A weather disaster for volcano in Hawaii

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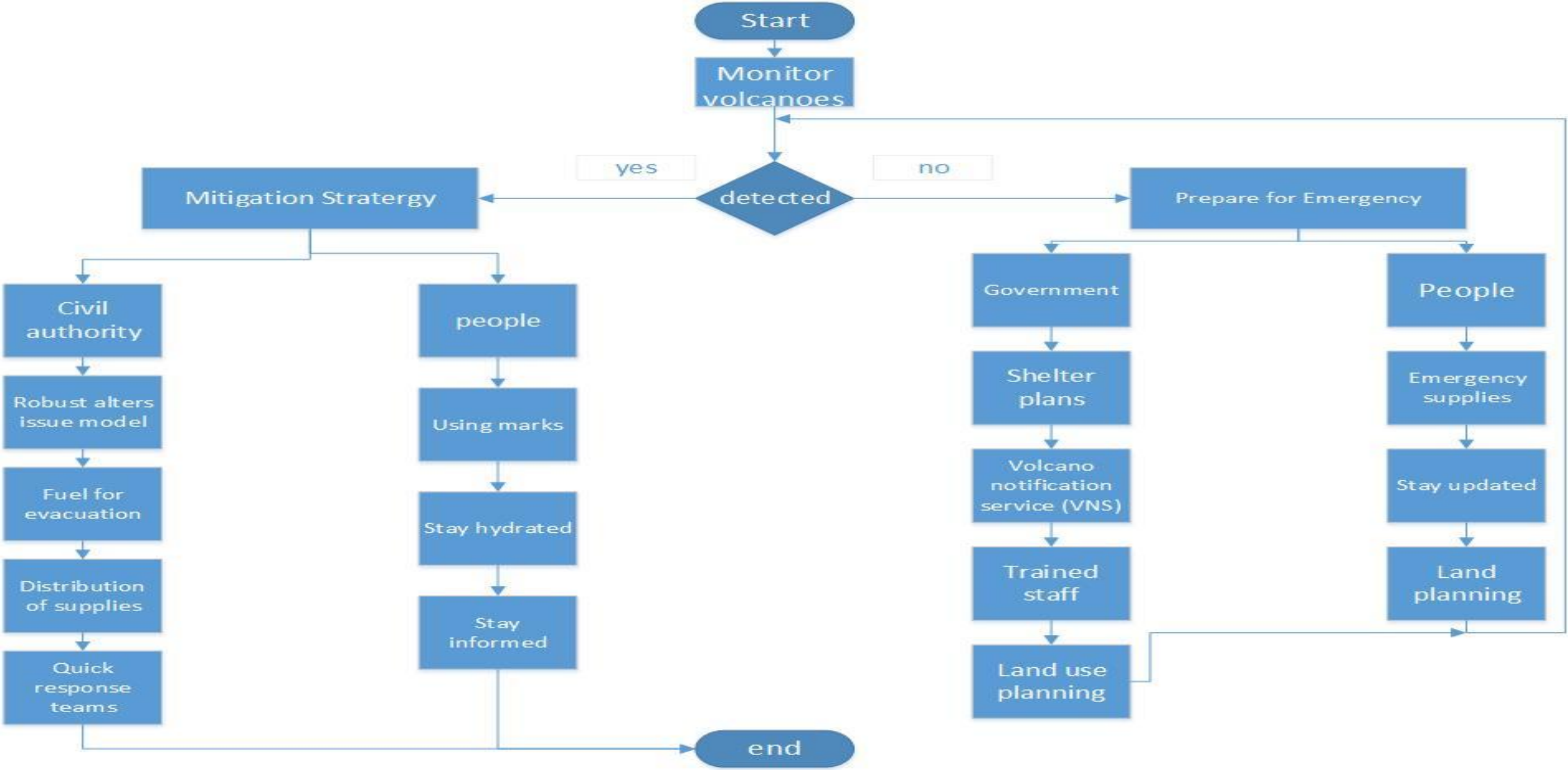
Topics

1. Background
2. Problems & Answers
3. Solution
4. List of individuals to interview
5. Internal failure cost & External failure cost
6. Flowchart
7. COPQ result
8. Affinity Diagram
9. Fishbone Diagram
10. Process Capability Analysis
11. Conclusions
12. Q&A

Background

A volcano is a rupture in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface.

