# Global Supply Chain Issue

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# Overview

- Customers want products that can meet their requirements and good quality. In addition, they want the product fast and on time. Customer loyalty is built on trust, so one **missed delivery** can compromise that trust and cost you a customer for good. **The supply chain is the most important factor to convert the promise.**
- **Focus**: Improve Customer Delivery
- Sections: Planning for prevention & Solutions for issues

# Process Flow Chart

# Brainstorming Session

Who are we getting our material from?

What equipment do we need to move and receive material?

What efficiencies can be made in the order process?

# Assessment and Analysis of COPC

| Process | Internal Failure | External Failure | Appraisal | Prevention |
|---|---|---|---|---|
| Order Management | Short of labor<br>Equipment quality<br>Money Issue | Unpredictable endang er<br>Repeated quality issues<br>Production efficiencies drop | *Maintenance feedback from customer and placing purchase order | Hiring more employee<br>Regular maintenance on equipment<br>Keep analysis on feedback from customers |
| Supplier | Shortage of raw material<br>Bad quality on raw material | Cannot delivery raw material to manufacturer company on time | * keep quality of raw material products<br>*Quality auditing of the raw materials | Has backup material supplier<br>Keep tracking on material & stored specific amount of raw materials |
| Packing & Distribution | Shortage of transport company<br>Requirement of packaging | Weather issues<br>Lockdown caused by covid-19 | *Pre-check packaging requirement from different countries<br>*Use standard packaging size of each product | Backup transport company<br>Notification to the customers |

# Affinity Diagram

## Suppliers

- Process Downtime
- Shortage of raw material

## Logistics

- Cranes
- Trucks

## Order Management

- Labor
- Materials
- Funding

## Packaging & Distribution

- Volunteer
- Government

# Introduction- How Six Sigma improve supply chain

Six Sigma methodology can effectively be employed in **SCM to measure, monitor and improve the performance of the whole supply chain network**.

Advantages:

1. Reduce waste
2. Reduce Variation
3. Improve Processes
4. Deliver sustainable savings

# Define Phase

Identify Potential Project: Nominating Screening and Selecting Projects.

Selection of Initial Projects: Form of evidence to the project team members that the improvement process does lead to useful results.

Problems and Mission Statement for Project: Identifies the visible deficiency in a planned outcome.

Select and Launch the Project: Selection of team members who will meet project goals.

# Identifying Potential Projects

- Employee feedback & analysis
- Equipment data
- Receive feedback from customers
- Analyze material supplier
- Take stock of material & stored specific amount of raw materials
- Understand transportation options

# Measure Phase

We **measure** the **process** performance in its current state in order to **understand the problem**

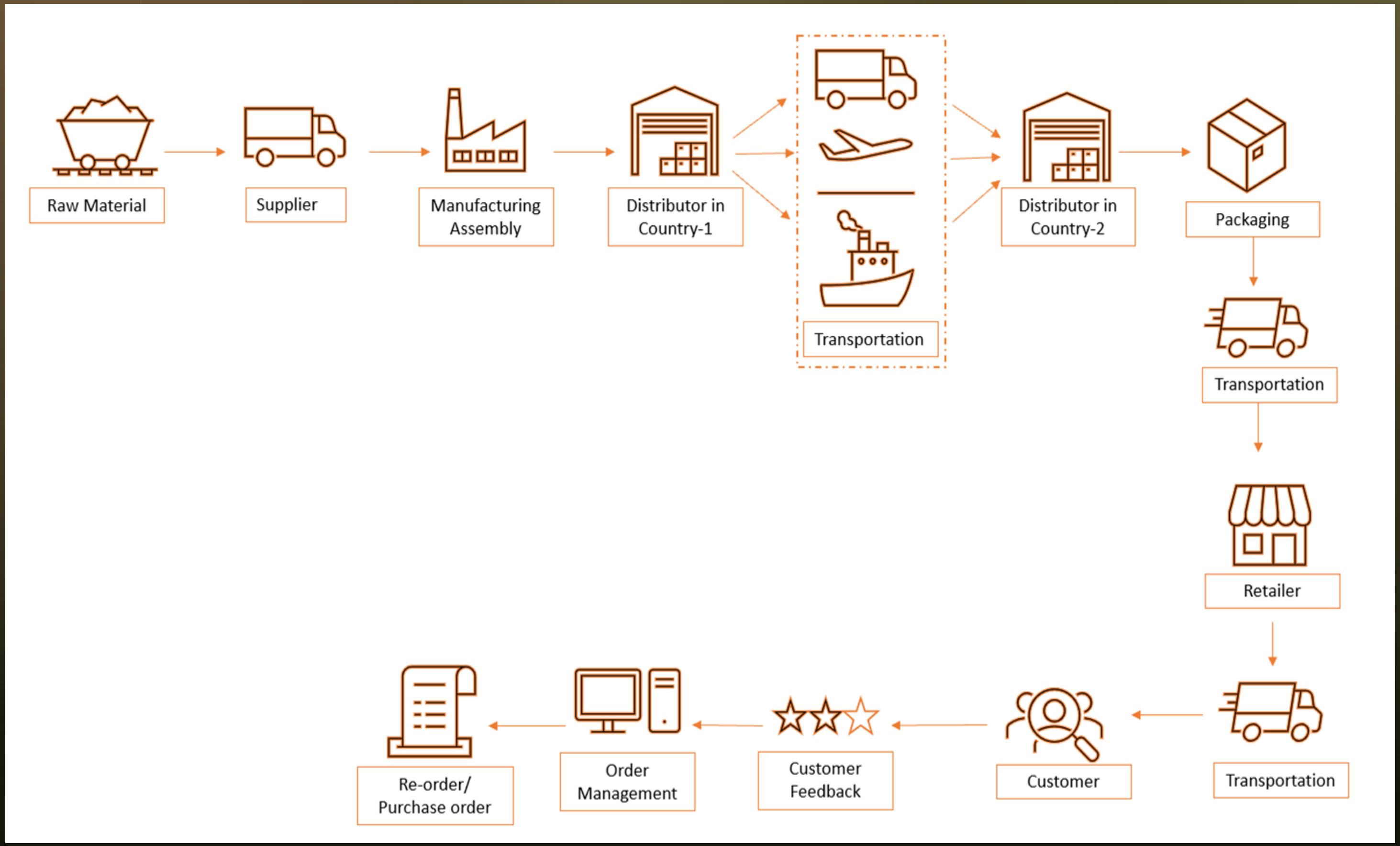
**Benefits of measure phase**:. Understanding the **degree** of different **causes** adding to the **problem** with the **help of data**

**Validate results** to **overcome resistance** to accepting and implementing a change with results

# Measure Phase

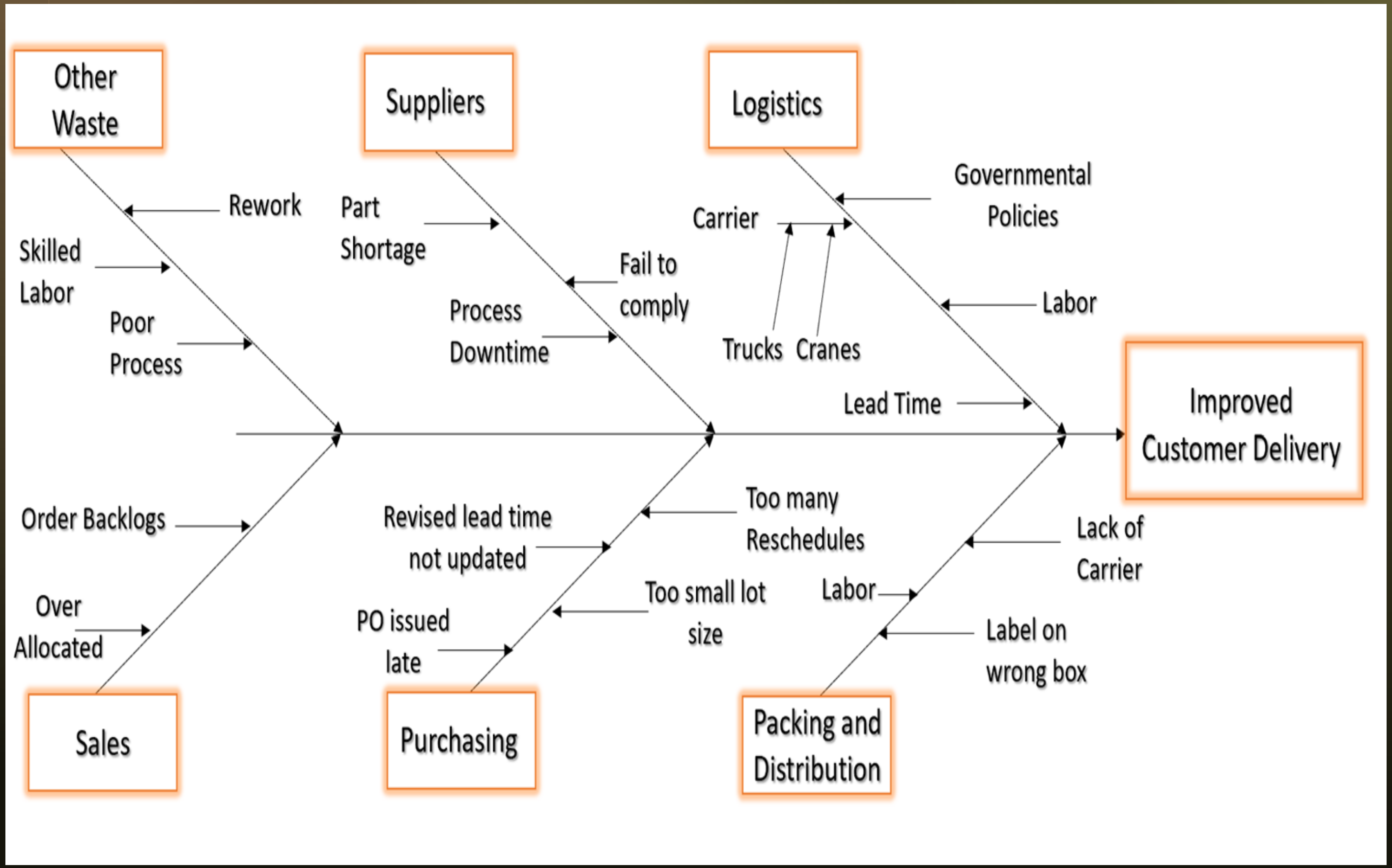
Document the Process:

- To begin with measurements, it's vital to understand the flow of the process
- This step **records** the **activities** under study and the sequence of **events undertaken** in the entire supply chain.
- A **useful tool** to undertake the desired task is a **process flow diagram**



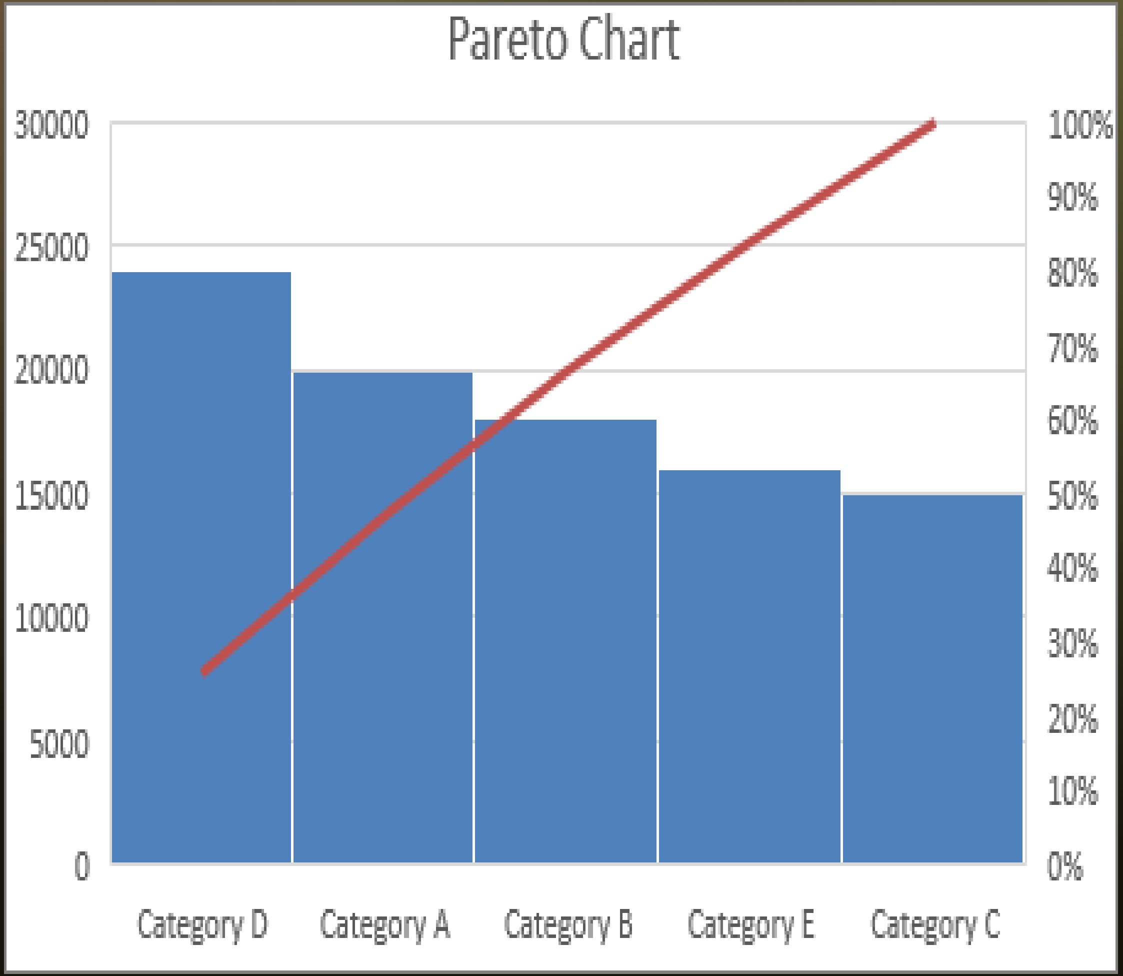
# Measure Phase

- Using a **fishbone diagram**, we have been able to identify the **major cause** for adding up the lead time in the manufacturing process.
- We included **all segments** of the supply chain to have a holistic view of the targeted problem.
- Furthermore, we did a different test to identify the root cause and the possibility of success.



# Measure Phase

- We are facing huge problems in the post-pandemic world to fulfill the high customer demands resulting in loss of opportunity and even loss of loyal customer base
- By using the Pareto chart, we mapped the process lead-time involved in manufacturing
- After further investigation by professionals, we have found the supplier lead time is a major source of delay



# Measure Phase

We identified the total length of duration associated with the all the processes; it was observed that the lead time was **110 days** with a **standard deviation of 9 days**. This was very large and had intangible problems like inventory and even in some cases missing the stated promise date.

So, we undertook a market study to shift the supply chain to a closer geometric region like Mexico which can significantly reduce the lead time-saving cost of warehousing as well as can help to take advantage of Just In Time inventory

# Analyze Phase

**Interpret the Data**

e-Surveys, blogs, focus groups, etc.

**Analyze Data**

Pareto Diagrams, Statistics, Control Charts, Histograms,  Process Capability

**Test Theories**

Flow Diagrams, Process Capability Analysis, Process Dissection, Time-to-Time Analysis

# Analyze Phase

In this phase we begin to analyze the problem through statistical methods. The families of variation would be reviewed and the conclusion about which are the significant contributors to the final output.

So, we decide to analyze the data we collected and try to find the root cause of variation in the process.

| Delivery Lead Time |
| --- |
| 111.824 |
| 106.149 |
| 86.982 |
| 103.013 |
| 109.324 |
| 112.595 |
| 114.546 |
| 110.659 |
| 118.649 |
| 103.183 |
| 123.573 |
| 116.456 |
| 105.881 |
| 88.846 |
| 117.752 |
| 111.410 |
| 121.924 |
| 109.408 |
| 100.633 |
| 114.385 |
| 106.963 |
| 101.268 |
| 104.088 |
| 120.236 |
| 114.431 |
| 112.385 |
| 101.678 |
| 108.617 |
| 119.295 |
| 118.611 |
| 113.934 |
| 118.955 |
| 111.604 |
| 93.073 |
| 98.171 |
| 120.824 |
| 106.451 |
| 102.226 |
| 113.075 |
| 113.141 |

# Analyze Phase

- Descriptive Statistics is as shown below

## Descriptive Statistics: Delivery Lead Time

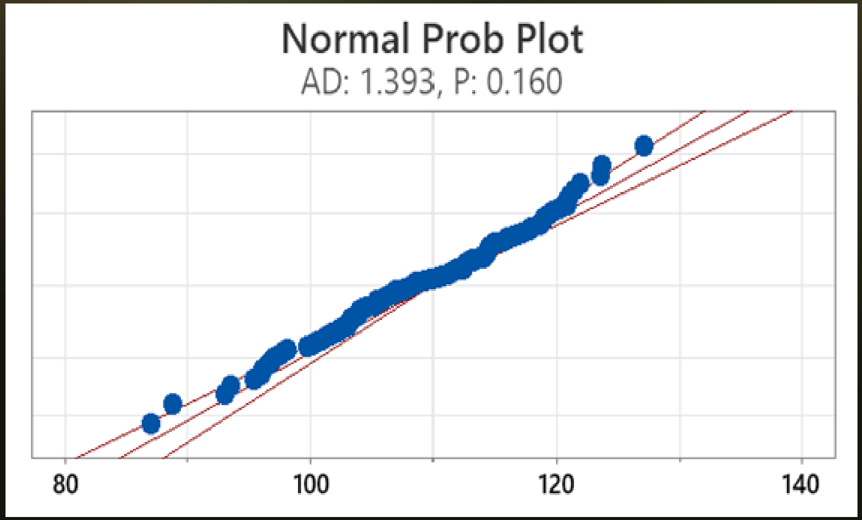
### Statistics

| Variable | N | N* | Mean | SE Mean | StDev | Minimum | Q1 | Median | Q3 | Maximum |
|---|---|---|---|---|---|---|---|---|---|---|
| Delivery Lead Time | 100 | 0 | 108.67 | 0.830 | 8.30 | 86.98 | 103.13 | 108.43 | 114.52 | 127.05 |

- Test for Normality:

We find P-value of our set of data is 0.160, which is >0.05

Therefore, we conclude that data follows normal distribution.



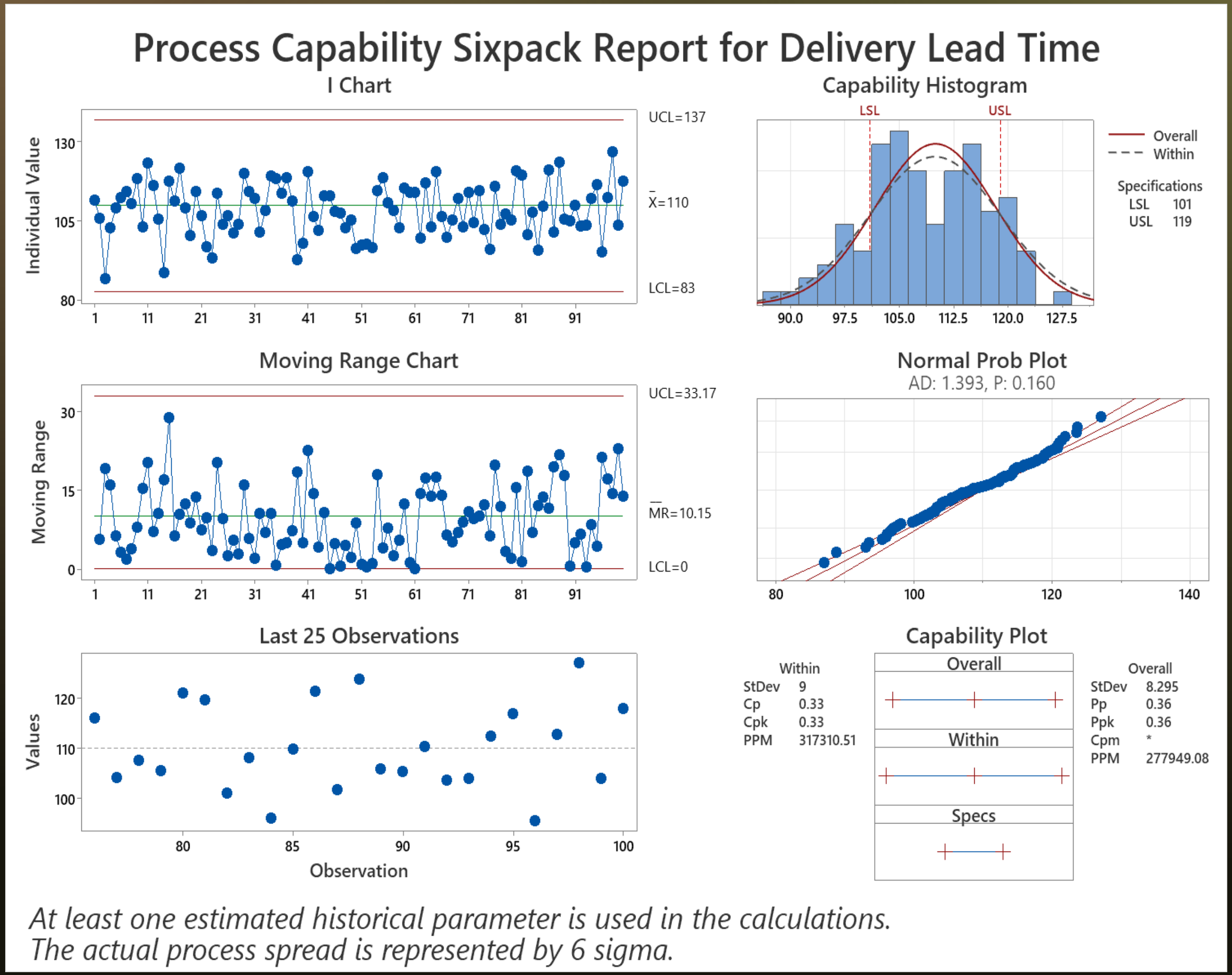
# Analyze Phase

From the capability analysis and capability sixpack we find that:

- LSL=101 ,USL=119, Mean=108 (which means process is more towards the LSL), Cp =0.33 (which is very low, <1), Cpk=0.33, Std Deviation= 8.30

*<u>Ideas to improve process:</u>*

- Increase mean, to center the process
- Reducing the standard deviation to improve Cpk and to fit the project in specification limit



# Improve Phase

BUILD OVERALL CAPACITY

BUILD LOCAL CAPACITY

BECOME STRATEGICALLY LEAN

BUILD STRONG CONNECTIONS

DIGITAL TRANSPORTATION

# Improve Phase

| Criterion | Remedy 1 | Remedy 2 | Remedy 3 |
|---|---|---|---|
| Remedy Name | Build overall & local capacity | Build strong connections | Digital Transporation |
| Total Cost | Over billion dollars | No money limit | Depends on systems |
| Impact on Issue | Increase overall capacity of products | Understanding customers' needs | Save more time for managing the orders |
| Benefit | Reduce the chances of semi-conductor shortage | Reduce the overproduction | Better management on capacity and products |
| Resistance to Change | Lack of government's supports | Lack of data analysis from customer's side | Lack of money and sources |
| Implements Time | 1 year – 3 years | During cooperation | 6 months |

# Improve Phase

- Build overall & local capacity
- Increasing overall output capacity.
- Allocating manufacturing capacity to more regions and reducing extreme local concentrations
- Hiring more strong talent and skills employees.
- Strategically Lean
- Reduce the amount of production and postpone the new products releasing
- Reduce overproduction issues for the products.
- Order more products when the market has plenty of semi-conductors.

# Control Phase

Design controls and document the improved process

Validate the measurement system

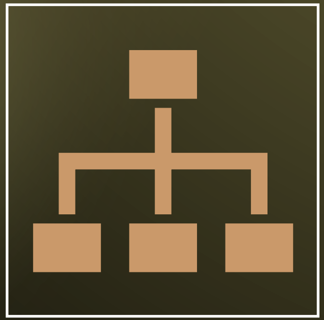
Determine the final process capability

Implement and monitor the process controls

# Control Phase

By creating a **Process Control Plan,** we were able to define what needs to be done to ensure the processes operate effectively and standardize reactions

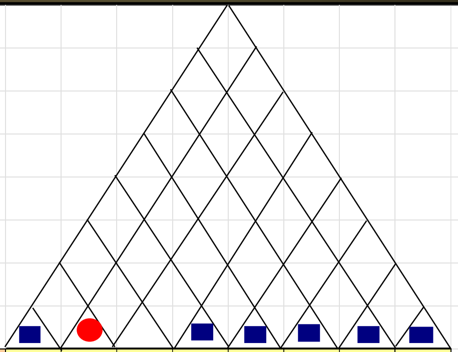
By creating **SOPs,** we can create standard work allowing us to create repeatable results



Implementing **Change Management** allows us to create a system to monitor changes and ensure changes have merit

# Quality Function Deployment (QFD Matrix)

**QFD**
**Global Supply Chain Issue**



| Customer Requirements \ Quality Characteristics | Priority | Delivery on time | Undamaged deliveries | No extra costs | IT Services | Reliable Manufacturing line | Order flexibility | Meet demand quantity | Improving transport |
|---|---|---|---|---|---|---|---|---|---|
| Delivery | 8 | 9 | 9 | 8 | | | | | 9 |
| Cost | 7 | 3 | | 9 | | | | 3 | 3 |
| Product quality | 6 | | 8 | 3 | | 9 | | | |
| Real time Shipment tracking | 5 | | | | 9 | | 8 | 8 | 9 |
| Order Fulfilment | 4 | 9 | 3 | | 8 | 9 | 3 | 9 | 8 |
| Quality Service | 3 | 3 | 3 | | 3 | 9 | 3 | 1 | 8 |
| Environmental friendly | 2 | | | 1 | | | 9 | | |
| After Sales Service | 1 | 1 | | 3 | | 1 | 9 | | 1 |
| CTQ Priority Score | | 139 | 141 | 150 | 86 | 118 | 88 | 100 | 195 |

| LEGEND | | |
|---|---|---|
| Priority | 8 | Highest |
| | 1 | Lowest |
| Relationships | 9 | Stronger |
| | 3 | Medium |
| | 1 | Small |
| | ■ | Positive |
| | ● | Negative |

# DOE/Experimental Design

Step 1: Acquire the inputs and outputs being investigated.

- **Output:** Customer Delivery (in Tons)
- **Input:** A. Number of containers
  B. Number of cranes
  C. Number of ships

Step 2: Determine the appropriate measurement for the output.

Collect historical data through a sample survey as a response.

- Annual Customer Delivery time generally varies from 75 to 95 days (cycle starting from supplier to customer)

# DOE/Experimental Design

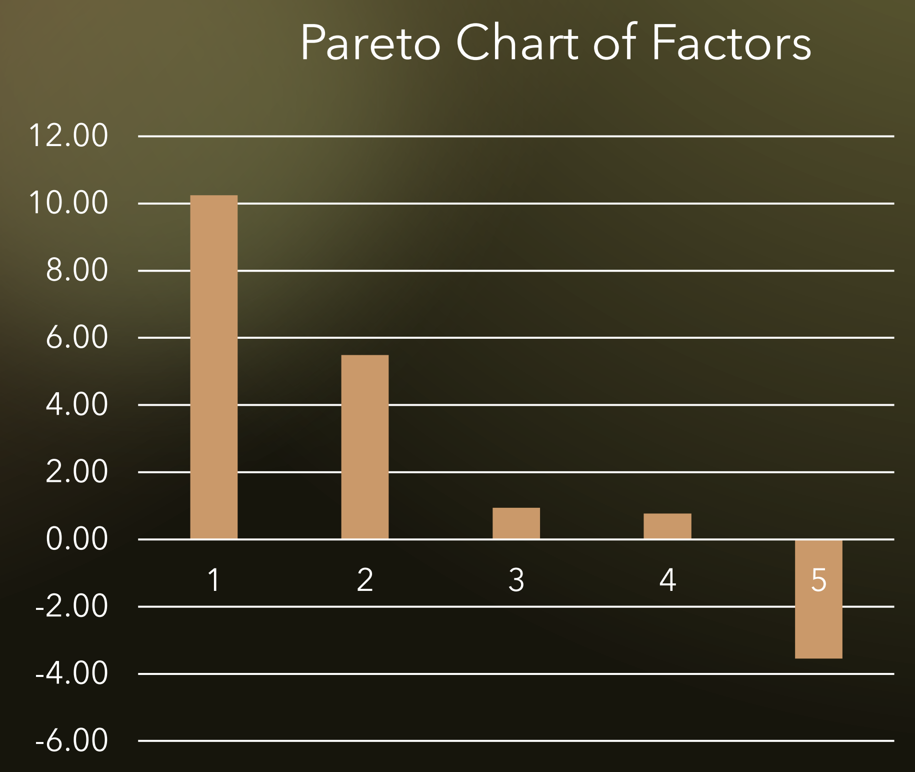
Step 3:  Create a design matrix for the factors being investigated.

Step 4: For each input, determine the extreme but realistic high & low levels to investigate.

- Factor A:  Number of containers
  - Low(-): 80
  - High(+): 120
- Factor B: Number of cranes
  - Low(-): 8
  - High(+): 10
- Factor C: Number of ships
  - Low(-): 3
  - High(+): 7
- The design was a 2^3 factorial with 3 different factors

