UKRAINE GRAINS EXPORT SUPPLY CHAIN ISSUES

Final Presentation

Group 2

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PROBLEM STATEMENT

Since the outbreak of the Russia-Ukrainian war, a large amount of grain produced in Ukraine has been unable to export because Russia has controlled the ports along the Black Sea. The crisis of food supply shortage on a global scale is causing chaos in nations that rely heavily on food imports. This issue is of utmost importance and has significant consequences.

DMAIC

Define: Problem statement and scope of our project

Measure: Fishbone chart and organization chart

Analysis: Process capability report

Improve: Solutions

Control: Measures to assess improvements

PROJECT SCOPE

Scope

Moving the grain stock out of war zone and delivering them to places on time

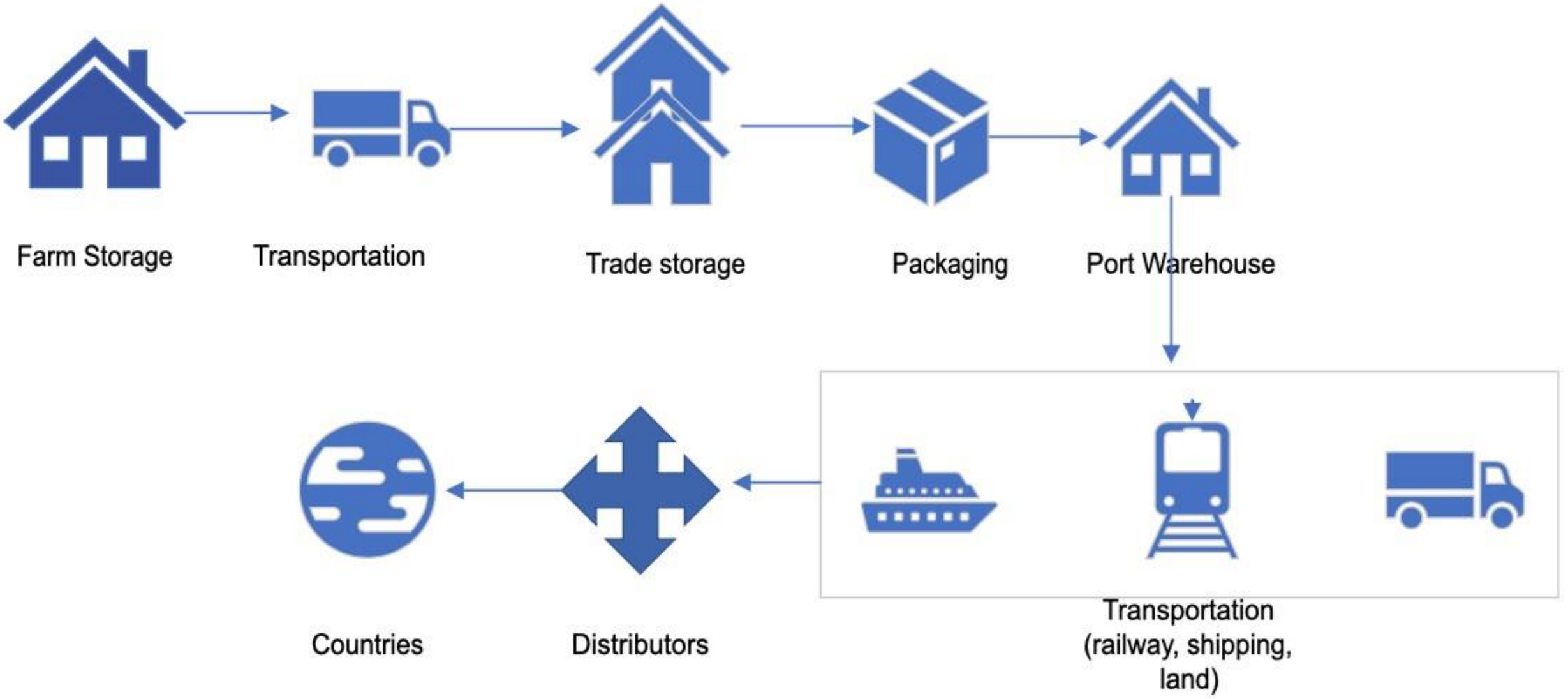
Within scope

Collecting grain from farmers, contacting distributors, transportation methods, transportation routes

Out of scope

Price of grains, politics

PROCESS FLOW CHART



COPQ ANALYSIS

	Internal failure	External failure	Appraisal	Prevention
Equipment	Equipment quality, money issue	Unpredicted danger, repeated quality issue	Check the equipment regularly	Regular maintenance of equipment
Process	Shortage of resources	Cannot deliver on time	Check the number of resources in advance and regularly	Prepare enough containers and vehicles
People	Shortage of labor, untrained worker	Cannot deliver on time, injuries on worksite	Check the work site regularly	Regular worker training, appoint more workers
Material	Quality issue	Quality issue, cannot deliver on time	Check product quality, keep track of material	Store the food grains properly, prepare backup plan for storage and transport
Management	Policies changes, lack of storage space	Fail to transport products, food deterioration	Check the available storage space regularly	Prepare more granary
Environment	Transportation Security, transportation route unavailable	Food deterioration	Check the transportation environment regularly	Backup transportation routes

AFFINITY DIAGRAM

Routes

- Recognize faster routes
- Avoid war zones
- Fast loading of food grains

Logistics

- Secured trucks in good condition
- Optimization of routes-based distribution center/ warehouse

Labor Management

- Appoint more people
- Drivers with route training

Distribution

- Sturdy packaging
- Tracking system for safe transportation
- Pre-approved legal trade documents

SIPOC

Suppliers

- Grain suppliers
- Fertilizer suppliers
- Granary/warehouse construction
- Labor management
- Fuel suppliers

Input

- Equipment
- Suppliers
- Resource
- Budget

Process

Route mapping & process documentation

↓

Transportation

↓

packaging

↓

Port warehouse

↓

Distribution

↓

Countries

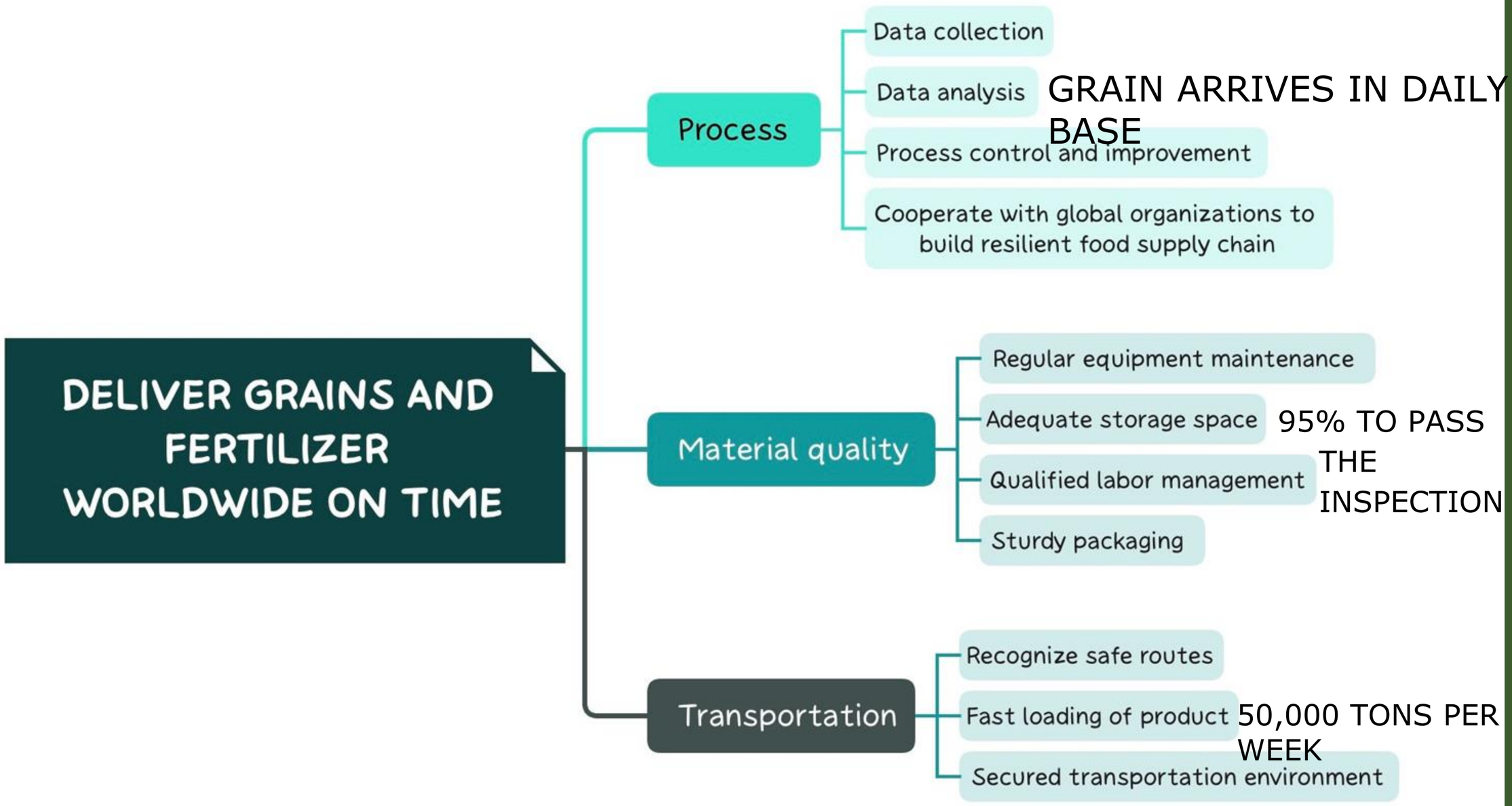
Output

- Successfully distributed to other countries
- Fewer grains and fertilizer wasted
- Create more job opportunities
- Higher revenue

Customers

- Community benefited from it
- Government revenue
- More job opportunities

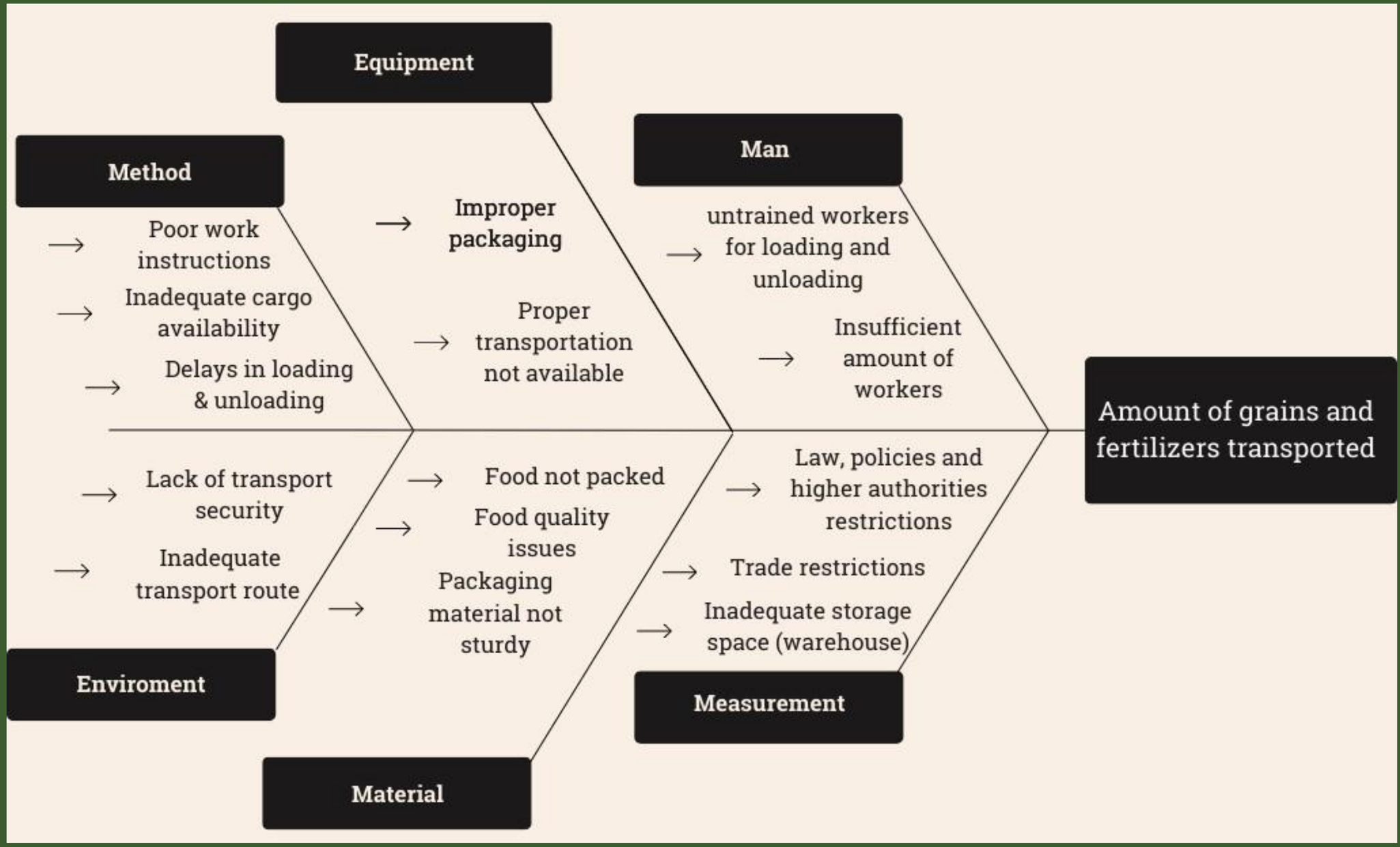
CTQ


DELIVER GRAINS AND FERTILIZER WORLDWIDE ON TIME
Process
Data collection
Data analysis
Process control and improvement
Cooperate with global organizations to build resilient food supply chain
GRAIN ARRIVES IN DAILY BASE
Material quality
Regular equipment maintenance
Adequate storage space
Qualified labor management
Sturdy packaging
95% TO PASS THE INSPECTION
Transportation
Recognize safe routes
Fast loading of product
Secured transportation environment
50,000 TONS PER WEEK

MESURE PHASE

This phase will verify the process needs, implement data collection and document process, implement a valid measuring system, and establish a baseline performance that is critical for the process in order to achieve goals set in the define phase.