Flow chart



Start
Monitor volcanoes
yes
no
detected
Mitigation Stratergy
Prepare for Emergency
Civil authority
people
Government
People
Robust alters issue model
Using marks
Shelter plans
Emergency supplies
Fuel for evacuation
Stay hydrated
Volcano notification service (VNS)
Stay updated
Distribution of supplies
Stay informed
Trained staff
Land planning
Quick response teams
Land use planning
end

Internal Failure Cost & External Failure Cost

1. Failure to do periodic equipment audit
2. Not maintaining emergency supplies
3. Untrained/Overworked staff

1. Unprepared to combat earthquakes
2. Most of people were not prepared
3. Equipments were not extremely accurate

List of individuals to interview

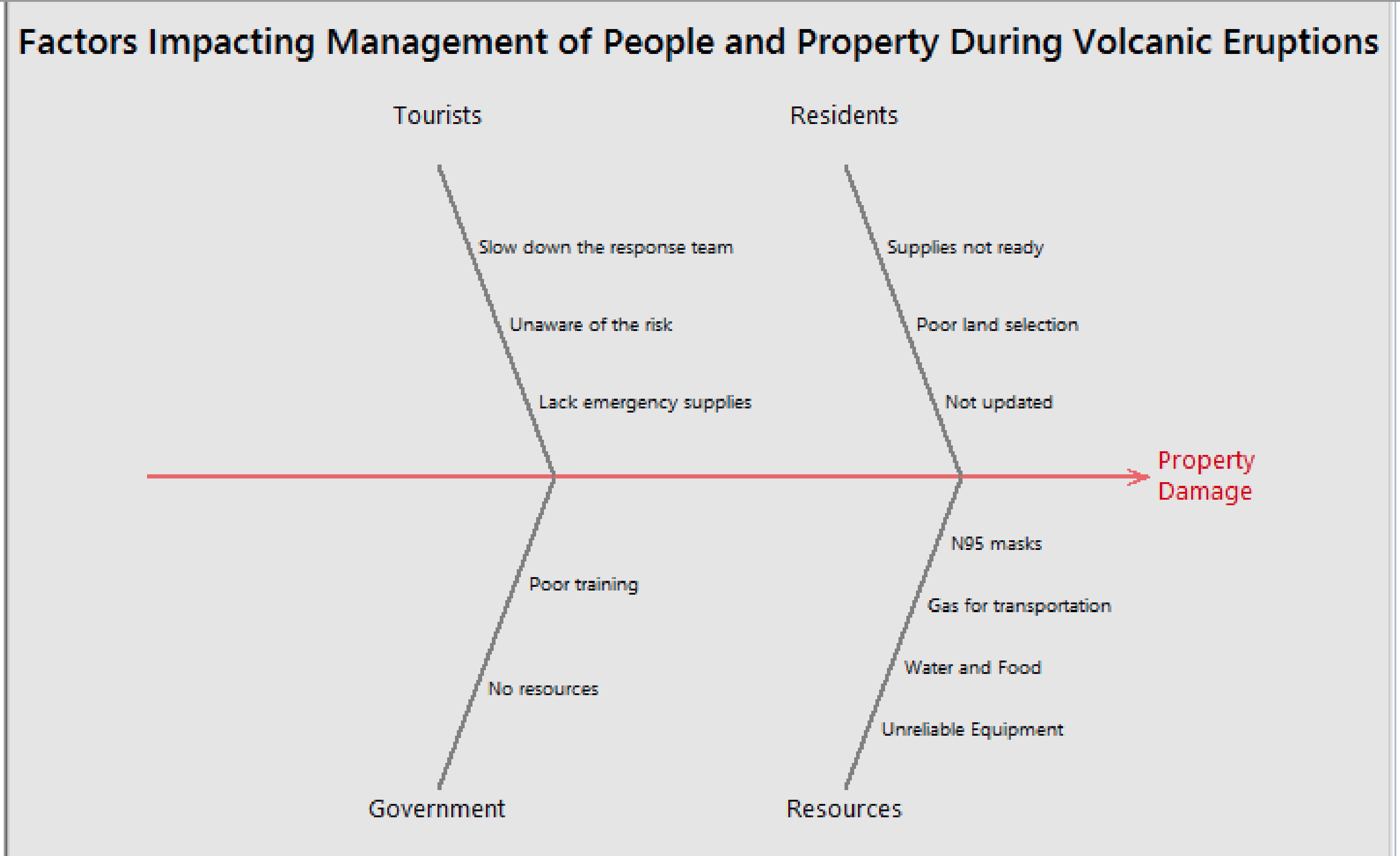
1. Lost home victim
2. State of Hawaii, Department of Health
3. Medical reserve corps
4. Government officials
5. Tourists