# DOE/Experimental Design

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Factorial Experiments 2^3 (Three Replications/Treatment) | | | | | | | Run Results | | | |
| Run | A | B | C | AB | AC | BC | ABC | Y1 | Y2 | Y3 | Avg. | Var. |
| 1 | -1 | -1 | -1 | 1 | 1 | 1 | -1 | -1.33 | 0.26 | 1.26 | 0.063 | 1.698 |
| 2 | 1 | -1 | -1 | -1 | -1 | 1 | 1 | 2.69 | 2.73 | 6.25 | 3.888 | 4.176 |
| 3 | -1 | 1 | -1 | -1 | 1 | -1 | 1 | 4.18 | -3.59 | 0.92 | 0.504 | 15.218 |
| 4 | 1 | 1 | -1 | 1 | -1 | -1 | -1 | 23.16 | 20.45 | 23.61 | 22.408 | 2.924 |
| 5 | -1 | -1 | 1 | 1 | -1 | -1 | 1 | 11.83 | 6.98 | 8.89 | 9.233 | 5.965 |
| 6 | 1 | -1 | 1 | -1 | 1 | -1 | -1 | 21.65 | 23.27 | 21.17 | 22.032 | 1.215 |
| 7 | -1 | 1 | 1 | -1 | -1 | 1 | -1 | 18.92 | 12.47 | 23.52 | 18.306 | 30.796 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 32.94 | 37.84 | 34.19 | 34.992 | 6.492 |
| TotSum | | | | | | | | 114.05 | 100.42 | 119.81 | 111.43 | 68.48 |
| SumY+ | 83.32 | 76.21 | 84.56 | 66.70 | 57.59 | 57.25 | 48.62 | | | | | |
| SumY- | 28.11 | 35.22 | 26.86 | 44.73 | 53.84 | 54.18 | 62.81 | | | | | |
| AvgY+ | 20.83 | 19.05 | 21.14 | 16.67 | 14.40 | 14.31 | 12.15 | | | | | |
| AvgY- | 7.03 | 8.80 | 6.72 | 11.18 | 13.46 | 13.54 | 15.70 | | | | | |
| Effect | **13.80** | **10.25** | **14.42** | **5.49** | **0.94** | **0.77** | **-3.55** | | | | | |
| Var+ | 3.702 | 13.858 | 11.117 | 4.270 | 6.156 | 10.791 | 7.963 | | | | | |
| Var- | 13.419 | 3.264 | 6.004 | 12.851 | 10.965 | 6.331 | 9.158 | | | | | |
| F | 3.625 | 0.236 | 0.540 | 3.010 | 1.781 | 0.587 | 1.150 | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Var. of Model | | 8.56 | | StdDv | 2.93 | | | | | | | |
| Var. of Effect | | 1.43 | | StdDv | 1.19 | | | | | | | |
| Student T (0.025;DF) = | | | | 2.473 | | | | | | | | |
| C.I. Half Width = | | | | **2.954** | | | | | | | | |
| | | | | | | | | | | | | |
| | | Significant Factors & 95% CI Limits: | | | | | | | | | | |
| | | | | | | | | | | | | |
| Factor | A | B | C | AB | AC | BC | ABC | | | | | |
| Signific. | Yes | Yes | Yes | Yes | No | No | Yes | | | | | |
| LwrLimit | 10.85 | 7.29 | 11.47 | 2.54 | -2.02 | -2.19 | -6.50 | | | | | |
| UprLimit | 16.76 | 13.20 | 17.38 | 8.45 | 3.89 | 3.72 | -0.59 | | | | | |



# DOE- Analysis Result

**Coded Coefficients**

| Term | Effect | Coef | SE Coef | T-Value | P-Value | VIF |
|---|---|---|---|---|---|---|
| Constant | | 13.928 | 0.597 | 23.32 | 0.000 | |
| A | 13.804 | 6.902 | 0.597 | 11.56 | 0.000 | 1.00 |
| B | 10.248 | 5.124 | 0.597 | 8.58 | 0.000 | 1.00 |
| C | 14.425 | 7.212 | 0.597 | 12.08 | 0.000 | 1.00 |
| A*B | 5.492 | 2.746 | 0.597 | 4.60 | 0.000 | 1.00 |
| A*C | 0.939 | 0.469 | 0.597 | 0.79 | 0.443 | 1.00 |
| B*C | 0.768 | 0.384 | 0.597 | 0.64 | 0.529 | 1.00 |
| A*B*C | -3.548 | -1.774 | 0.597 | -2.97 | 0.009 | 1.00 |

- Thus, we can say the A*C & B*C are not significant as the P-value is less than 0.05

**Model Summary**

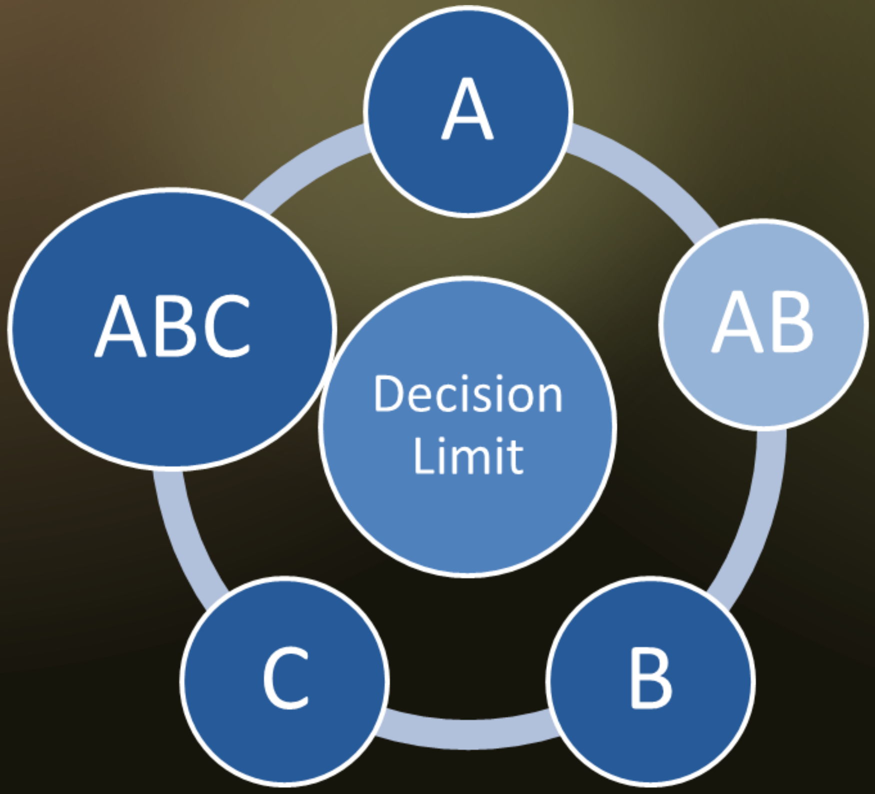
| S | R-sq | R-sq(adj) | R-sq(pred) |
|---|---|---|---|
| 2.92584 | 96.00% | 94.25% | 91.00% |

**Analysis of Variance**

| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
|---|---|---|---|---|---|
| Model | 7 | 3287.17 | 469.60 | 54.86 | 0.000 |
| Linear | 3 | 3021.85 | 1007.28 | 117.67 | 0.000 |
| A | 1 | 1143.24 | 1143.24 | 133.55 | 0.000 |
| B | 1 | 630.17 | 630.17 | 73.61 | 0.000 |
| C | 1 | 1248.45 | 1248.45 | 145.84 | 0.000 |
| 2-Way Interactions | 3 | 189.78 | 63.26 | 7.39 | 0.003 |
| A*B | 1 | 180.96 | 180.96 | 21.14 | 0.000 |
| A*C | 1 | 5.29 | 5.29 | 0.62 | 0.443 |
| B*C | 1 | 3.54 | 3.54 | 0.41 | 0.529 |
| 3-Way Interactions | 1 | 75.54 | 75.54 | 8.82 | 0.009 |
| A*B*C | 1 | 75.54 | 75.54 | 8.82 | 0.009 |
| Error | 16 | 136.97 | 8.56 | | |
| Total | 23 | 3424.14 | | | |

# DOE- Significant effects that improve (increase) product delivery (in tons)

| Target: 80 |
|---|
| Effect A: 13.804<br>(**Number of containers**) |
| Effect B: 10.248<br>(**Number of cranes**) |
| Effect AB: 5.492<br>(Interaction) |
| Effect C (**Number of Ships**): 14.425 |
| Effect ABC: -3.548 |

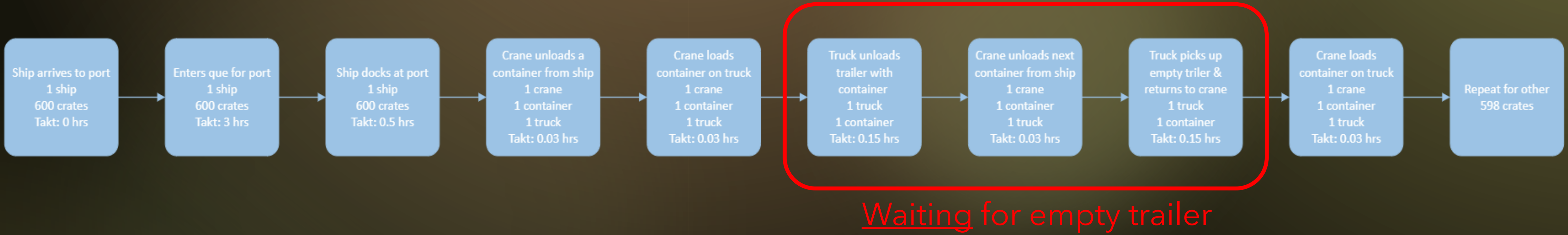


# Supply Chain and Lean/VSM

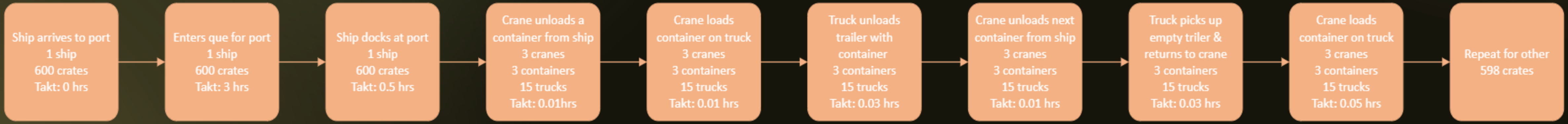
- Value-stream map is a tool used to analyze all steps in a process
  - This map helped us identify value-added steps and non-value-added steps in the supply chain process
  - By comparing the current state VSM & future state VSM we can visually show the improvements to be made to the process

