fish bone diagram). The data baseline and process capabilities which was accident record was analyse to know the state of process before improvement. Data collection plan also derived in this phase. Thirdly, in Analyse phase, the root cause identify in the measure phase will be further analyse as significance variables, X. Each of the variables will be analyse whether to have significant or not with accident cases. Fourthly, in improve phase, improvement initiatives will be implemented based on the priority set in previous phase. Lastly, in control phase, to ensure the continuous improvement, the checklist or worksheet shall be introduced. After a period of implementation, project closure will be done which the process capability will be analyse again and compared to the process capability before improvement. The financial implication also will be took into account to prove the cost reduction.

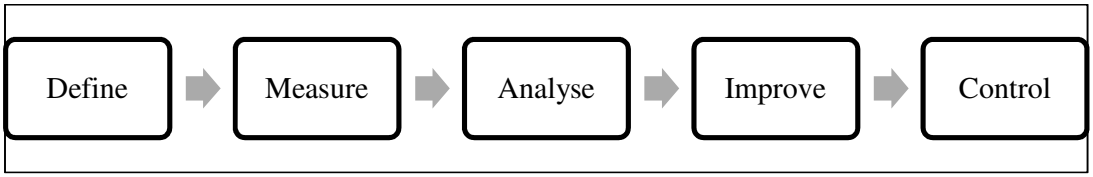

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**Figure 2:** Cycle of Six sigma

## 4.0 RESULTS AND DISCUSSION

### 4.1 Define Phase

The objectives of the project was to reduce number of accident and improve safety performance. The scope limited to conventional services department and it can save up to RM24, 000 in a year (17 injury cases per year).The voice of customer was identified as shown in Figure 3 and Table 1. The voice of customer shall be focused on critical to quality to achieve zero number of accident by measuring the number of accident and lost time injury rate.

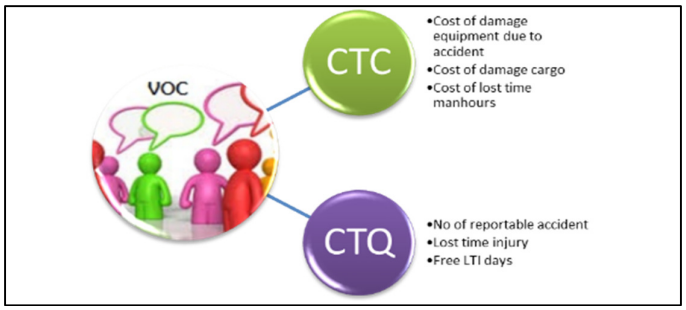


**Figure 3:** Voice of customer

**Table 1:** Critical to quality

| VOC | NEED | CTQ | METRIC | CATEGORY |
|---|---|---|---|---|
| Zero of accident | Safe Work place | (no of reportable accident/No. of tonnage)*100,00 tonnage | No of accident rate | Must Be |
| | | Reduce lost time injury | LTIF | Linear |

The overall process was illustrated in SIPOC diagram in figure 4. The area improvement focused will be at corrective and preventive action and setting up the prevention program.

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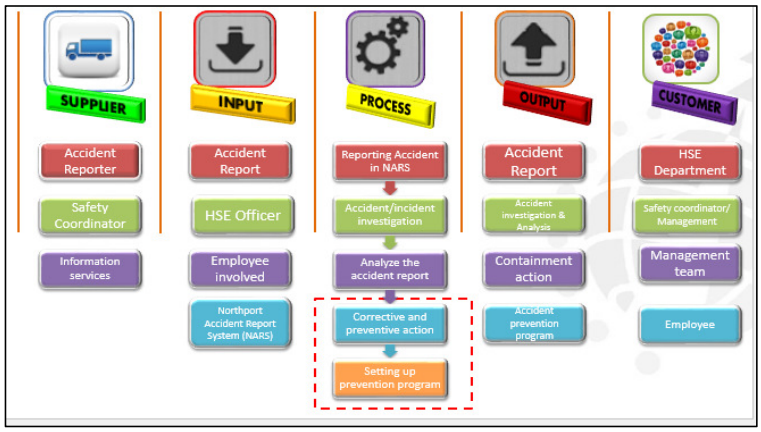


**Figure 4:** SIPOC diagram

### 4.2 Measure Phase

In measure phase, the process mapping of accident reporting was determined as shown in Figure 5. The area focus to be improved during accident investigation is during investigation and identification of accident root cause and recommending corrective and preventive action by accident investigation team.