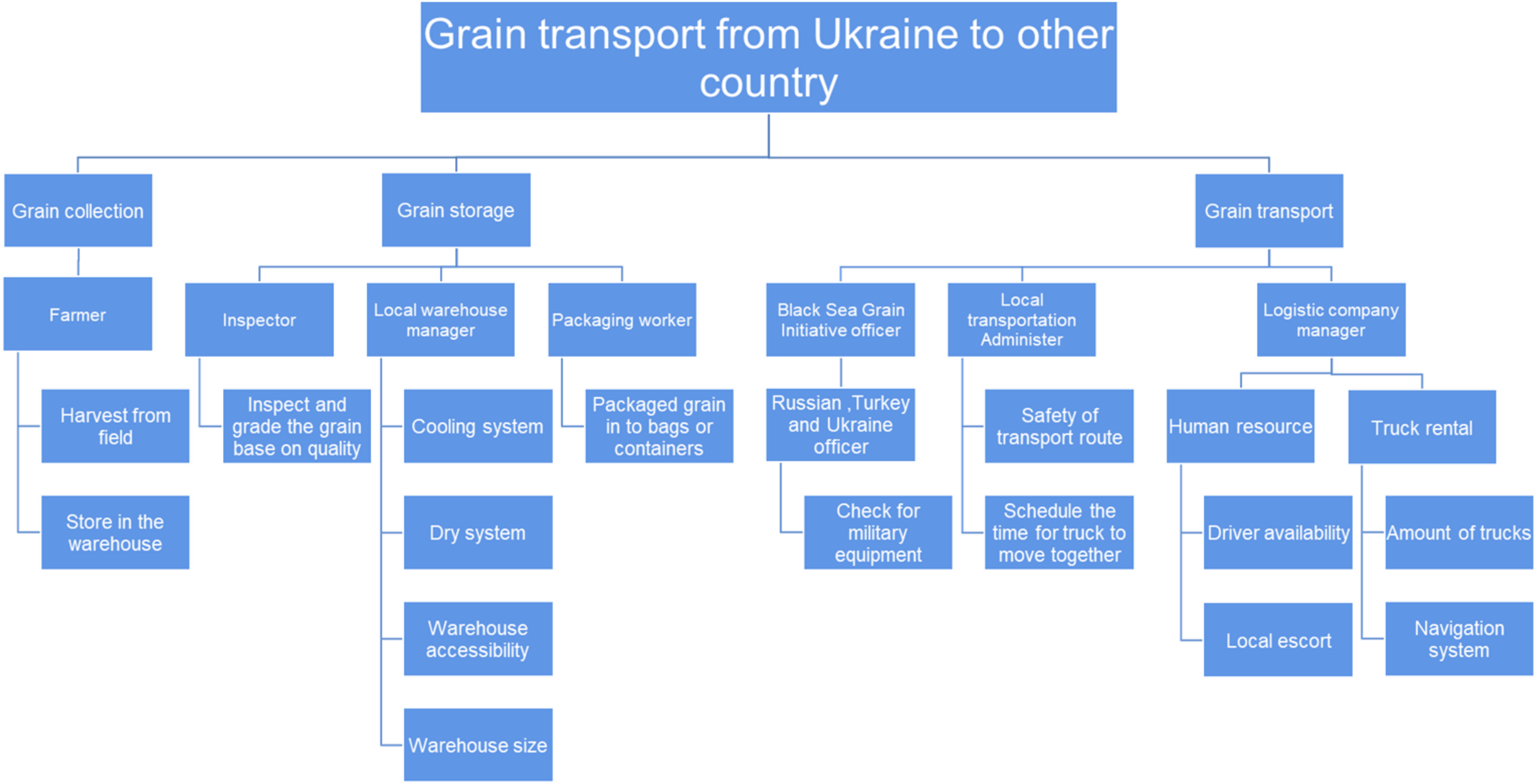
CAUSE EFFECT DIAGRAM



FMEA

Potential Failures in the Process	Potential causes	Severity	Occurrence	Detection	Risk Priority Number RPN	Corrective Actions
Farm's storage: Space not enough	War crises caused panic and overproduction of grains	3	1	1	3	Rent a place if possible. Ask for government's help
Poor quality grains	Weather conditions and long storage time Unavailability of proper storage facilities	5	3	3	45	Arrange equipment and facilities to store the food grains
Transportation getting delayed	Poor Management Inefficient route planning Poor vehicle conditions Less options of mode of transportation Disruptions of supply chain	5	5	2	50	Map alternative Routes. Availability of spare vehicles
Goods taking longer than usual to reach distributor location	Too many legal steps to follow during the export	4	5	2	40	Assign a legal person knowledgeable in the trade sector
Drop in quantity of export grains	Less farming facilities Farming machinery and equipment not upgraded or damaged	3	3	3	27	Carry out acceptance sampling for each batch

ORGANIZATION CHART



ANALYSIS PHASE

This phase will comprise the collection and analysis of the data required for the process.

GRAIN LOADING TIME

S 54

48

55

56

64

60

68

62

59

60

58

63

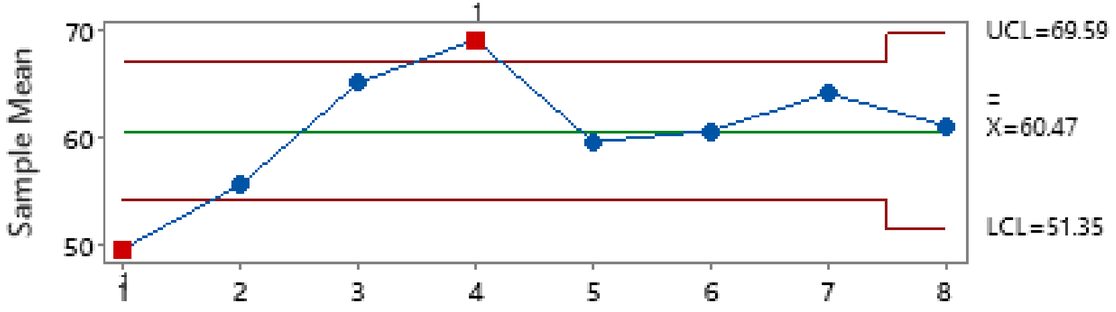
61

62

65

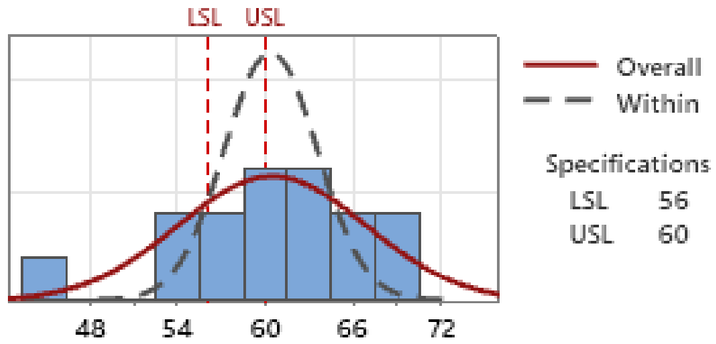
Process Capability Sixpack Report for Loading time

Xbar Chart

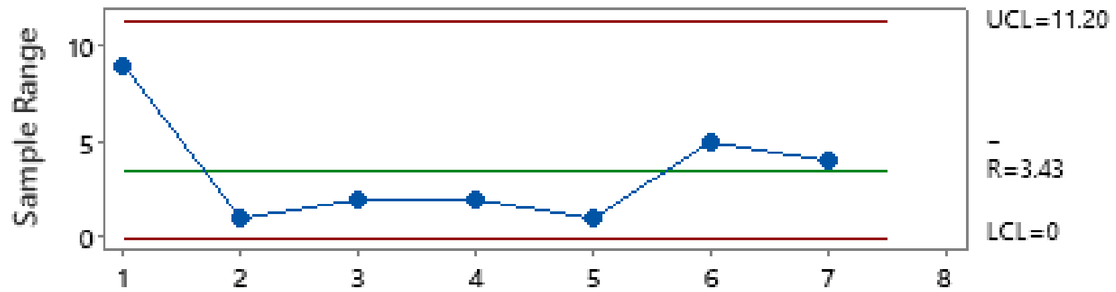


Tests are performed with unequal sample sizes.

Capability Histogram

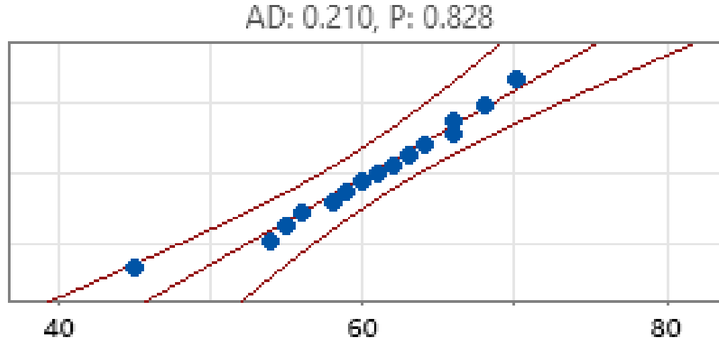


R Chart

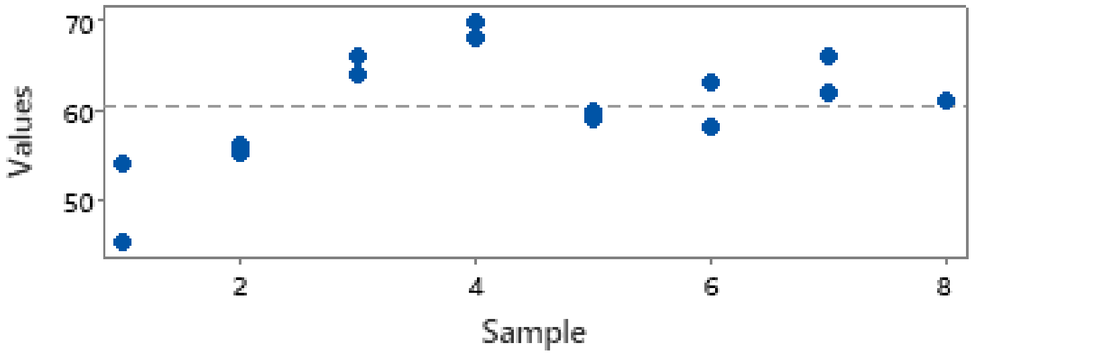


Tests are performed with unequal sample sizes.

