**UNIVERSITY OF NEWCASTLE**

**BUSINESS SCHOOL**

**OPERATIONS, LOGISTICS AND SUPPLY CHAIN MANAGEMENT MSc**

# QUALITY MANAGEMENT TOOLS AND TECHNIQUES

**Project**

by

**Nikolaos Kostoulias**

Student No 210060146

Dataset number: 6

**Module Leader**

David McGeeney

**Newcastle upon Tyne**

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## SECTION A: TOOLSAND TECHNIQUES QUIZES

1. *Quantitative variables can be discrete or continuous. Explain the difference between discrete data and continuous data and give one example (related to Quality Management) of each.*

Discrete and continuous data are quantitative (or numerical) data types. Discrete data are countable data. In other words, they are measured by counts, for example the number of students in my class.

Continuous data are measured on a continuous scale and can have any numeric value, like my height in centimetres.

2. *A measure of location is a quantity which is 'typical' of the data. Give the names of three such measures, and explain (in words, not formulae) how each is found.*

The measures of location are three, the mean, the mode, and the median. They can all be called averages. The mean is the sum of all the data divided by the number of observations.

The mode (or fashion) is the value that occurs most often. If two or more values occur most often, then there is more than one mode. On the contrary, if the values occur only once, then the dataset has no mode.

To find the median (or $50^{th}$ percentile), we need to find the middle of a set of data being put into rank order. When the number of observations is an odd number, the middle rank will fall on one observation, the value of which is the median. If it is an even number, the middle rank will fall on two observations. Then the median will be the mean of the values of the two observations.

3. *A random sample of data yields the histogram shown in Figure 1. Suggest a suitable measure of location and a suitable measure of dispersion for these data and explain your reasoning.*

Since the histogram is skewed and asymmetric, as a measure of location I would suggest the median, because it is more robust to extreme values and is not affected significantly by them. As a measure of dispersion, I would suggest the inter-quartile range. The inter-quartile range ignores extreme values, because it only considers the position of the observations and not their magnitude.

4. *Total Quality Management peaked in popularity during the late 1980s and early 1990s. It has since been overshadowed by Six Sigma. Briefly explain some reasons for this.*

The reasons that Six Sigma overshadowed Total Quality Management (TQM) are the following. Firstly, the infrastructure, because with the Six Sigma strategy the employers of the company know that this strategy is implemented, and they have different roles. Secondly, the training. While TQM was thought as a training exercise, with Six Sigma the intensity of the training depends on the job role. Along with the training, are projects, where the employers apply the tools and techniques that they have learnt. And finally, the framework DMIC (Define and Measure the problem, Analyse the relationships, Improve and Control the process) with its tools and techniques, which only appears in Six Sigma.

5. *Explain how Affinity Diagrams and Fishbone Diagrams are similar yet different.*

They are both qualitative methods, but while the Fishbone diagram tries to find the root causes of a problem, the Affinity diagram is focused on finding the problem or the scope. It gathers large amount of data, generated by brainstorming, and organizes them into groups based on their relationships.

6. *A Strategy Map illustrates how objectives belonging to the 4 Balanced Scorecard perspectives (Learning & Growth / Internal / Customer / Financial) are related to each other. Explain the general cause and effect relationship between the perspective objectives.*

7. *Does a Gage Repeatability & Reproducibility Study quantify the precision or the accuracy of a measurement system? Explain your answer.*

A Gauge Repeatability and Reproducibility Study quantifies the precision of a measurement system. This is because there is no difference in the results when the same or different appraisers measure the same characteristic on the same part using the same device. Therefore, there is any issue of repeatability or reproducibility error correspondingly.

8. *Explain the relationship between the 2-Sample t-test and One-Way ANOVA.*

2-Sample t-test is used to find out the difference in the mean performance between two groups, while One-Way ANOVA is used to find out if there is a significant difference in the mean performances between more than two groups. 2-Sample t-test and One-Way ANOVA have the same assumptions. The data have a normal distribution and equal standard deviations.

9. *Explain what residuals are and how we use them to check adequacy of predictive models.*

A residual is the vertical distance between a data point and the regression line. They represent the errors about the fitted regression line. They are positive, when they are above the regression line, negative, when they are below the regression line, and zero, when the regression line passes through them. When the residuals are independent and normally distributed, the predictive models are adequate.

10. *If you have 8 factors, each with 2 levels, and you intend to analyse them in a half-fractional design, how many trials will you need to carry out? Explain your answer.*

Half factorial=$2^{8-1}$=128 trails.

## SECTION B: LONGER QUESTIONS

### Question 1

*The data in column A are the times (in days) for customers to receive their orders from a technology company – Pineapple Inc. – for the most recent 100 orders of tablet computers. The data is in time order, so the first value is the oldest observation, and the last value is the newest observation*

a. *Summarise the data numerically using suitable measures of location and dispersion. Produce appropriate graphical summaries of your data and interpret them. Comment on the shape of the sample distribution. Does the data appear to be approximately normally distributed?*

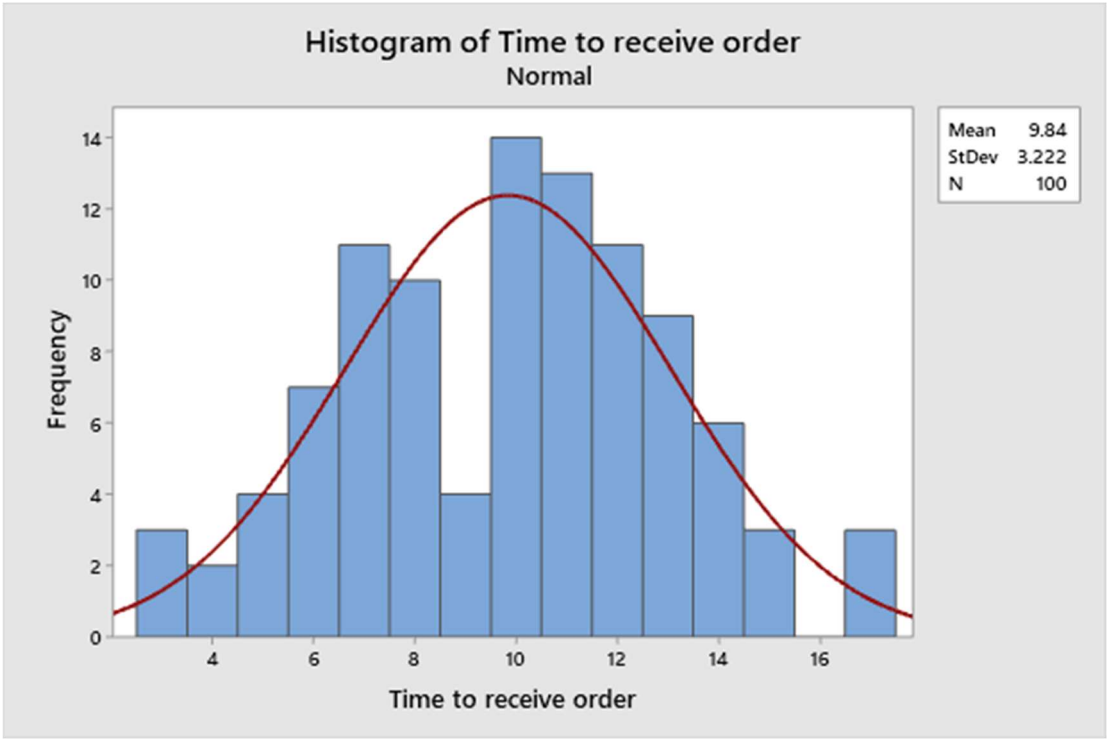
### Measures of location

| Variable | Mean | Q1 | Median | Q3 | Mode | N for Mode |
|---|---|---|---|---|---|---|
| Time to receive order | 9.840 | 7.000 | 10.000 | 12.000 | 10 | 14 |

### Measures of dispersion

| Variable | StDev | Variance | Minimum | Maximum | Range | IQR |
|---|---|---|---|---|---|---|
| Time to receive order | 3.222 | 10.378 | 3.000 | 17.000 | 14.000 | 5.000 |

### Histogram graph

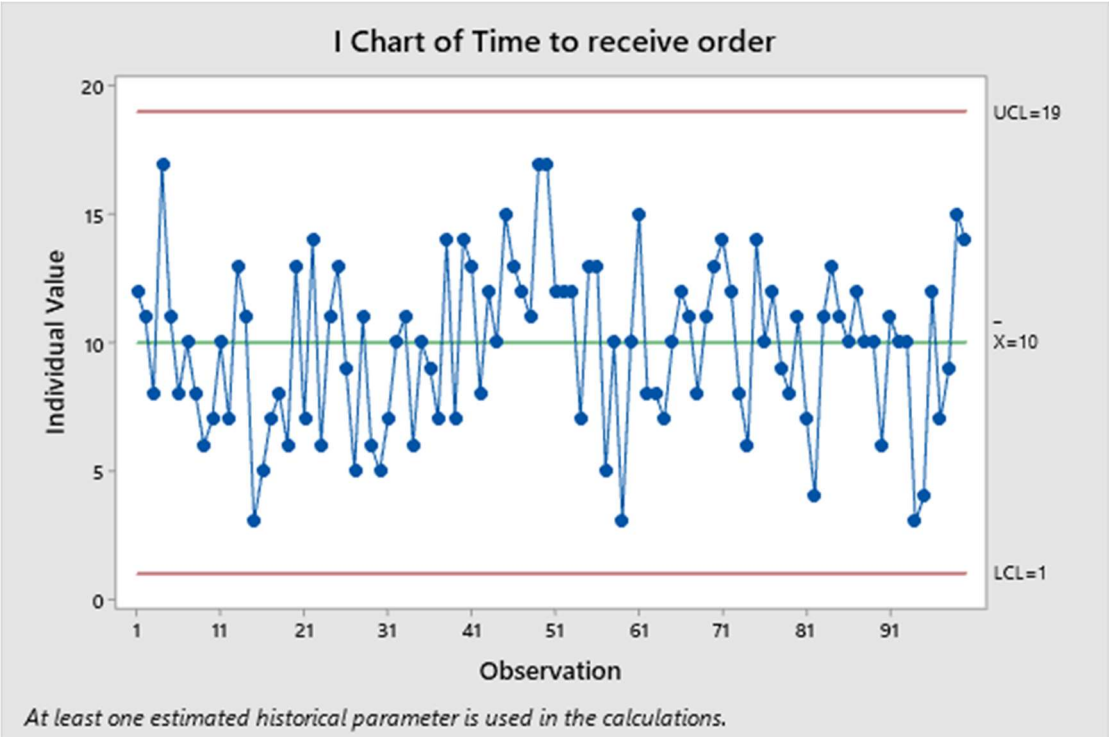


Measures of location show that customers wait on average (mean) 9,84 days to receive their order. Almost similar is the mode, which show that customers wait 10 days to receive their order from Pineapple Inc. According to the median, customers have to wait 10 days to receive their orders. 25% customers wait less than 7 days and 75% less than 12 days correspondingly.