# Supply Chain and Lean/VSM

- Current State: 1 ship, 600 containers, 1 crane, 1 truck = 219.5 hrs/ship




- Future State: 1 ship, 600 containers, 3 crane, 15 truck = 27.5 hrs/ship



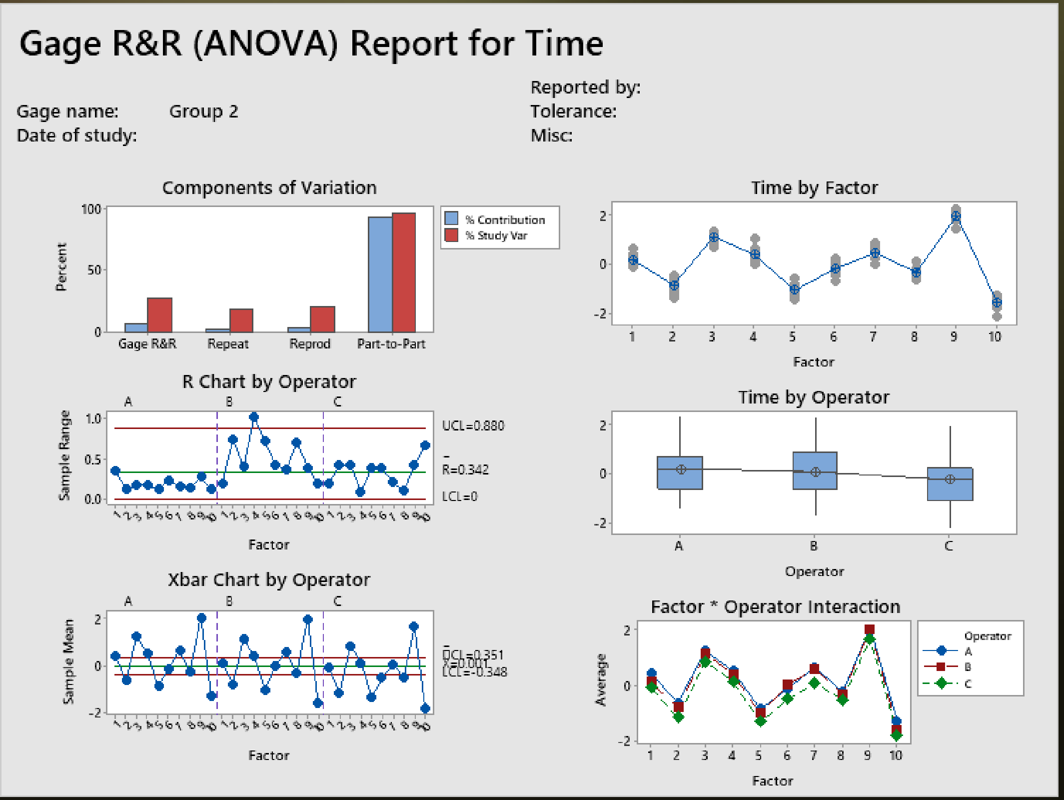
# Gage R&R Metrology MSA study

- The measurement will be the time delivery of the containers from suppliers to the customers.
- Have three officer groups to track the containers delivery times
- Sample will be the total time measurement with different operators and factors

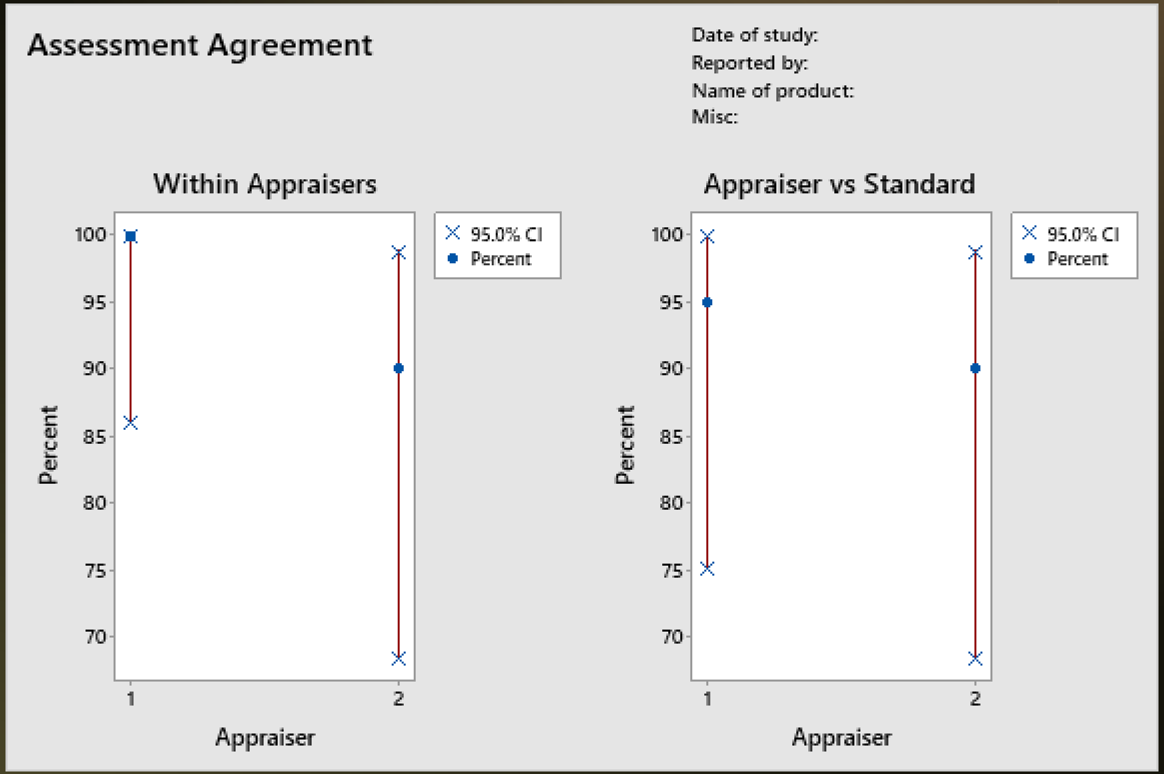
| Effects | Definition | Numbers |
|---|---|---|
| Operators | Officer Groups | 3 |
| Factors | Factors for Container Delivering | 10 |
| Sample | Operators * Factors | 30 |
| Number of Trails | Trails for each Containers | 3 |

# Gage R&R Metrology MSA study

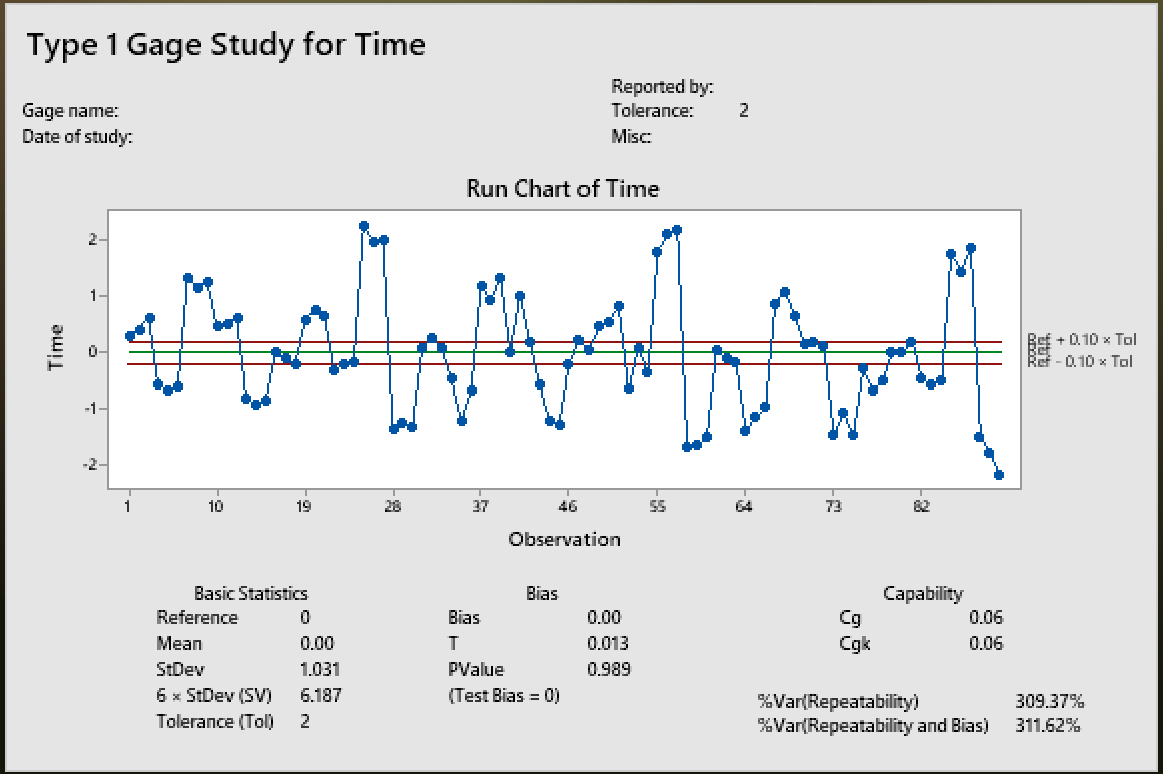
- There is a favorable relationship of the Gage R&R graph & Part to Part graph
- We do have one outlier in the R Chart by Operator Graph which may indicate a problem with one factor
- Operator C has lower time than others which should be looked at



# Gage R&R Metrology MSA study




Attribute Agreement




Type 1 Gage Study

# *Steps in Acceptance Sampling*


**Why Acceptance Sampling for global supply chain?**

Process of evaluating a portion of the lot for the purpose of accepting or rejecting the entire lot

**Why is Acceptance Sampling used?**

a) Cost of inspection is high in relation to the damage cost resulting from passing a defective product

b) 100% inspection is monotonous and causes inspection errors or,

**Sampling Risks** - Greater administrative costs and less information about the product than provided by 100% inspection

# Acceptance Sampling Plan

- Lot size, N (total number of containers arriving) = 1,000
- α probability (producer's risk) = 0.05
- β probability (consumer's risk) = 0.02
- AQL (acceptable quality level) = 0.01
- LTPD (lot tolerance percent defective) = 0.05
- Depending on lot size we must:
  - Normal Inspection = General II
  - Plan: J

| | |
|---|---|
| α | 0.05 |
| β | 0.02 |
| AQL | 0.01 |
| LTPD | 0.05 |
| Lot Size | 1000 |