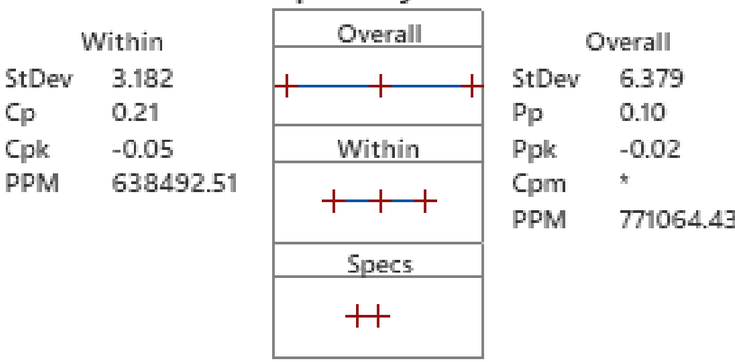
Normal Prob Plot



Last 8 Subgroups

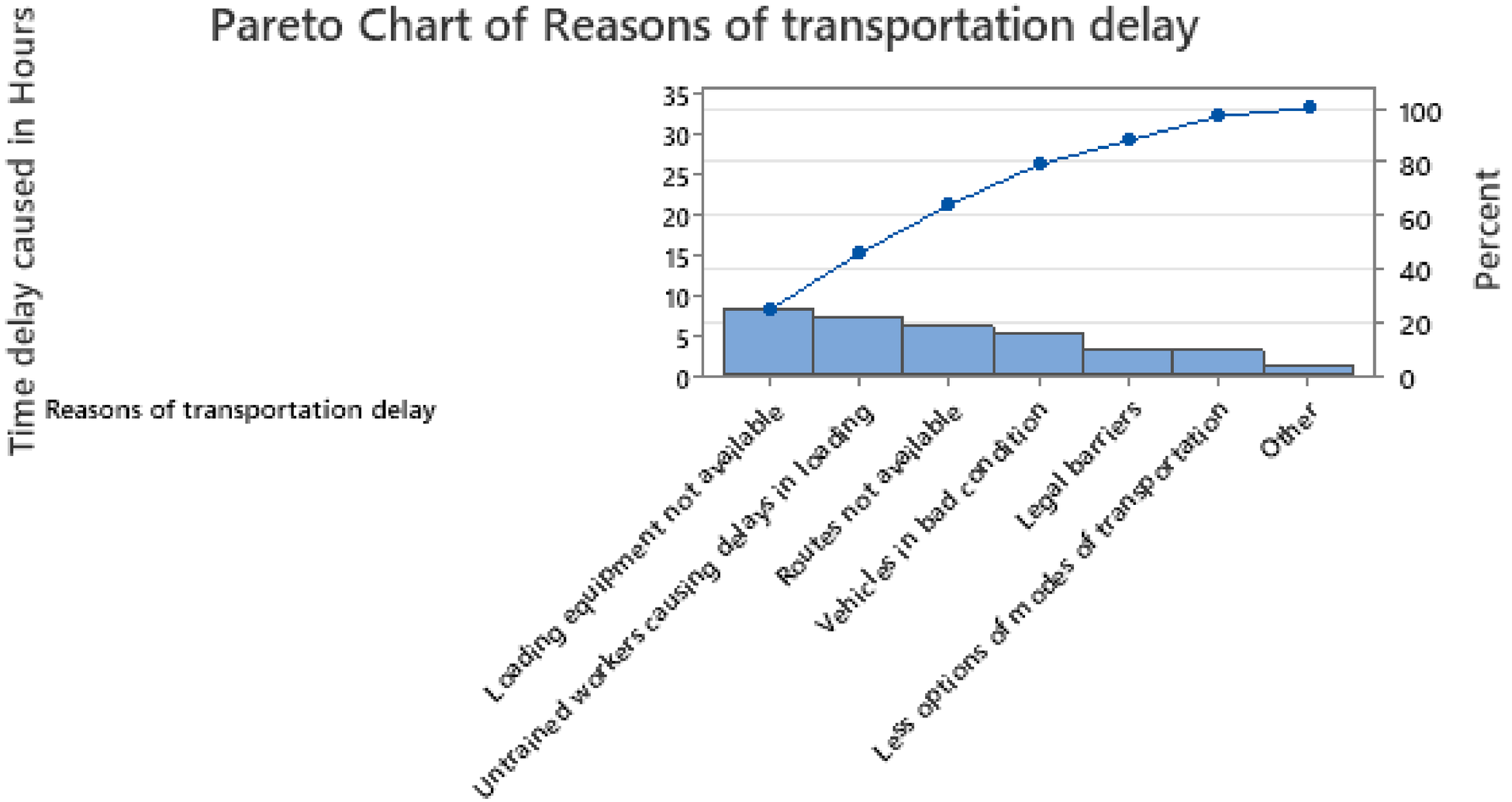


Capability Plot



The actual process spread is represented by 6 sigma.

PARETO CHART



Time delay caused in Hours	8	7	6	5	3	3	1
Percent	24.2	21.2	18.2	15.2	9.1	9.1	3.0
Cum %	24.2	45.5	63.6	78.8	87.9	97.0	100.0

IMPROVE PHASE & CONTROL PHASE

- In the improve phase, we propose process improvement strategies and solutions for transportation of food grains out of the war zone to other countries.
- In the control phase, we implement control measures to ensure the process is sustained, and we use Control Plan, Standard Operating Procedures (SOP), Change Management as tools.

AREAS OF IMPROVEMENT AND SOLUTIONS

Criterion	Remedy 1	Remedy 2	Remedy 3
Remedy Name	Build railways to connect farms, warehouse, and port	Move trade storage and packaging station to port	Create a communication center
Total Cost	2.3 million per mile	At least 281 million	250k per month
Impact on Issue	Decrease the grain waste on the way	Everything is safer around the port	Higher succus to have grains arrive on time
Benefit	Reduce the time to transport, easier to secure the route after the railway built	Less stop needs to make, less truck needed	Safer for transportation Easy to let driver know which route is available
Resistance to Change	Hard to build railway in the war zone	Need a very large space near the port	Need GPS company communication company to cooperation

Waterfall relationship of QFD

CUSTOMER NEEDS

- On-time delivery
- High-quality, Edible food grains Efficient logistics with no lead time Transparent communication
- Meet the food demand

DESIGN REQUIREMENTS

- Reliable transportation modes: heavy-duty, 98% efficient, trucks and trains
- Proper storage facilities: dry space, large-scale silos, and granaries
- Efficient handling and loading of equipment: cranes, trolleys, dry storage containers Effective communication tools and software: tracking software, phones
- Advanced tracking and tracing systems: GPS Robust quality control and assurance processes: Structured quality inspection processes

QFD Cont.

PRODUCT CHARACTERISTICS

- On-time delivery: Timely dispatch from warehouses, prompt customs clearance, efficient handling and loading, timely shipping schedules
- High product quality: Strict quality control at every stage of the supply chain, proper storage, and handling, appropriate packaging and labeling, compliance with international standards and regulations
- Efficient logistics: Advanced tracking and tracing systems, real-time data sharing and analysis, reliable transportation modes, seamless communication, and collaboration
- Transparent communication: Clear and timely communication with customers, suppliers, partners, and other stakeholders, effective use of communication tools and software, regular updates and feedback

QFD Cont.

MANUFACTURING PROCESS

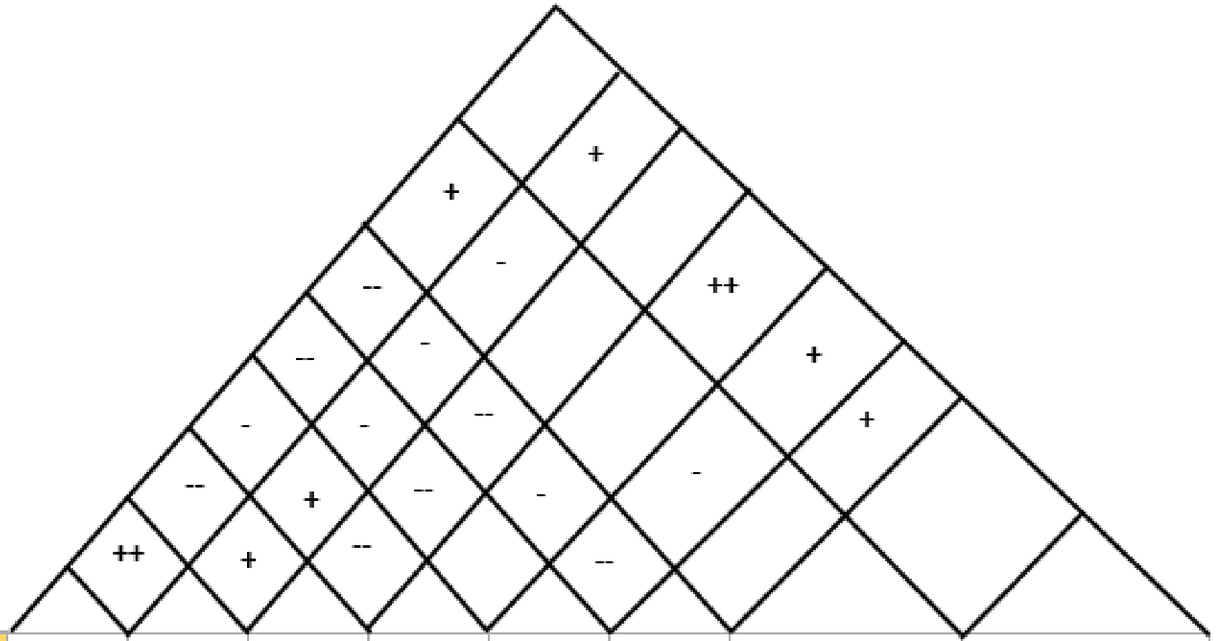
- Procurement of grains from farmers and suppliers
- Inspection and grading of grains for quality & quantity Storage of grains in proper facilities
- Handlingand loading of grains onto transportation modes
- Transportation of grains to the ports and/or customers
- Documentation and reporting of all activities

QUALITY CONTROL

Inspection and testing of grains for quality and quantity
Monitoring and controlling storage conditions
Inspection and maintenance of transportation modes and equipment
Analysis and reporting of quality data
Continuous improvement of quality control processes

House Of Quality

			Technical Specifications (How)								Competitive Assessment		
			Edible	To meet the demand	Heavy-duty, efficient and advanced vehicles	Safe routes avoiding war zones to save time	Working robust equipments	Trained, efficient workers	Spaceous place to fit food grains	Live communication systems for co-ordination			
Sr. No.	**Process Requirements (What)**	**Importance**	1	2	3	4	5	6	7	8	Our Process	Competitor A's Process	Competitor B's Process
1	Quality of grains	5	9	1	3	1	1	1	9	1	5	5	4
2	In-time supply	3	1	9	9	3	3	3	1	9	2	4	5
3	Proper transportation	4	1	3	9	3	1	1	1	3	3	3	5
4	Routes	4	1	3	1	9	1	3	1	3	4	5	3
5	Proper Equipments	5	1	3	1	1	9	3	1	1	2	4	5
6	Workers	5	1	3	1	1	3	9	1	1	4	3	3
7	Warehouses to store the food grain	3	9	3	1	1	1	1	9	1	2	3	1
8	Communication Centers	4	1	9	1	3	1	1	1	9	3	2	3
	Target		Max 13% moisture content	36 Million Tonnes	98% efficient and well maintained	Within less than 3 weeks	Million tonnes capacity , eficient	Trainned in heavy lifting, operating	100% clean dry, safe place with all the facilities	Up-to-date communication of the all activites in the process			
	Importance		24	34	26	22	20	22	24	28			



Minimize or Maximize	↑	↓	↑	↓	↑	↑	↑	↑
House Of Quality	Technical Specifications (How)							
	Edible	To meet the demand	Heavy-duty, efficient and advanced vehicles	Safe routes avoiding war zones to save time	Working robust equipments	Trained, efficient workers	Spaceous place to fit food grains	Live communication systems for co-ordination

DESIGN OF EXPERIMENT

- **Step 1: Identify factors that may impact the supply chain**

  Transportation modes: Faster and slower modes Export routes: Longer and shorter routes Workers: Trained and untrained

- **Step 2: Determine the level of each factor**

  Factor A: transportation modes: Low(-): Rail, Road High(+): Sea, Air

  Factor B: Export routes: Low(-): Land routes High(+):Black Sea, Air freight

  Factor C: Workers: Low(-): Inexperienced, untrained workers High(+): Efficient, well-trained workers

DESIGN OF EXPERIMENT

- **Step 3: A decision matrix is used to decide which aspect of the overall problem of long time delays in grain transportation to tackle first**

Decision Making Matrix					
Solutions	**Impact**	**Effort**	**Cost**	**Alignment to the goal of project**	**Total**
Faster Transportation routes: By sea	2	4	4	5	15
Faster Transportation routes: By air	4	2	1	5	12
Shorter export routes: Air freight	4	2	1	5	12
Shorter export routes: Ocean freight	2	4	4	5	15
Well-trained workers	4	4	5	5	18

Score Chart:

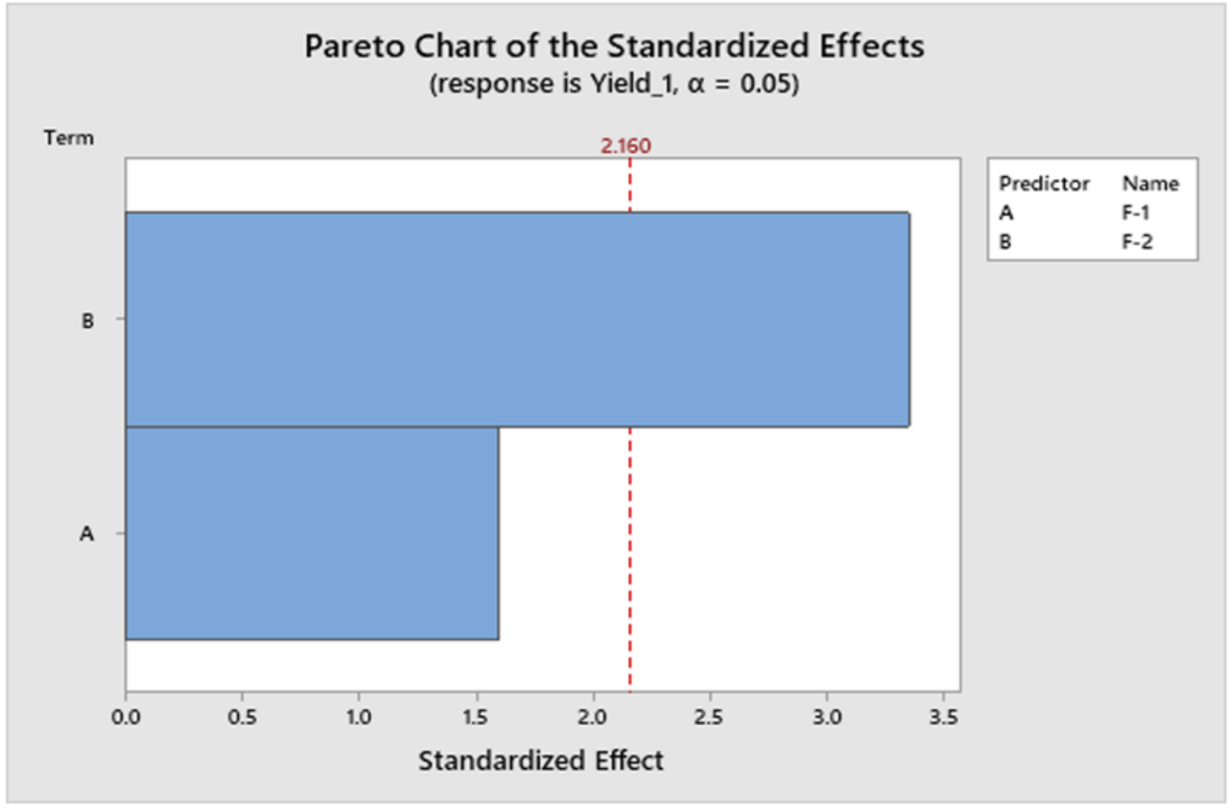
1 = Low impact i.e. less or no time delays 5 = High impact i.e will not cause any delays

1 = Lots of effort 5 = Ease of supply chain process

1 = Expensive 5 = In budget

1= Not successfully transporting all the grains 5 = Successfully exporting all the grains

DOE RESULTS



WORKSHEET 1

Regression Analysis: Yield_1 versus F-1, F-2

Regression Equation

Yield_1 = 31.893 + 0.891 F-1 + 1.867 F-2

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	31.893	0.557	57.23	0.000	
F-1	0.891	0.557	1.60	0.134	1.00
F-2	1.867	0.557	3.35	0.005	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.22926	51.45%	43.98%	26.46%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	68.463	34.2317	6.89	0.009
F-1	1	12.695	12.6946	2.55	0.134
F-2	1	55.769	55.7688	11.22	0.005
Error	13	64.605	4.9696		
Lack-of-Fit	1	0.037	0.0371	0.01	0.935
Pure Error	12	64.568	5.3806		
Total	15	133.068			

WORKSHEET 1

Factorial Regression: Yield_1 versus Time_1, Temp_1

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		31.893	0.557	57.23	0.000	
Time_1	1.781	0.891	0.557	1.60	0.134	1.00
Temp_1	3.734	1.867	0.557	3.35	0.005	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.22926	51.45%	43.98%	26.46%

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	2	68.463	34.2317	6.89	0.009
Linear	2	68.463	34.2317	6.89	0.009
Time_1	1	12.695	12.6946	2.55	0.134
Temp_1	1	55.769	55.7688	11.22	0.005
Error	13	64.605	4.9696		
Lack-of-Fit	1	0.037	0.0371	0.01	0.935
Pure Error	12	64.568	5.3806		
Total	15	133.068			