Measures of dispersion show that the data is roughly symmetrically distributed around a value of 10 days. Within a range of 14 days, it is unlikely for customers to receive their order in less than 3 days (Minimum) or in more than 17 days (Maximum). The data appear to be normally distributed. The data almost fit the distribution, but there is only one outlier.

b. *Pineapple knows that historically the mean and standard deviation of the delivery times were 10 and 3 respectively, prior to when this data was collected, and they would like to know whether the process has changed since then. Produce an appropriate chart and interpret it. Comment on whether there has been a change. What would your recommendations be?*

**Control chart**




According to the control chart all 100 observations are located inside control limits. None of the points exceed the control limits and there is any evident trend, which means that only random (or natural) causes of variation are present. The chart shows the Upper

Control Limit (UCL) and Lower Control Limit (LCL), being 19 days and 1 day correspondingly. It is calculated at ±3 standard deviation from the overall average (10 days).

c. *Pineapple is considering calculating a Capability metric to quantify how good their delivery service is. Which metric should they use and why?*

What customers require from Pineapple Inc. is short delivery times to receive their orders. Therefore, delivery time is the Critical to Quality characteristic (CTQ). The process capability index Cpk is the capability metric that is able to quantify this CTQ characteristic. Cpk quantifies the actual capability and can help Pineapple to evaluate how good its delivery service is.

## QUESTION 2

*The data in columns B and C are the failure times (in months) of a random sample of 50 tablets that Pineapple engineers have tested in-house. Of these 50 tablets, the majority broke (denoted by a 1) but some were still working (denoted by a 0) when the study ended. Pineapple is interested in the percentage of tablets that fail before the warranty period (24 months).*

a. *Explain the terms population and sample, and the need to study the latter rather than the former in the context of Reliability Analysis.*

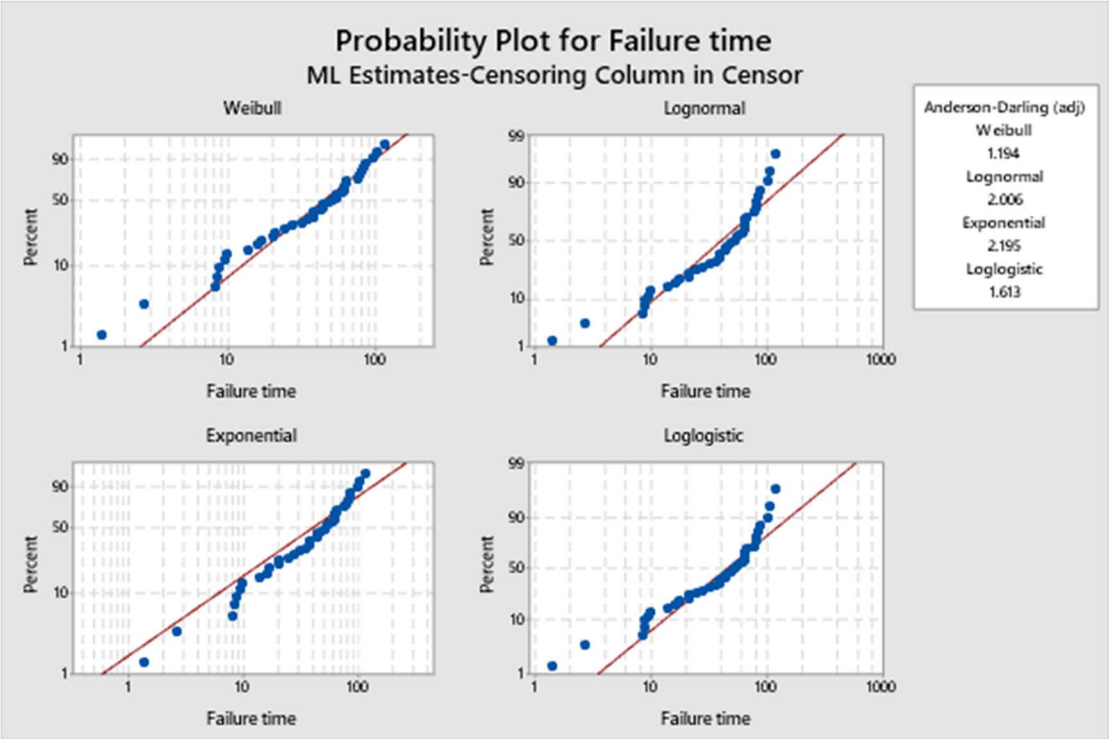
A population is a list of all the units that have the characteristic of interest, while a sample is any subset of the population. Reliability Analysis examines how long does it take for a product to fail. In other words, it measures time to failure. To collect the data, products must fail. If the Reliability Analysis was done to the entire population, the company would end up having any products and it would have nothing to sell and thus the company would fail. For this reason, samples are studied in the context of Reliability Analysis.

b. *The study ended at 180 months. An engineer suggests the failure time for the units that are still working should be estimated to occur at exactly 181 months, to simplify the analysis. Why would this be a bad idea?*

The engineer's suggestion is not right because the products might last longer than 181 months. The exact failure time of the products is unknown, and censoring is required. Censoring is a condition in which the value of an observation is not completely known.

Although data points are excluded as failures, they are still included in the operating time of the tablet.

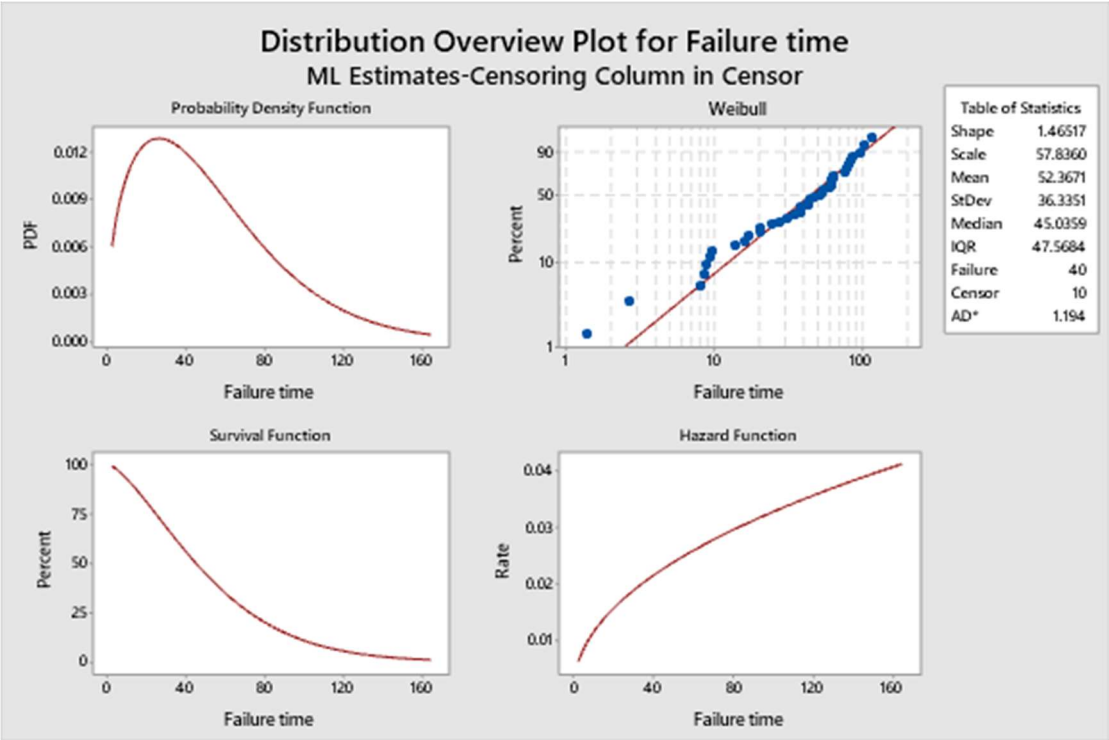
c. *Carry out a Reliability Analysis on the data and include relevant output in your solutions and interpret your results. Answer the question Pineapple are interested in.*




Weibull distribution fits the data the best. This is because, Weibull distribution has the lowest Anderson-Darling statistic and the datapoints are located close to the fit line.