*Table I—Sample size code letters*

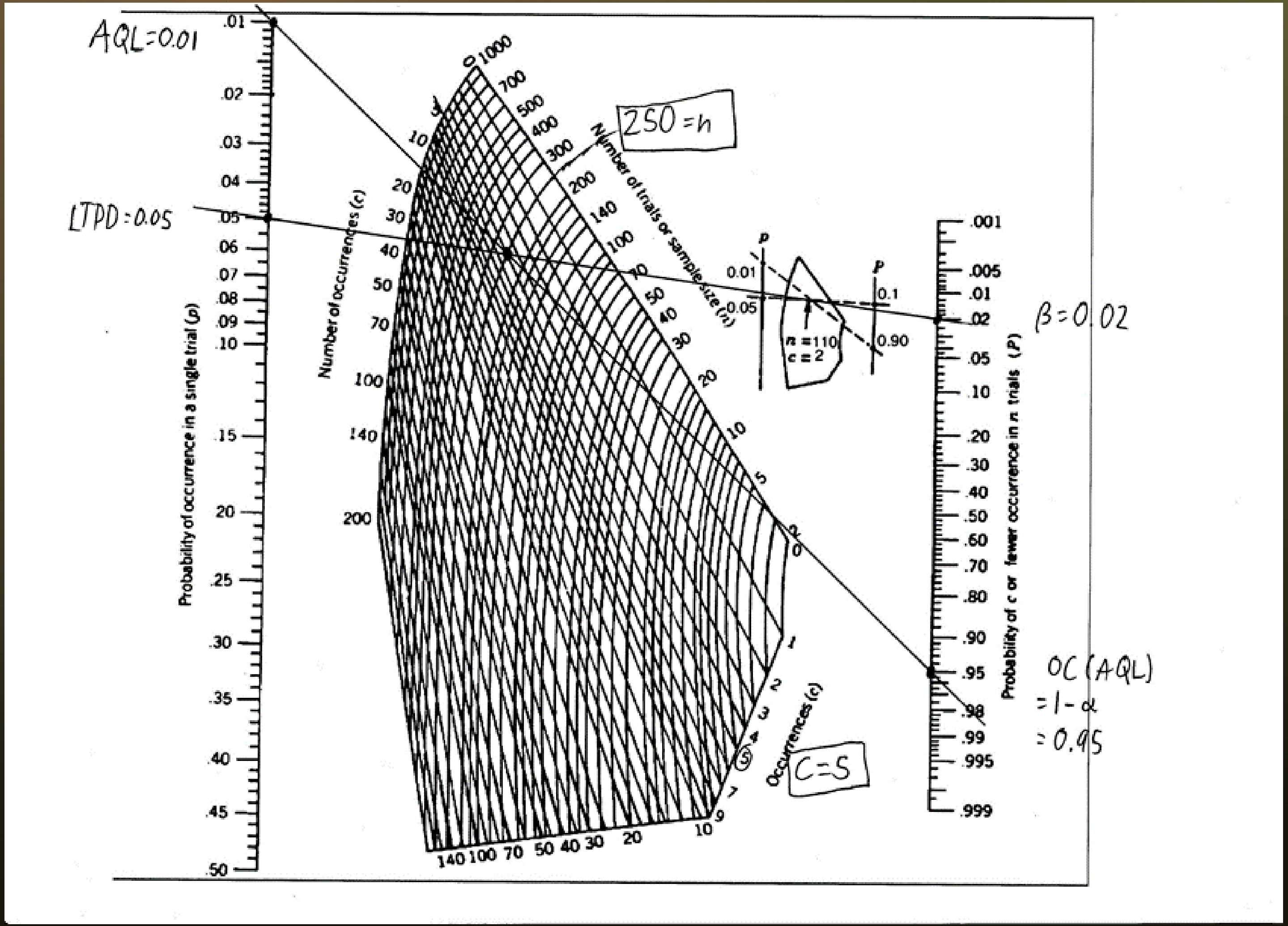
*(See 9.2 and 9.3)*

| Lot or batch size | | | Special inspection levels | | | | General inspection levels | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | S-1 | S-2 | S-3 | S-4 | I | II | III |
| 2 | to | 8 | A | A | A | A | A | A | B |
| 9 | to | 15 | A | A | A | A | A | B | C |
| 16 | to | 25 | A | A | B | B | B | C | D |
| 26 | to | 50 | A | B | B | C | C | D | E |
| 51 | to | 90 | B | B | C | C | C | E | F |
| 91 | to | 150 | B | B | C | D | D | F | G |
| 151 | to | 280 | B | C | D | E | E | G | H |
| 281 | to | 500 | B | C | D | E | F | H | J |
| 501 | to | 1200 | C | C | E | F | G | J | K |
| 1201 | to | 3200 | C | D | E | G | H | K | L |
| 3201 | to | 10000 | C | D | F | G | J | L | M |
| 10001 | to | 35000 | C | D | F | H | K | M | N |
| 35001 | to | 150000 | D | E | G | J | L | N | P |
| 150001 | to | 500000 | D | E | G | J | M | P | Q |
| 500001 | and | over | D | E | H | K | N | Q | R |

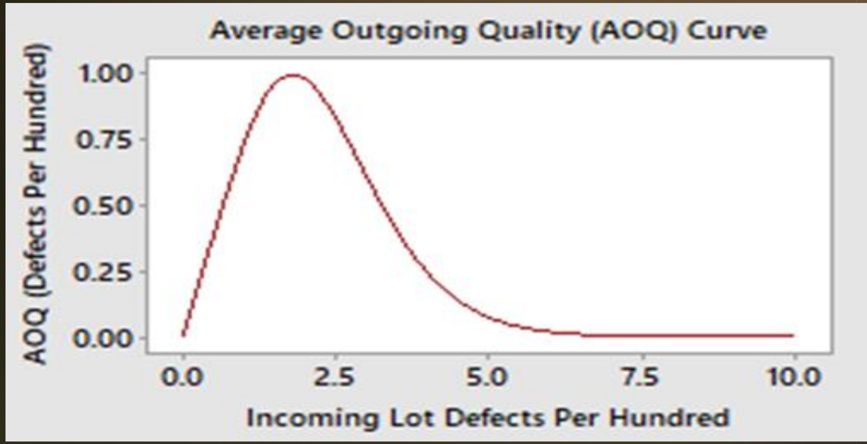
# Acceptance Sampling Plan

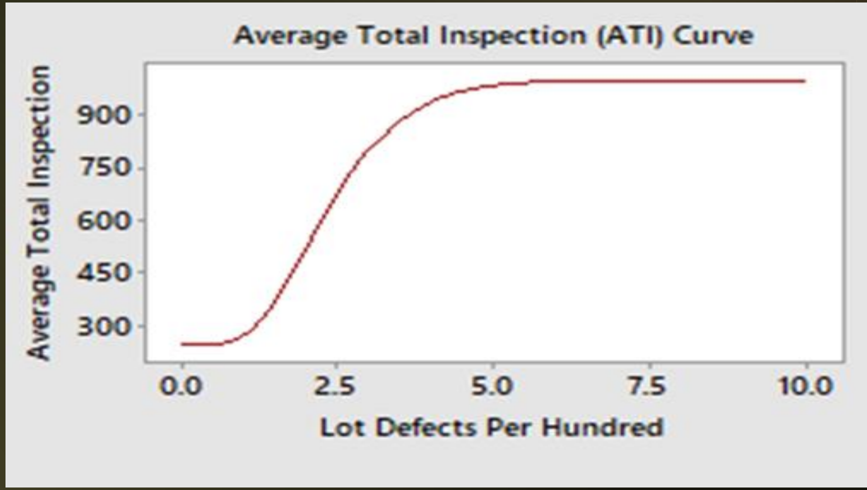
Use **Nomograph** with the parameter given to find the starting point

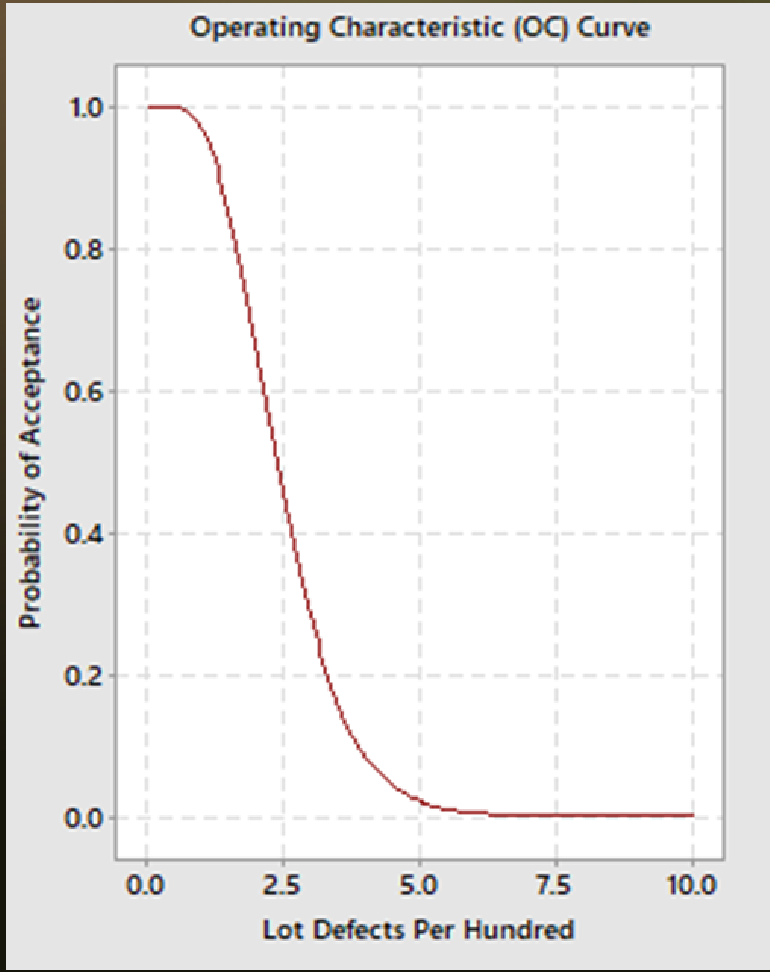
- **OC (AQL)** =1-α =0.95
- **OC(LTPD)** = β =0.1
- **LTPD** = 0.05
- **AQL** = 0.01
- **N** = 1000
- **n** = 250
- **C** = 5