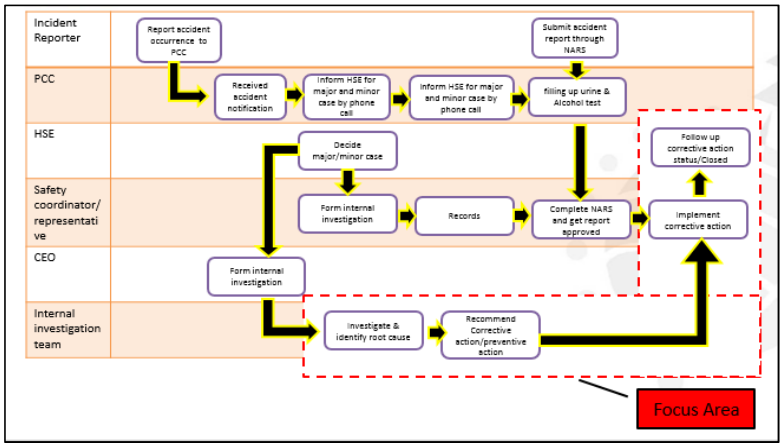


**Figure 5:** Process mapping

The root cause analysis was conducted by engaging supervisor, employees and safety officer in brainstorming session to identify the cause of high accident rate. As outcome, the cause and effect diagram was draw out and the variables are determined (Figure 6).

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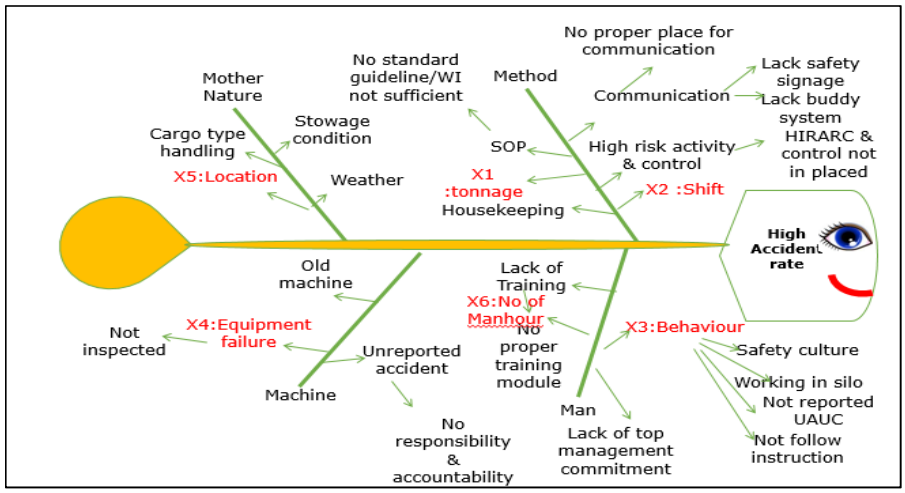