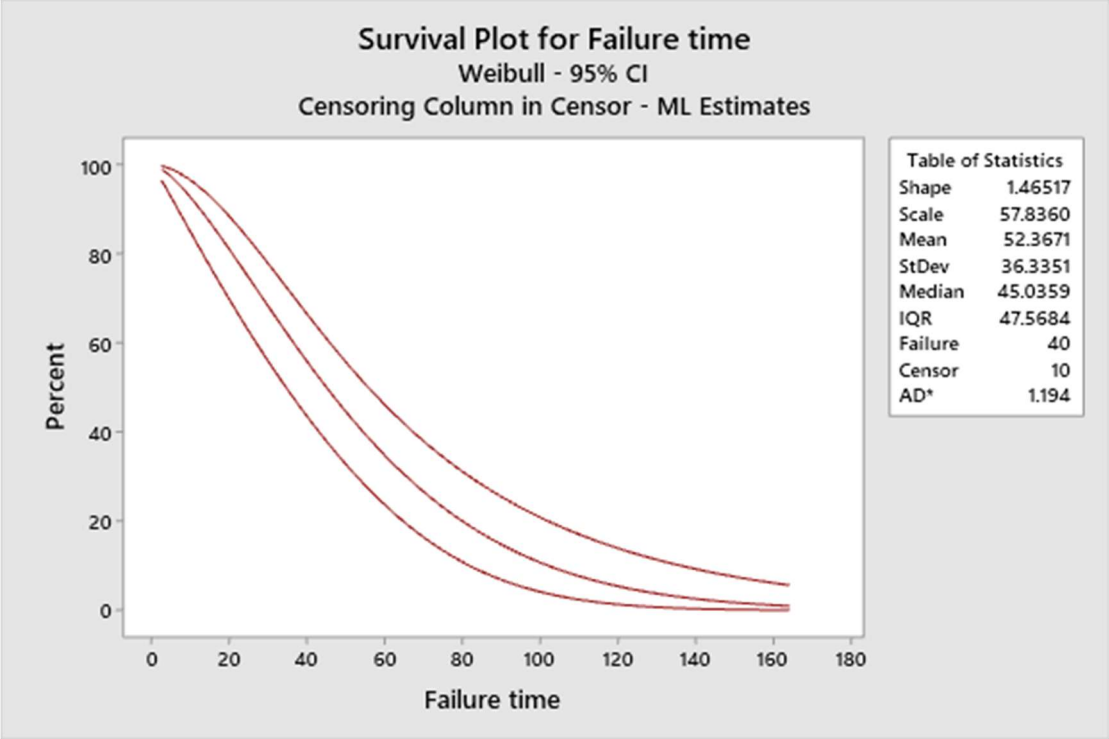
## Goodness-of-Fit

| Distribution | Anderson-Darling (adj) |
|---|---|
| Weibull | 1,194 |




## Table of Survival Probabilities

| | | 95,0% Normal CI | |
|---|---|---|---|
| Time | Probability | Lower | Upper |
| 24 | 0,759094 | 0,640321 | 0,843309 |



According to the survival plot, it is estimated that 75,9% of tablets are expected to last beyond the warranty period of 24 months. Likewise, 24,1% of tablets will fail within the warranty period. The sample is big and thus the above estimate is more precise.

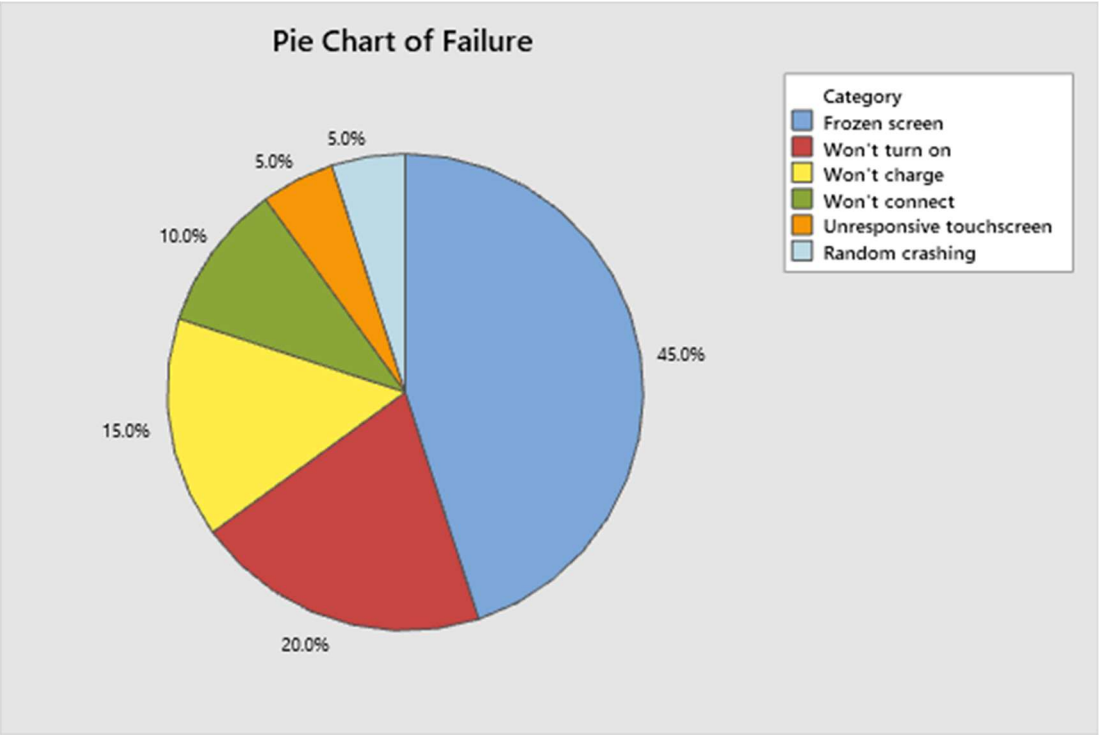
d. *If the data hadn't been censored, one approach to estimating the probability of a tablet's lifetime being less than 24 months would be to count the number of observations less than 24 and divide that by 50. Apply this approach to your data and record your answer, and then explain the limitations of this logic, and why it's better to use distribution theory to generate probabilities.*

There are 15 observations less than 24 months. After dividing 15 by 50 we get 0,3. Therefore, 30% is the empirical estimate of the percentage of tablets that will fail within the warranty period time. If the empirical approach was used to estimate the probability of a tablet's lifetime being greater than 117 months, then this would end up with a probability of zero (p(life time>117=0). In this case the event would be impossible. Compared to the empirical approach, the theoretical approach is better for generating distribution theory because it never ends up with zero probabilities. It is impossible for a tablet to last beyond 117 months, because there is any observation above this value.

## QUESTION 3

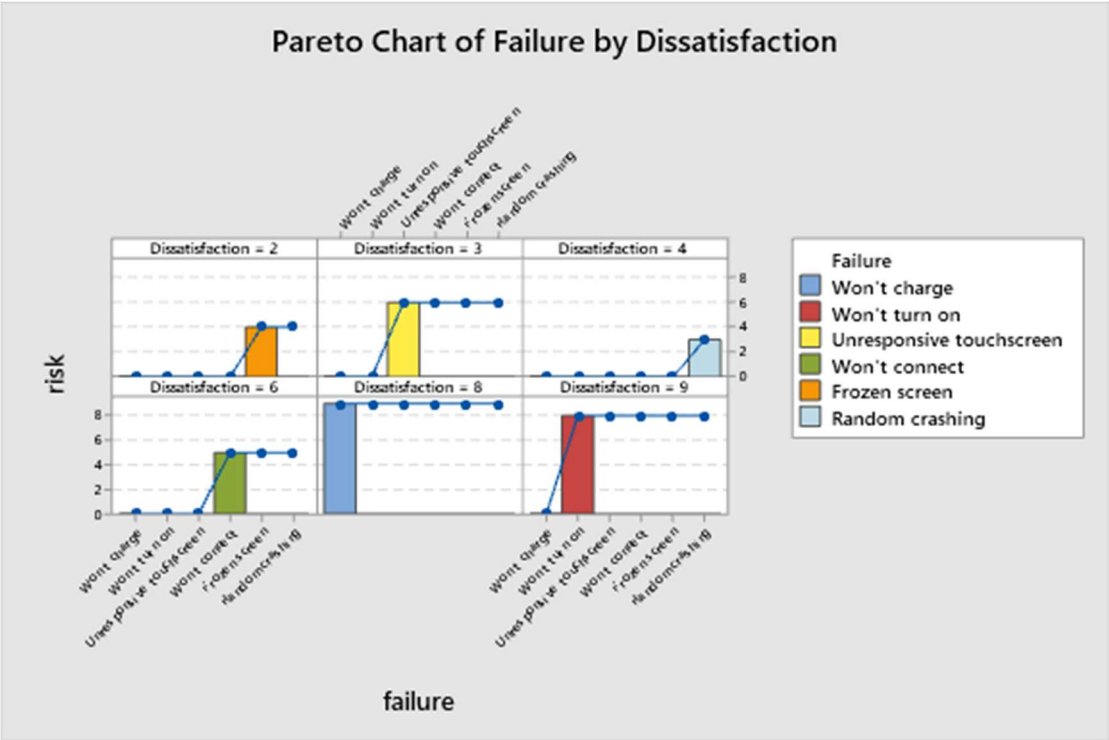
*The data in columns D and E are failure modes and frequencies because the tablets can fail in different ways (e.g., frozen screen, won't turn on, won't charge, won't connect to Wi-Fi, unresponsive touchscreen, random crashing).*

a. *Produce a chart which will allow Pineapple to visualise the frequencies of the failure modes and interpret it.*