# Operating Characteristic Curve



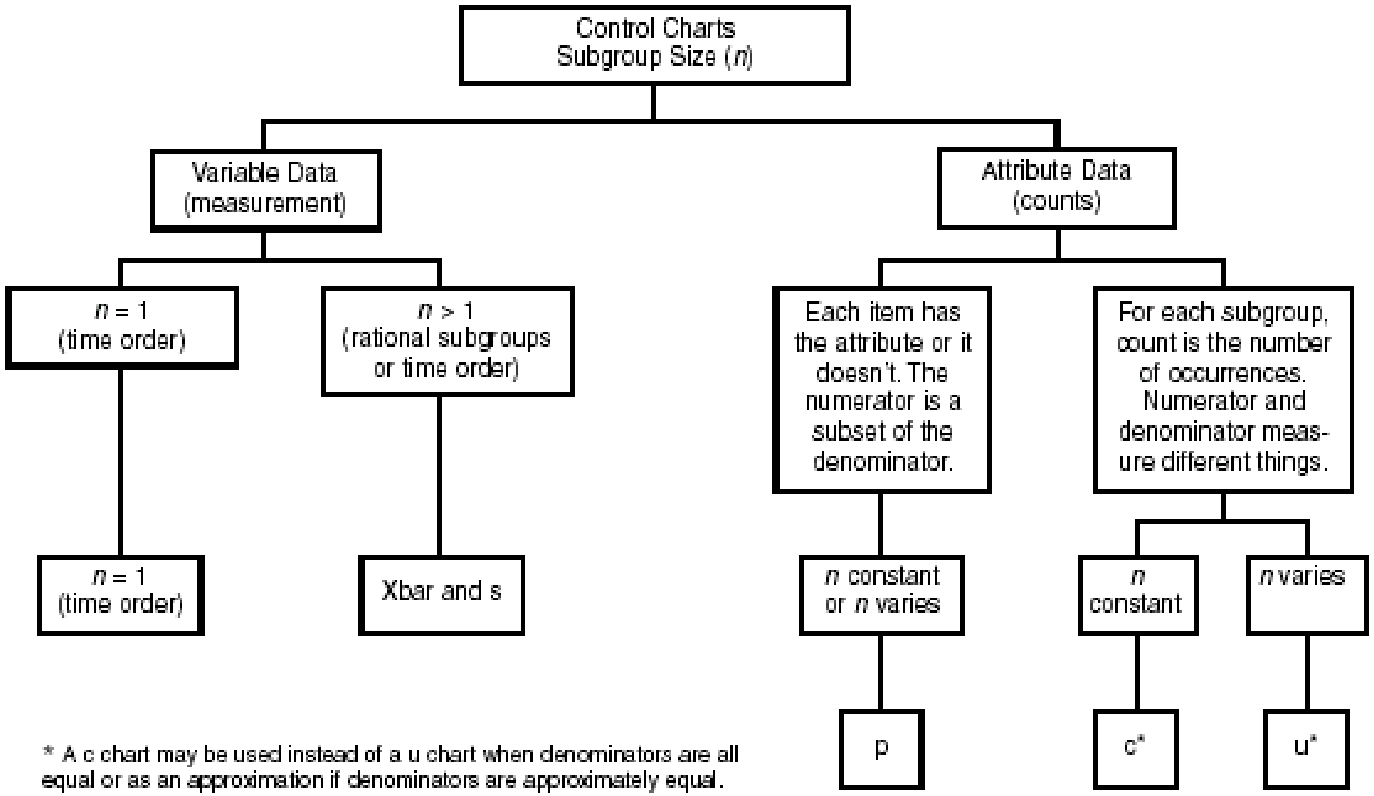



## Decision Matrix for Attribute Data

| | Equal size subgroups | Unequal size subgroups |
|---|---|---|
| Count may be larger than the subgroup size | c chart (or could use a u chart) | u chart |
| Count is limited by the subgroup size | np chart (or could use a p chart) | p chart |

The np chart is seldom used.




* A c chart may be used instead of a u chart when denominators are all equal or as an approximation if denominators are approximately equal.

*Source:* Hart M, Hart R. *Statistical Process Control for Health Care*. Pacific Grove, CA: Duxbury; 2002.

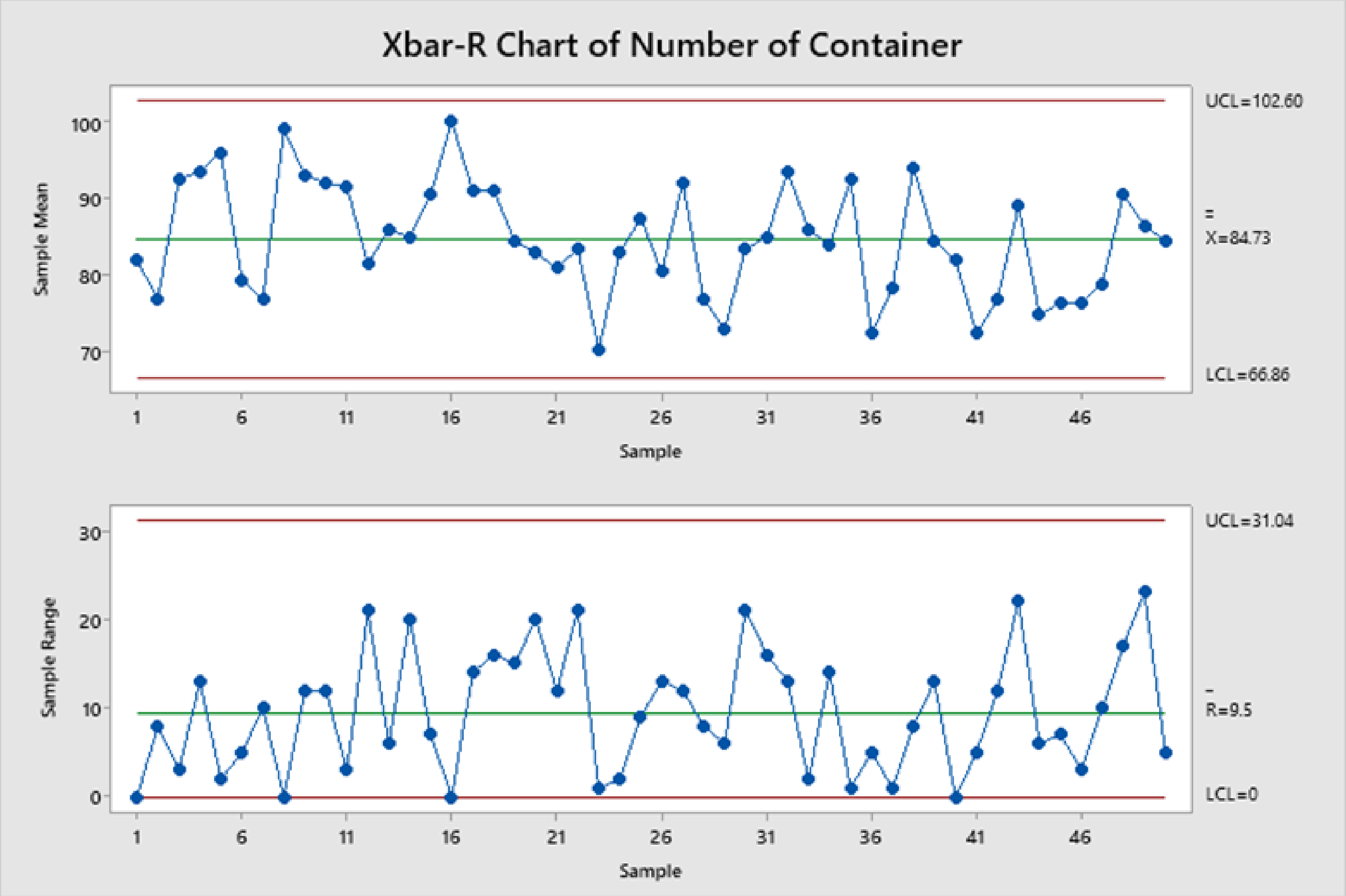
# *Why did we use Charts?*

- **X (bar) and R charts** can be used for quality characteristics that can be measured and expressed in numbers
- **X (bar) and R charts** can be used for one measurable quantity at a time
- Although many times measurement of variable characteristics is possible, for reason of economy, common practice is to classify items as good or bad (use attribute charts)