Problem & Answer

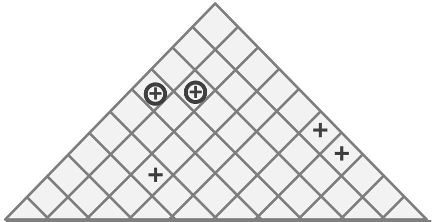
1. How was the volcanic eruption aftermath?
2. How many breathing problems were encountered?
3. How much help was gathered from the federal government?
4. How many victims?
5. After the eruption, what was the warning time？
6. Was the equipment at fault?
7. What was the total monetary damage?
8. How many tourists were affected?
9. What was the percentage of people evacuated?
10. Were the food and shelters enough？
11. Were the residents warned to have enough emergency supplies?
12. Did the residents have enough supplies?

1. It was followed by an earthquake
2. 172,000
3. Five million dollars
4. Five hundred people
5. 20 minutes
6. In some cases yes
7. $100,000,000
8. 800 hundred tourists
9. Unfortunately No
10. No, they weren’t
11. Yes
12. No

Fishbone Chart



Quality Function Deployment in Management



Customer Requirements	Customer Priority	Radio communication	Reliable fire fighter trucks	Medical supplies	Available relocation quarters	PPE	Available responders	Satellite communication	Enough vehicles	Food and Water	Volunteers
Food and Water	10								●●	●●	●
Medical Supplies	10			●●	⊙						
PPE	10					●●	○			●	○
Clothes	6			○			●				
Shelter	10									○	
Security	10			⊙		●		●●			
Communication	7	●●	●			○		●●			
Reuniting families	8	⊙						⊙	●		●
Importance Rating		102	7	146	40	177	52	202	156	120	136

Correlations:
- ⊕ Strong Positive
- + Positive
- ⊖ Strong Negative
- – Negative

Relationships:
- ●● Strongest= 10
- ● Strong= 7
- ⊙ Fair= 4
- ○ Weak= 1

- Stock enough PPE and medical supplies
- Ensure the Hawaii has reliable satellite communication
- Purchase vehicles that can withstand different terrains for emergency relocations

Solution

- Buy new equipment with better predictive accuracy
- Stock enough PPE and medical supplies
- Ensure the Hawaii has reliable satellite communication
- Purchase vehicles that can withstand different terrains for emergency relocations

Solution Focus:

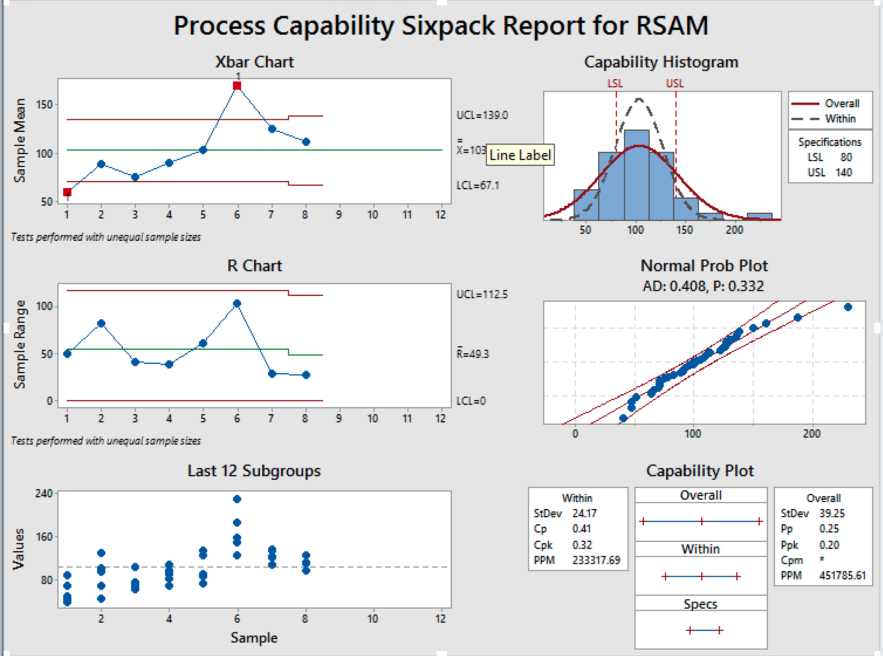
Better equipment with better predictive accuracy which will allow timely response and management of people