To visualize the frequency of the failure modes, a pie chart is used. According to the pie chart, the likelihood of a frozen screen gathers the largest percentage, accounting to 45,0%. The likelihood of tablets not to turn on or not to be charged is 20% and 15% respectively. The rest of the failure modes, i.e., not connecting, the touchscreen not working, or a random crash, appear to be less frequent accounting to 10%, 5%, and 5% correspondingly.

b. *As well as frequencies, Pineapple evaluate 'customer dissatisfaction at the effect of the failure mode' on a scale 1-10, and 'the risk the failure mode will escape detection by any in-built mechanism' on a scale 1-10. Use columns F and G (as well as D and E) to create a new chart which will allow Pineapple to visualise the impact of the failure modes and interpret it.*

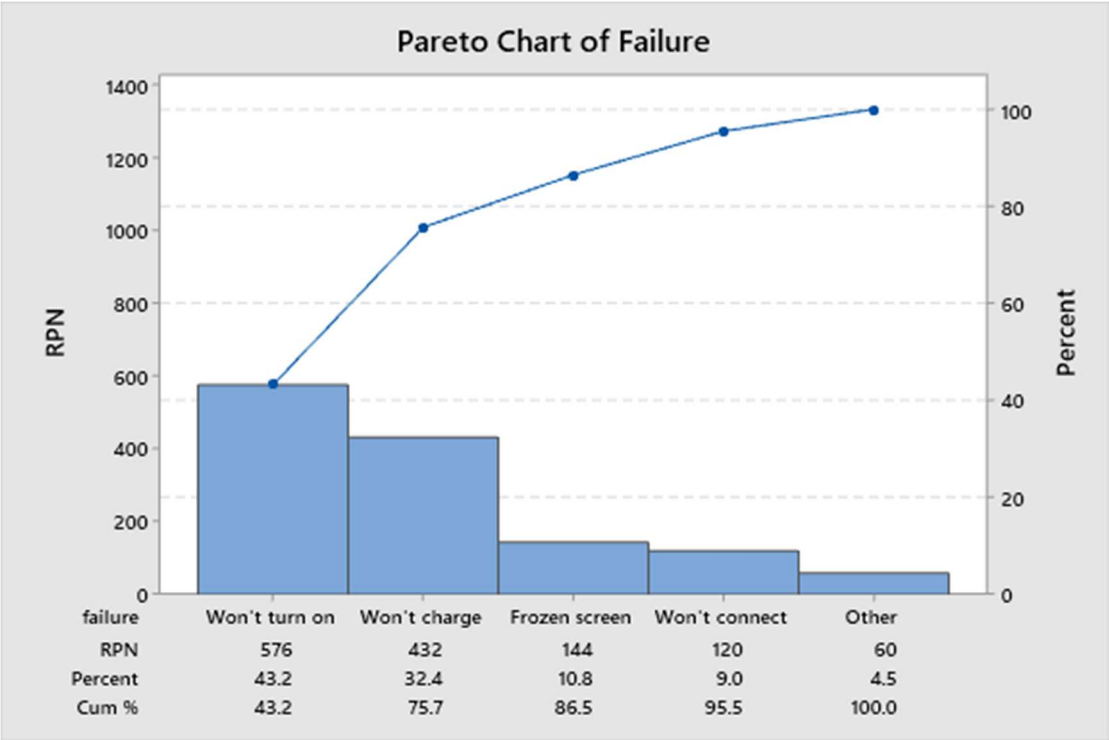



In *level 2* a frozen screen is most likely to occur having a risk level of 4. In *level 3* of dissatisfaction an unresponsive touchscreen has the highest probability of failure with a risk level of 6. In terms of *dissatisfaction level 4*, random crashing is most likely with a risk level of 3.

In *dissatisfaction level 6*, the failure mode of *'won't connect'* is most likely with a risk level of 5. In *dissatisfaction level 8*, the failure mode of *'won't charge'* has the highest probability with a risk level of 9. Finally, in *dissatisfaction level 9*, the failure mode of *'won't turn on'* is most likely to occur with a risk level of 8.

c. *Which failure mode should Pineapple be prioritising? Explain the FMEA methodology and how it ties in with this scenario.*

As shown in the Pareto Chart below, Pineapple should prioritize the *'won't turn on'* failure mode because it has the highest Risk Priority Number (RPN) (576), contributing most to the problem (43,2%).




The Failure Mode and Effects Analysis (FMEA) is a methodology for identifying all the failure modes that a product or process may encounter. In other words, it is a way to make the design of a product or a process more robust. It follows a procedure that identifies process or design features with the potential to fail. The procedure requires the identification of all potential failures, as well as both the causes and effects of those failures.

The most demanding part of the FMEA methodology is identifying the most likely causes of failure. As soon as they are identified, they are assigned an RPN. The RPN is established by assigning values to occurrence, severity, and detection on a scale of 1 to 10. It is the product of the occurrence (O), severity (S), and detection (D). Therefore, the formula is defined as, RPN=O*S*D.

FMEA follows a specific process. *Firstly*, the scope and function of the process or design are defined and analysed. *Secondly*, the components of the process or the elements of the design are identified. *Thirdly*, all the failure modes are identified, followed by the identification of all the causes of failure and effects of each mode. Subsequently, the possible effects of each type of failure are determined. The likelihood of occurrence of each cause, severity of each effect, as well as the likelihood of not detecting the cause are estimated. Finally, the RPN is calculated, and an action plan is produced. The action plan must minimize failure by prioritizing actions based on RPN.

d. *Which diagram can be used to identify potential causes and effects of failure modes and what are the different names this diagram has?*

Potential causes and effects of failure modes can be identified by using an Ishikawa Diagram. Alternatively, Ishikawa Diagram is called Fishbone Diagram, Cause and Effect Analysis, or Affinity Diagram.

## QUESTION 4

*The data in column H are the tensile strengths (in N/m^2) of 36 randomly selected tablet glass screens.*

a. *Pineapple have always believed that the glass screens of the tablets have a tensile strength of 60 N/m^2. Apply a technique or test which will check their belief and interpret the output, stating any assumptions you've made.*

### Descriptive Statistics

| N | Mean | StDev | SE Mean | 95% CI for μ |
|---|---|---|---|---|
| 36 | 61.637 | 5.996 | 0.999 | (59.608, 63.665) |

*μ: mean of Tensile strength*

### Test

| | |
|---|---|
| Null hypothesis | $H_0$: μ = 60 |
| Alternative hypothesis | $H_1$: μ ≠ 60 |

| T-Value | P-Value |
|---|---|
| 1.64 | 0.110 |

The p-value is the probability of obtaining our results or something more extreme if the Null Hypothesis ($H_0$) is true. The p-value is 11,0%. Therefore, and since the p-value>5%, there is no evidence against $H_0$. The results are not significant at the 11,0% level.

b. *Pineapple also believes that there might be a difference between the two different machines which are used to measure tensile strength, so they test the strengths of the same 36 tablets on both machines. Using the information in columns I, J and K, carry out an appropriate test on the data in columns J and K which will verify whether there is a difference between the machines and interpret the output, stating any assumptions you've made.*

### Descriptive Statistics

| Sample | N | Mean | StDev | SE Mean |
|---|---|---|---|---|
| Machine 1 | 36 | 61.64 | 6.00 | 1.00 |
| Machine 2 | 36 | 61.72 | 6.30 | 1.05 |

## Estimation for Paired Difference

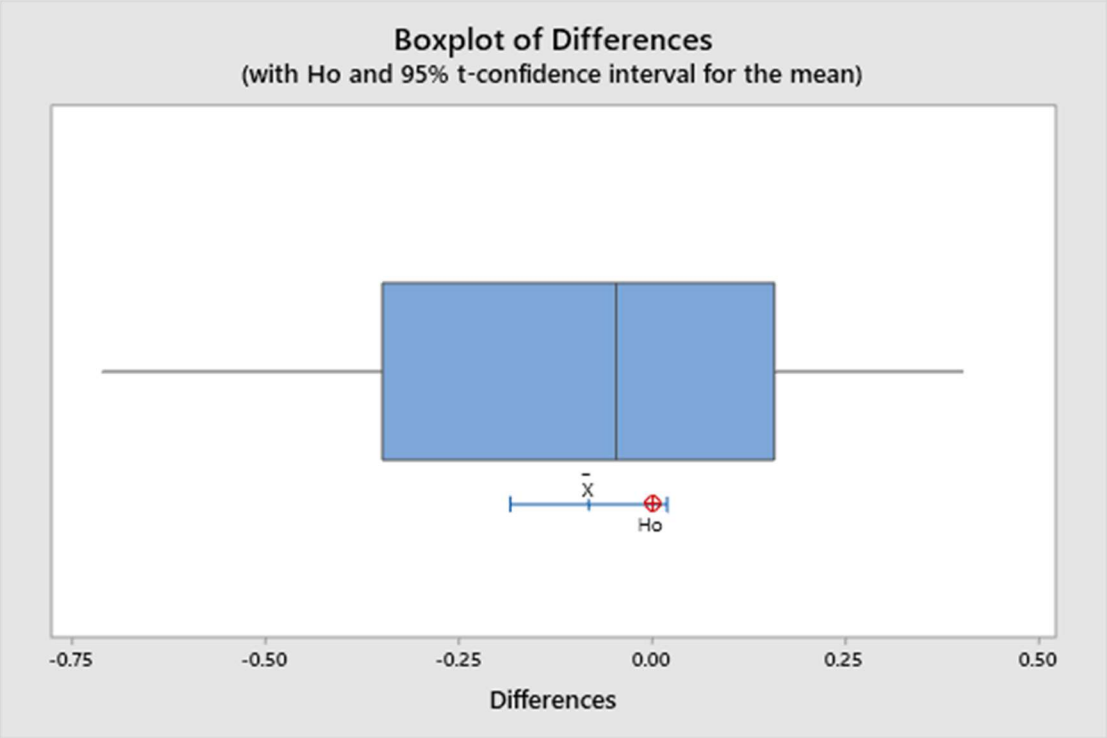
| Mean | StDev | SE Mean | 95% CI for μ_difference |
|---|---|---|---|
| -0.0818 | 0.2998 | 0.0500 | (-0.1833, 0.0196) |