Regression Equation in Uncoded Units

Yield_1 = 16.75 + 0.0594 Time_1
+ 0.0747 Temp_1

DOE RESULTS

Alias Structure

Factor	Name
A	Time_1
B	Temp_1

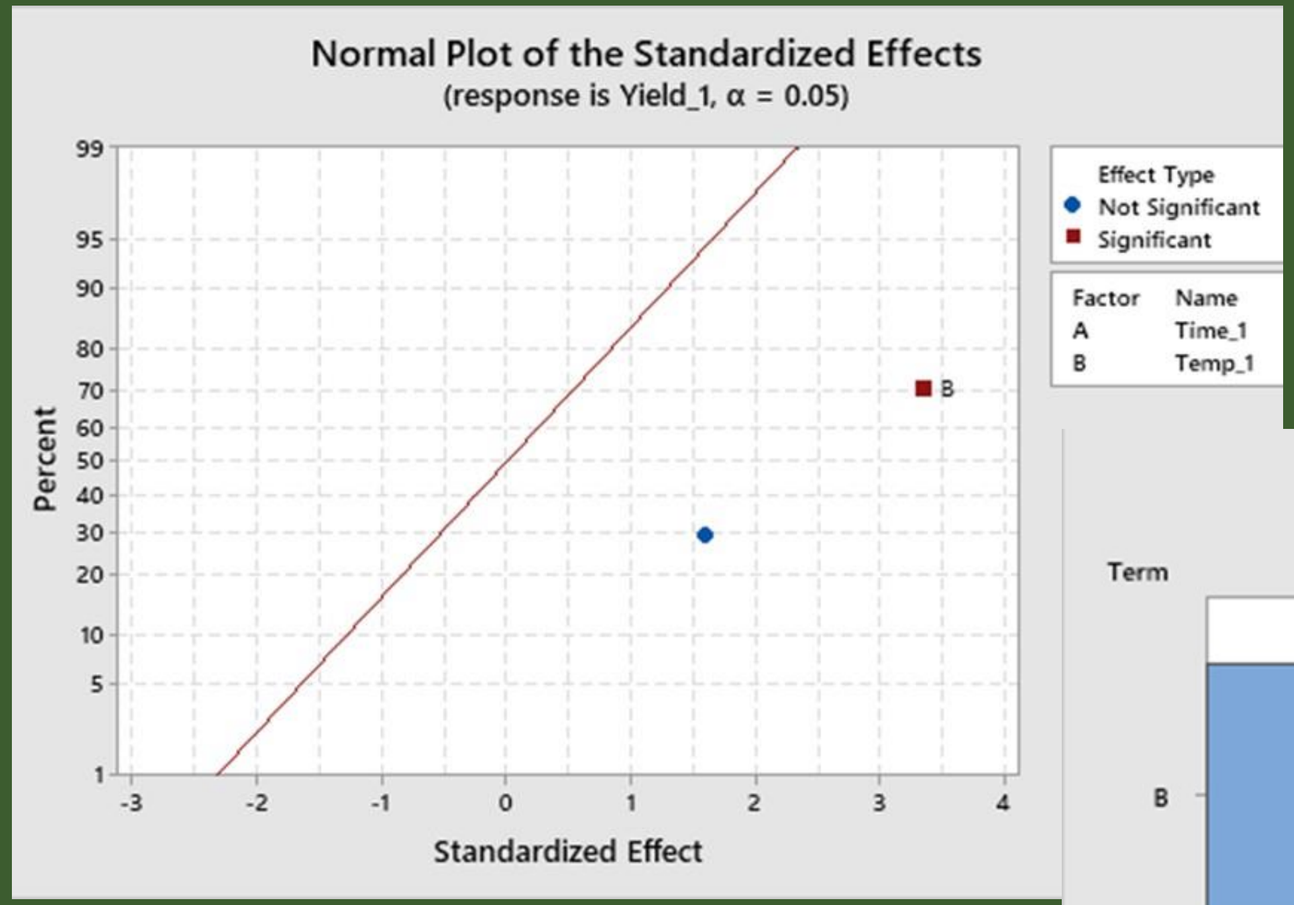
Aliases

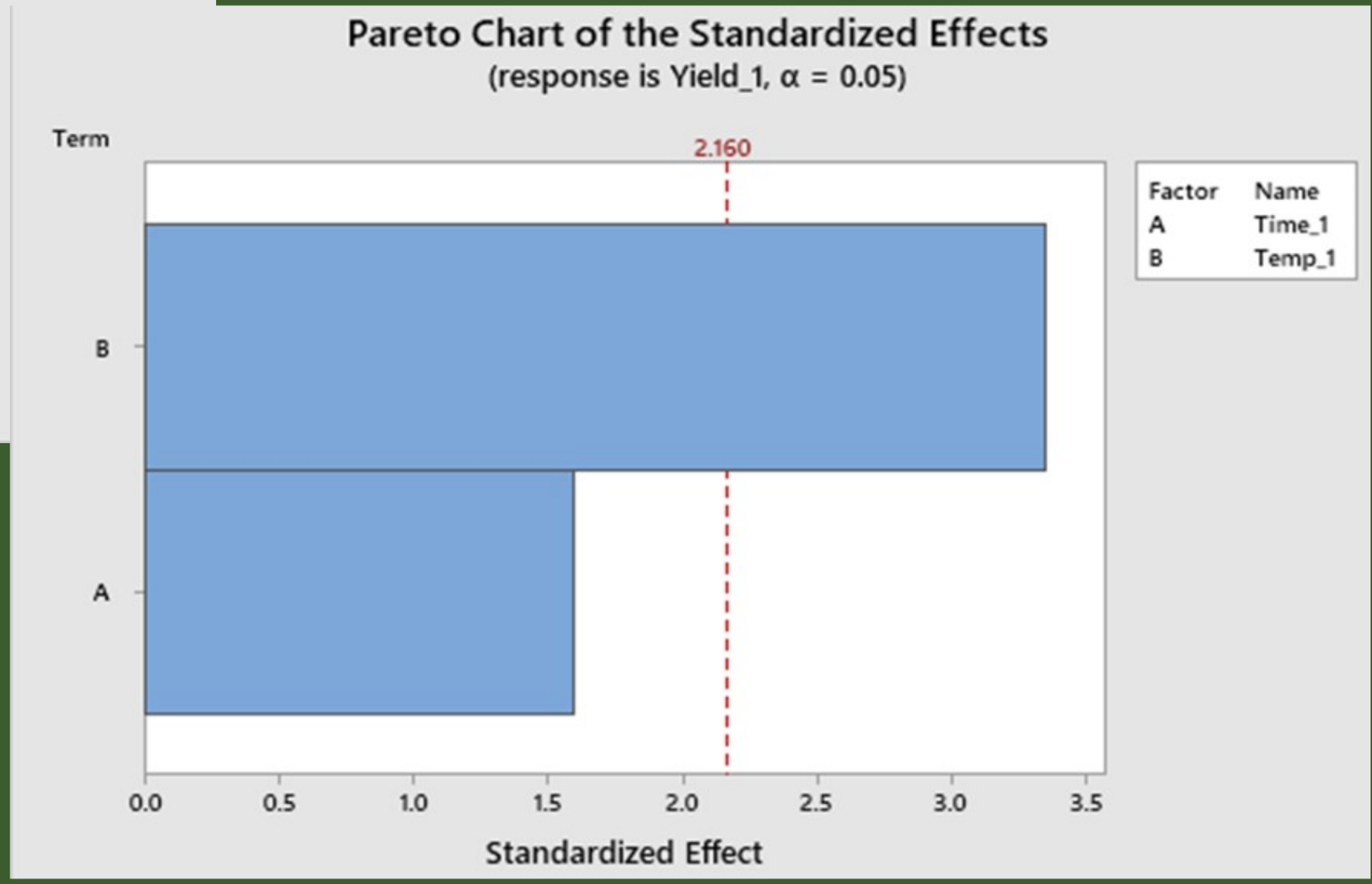
I

A

B

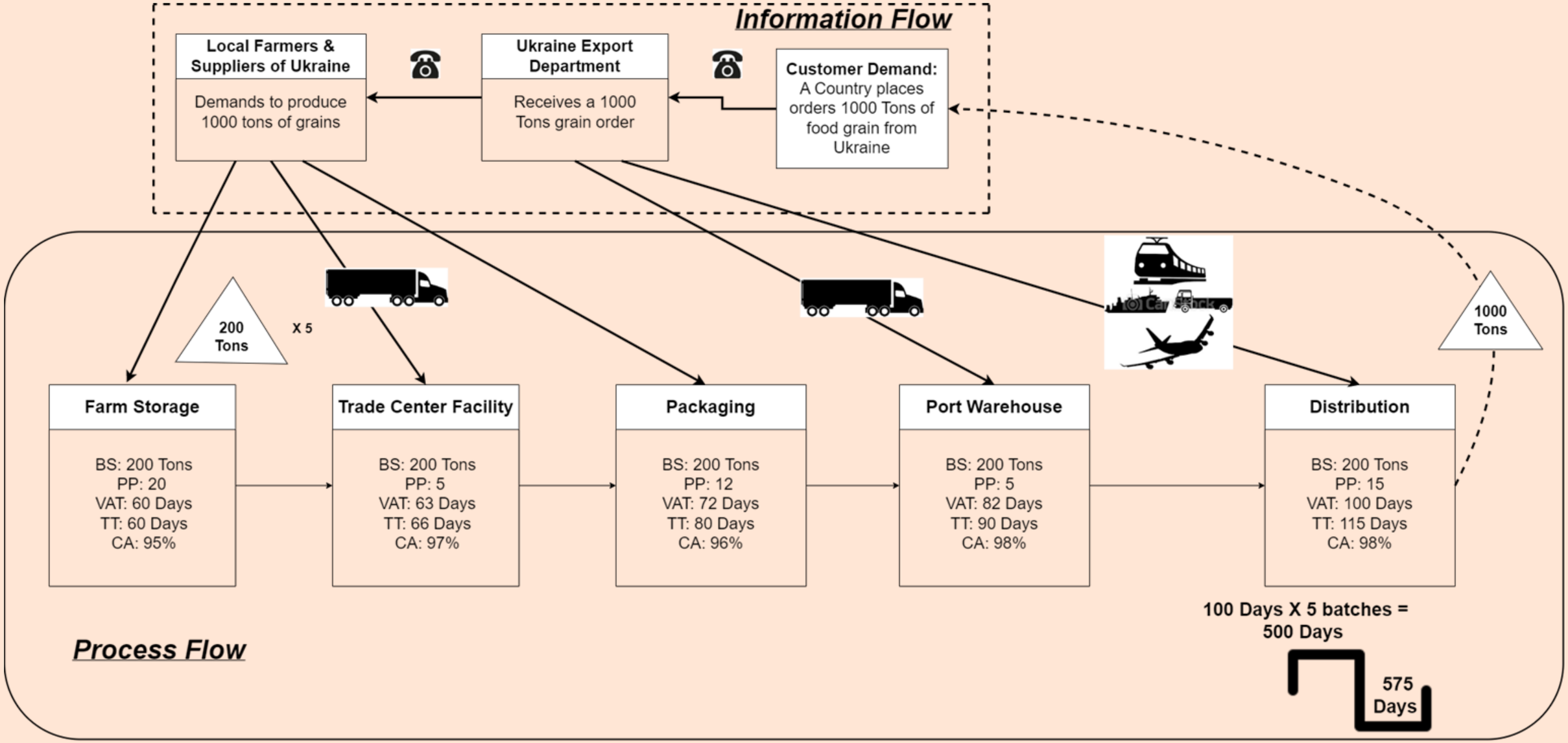
DOE RESULTS


Normal Plot of the Standardized Effects
(response is Yield_1, α = 0.05)
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
-3
-2
-1
0
1
2
3
4
Standardized Effect
B
Effect Type
Not Significant
Significant
Factor Name
A Time_1
B Temp_1


Pareto Chart of the Standardized Effects
(response is Yield_1, α = 0.05)
Term
2.160
B
A
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Standardized Effect
Factor Name
A Time_1
B Temp_1

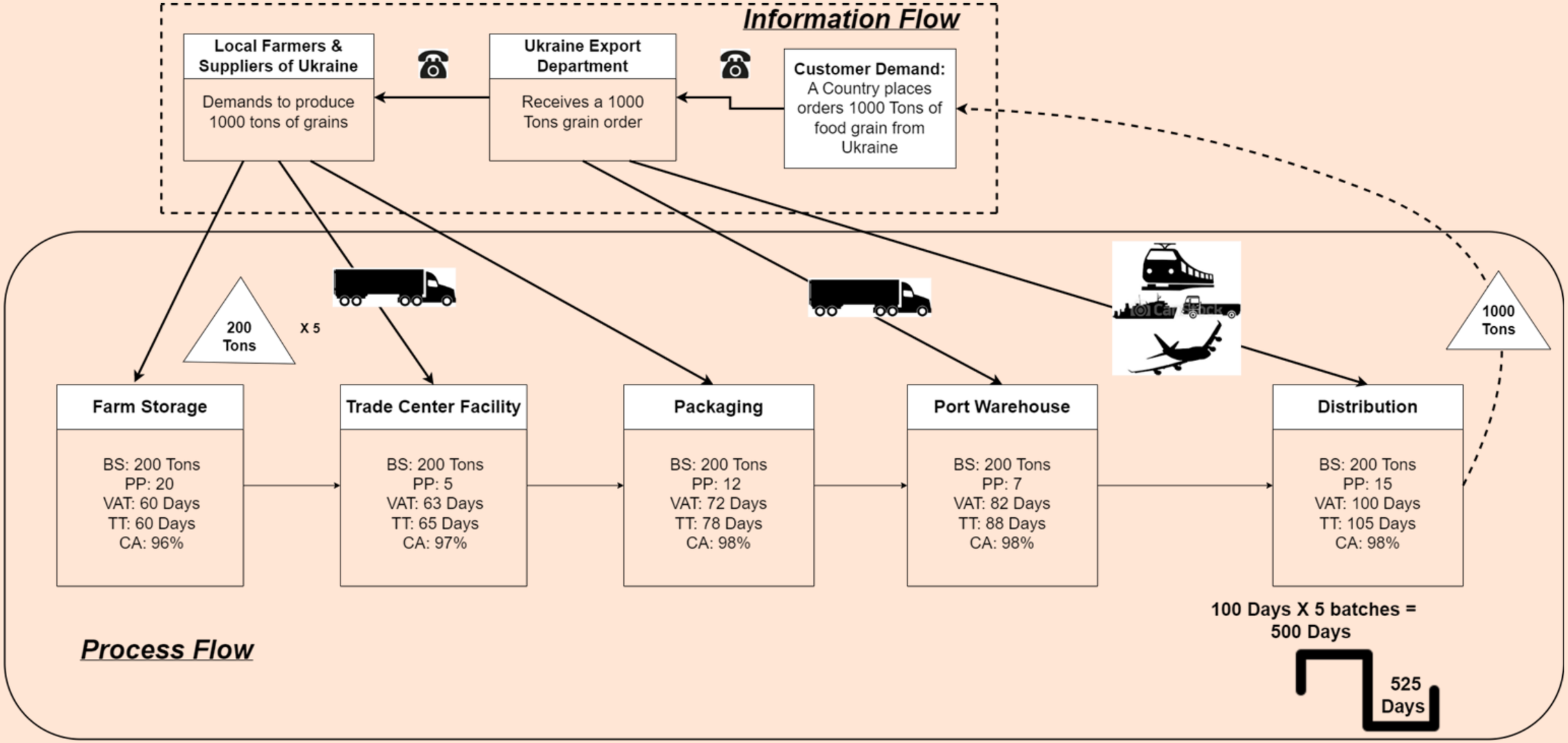
VALUES STREAM MAP

Current state



VALUES STREAM MAP

Future state



GAGE R&R ANALYSIS

- In the food supply chain, there are weighing scales used to measure the weight of sacks of grains.
- There are 3 weighing scale equipment at the trade center.
- We would like do MSA using gauge R&R to evaluate the accuracy of this weighing scale.

GAGE STUDY RESULTS FOR DIFFERNET SCALES

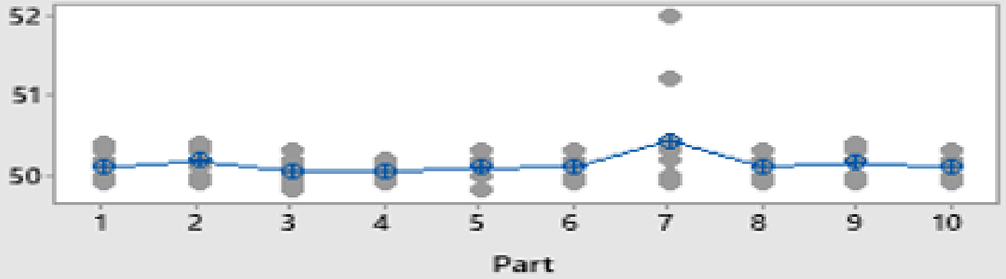
Gage R&R (Xbar/R) Report for Measurement

Gage name:
Date of study:

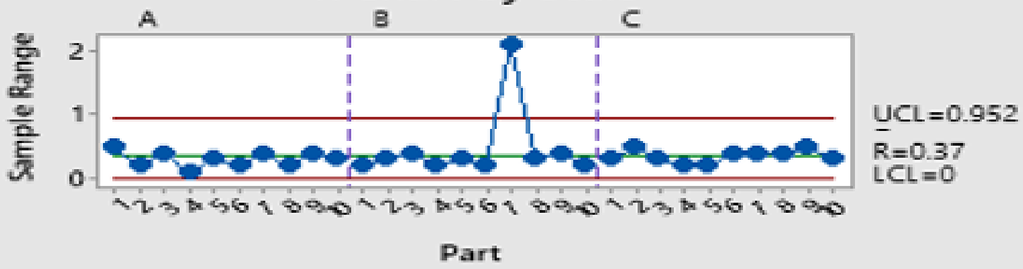
Reported by:
Tolerance:
Misc:

Components of Variation

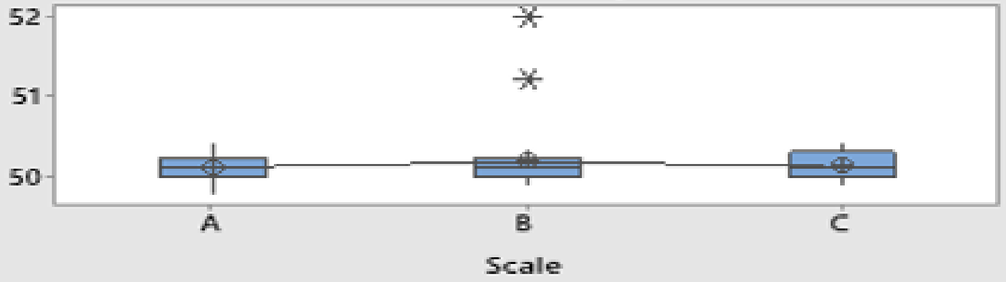
Measurement by Part



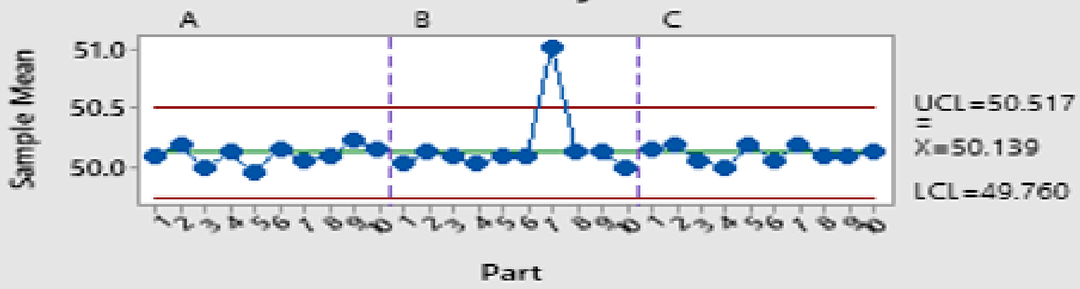
R Chart by Scale



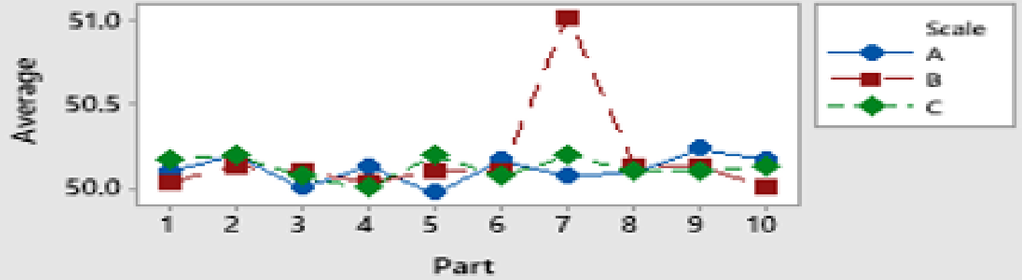
Measurement by Scale



Xbar Chart by Scale



Part * Scale Interaction



GAGE STUDY ANOVA METHOD

Gage R&R Study - ANOVA Method

Two-Way ANOVA Table With Interaction

α to remove interaction term = 0.05

Two-Way ANOVA Table Without Interaction

Gage R&R

Variance Components

Gage Evaluation

Number of Distinct Categories = 1

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.271542	1.62925	97.41
Repeatability	0.271542	1.62925	97.41
Reproducibility	0.000000	0.00000	0.00
Scale	0.000000	0.00000	0.00
Part-To-Part	0.062990	0.37794	22.60
Total Variation	0.278752	1.67251	100.00