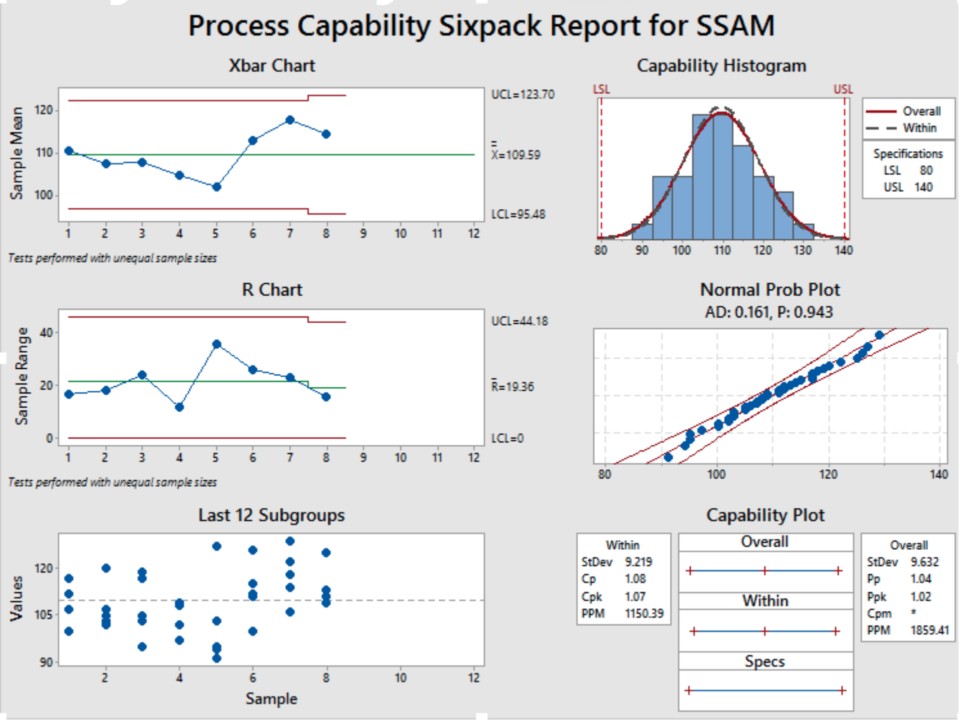
Process Capability Analysis

1. To check the accuracy and reliability of the Seismic Spectral Amplitude Measurement (SSAM) compared to the Real-time Seismic Amplitude Measurement (RSAM) in predicting volcanic eruptions
2. Estimators: Process capability Ppk and Cpk

Process Capability Analysis

Before





After

OC plan data

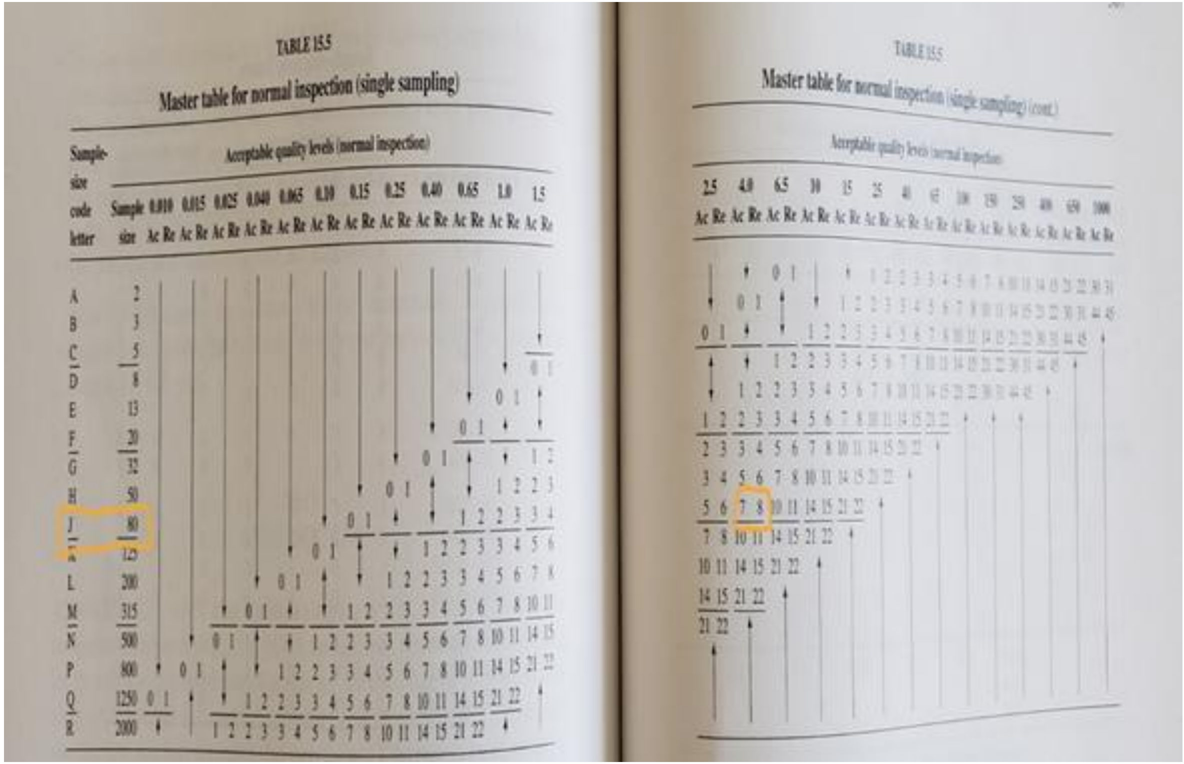
<u>Here we do the OC plan for Seismic equipment</u> GOOD SAMPLE<u>:</u> Here we have N=80 and C=7 so the first run that we did is with PD= 0.04, which is less than 0.05 which is our α, so we find the number of samples throughout the lot which are more than 7, after testing 100 lots (randomly) we find that only one lot is more than 7 (highlighted in red colour).