*μ_difference: mean of (Machine 1 - Machine 2)*

## Test

| | |
|---|---|
| Null hypothesis | $H_0$: μ_difference = 0 |
| Alternative hypothesis | $H_1$: μ_difference ≠ 0 |

| T-Value | P-Value |
|---|---|
| -1.64 | 0.110 |

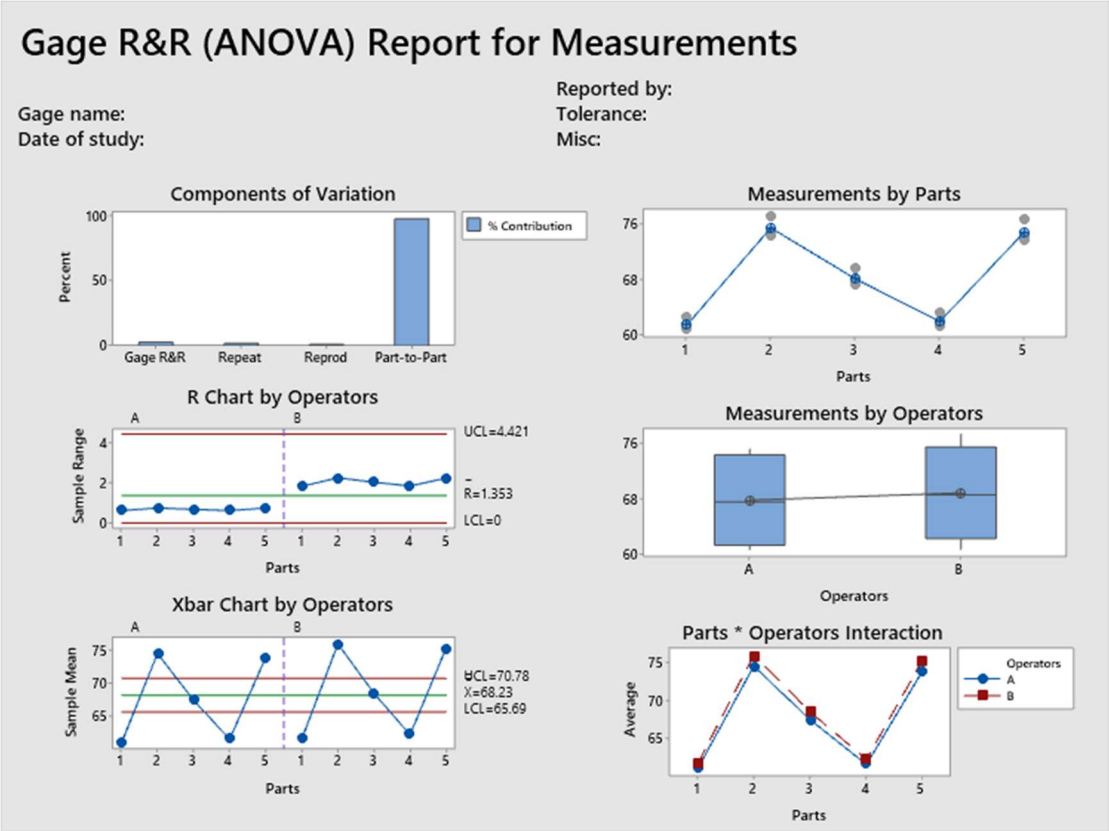



The important values are: The mean change in machine, which is the mean (-0,0818) labelled 'Estimation for Paired Difference', the p-value of 0,110, and the 95% confidence interval (CI) for the mean change in machine is (-0,1833, 0,0196) to two d.p.s.

This CI includes zero and thus there is no significant evidence to suggest that the mean of the differences is not zero. Therefore, the Null Hypothesis is not rejected. There is no significant difference between the machines 1 and 2. Looking also at the p-value, 0,110>0,05.

c. *Pineapple also believes that, as well as there being variation due to the machines, there may be variation due to the operators who use the machines,*

*so they decide to carry out a Gage R&R Study and the results are in columns L, M and N. Analyse the results and include relevant output in your solutions and interpret your results.*

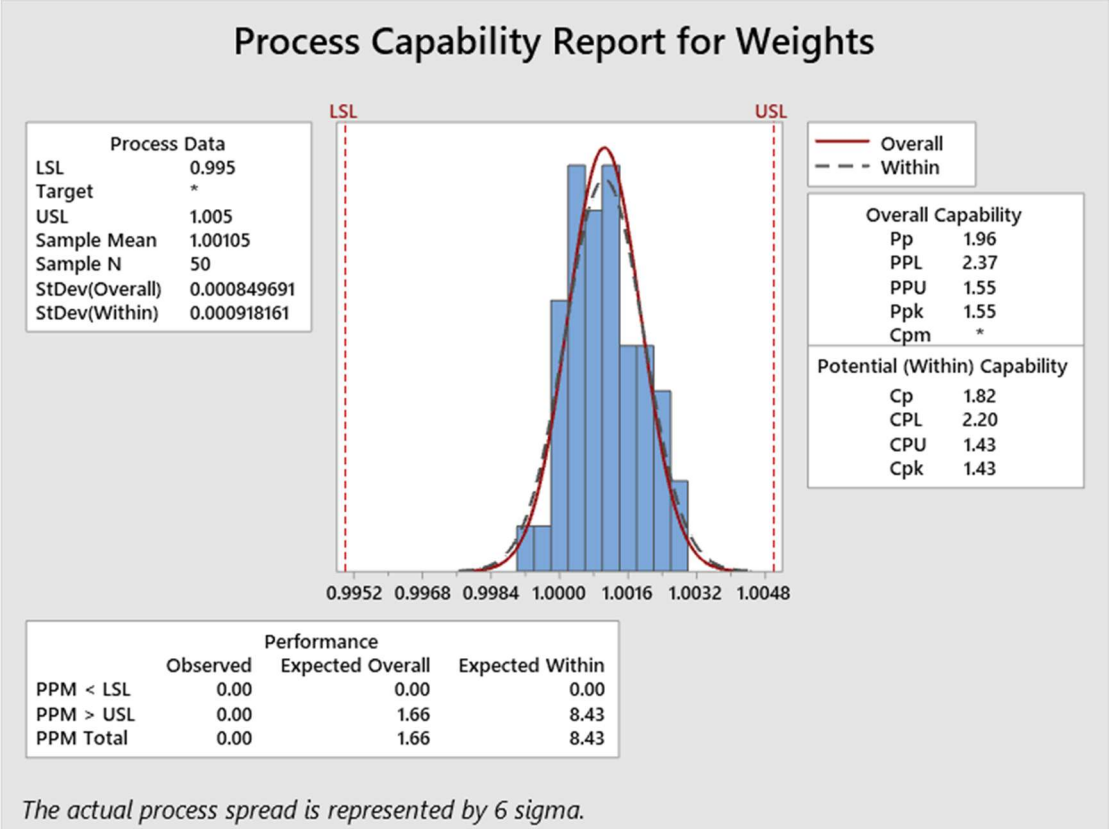



The Gage R&R contribution is 2,88%. It is a borderline acceptable measurement system in terms of precision. There is slightly more repeatability error (within-appraiser variation) than reproducibility error (between-appraiser variation), although both are small. Looking at the *'Measurement by Parts'* (top right), part 4 was measured the least precisely. Looking at the *'Measurements by Operators'* (middle right), machine B has a larger average than machine A. The mean would be horizontal, and the boxes would be the same only if the measurement system was perfectly precised. Looking at the *'R Chart by Operators'* (middle left), machine B is the least precise because it gives much bigger ranges. In other words, machine A measures more precisely than machine B and thus machine A should be used as a method of best practice.