**Figure 6:** Cause and Effect Diagram (Fish bone diagram)

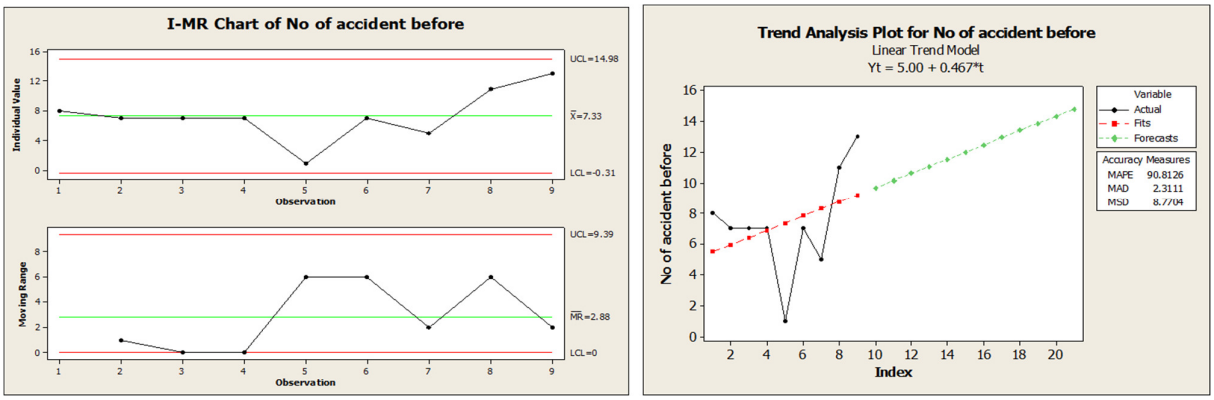


**Figure 7:** Trend analysis

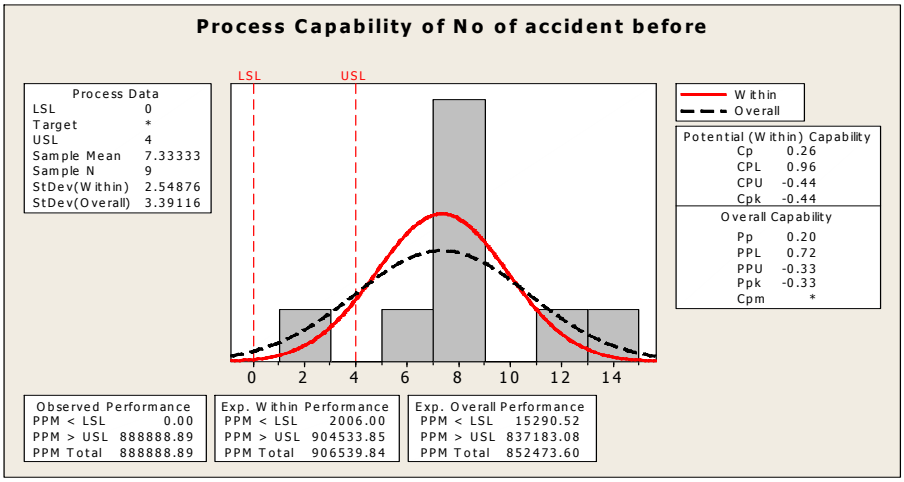


**Figure 8:** Process capability

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The process capability was analyze as shown in Figure 7 and 8. It show the average number of accidents in a month is 7.33 and with current safety performance the number of accident will increase (forecast for 12 months) based on trend analysis. Process Sigma with sigma level was 1.32, which was low. Thus, it proven that process need improvement. The data collection then being structured to proceed with analyse phase.

### 4.3 Analyze Phase

By using identified variables of root cause in measure phase, the data was collected and analysed by using statistical method. All variables was analyse to find correlation between root cause and number of accident whether it was significant effected or not. The Figure 9 shows the pareto chart of department involved in the accident which Conventional Logistics department was the highest contribution of number of accident. By using 80-20 rules, it shows, the process can be improved by solving the highest department accident contributor.