BAD SAMPLE: We do the second testing but this time it is to check whether our PD=0.16 produces 5 or more good lot or not, and safe to say that it produces all the batches (except 2 of them which passed in error highlighted in green) which failed, so our β value is correct as well.

	PD	OC	Good	Bad
1	0.05	0.95	3	10
2	0.06	0.89	5	12
3	0.07	0.80	6	12
4	0.08	0.69	4	14
5	0.09	0.56	3	9
6	0.10	0.44	5	12
7	0.11	0.33	3	7
8	0.12	0.24	4	12
9	0.13	0.16	2	16
10	0.14	0.11	5	15
11	0.15	0.07	3	12
12			1	10
13			7	14
14			1	13
15			5	13
16			4	15
17			1	13
18			1	17
19			2	9
20			5	16
21			3	14
22			2	16
23			1	14
24			3	12
25			4	15
26			2	15
27			1	13
28			3	14
29			5	9
30			3	13
31			4	14
32			3	12
33			2	12
34			1	16
35			2	14
36			4	8
37			5	10
38			5	10
39			3	11
40			2	15
41			2	10
42			1	20
43			2	5
44			4	13
45			5	12
46			3	10
47			6	16
48			2	12
49			3	7
50			2	15
51			6	11
52			4	13
53			0	17
54			0	13
55			4	15
56			1	15
57			3	9
58			3	17
59			2	8
60			4	8
61			2	14
62			3	14
63			1	19
64			5	12
65			4	14
66			5	18
67			6	12
68			4	18
69			7	12
70			0	12
71			1	11
72			4	14
73			3	16
74			1	10
75			4	13
76			2	10
77			1	18
78			1	12
79			2	12
80			2	15
81			1	14
82			5	7
83			2	15
84			4	14
85			2	7
86			1	17
87			5	12
88			3	15
89			2	9
90			4	17
91			4	13
92			9	11
93			3	11
94			2	13
95			4	8
96			6	12
97			2	13
98			4	8
99			4	13
100			3	13