## QUESTION 5

*The data in columns O are the weights (in kg) of 50 randomly selected tablets. Pineapple set a tight tolerance on this characteristic, with a lower specification limit (LSL) of 0.995 and an upper specification limit (USL) of 1.005.*

a. *Carry out a Capability Analysis and include relevant output in your solutions and interpret your results and make recommendations.*



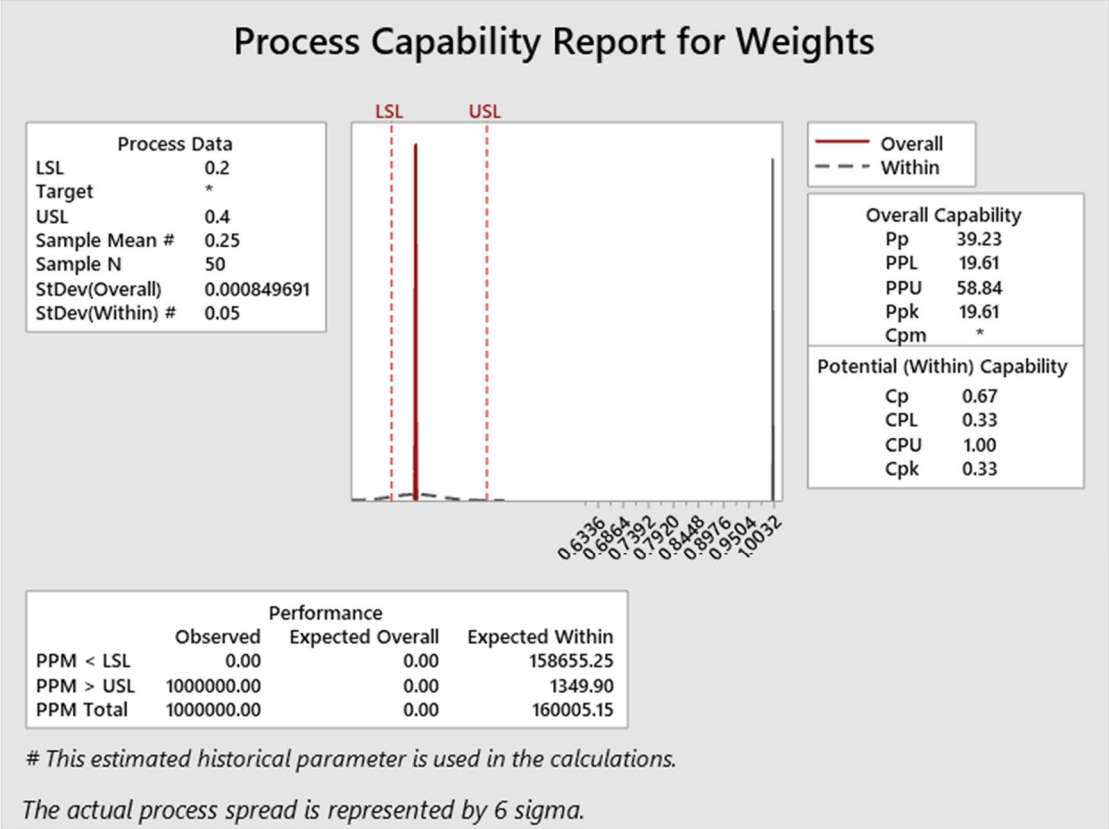

According to the above histogram, Cp=1,82 and Cpk=1,43. If the Pineapple wants to reduce random variation, it should try to improve the Cp value with a process improvement technique, like the Design of Experiments. When Cpk is roughly equal as Cp the process is centred.

As shown in the capability graphic, the mean is closer to Upper Specification Limit (USL). From Pineapple's perspective, if random variation was reduced and it was decided to run the process 'off-centre' it would be better to run the process closer to Lower Specification Limit (LSL) than USL because this would help Pineapple to save more money.

Since the Overall and Within Standard Deviations are similar, Cp (1,82) is similar Pp (1,96) and Cpk (1,43) is similar to Ppk (1,55). This happens only when random causes of variation are present, and this should always be the situation in Capability Analysis.

b. *The weights of the tablet covers are also of importance, but Pineapple receive these from a supplier. When asked by Pineapple for the mean and standard deviation of their tablet cover weights, the supplier gives answers of 0.25 and*

*0.05, with a tolerance of 0.2 (LSL) and 0.4 (USL). Calculate capability metrics for the supplier's process and interpret your results.*




For the supplier's process Cp=0,67 and Cpk=0,33. The value of Cpk is closer to Cp. This means that there is less variation in the process. Moreover, the mean is located closer to LSL, which is beneficial for the supplier but not for Pineapple.

c. *Pineapple isn't satisfied with the capability of the supplier's process, so they ask other suppliers for their capability metrics. What advice would you give Pineapple when comparing capability metrics?*

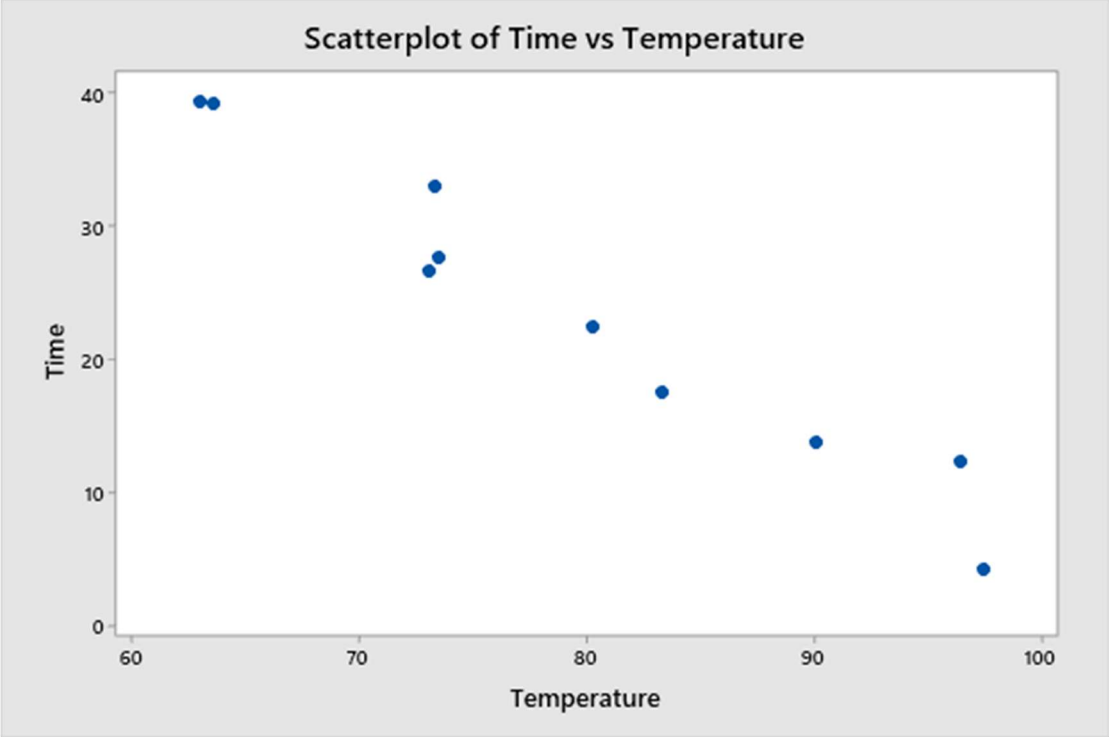
The capability of supplier's process is closer to LSL, which means that Pineapple spends more to buy items from this supplier. A good advice could be to centralize the process. For this to be achieved, Cpk should be equal to Cp and the process mean should be centred.

## QUESTION 6

*The data in columns P and Q are the failure times (in days) of 10 randomly chosen tablets, and the temperatures (in degrees Celsius) which they were subjected to. This*

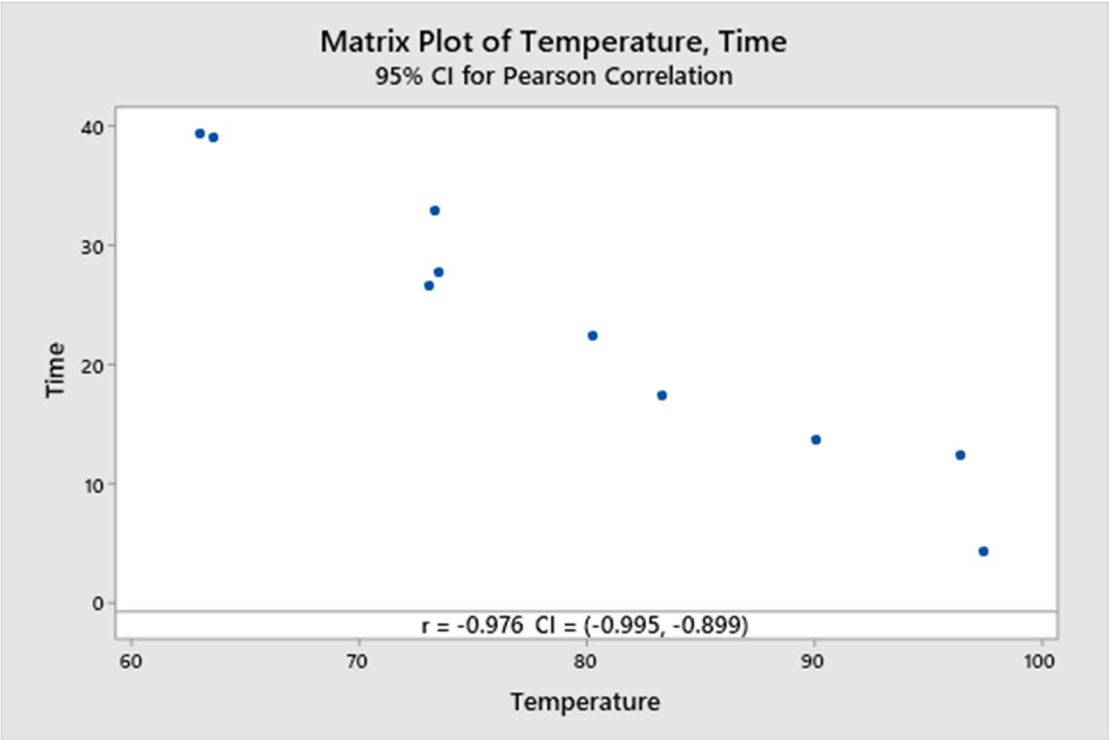
*data has arisen because Pineapple realise that it takes too long to gather data for a Reliability Analysis study, so in future they would like to run accelerated life tests, where conditions are imposed upon the test units which far exceed conditions in the customer field. It's believed that one way to accelerate the life of a tablet, is to increase the temperature, but the relationship between failure time and temperature needs to be understood.*