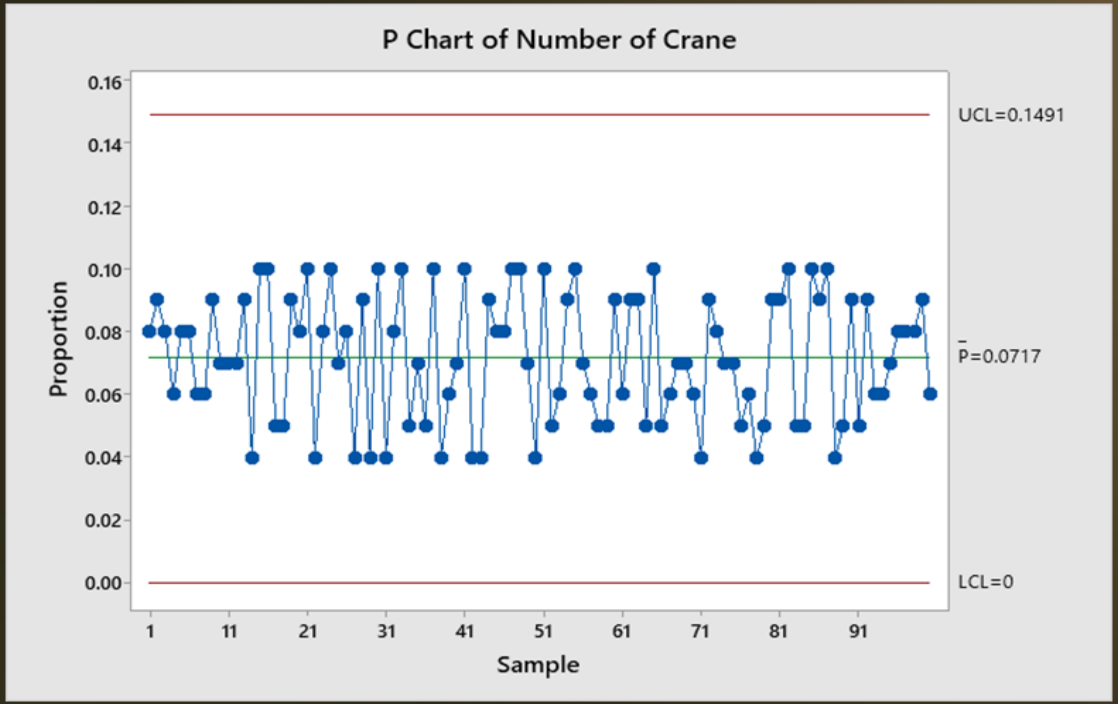
$$UCL = \mu + 3\sigma$$

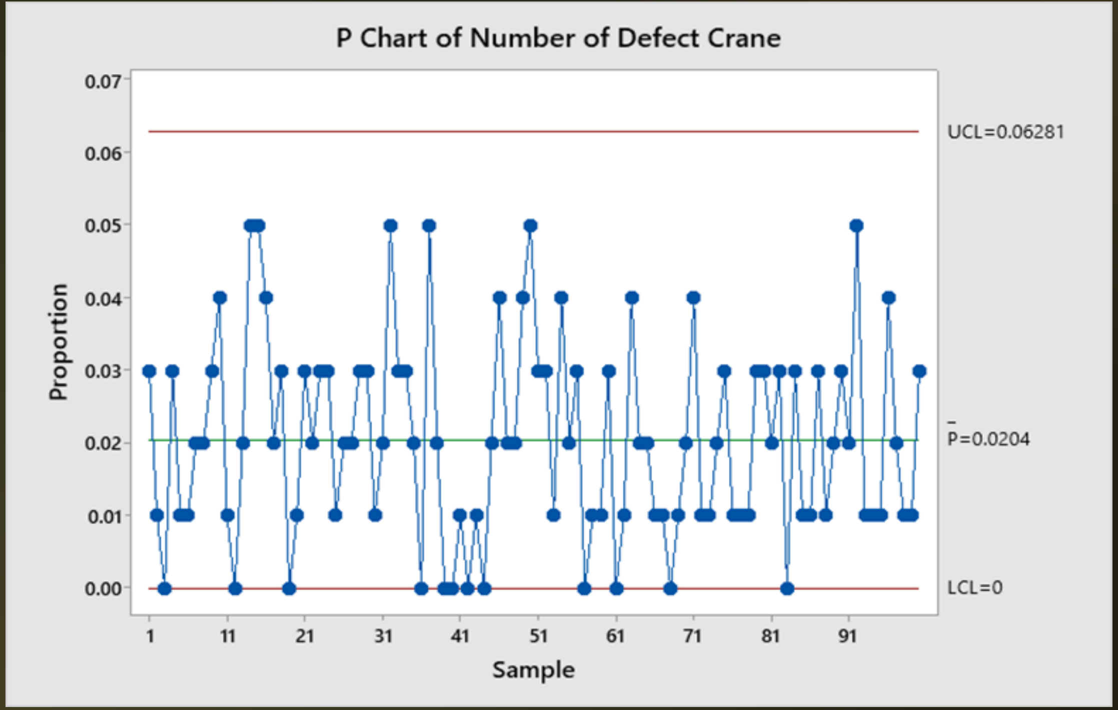
$$LCL = \mu - 3\sigma$$

# *X bar- R Chart*




- After the improved process we tried to understand where the increased number of containers will bring our uncontrolled process back to the improved state or not.
- We used the X-bar chart to examine the range of the number of containers and found the revised plan with the varying demand will keep our process under control.
- With this good news, we were curious to understand the effect of newly calculated values for cranes too.




# *P - Chart*

- After the improved process we tried to understand where the expected number of defective cranes due to downtime expected will result in uncontrolled process.
- We used the P-chart to examine the effect of containers and found the revised plan with the varying demand will keep our process under control.
- Thanks to P Chart we will now be able to cope with defects too.

Mean (Target) = $\lambda$; UCL = $\lambda + 3\sqrt{\lambda}$; and
LCL = $\lambda - 3\sqrt{\lambda}$ (if LCL is > 0; otherwise LCL = 0)

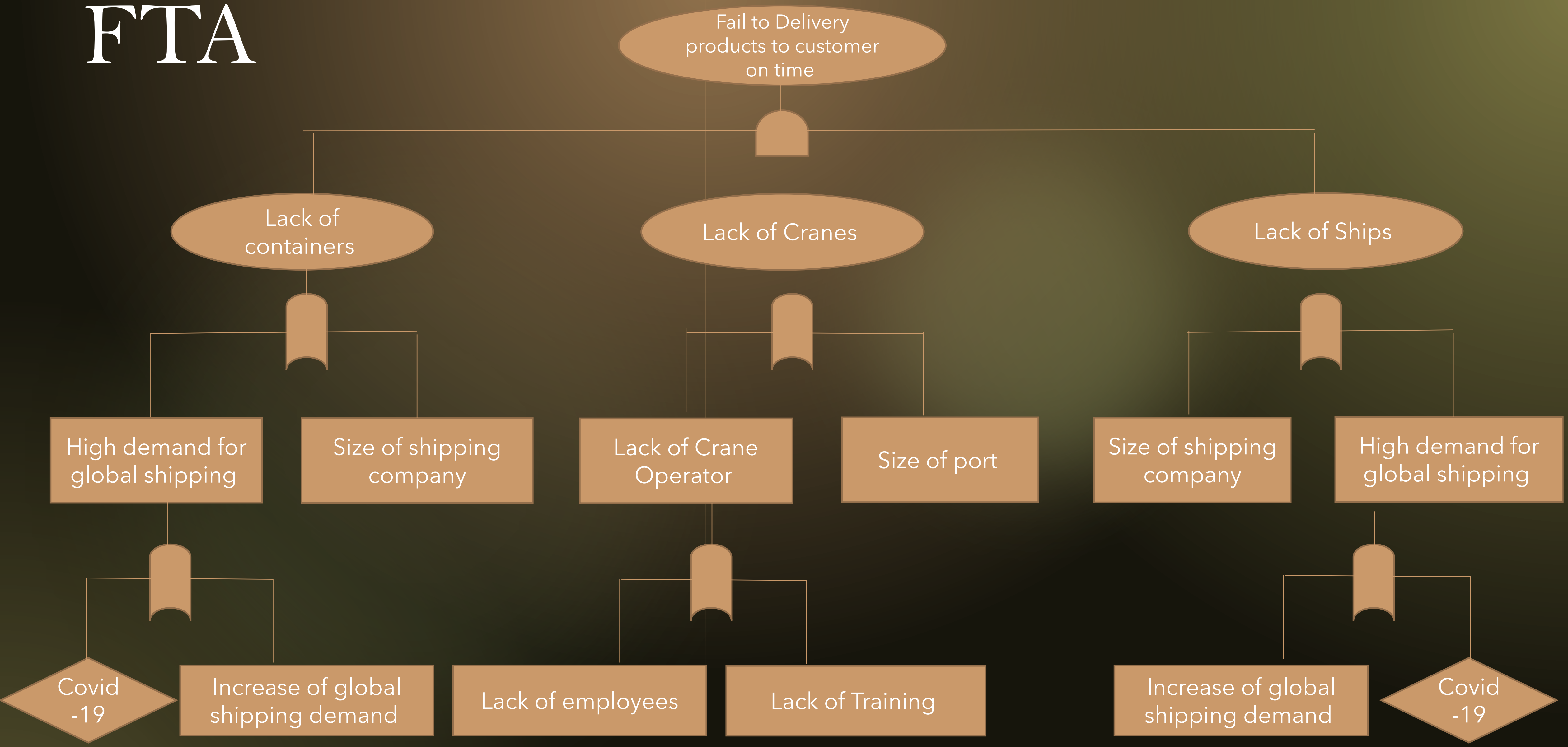
# Reliability analysis

- Reliability is defined as the probability that a product or system will operate in a defined environment without failure.
  - The quantification of reliability in terms of a probability
  - A statement defining successful product performance
  - A statement defining the environment in which the equipment must be operated
  - A statement of the required operating time between failures
- Determination of Failure Mode Effects Analysis (FMEA) & Fault Tree Analysis (FTA).
  - Failure modes and effects analysis are actions about the risks of failures, for use in continuous improvement. (FMEA)
  - FTA is a graphical tool to explore the causes of system-level failures. It's to identify the component level failures (basic event) that cause the system level failure (top event) to occur.

# FMEA

| Function | Failure Mode | Effects | Severity (10-Most) | Causes | Occurrences (10-Most) | Detection Action | Ease of Detection (10-Lowest Prob) | Risk Priority Number | Recommended Action |
|---|---|---|---|---|---|---|---|---|---|
| Packing & Distrubutions Part 1 | Shortage of Container | Multiple shipping for one large product order | 8 | Increase of ship container demands | 7 | None | 5 | 280 | Pre-order & back up plan |
| Packing & Distrubutions Part 2 | Shortage of Cranes | Extra loading time at port | 5 | Shortage of Crane operators | 6 | None | 5 | 150 | Hire and train more crane operators |
| Packing & Distrubutions Part 3 | Shortage of Ships | Longer waiting and shipping time for large amount of product | 8 | Size of ship company | 7 | Pre-investigation | 5 | 280 | Back up shipping company |
| | | | | Covid | 3 | None | 5 | 120 | Backup plan for uncontrollable factors |

# FTA


Fail to Delivery products to customer on time
Lack of containers
Lack of Cranes
Lack of Ships
High demand for global shipping
Size of shipping company
Lack of Crane Operator
Size of port
Size of shipping company
High demand for global shipping
Covid -19
Increase of global shipping demand
Lack of employees
Lack of Training
Increase of global shipping demand
Covid -19

# Results in MTTF & Failure Rate

- Using 95% confidence interval of MTTF & Failure Rate
  - Mean Time to Failure is a maintenance metric that measures the average amount of time a non-repairable asset operates before it fails.
  - Failure rate refers to how often the supply chain system fail.

| | **Complete** | **Truncated 3rd Failure** | **Truncated at T = 500 days** |
|---|---|---|---|
| 95% CI for MTTR | (856.431 , 2396.374) | (584.20 , 6807.85) | (855.676 , 6880.734) |
| 95% CI for FR | (0.000417 , 0.001168) | (0.000147 , 0.001712) | (0.000145 , 0.001169) |
| 95% CI for reliability at Mission time = 500 days | (0.4165 , 0.7312) | (0.2769 , 0.8957) | (0.4162 , 0.8967) |

- For the supply chain system for 500 days of mission time, the reliability for the completed set is between 41.65% and 73.12%.
- The upper bond of reliability will be increased & lower bond will be decreased for incomplete set of truncated data set.

# Conclusions

- From FMEA & FTA analysis we conclude
  - For fixed set of number of container, cranes, and shipping company in supply chain, the reliability was calculated to determine the sense of trust for the supply chain.
  - Using mission time to track the reliability of the supply chain system.
  - FMEA analysis the causes & effect and potential solution to increase the reliability of the system.
  - FTA gives the failures for each components that lead to failure of delivery the product on time.

# Conclusions

- From DOE analysis we conclude:
  - All three factors are significant to the problem. Working on them will help us reach our target.
  - The interactions aren't significant except interaction of AB. However, it doesn’t have much impact on the project.
  - It's important to note that the value of ABC has a negative co-efficient thus we must be circumspect while increasing the values of the factors.
  - To reduce the lead cycle, we should have number of ships, cranes as well as containers

# Conclusions

- From SPC charts we conclude
  - The **Variable and Attribute** charts were plotted for the data set until a shift in mean or an abnormal condition was detected. We observed that the warning limits predict a trend and can be used to stall a process before it becomes unstable.
  - The direct impacts noticed:
    - Quality affects **every** process
    - Quality affects **profits/market share**
    - Quality **issues** are often unnoticed
    - Quality assessments **uncover** them
    - Quality methodology **solves** them
    - Quality **improvement** pays for itself

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# Questions?

# Thank you