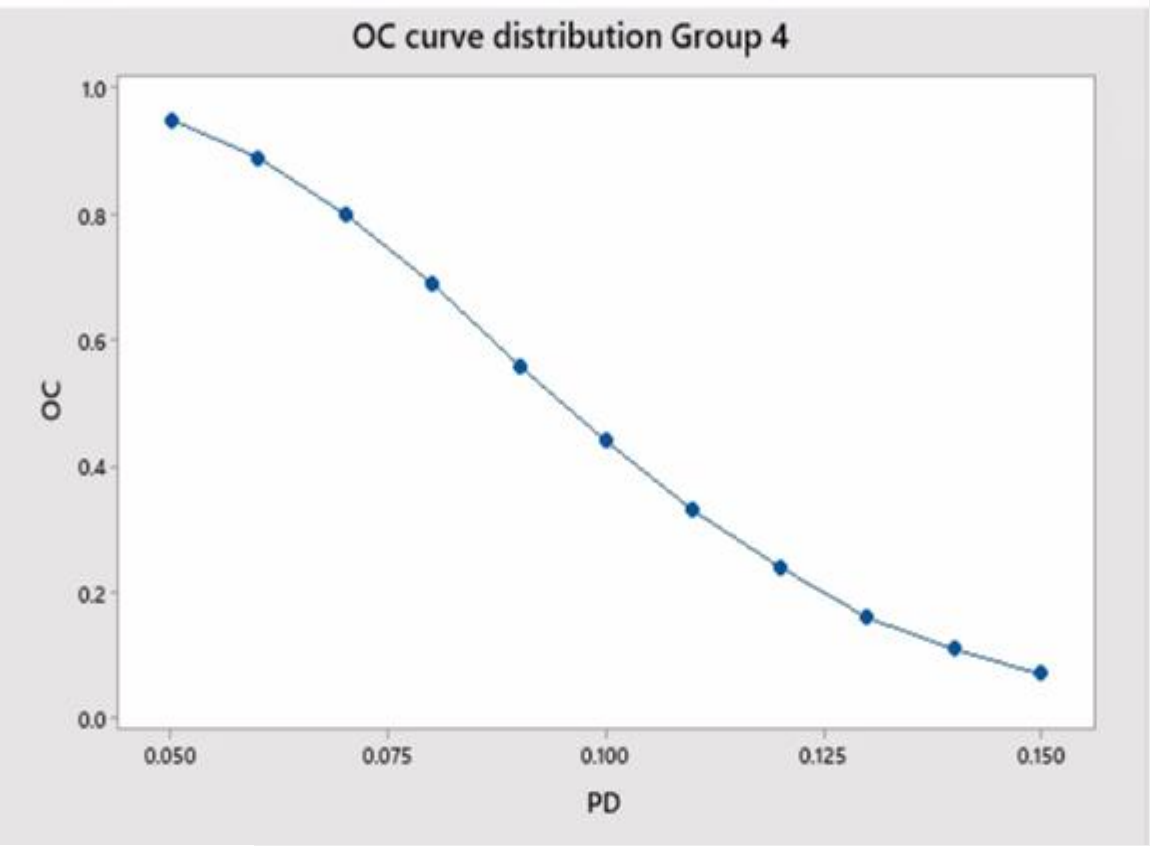
OC plans example

- Now we can see that since our N=80 and C=7 we fall into “J” bracket.
- And from the figure below we can see that lot size is between 500-1200.
- Thus we can see that both procedures lead to same result.
- So we can see that the statisticians and quality engineers who made the ANSI table used Nomograms and binomial distributions over a lot of data samples to get the fairly accurate table.



OC plans

1. The X axis is Percent defective and Y axis is OC.
2. This is our OC curve with 10 points between 0.05 to 0.15
3. If there were more points taken then it would give even more details and it would look like an “S” shape, hence the name.



DOE analyze

For the analysis we are conducting a full factorial design. 3 factors (**A is keeping the gas tank full, B is Engine maintenance, C is maintenance of Tires)** each of which have two levels and 2 replicates are considered.

GROUP 4

		Design of Experiments Analysis									
	Factorial Experiments 2^3 (Three Replications/Treatment)							Run Results			
Run	A	B	C	AB	AC	BC	ABC	Y1	Y2	Avg.	Var.
1	-1	-1	-1	1	1	1	-1	6.10174717	3.459063504	4.780	3.492
2	1	-1	-1	-1	-1	1	1	5.91534636	3.204600038	4.560	3.674
3	-1	1	-1	-1	1	-1	1	7.14254516	-1.407847304	2.867	36.555
4	1	1	-1	1	-1	-1	-1	9.37881551	10.93316371	10.156	1.208
5	-1	-1	1	1	-1	-1	1	7.84814906	12.02498979	9.937	8.723
6	1	-1	1	-1	1	-1	-1	16.3282885	14.30381983	15.316	2.049
7	-1	1	1	-1	-1	1	-1	7.46674486	12.76465375	10.116	14.034
8	1	1	1	1	1	1	1	23.1017211	27.78866261	25.445	10.984
TotSum								83.28	83.07	83.18	80.72