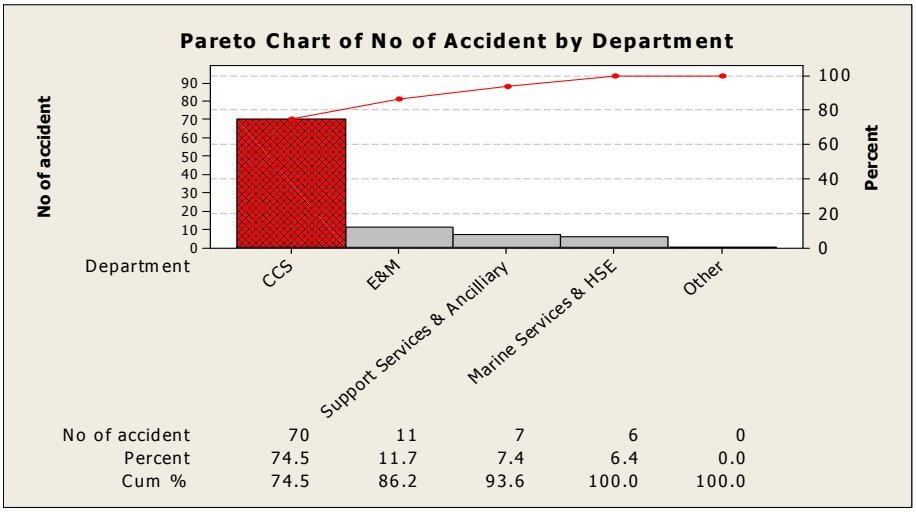


**Figure 9:** Pareto analysis

The analysis of data as show in Table 2. Based on the hypothesis testing, the p-value was obtained and discussed. Based on the p-value, it was found the shift pattern, safety culture (unsafe act unsafe condition report submission), accidents location, type of activity and contractors have significance impact to number of accident. Meanwhile, number of tonnage handle (productivity) and number of man-hour does not have significance impact to the number of accident. It was also found that there is no significance between numbers of accident happen at night shift, morning shift or afternoon shift which is differ from people's perspective which concluded accident highly occurred during night shift.

### 4.4 Improve Phase

Based on the data analysis, brainstorming between safety representative, department management representative and employees was conducted to suggest implementation of safety initiatives. Each initiative was given a dateline and person in charge to ensure the implementation was well conducted and to be able monitored. The improvement phase took place 3 months to be done. Once the improvement being implemented, the process will be analysed again to fine tune the initiative effectiveness.

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**Table 2:** Data analysed base on variables

| No | Potential cause | Null Hypothesis | Alternative Hypothesis | Statistical Test | Test Result | Discussion |
|---|---|---|---|---|---|---|
| X1: | Accident Occurrence by No of tonnage | No of accident does not associate with no of tonnage. | No of accident does associate with no of tonnage. | | P value =0.134 which is more than 0.05. | Accept $H_0$. Thus, No of accident does not associate with no of tonnage handle. |
| X2a | Accident Occurrence by Shift Pattern | Shift Pattern does not have differences. [P(Morning)=P(Afternoon)= P(Midnight] | Shift Pattern does not have differences. [P(Morning)=P(Afternoo n)=P(Midnight] | Chi-square | Since p-Value is equal to 0.025 which is less than 0.05. | Reject $H_0$. Thus, shift pattern does have differences. |
| X2b | Accident Occurrence by Shift Pattern | Shift does not have differences. [P(Early Shift)=P(Late Shift)] | Shift does have differences. [P(Early Shift)=P(Late Shift)] | Chi-Square | Since p-Value is equal to 0.473 which is more than 0.05. | Accept $H_0$. Thus, shift does not have differences. |
| X3: | Culture (Reporting unsafe act unsafe condition) | The distribution of submission is same. | The distribution of submission differ. | Chi-Square | Conclusio n : Since p-Value is equal to 0.00 which is less than 0.05. | Reject $H_0$. Thus, the distribution of submission is differ. |
| X4 | Equipment Inspection | - | -- | - | - | Low passing rate and low submission of inspection |
| X5 | Accident Occurrence by Location | Location does not have differences. | Location does have differences. | Chi-Square | Since p-Value is equal to 0.025 which is less than 0.05. Reject H0. | Thus, Location does have differences. Accident often happen at dry bulk and break bulk area. |
| X6a | No of Accident by Total Man hour | No of accident does not associate with total of man-hour. | No of accident does associate with total of man-hour. | Regression | Since p-Value is equal to 0.538 which is more than 0.05. | Accept H0. Thus, No of accident does not associate with no of total manhour. |
| X6b | No of Accident by type of activity | No of accident does not associate with type of activity | No of accident does associate with type of activity | Chi-Square | Since p-Value is equal to 0.00 which is less than 0.05. | Reject H0. Thus, No of accident does associate with no of type of work group, highest handling crane |
| X6c | No of Accident by company involved | No of accident does not associate with company involved in the accident | No of accident does associate with company involved in the accident | Chi Square | Since p-Value is equal to 0.00 which is less than 0.05. | Reject H0. Thus, No of accident does associate with company involved in the accident. |