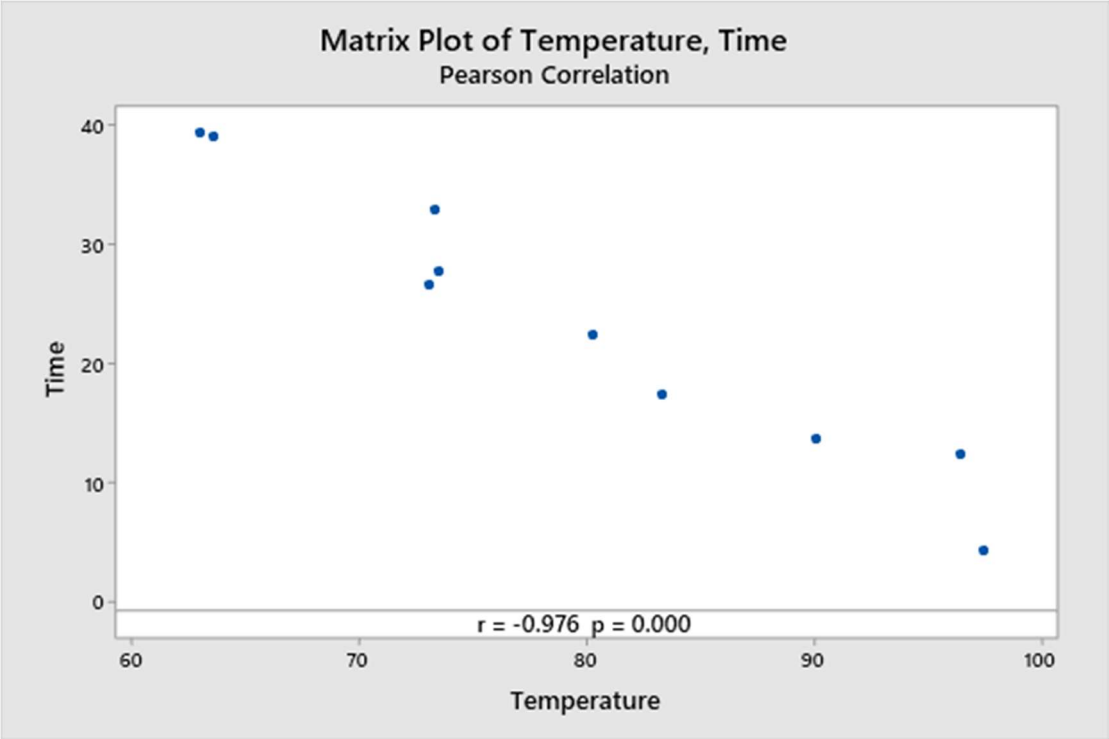
*a. Produce a graphical display that will allow Pineapple to visualise the relationship between failure time and temperature and interpret it.*




The above scatterplot shows a clear relationship between the failure time and temperature. The failure time decreases as the temperature increases.

*b. Calculate a statistic which will quantify the strength and direction of this relationship and interpret it.*




The scatterplot allows to visualize the strength and direction of the relationship between failure time and temperature. This relationship is a negative relationship because there is a downward slope. If there was an upward slope the relationship would be positive. The two variables have also a linear and strong relationship. A straight line could be drawn through the middle of the data without the points straying far from this straight line. If the points were straying far from this line, there would be a weak relationship.

Therefore, the relationship between failure time and temperature is a negative, linear, and strong relationship.

c. *Carry out a Regression Analysis and include relevant output in your solutions and interpret your results. Predict what the failure time will be when the temperature is 75.*

## Regression Equation

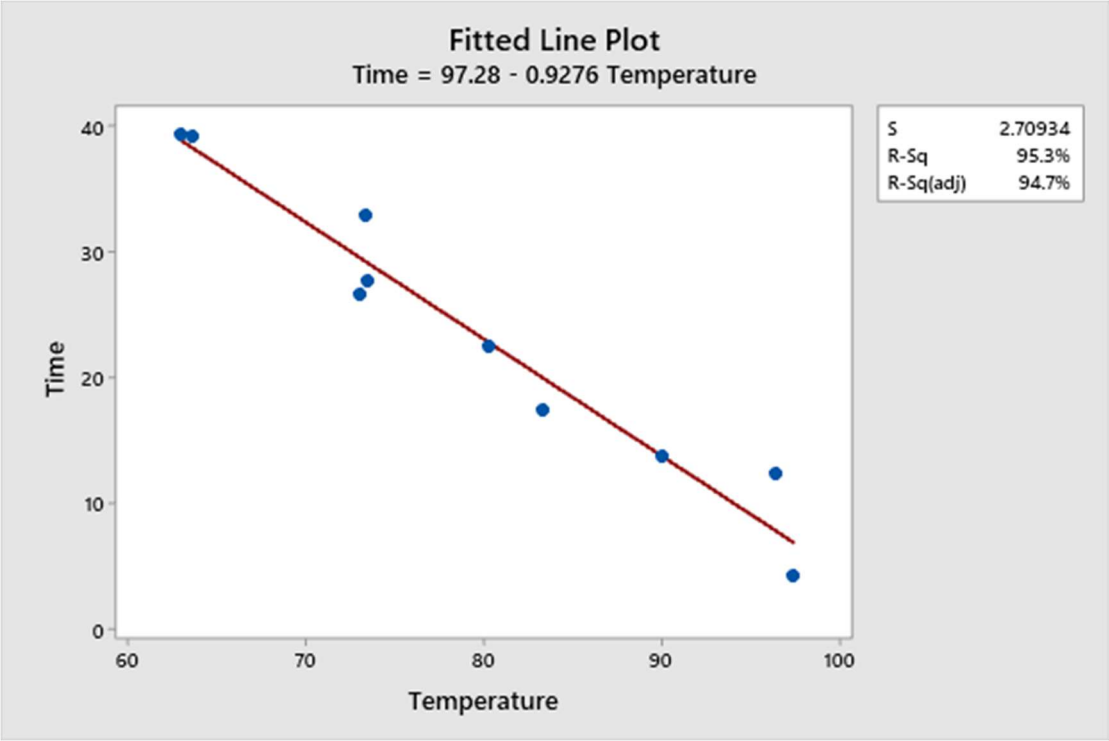
Time = 97.28 - 0.9276 Temperature

## Coefficients

| Term | Coef | SE Coef | T-Value | P-Value | VIF |
|---|---|---|---|---|---|
| Constant | 97.28 | 5.85 | 16.62 | 0.000 | |
| Temperature | -0.9276 | 0.0729 | -12.72 | 0.000 | 1.00 |

## Model Summary

| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 2.70934 | 95.29% | 94.70% | 91.97% |




The Regression Equation is given as Time=97,28-0,9276*Temperature. Therefore, the estimates of intercept and slope are a=97,28, and b=0,9276 correspondingly. The slope (Temperature) has a p-value of zero, so we can assume that it is not significant in the analysis (and equal to zero). The $R^2$ statistic with a value of 95,3% means that all points lie very close on the regression line.

According to the Regression Equation, Time=97,28-0,9276*Temperature. If the temperature is 75, the failure time would be 27,71. Therefore, the failure time will be approximately 28 days.

d. *An engineer suggests "as well as increased temperature, increased pressure and increased vibration could be used to accelerate life and identify the Red X". What does the engineer mean by "the Red X" and what analysis method could be used to identify it (you do not need to apply this method)?*

The Red X refers to a dominant cause. Although there are thousands of variables that can cause a change in the value of an output, there is a one cause and effect relationship that has to be stronger than the others. This dominant cause is the Red X, and it has to be isolated and identified.

## QUESTION 7

*The data in columns R, S, T, U, V, W and X are the technical characteristics (length (mm), width (mm), depth (mm), weight (g), resolution (ppi), chip (GHz) and battery (mAh)) of Pineapple's tablet, and 6 of their competitors' tablets.*

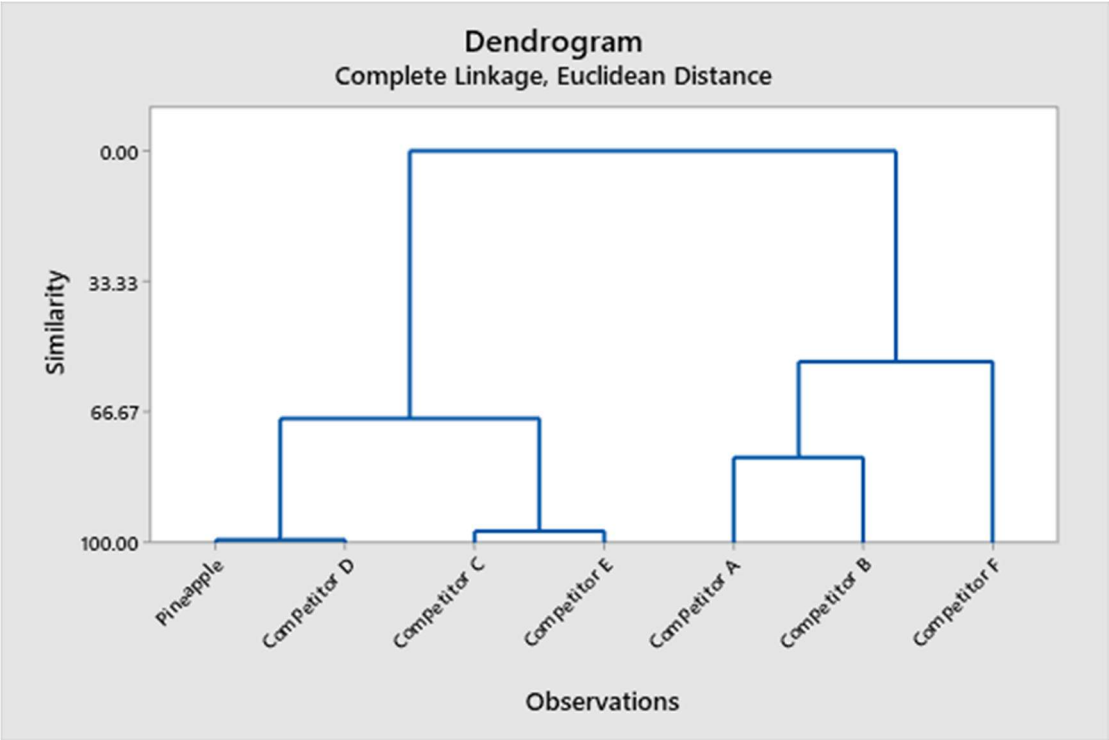
a. *Carry out a Cluster Analysis and include relevant output in your solutions and interpret your results. Which tablet is the most similar to Pineapple's? Which tablet is the least similar to Pineapple's*?