Gage R&R Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0737350	94.89
Repeatability	0.0737350	94.89
Reproducibility	0.0000000	0.00
Scale	0.0000000	0.00
Part-To-Part	0.0039677	5.11
Total Variation	0.0777028	100.00

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Part	9	0.98500	0.109444	1.07965	0.422
Scale	2	0.07756	0.038778	0.38254	0.688
Part * Scale	18	1.82467	0.101370	1.54895	0.105
Repeatability	60	3.92667	0.065444		
Total	89	6.81389			

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Part	9	0.98500	0.109444	1.48429	0.169
Scale	2	0.07756	0.038778	0.52591	0.593
Repeatability	78	5.75133	0.073735		
Total	89	6.81389			

ACCEPTANCE SAMPLING PLAN OVERVIEW

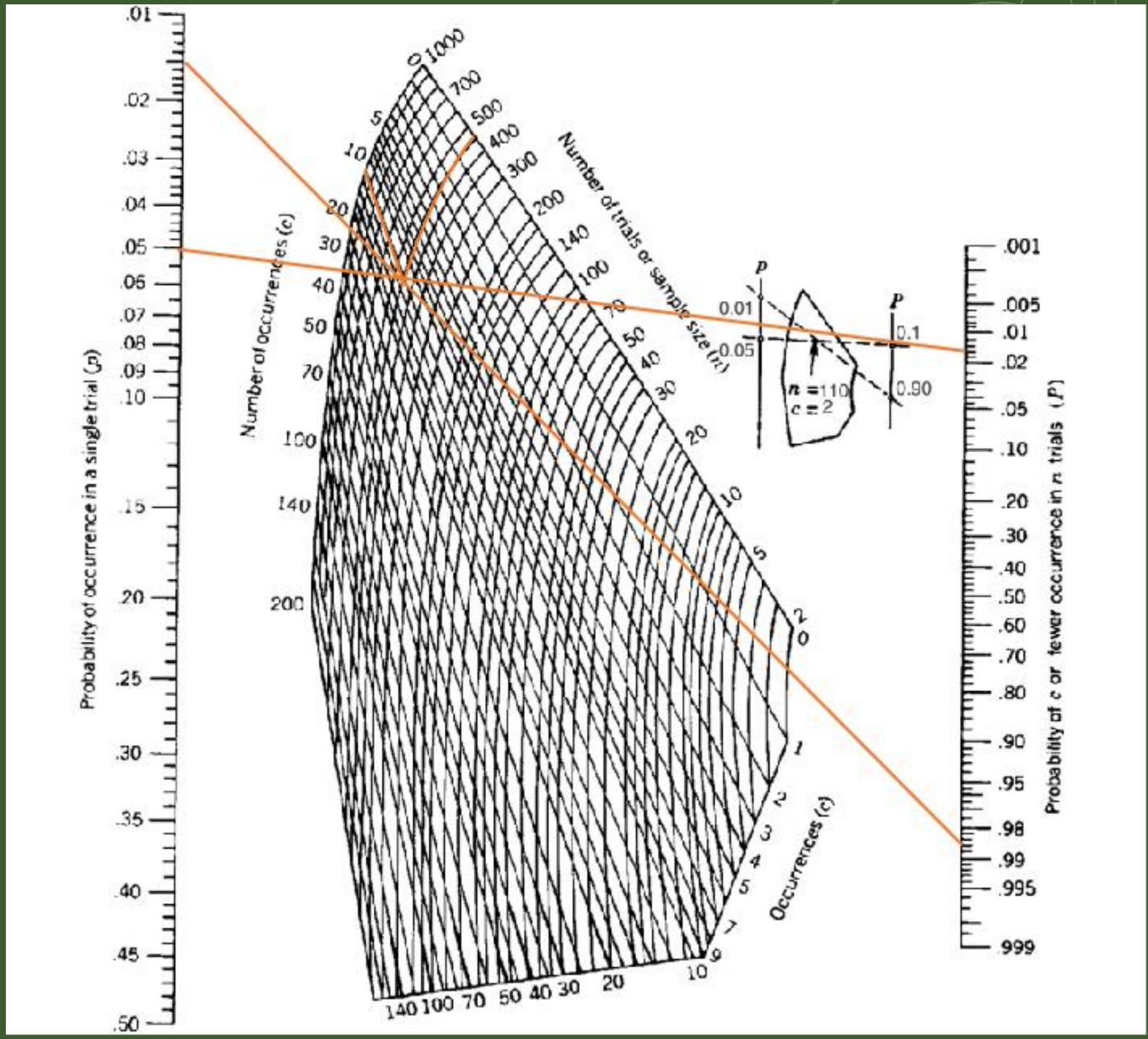
- **Project overview**
  1. Acceptance sampling is used to determine whether the quality of grains that are transported is satisfactory.
  2. The product being sampled is packaged grains.
  3. The relevant quality characteristics to be inspected include the weight of the package and the number of defective sacks of grains.
- **Acceptance sampling plan parameters**
  1. Lot size, N (total tons of grain arriving per week) = 50,000 packages
  2. α probability (producer's risk, the probability of deciding that the altenative hypothesis (H1) is true, when in fact the null (H0) is true)= 0.015
  3. ß probability (consumer's risk, the probability of deciding that the null hypothesis (H0) is true, when the alternative (H1) is true) = 0.05
  4. AQL (acceptable quality level) = 0.015
  5. LTPD (lot tolerance percent defective) = 0.05

NOMOGRAPH

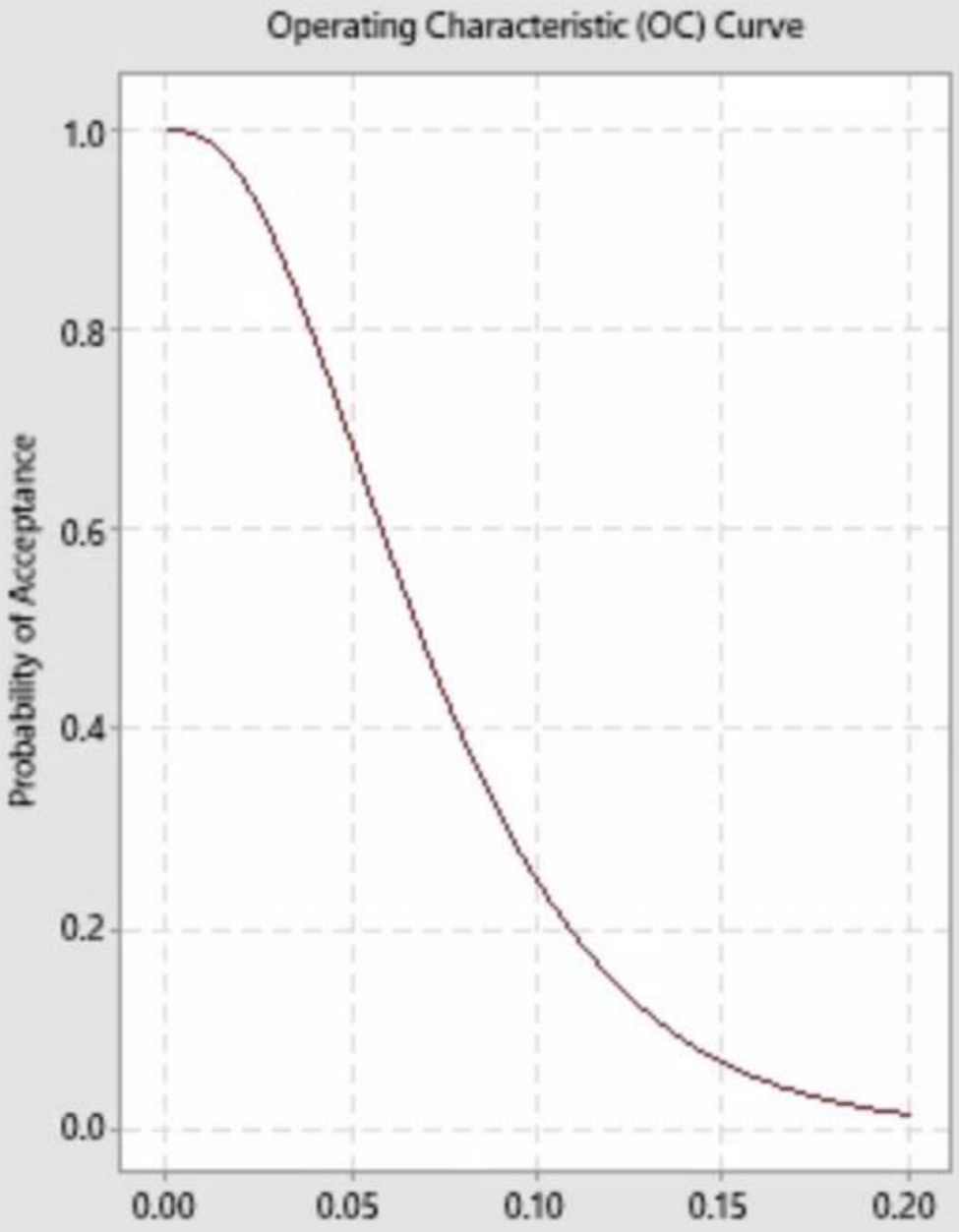
Using Nomograph with the given parameters, we obtained the following results:

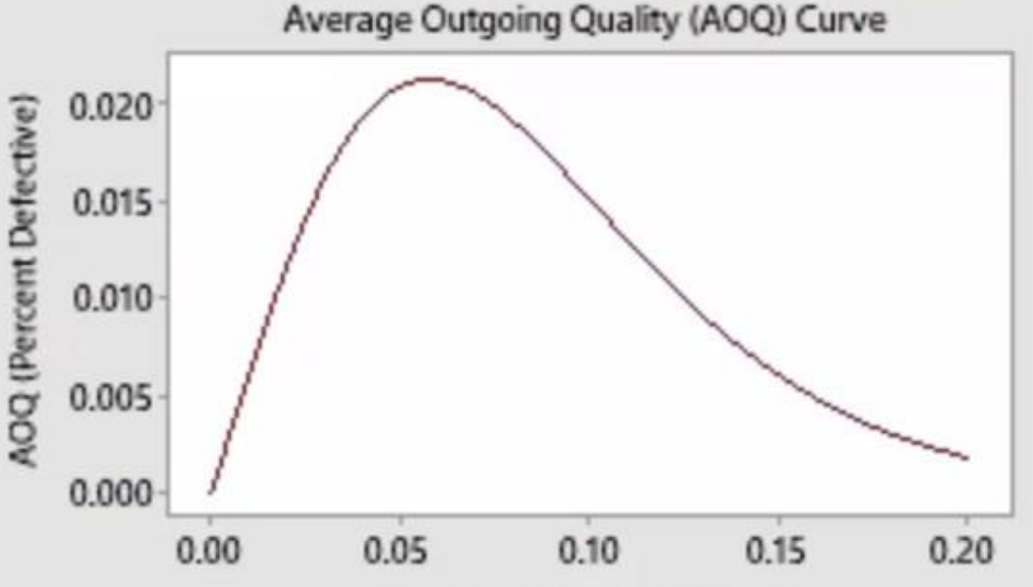
n (sample size) = 450

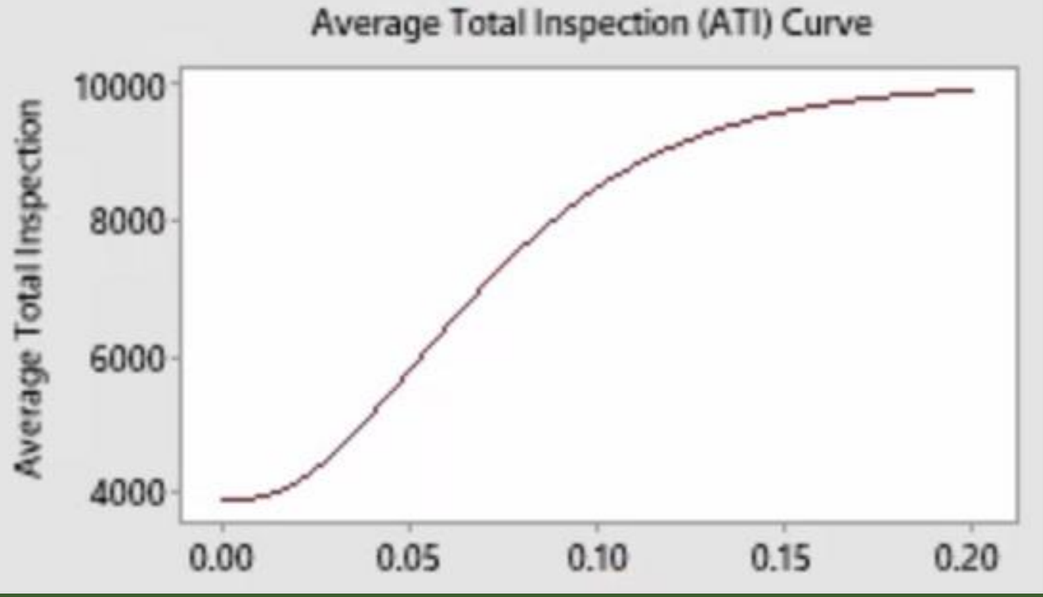
c (number of occurrences) = 12



OC CURVE


Operating Characteristic (OC) Curve
Probability of Acceptance
1.0
0.8
0.6
0.4
0.2
0.0
0.00
0.05
0.10
0.15
0.20