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**Table 3:** Audit implementation improvement

| Audit Areas | Monthly | Quarterly | Yearly | Process Owner |
|---|---|---|---|---|
| HIRADC and SWP | | | √ | CLS/HSE |
| Compliance of SOPs | | √ | | PQM |
| Contractors/Tenants audit | | | √ | CLS/HSE |
| Monthly Information Board | √ | | | CLS |
| CLS HSE plan 2015 | √ | | | CLS |
| CLS HSE Performance Dashboard | √ | | | CLS |
| Accident investigation CA/PA status | √ | | | HSE |
| Equipment inspection | √ | | | CLS |

## 4.5 Control Phase

As control phase the audit checklist has been constructed as shown in Table 3. The checklist will be referred by responsible people to ensure the continuous improvement of the study. In safety, the most important thing is to maintain and improve the safety key performance indicators (KPIs). By achieving the KPIs, it can be a benchmark of safety level in an organization.

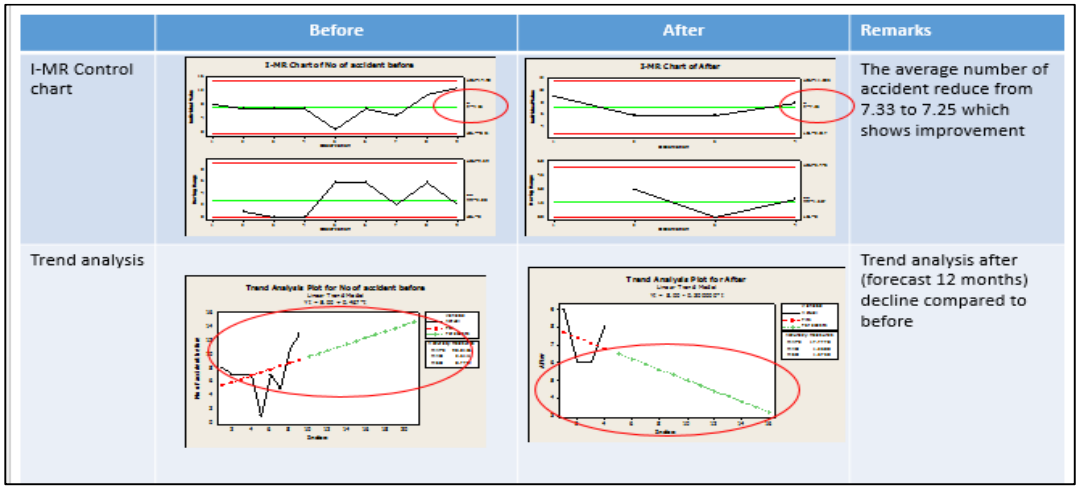


**Figure 10:** Process capability and trend analysis after process improvement

## 4.6 Project Closure

Once the improvement being conducted for 3 month period, the process capability are analysed again to determine the process improvement. I-MR control chart and trend analysis was constructed as show in Figure 10. The average number of accident decrease from 7.33 to 7.25 and the trend analysis shows decline graph compared to before. Although there was only

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slightly reduce, but the overall process is improved. The capability process was predicted to be improve in long term period.

## 5.0 CONCLUSSION

As the port going through massive development, the company that is very concerned about the safety and health of their employee. Based from the record, compared with a competitor, this company among the best port in the world in ensuring that effort been fully taken to protect the safety and health of their employee. With all these developments over the years, managing a good performance thus becomes a true challenge to the port. One of the company goals is strive for cost reduction and minimizing the cost of operation. An accident can affect the productivity by causing a delay time and it will include the cost by equipment damages or cargo damages. In this study, the average number of accident for conventional & logistics division was 7.33 per month. After process improvement, the average number of accident decrease from 7.33 to 7.25 and the trend analysis shows decline graph compared to before. Although there was only slightly reduce, but the overall process is improved. The capability process was predicted to be improve in long term period. The process still need to be monitored tightly to ensure the implementation was smooth and continuous being improved. It also concluded that, based on the hypothesis testing, using the p-value, it was found the shift pattern, safety culture (unsafe act unsafe condition report submission), accidents location, type of activity and contractors have significance impact to number of accident. Meanwhile, number of tonnage handle (productivity) and number of man-hour does not have significance impact to the number of accident. It was also found that there is no significance between numbers of accident happen at night shift, morning shift or afternoon shift. It can be concluded that, the six sigma approach are suitable method to analyse accident and can be a significance approach in determining the root cause of accident in the company.

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