### Amalgamation Steps

| Step | Number of clusters | Similarity level | Distance level | Clusters joined | | New cluster | Number of obs. in new cluster |
|---|---|---|---|---|---|---|---|
| 1 | 6 | 99.2824 | 49.46 | 1 | 5 | 1 | 2 |
| 2 | 5 | 97.0812 | 201.16 | 4 | 6 | 4 | 2 |
| 3 | 4 | 78.2002 | 1502.46 | 2 | 3 | 2 | 2 |
| 4 | 3 | 68.2540 | 2187.96 | 1 | 4 | 1 | 4 |
| 5 | 2 | 53.7763 | 3185.77 | 2 | 7 | 2 | 3 |
| 6 | 1 | 0.0000 | 6892.07 | 1 | 2 | 1 | 7 |

### Final Partition

| | Number of observations | Within cluster sum of squares | Average distance from centroid | Maximum distance from centroid |
|---|---|---|---|---|
| Cluster1 | 7 | 38686553 | 2026.32 | 3988.33 |




According to the above dendrogram, Pineapple has the most similar tablet with Competitor D and the least similar tablet with Competitor F. Competitors C and E, as well as Competitors A and B have the same product characteristics respectively. The tablet of Competitors D, C, and E is different from the tablet of Competitors A, B, and F.

b. *The technical characteristics could also be called design requirements because they are the measurable features of the product. Explain the QFD methodology and how it can be used to translate customer requirements into design requirements and help to identify the most important design requirement.*

The Quality Function Deployment is a methodology that captures customer requirements and translates them into design requirements. Customer requirements may be obtained through questionnaires or interviews on focus groups. Vague customer statements, like ‘this product looks good’ or ‘easy to use’ are translated into design requirements which are measurable attributes of the product or service. When these are implemented, the product is able to satisfy the customer verbatim.

The House of Quality chart is used to conduct a QFD. The House of Quality identifies the most important design requirements. It classifies and identifies the customer needs and identifies the most important design requirements. It correlates and verifies those

two, assigning objectives and priorities for the design requirements. The most important rooms of a House of Quality are Room 1, which includes customer requirements (or the What has customer said) and Room 2, which includes the design requirements (or the How the needs will be fulfilled).

c. *An engineer suggests that all customer requirements need to be focused on in any improvement project. Explain project scope and how it relates to this scenario.*

Project Scoping defines and controls what is included in a project and what is not. For this reason, worksheets are used, allowing a problem to be investigated in detail. Worksheets define better the problem and discover important details. People from different departments are asked to complete them. Project scoping offers a better understanding of the problem and thus improves projects significantly.

d. *Another engineer suggests that certain customer requirements must be fulfilled because they're expected by the customer, whereas other unexpected customer requirements won't be as high a priority but may delight the customer if fulfilled. What customer satisfaction model is the engineer referring to, and how does it relate to this scenario?*

The engineer is referring to the Kano Model, developed in 1980's by Professor Noriaki Kano. The Kano model divides customer requirements and potential new product features into three groups. Each group has a different impact on customer satisfaction. The first group includes basic quality features, like the cleanliness in a hotel room. These features are expected by the customers and if they are not present, customers get extremely dissatisfied. Improvement in the performance will not increase satisfaction, as they are taken for granted.

The second group includes one-dimensional features, such as a comfortable bed. They are requirements that customers would like to have fulfilled and if they would, their satisfaction would increase significantly.

The third group includes attractive features. The features of this group are not expected by customers, but if they are present, customer satisfaction increases dramatically.

Therefore, Kano model can help engineers to decide which features need to be improved so that Pineapple's products will increase customer satisfaction.

## SECTION C: CRITICAL APPRAISER

*A number of Quality Management (or Process Improvement) Strategies have been established and subsequently applied by practitioners and various organisations throughout the 20th and into the 21st century. Such examples are Statistical Process Control (SPC), The Shainin System, Total Quality Management (TQM), Six Sigma, Lean Manufacturing, Lean Six Sigma and Quality Circles. Mainly the initial application and observed benefits of these strategies have been witnessed within the manufacturing sector but more recently, successful case studies have been reported within service sector organisations.*

*Find a technical paper which is a case study of a Quality Management strategy being applied within an organisation and describe the methods used. What assumptions have the practitioners made in their applications of the tools & techniques? Comment critically on the data collection, presentation, analysis, and interpretation of the results. What were the conclusions? What were the benefits? What went wrong? What went right? What, in your opinion, could have been done differently? You should try to cover these details in no more than two sides of A4 paper. Attach a copy of the paper to your report. Please try to ensure that you are describing a different paper to your colleagues.*

**Lean Manufacturing: A case study in the Malaysian B2 Sdn Bhd automotive parts manufacturing**

B2 Sdn Bhd is a second-tier automotive parts supplier to the national car manufacturers in Malaysia. The company has an authorized capital of RM5 million with paid-up capital of RM2.5 million. It is certified to ISO 9001:2008 and ISO/TS 16949:2009. In 2011 the company started implementing the lean manufacturing system with the support of the Malaysian Automotive Institute (MAI). Their existing company policy is focused on three core areas. Firstly, lowering the costs by eliminating the waste throughout the organization. Secondly, it tries to improve its responsiveness to customer demands, and thirdly, it tries to reduce time throughout the entire business process. The implementation of the lean manufacturing system is assisted by lean production system departments that are established in the company. Rapid improvement processes or Kaizen groups were formed to highlight the lean manufacturing pursuit.

Lean activities were implemented by the top management so that its problems could be identified and solved. Particularly, the use of a Material Information Flow Chart (MIFC) identified problems that could block the lean implementation. MFIC managed to identify some important issues. *Poor 5S and safety*, which led to mixing parts, longer times for machine changeover (83 minutes for dark colour and 112 minutes for light colour), longer in-process quality control (IPQC) for dark colour (208 minutes), and low productivity of specific machines. Moreover, it recognized issues related to its *inventory management*. High stock for raw materials (approximately 31 days) and finished good stock being kept for two weeks.

In order to deal with these problems, the company implemented a number of steps. First of all, the company implemented the 5S+1S activity in their organization. This 6S training was given to all staff. Once the training was completed, the implementation activity put into action. Along with this activity, an internal audit carried out to measure the improvements and effectiveness. Adjustments were also made to reduce the time for both colour processes.

Three main problems occured, namely the extruder machine had a long heat-up time, a long start-up process and a long wash-up time. These processes are taking place during the production time. A new standard of procedure (SOP) was introduced to reduce the changeover time problems. SOP ensured that the machine operator would use it 45 minutes before the production activity, starting every first day of the week for the heating up process. This method managed to reduce 70% of the time needed for dark colour (25 min) and 47% of time needed for light colour (60 min).

Furthermore, IPQC ensured the consistency in quality during all stages of the production processes. Long time in the IPQC activity could lead to other productivity problems. In order to tackle this danger a pilot study was conducted. The findings of the study showed five big issues contributing to the IPQC time: Colour matcher competency, colour consistency, long sample collection time, injection process set-up time, and production processes.

For the product to be solved effectively and to preserve the quality a new SOP was introduced. The new SOP inspected the colouring process, while the production size has been reduced to batch sizes, so that the IPQC time could be reduced. Along with

SOP, a workforce skill chart for IPQC established, managing to decrease the IPQC time from 208 minutes to 59 minutes.

At the beginning of lean manufacturing implementation system, the company's achievements were remarkable. The top management commitment in implementing the lean manufacturing was critical to success. The strategic approach along with the policy direction that company followed towards a company-wide objective change mentality, gave the chance for an effective process improvement. The lean implementation is a knowledge intensive phenomenon. This means that the top management in Malaysian manufacturing companies needed a clear vision and strategic initiatives, good educational levels, and to be willing to support product improvements.

The lean manufacturing system can become even more successful with teamwork and when individuals understand their roles within the system. Lean implementation is a continuous process, and therefore, long-term investment in lean activities should not be seen as an unnecessary loss of resources and they should not anticipate immediate returns (Roslin et al., 2012, pp. 1-5).

A lean manufacturing system requires frequent changes in working practices. It is important to be designed as simple as possible, so that it would be easier to monitor and eliminate waste. Continuous improvement of the designs and processes should be done along with the appropriate metrics, while incremental changes should be small. The company should also aim to continuous improvement, as it is the only way to become even more effective. Its workflows should be checked regularly by conducting the appropriate control charts, while Kanban boards can help to visualize this workflow. And finally, the use of Poka Yoke technique can assist the company in the prevention of any error.

## REFERENCES

Roslin E. N., Shamsuddin A., Dawal S. Z. Md., and Tamri N. (2012), 'Strategies For The Successful Lean Manufacturing Implementation: A Case Study In A Malaysian Automotive Parts Manufacturing', *International Journal of Engineering Research & Technology*, 1(9), pp. 1-5.