Average Outgoing Quality (AOQ) Curve
AOQ (Percent Defective)
0.020
0.015
0.010
0.005
0.000
0.00
0.05
0.10
0.15
0.20
Incoming Lot Percent Defective


Average Total Inspection (ATI) Curve
Average Total Inspection
10000
8000
6000
4000
0.00
0.05
0.10
0.15
0.20

STATISTICAL PROCESS CONTROL

- Problem statement: weekly 50,000 tons of grain should be exported
- Maximum 200 tons that can fail the inspection allowed Assume
- that we inspect grains after packaging, and consider package of spoiled grain as defective unit.

X-Bar Chart

Control limits for X bar chart

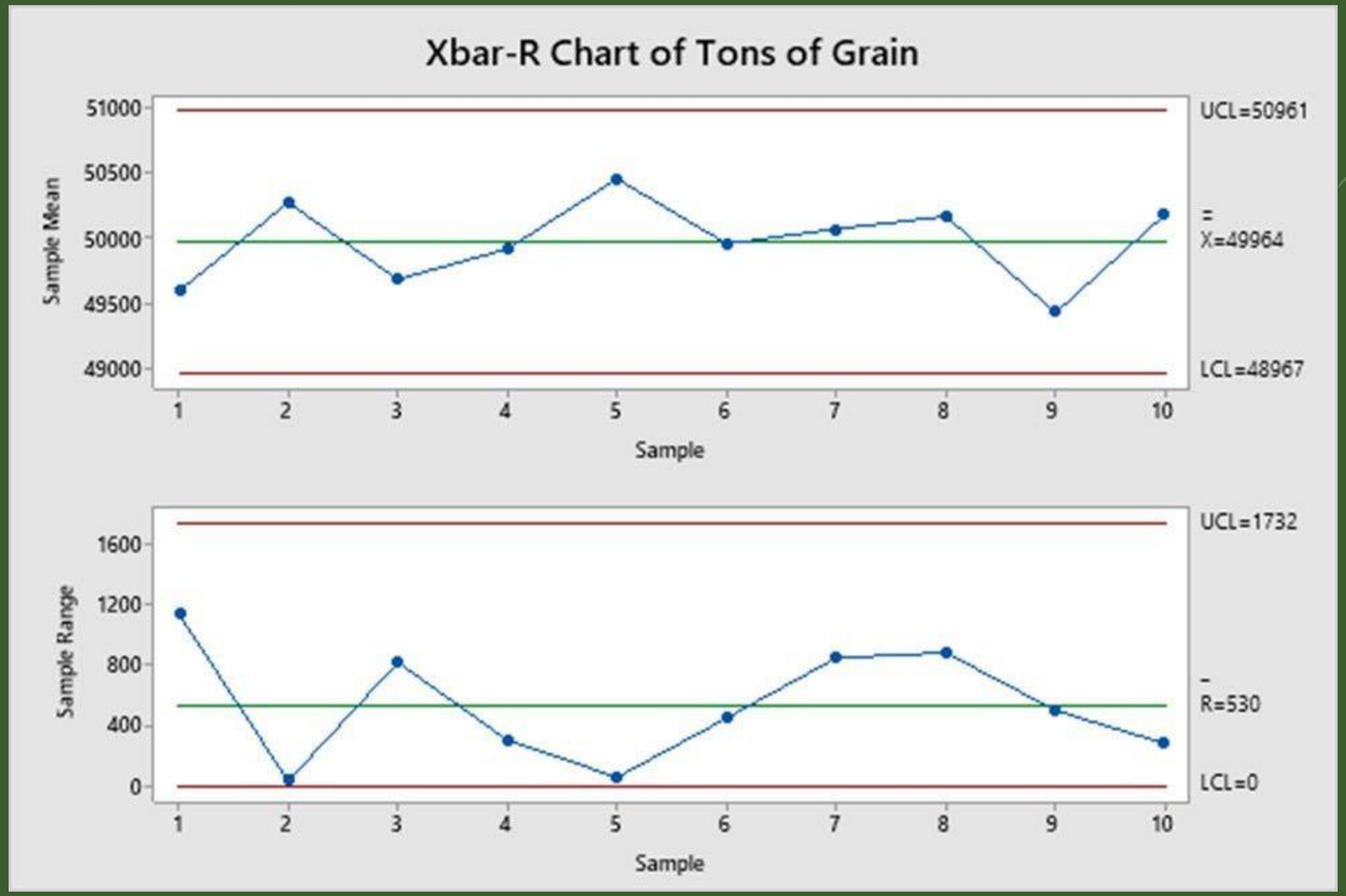
Upper control limit :

$$UCL = \overline{\overline{X}} + A_2 \overline{R}$$

Lower control limit :

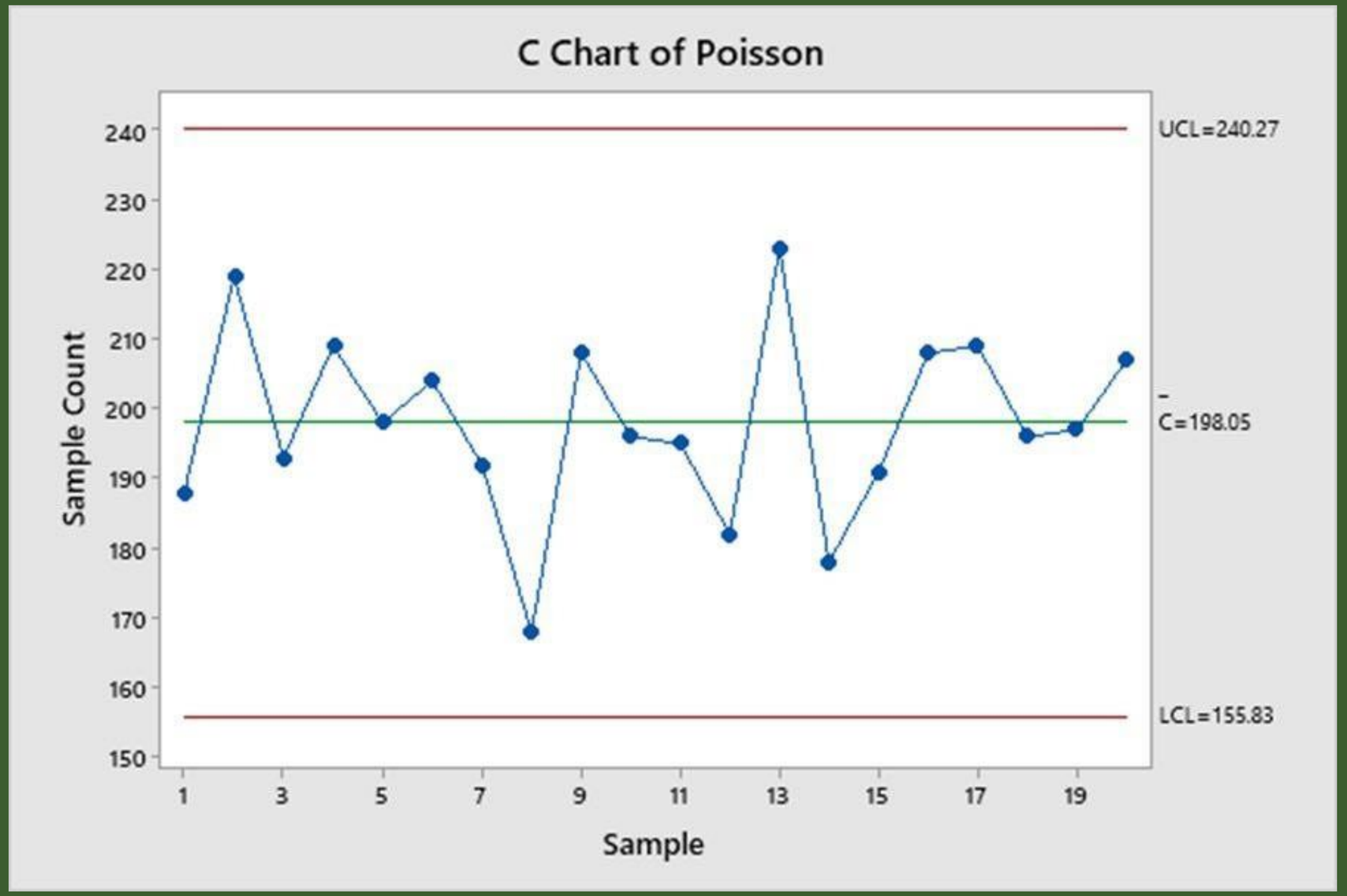
$$LCL = \overline{\overline{X}} - A_2 \overline{R}$$

X(BAR) - R CHART



TONS OF GRAIN
49015.4
50154.7
50277.9
50246.3
50085.2
49268.7
49758.8
50061.9
50415.3
50471.8
50172.9
49724.1
50485.0
49638.2
49716.8
50597.4
49673.0
49174.9
50033.5