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Run	A	B	C	AB	AC	BC	ABC	Y1	Y2	Avg.	Var.
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3	-1	1	-1	-1	1	-1	1	7.14254516	-1.407847304	2.867	36.555
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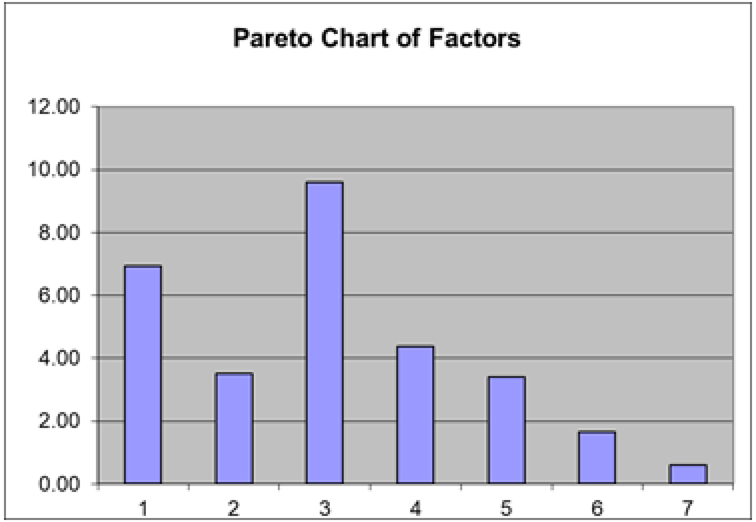
5	-1	-1	1	1	-1	-1	1	7.84814906	12.02498979	9.937	8.723
6	1	-1	1	-1	1	-1	-1	16.3282885	14.30381983	15.316	2.049
7	-1	1	1	-1	-1	1	-1	7.46674486	12.76465375	10.116	14.034
8	1	1	1	1	1	1	1	23.1017211	27.78866261	25.445	10.984
TotSum								83.28	83.07	83.18	80.72
SumY+	55.48	48.58	60.81	50.32	48.41	44.90	42.81				
SumY-	27.70	34.59	22.36	32.86	34.77	38.28	40.37				
AvgY+	13.87	12.15	15.20	12.58	12.10	11.23	10.70				
AvgY-	6.93	8.65	5.59	8.21	8.69	9.57	10.09				
Effect	**6.94**	**3.50**	**9.61**	**4.38**	**3.41**	**1.66**	**0.61**				
Var+	4.479	15.695	8.947	6.102	13.270	8.046	14.984				
Var-	15.701	4.485	11.232	14.078	6.910	12.134	5.196				
F	3.506	0.286	1.255	2.307	0.521	1.508	0.347				

Pareto Chart of Effects

1) We first calculate the CI half width. The half width is the multiplication of the Effects std Deviation times the Student T value, in this case 2.473., note the T value is based on a confidence value along with degrees of freedom.

1) To determine significant factors we compare the factors "Effect" which is the delta between the AvgY+ and the AvgY-, see figure 2-5, factors and interactions that are significant are those that have an effect that is greater than the CI half width calculated above. The below figure 2-7 shows the significant effects.



Var. of Model		10.09		StdDv	3.18
Var. of Effect		2.52		StdDv	1.59
Student T (0.025;DF) =				2.752	
C.I. Half Width =				**4.370**	

DOE minitab

C9	C10	C11	C12	C13	C14	C15	C16
StdOrder	RunOrder	Blocks	CenterPt	Humidity (A)	Temperature (B)	Production Process (C)	Yield
1	1	1	1	-1	-1	-1	
2	2	1	1	1	-1	-1	
3	3	1	1	-1	1	-1	
4	4	1	1	1	1	-1	
5	5	1	1	-1	-1	1	
6	6	1	1	1	-1	1	
7	7	1	1	-1	1	1	
8	8	1	1	1	1	1	
9	9	1	1	-1	-1	-1	
10	10	1	1	1	-1	-1	
11	11	1	1	-1	1	-1	
12	12	1	1	1	1	-1	
13	13	1	1	-1	-1	1	
14	14	1	1	1	-1	1	
15	15	1	1	-1	1	1	
16	16	1	1	1	1	1	

The figure above shows the experiment design created by Minitab. The design includes three (3) factors (A, B and C), two (2) levels and sixteen (16) runs. Minitab randomizes and provides the order in which each run should be performed in the RunOrder column.

In this example the RunOrder is the same as the StdOrder, therefore, the runs are the same. The experimental runs are thus performed according to the default Minitab row numbers. After each run the results are recorded in the Yield column.

Yield results

Each experimental run is performed twice. Therefore, two data points are obtained per run.