C-CHART

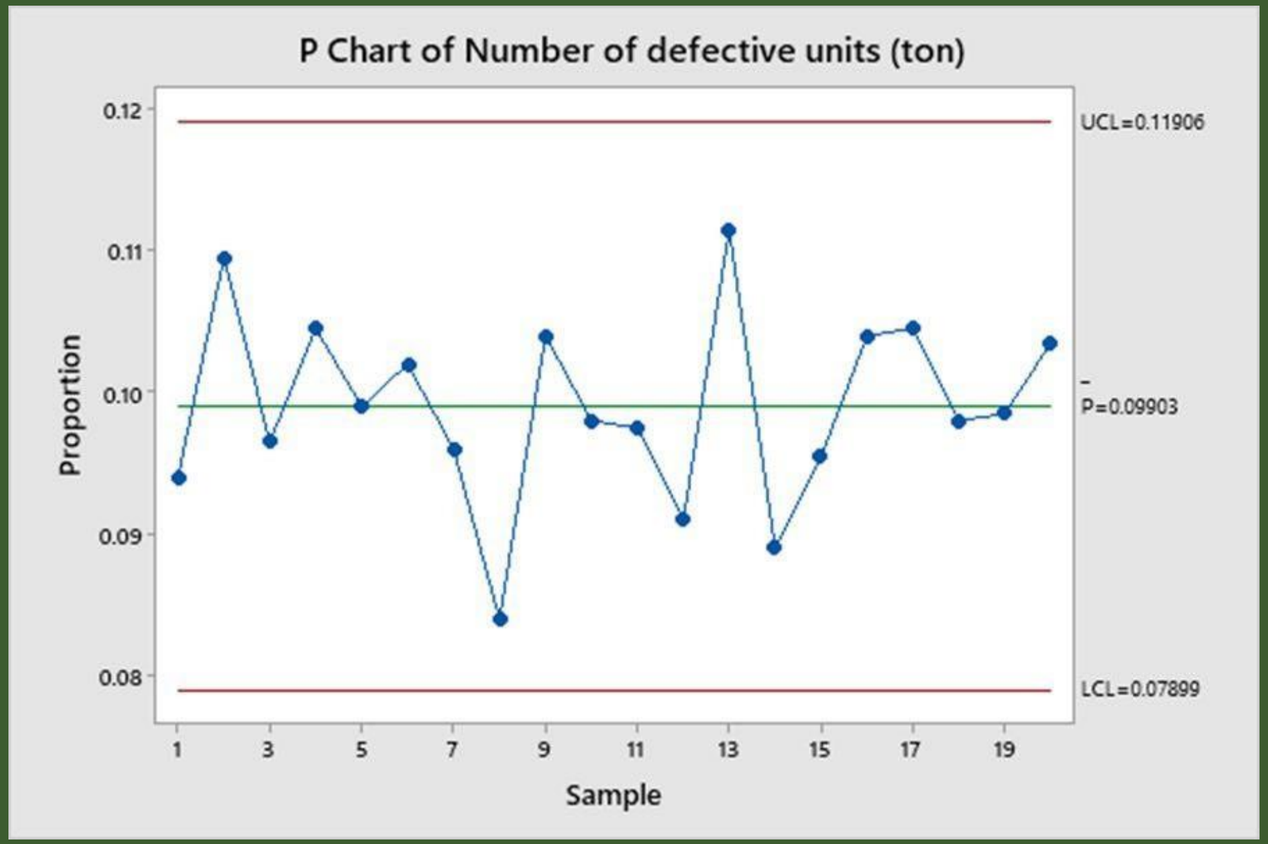


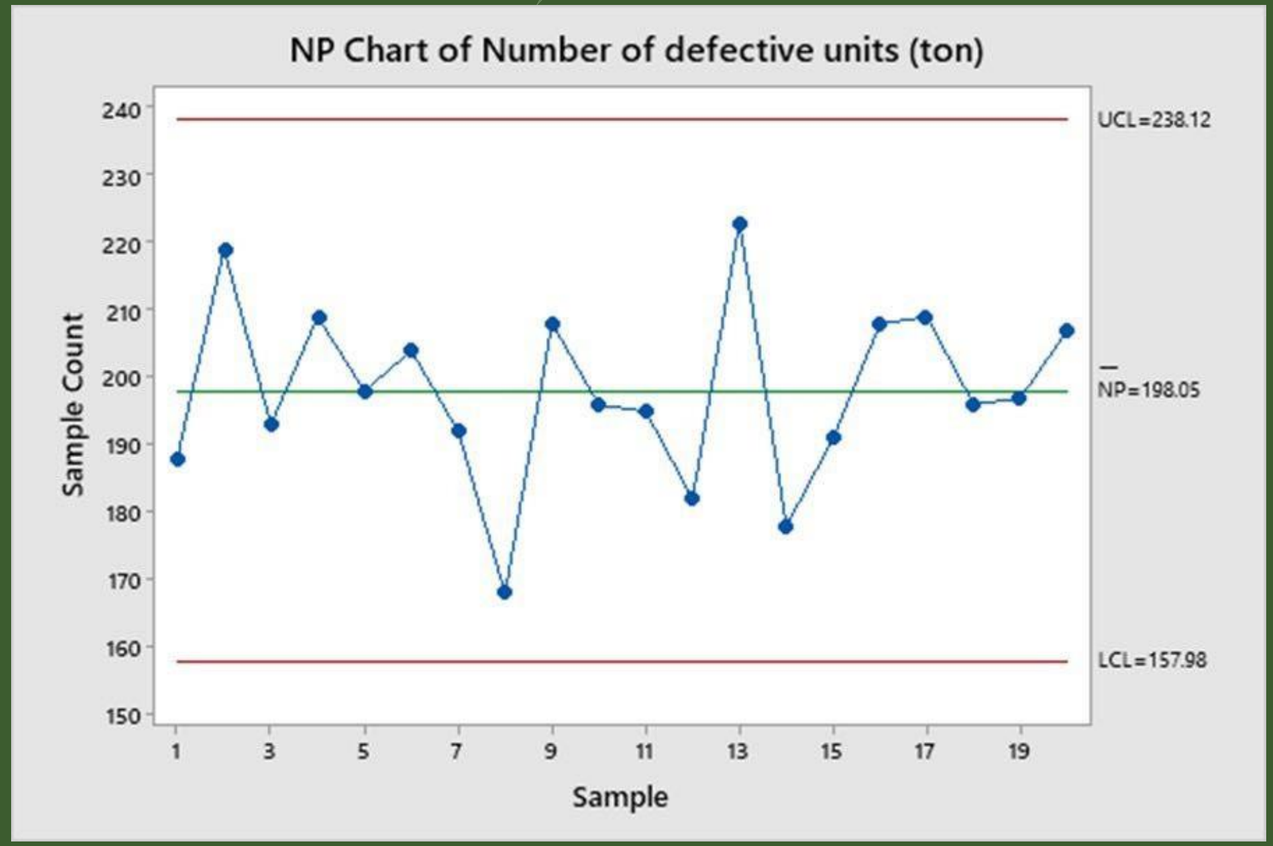
POISSON

188
219
193
209
198
204
192
168
208
196
195
182
223
178
191
208
209
196
197
207

P-CHART & NP CHART

- Process under consideration
- Assume that we inspect grains after packaging, and consider package of spoiled grain as defective unit.
- Here we draw p-chart and np-chart to check whether the number of defectives (wrong or mistaken) i.e. ‘defective units’ are within limits. And hence the process is stable or not stable.





RELIABILITY ANALYSIS

- Reliability analysis is a statistical method used to evaluate the reliability or consistency of a process
- Involves the use of statistical techniques to analyze and interpret data related to the performance of a
- process This can include analyzing failure rates, determining mean time between failures (MTBF), calculating reliability indices, and identifying potential sources of failure

RELIABILITY ANALYSIS PLAN

To conduct a reliability analysis of the trucks used in food grains transportation, to determine

- The likelihood of failures
- Identify potential sources of failure
- Develop strategies to improve the reliability and performance of the vehicles

Factors to consider:

- The age of the truck
- Maintenance history
- Driving conditions
- Load capacity to provide insights into the reliability and safety of the transportation system

RELIABILITY ASSUMPTIONS

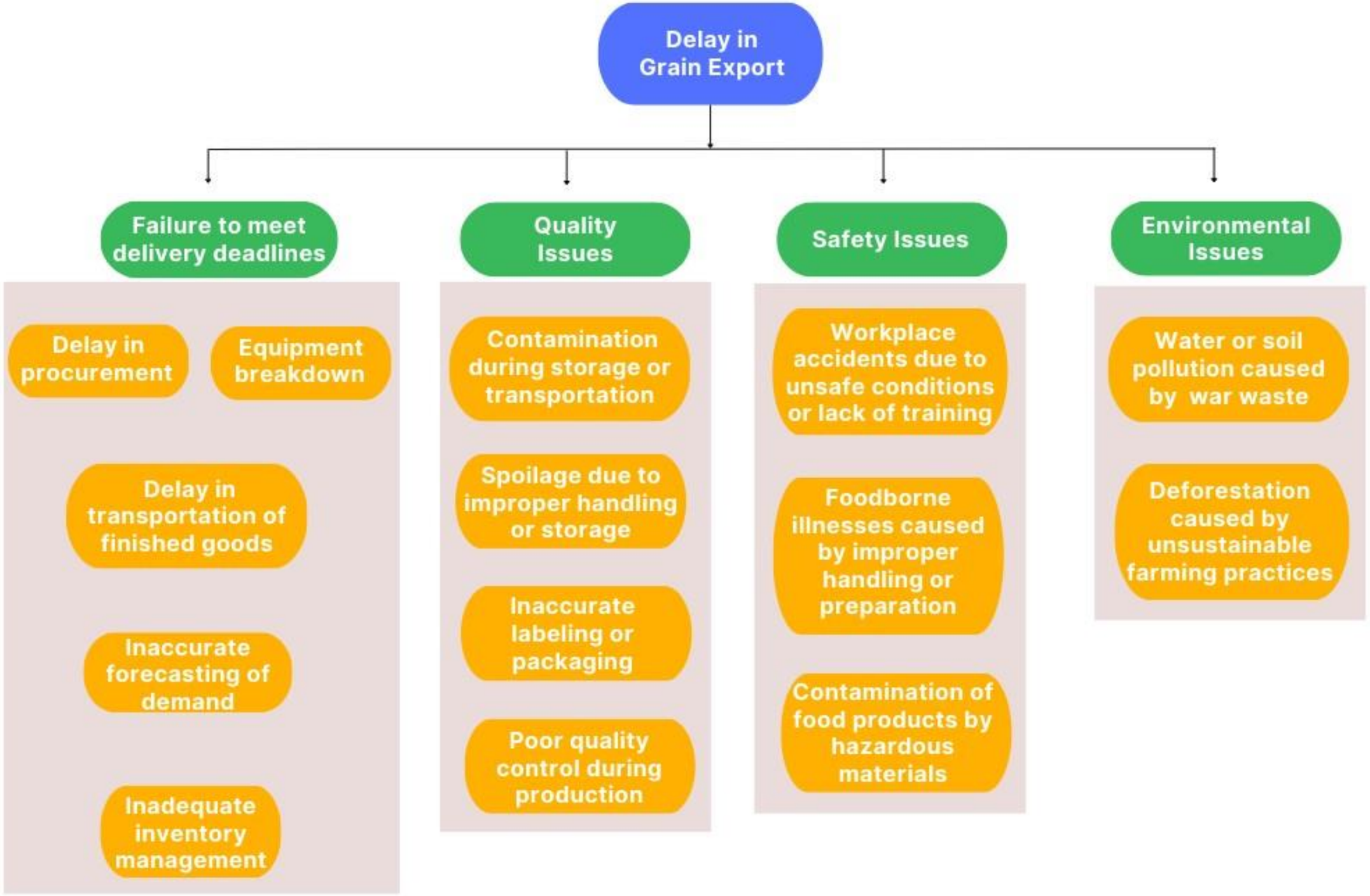
- Assume the lives are independent
- Suppose the distribution of the Times to Failure is exponential
- Use the complete data
- Confidence Level α = 0.05
- Assume the Mean Time To Failure (MTTF) is 24 months N=
- 20

  DF= N*2 = 40

RELIABILITY RESULTS

- Chi-Square with 40 DF
- $X2_{n,\alpha/2} = X2\ (40, 0.025) = 24.4330$
- $X22_{n,\ 1-\alpha/2} = X2\ (40, 0.975) = 59.3417$
- C.I = (29.3381, 71.2549)
- Assume Mission Time = 100
- Failure Rate = EXP(- 0.034085* 100) , EXP(- 0.0140341* 100)
- Failure Rates = (0.0330895 0.245757)
- Therefore, 95% of the times we derive a truck for a mission time T from test data there is a 3.30% to 24.5% chance that a truck fails a reliability test.
- The goal for reliability is 98%.

FTA


Delay in Grain Export
Failure to meet delivery deadlines
Delay in procurement
Equipment breakdown
Delay in transportation of finished goods
Inaccurate forecasting of demand
Inadequate inventory management
Quality Issues
Contamination during storage or transportation
Spoilage due to improper handling or storage
Inaccurate labeling or packaging
Poor quality control during production
Safety Issues
Workplace accidents due to unsafe conditions or lack of training
Foodborne illnesses caused by improper handling or preparation
Contamination of food products by hazardous materials
Environmental Issues
Water or soil pollution caused by war waste
Deforestation caused by unsustainable farming practices

FTA Corrective Solutions

Transportation Delays:

- Develop and implement a procurement plan that ensures adequate lead time for ordering and delivery of food grains.
- Establish a transportation plan that includes backup plans for unexpected delays or disruptions.
- Use real-time tracking and monitoring tools to identify and address delays in transportation.

Equipment and vehicles:

- Implement a preventative maintenance program to ensure equipment & trucksis regularly inspected and maintained.
- Establish procedures for equipment & trucks repair or replacement in case of breakdown.

Quality:

- Use appropriate packaging materials and storage conditions to minimize the risk of contamination.
- Regularly monitor and test products for quality and safety.

CONCLUSION

- FMEA identified the most severe risks in our project are transportation getting delayed, and poor quality grains, FTA can help identify the root causes of failures in the supply chain process.
- We could test a backup plan for shipping delays against different scenarios to see if it is robust enough to handle unexpected changes in the supply chain.
- The VSM process can help identify areas of waste, such as inventory buildup, waiting time, and overproduction, can also help identify process improvement opportunities, and identify value-added process.
- From Gauge R and R analysis we conclude that our measurement system is biased and needs calibration.
- An acceptance sampling plan can help ensure that the grain being exported meets the quality standards agreed upon with the buyer.

THANK YOU!