C9 StdOrder	C10 RunOrder	C11 Blocks	C12 CenterPt	C13 Humidity (A)	C14 Temperature (B)	C15 Production Process (C)	C16 Yield
1	1	1	1	-1	-1	-1	6.1017
2	2	1	1	1	-1	-1	5.9153
3	3	1	1	-1	1	-1	7.1425
4	4	1	1	1	1	-1	9.3788
5	5	1	1	-1	-1	1	7.8481
6	6	1	1	1	-1	1	16.3283
7	7	1	1	-1	1	1	7.4667
8	8	1	1	1	1	1	23.1017
9	9	1	1	-1	-1	-1	3.4591
10	10	1	1	1	-1	-1	3.2046
11	11	1	1	-1	1	-1	-1.4078
12	12	1	1	1	1	-1	10.9332
13	13	1	1	-1	-1	1	12.0250
14	14	1	1	1	-1	1	14.3038
15	15	1	1	-1	1	1	12.7647
16	16	1	1	1	1	1	27.7887

P value

From the coded coefficients table above, for factor B and interactions A*C, B*C and A*B*C hypothesis tests we fail to reject the null hypothesis. The p-values for each are 0.059, 0.064, 0.327 and 0.711, which is above the alpha value of 0.05 (95% confidence). Therefore, the yield in this experiment is governed by humidity, the production process and the interactions between the humidity and temperature.

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		10.397	0.794	13.09	0.000	
A	6.944	3.472	0.794	4.37	0.002	1.00
B	3.498	1.749	0.794	2.20	0.059	1.00
C	9.612	4.806	0.794	6.05	0.000	1.00
A*B	4.365	2.182	0.794	2.75	0.025	1.00
A*C	3.410	1.705	0.794	2.15	0.064	1.00
B*C	1.656	0.828	0.794	1.04	0.327	1.00
A*B*C	0.610	0.305	0.794	0.38	0.711	1.00

Minitab regression

The table below formerly used in the DOE with the response (yield results) populated is used for the analysis. For the first regression analysis all the factors (humidity, temperature and production process) and their interactions are analyzed.

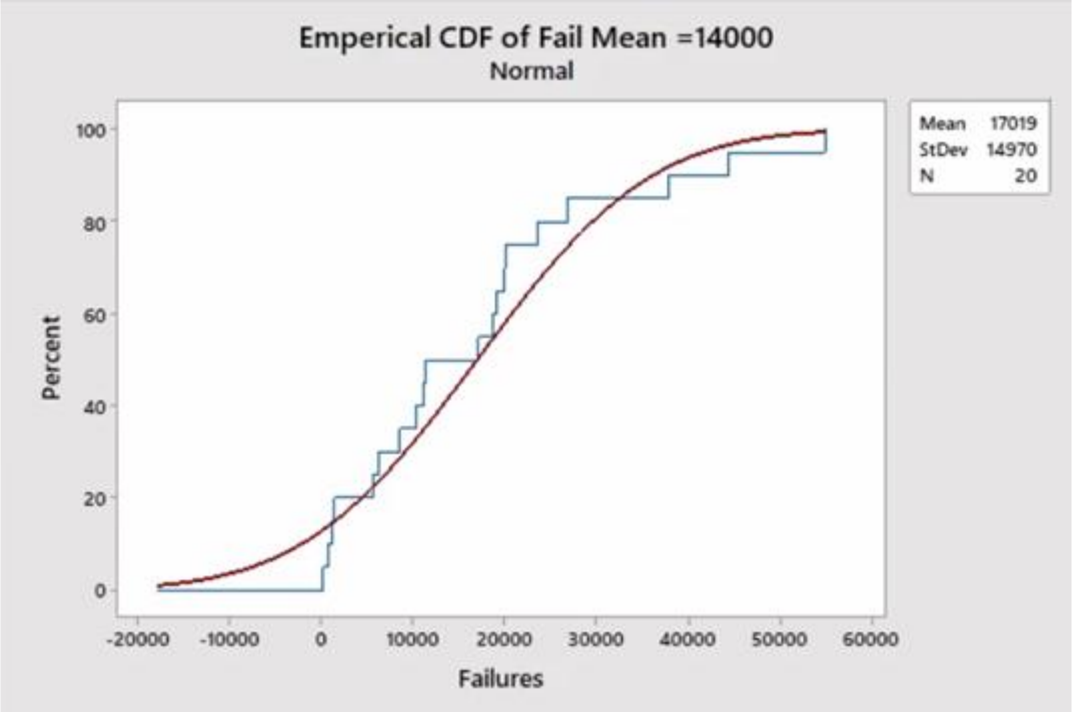
A	B	C	AB	AC	BC	ABC	Y
-1	-1	-1	1	1	1	-1	6.1017
1	-1	-1	-1	-1	1	1	5.9153
-1	1	-1	-1	1	-1	1	7.1425
1	1	-1	1	-1	-1	-1	9.3788
-1	-1	1	1	-1	-1	1	7.8481
1	-1	1	-1	1	-1	-1	16.3283
-1	1	1	-1	-1	1	-1	7.4667
1	1	1	1	1	1	1	23.1017
-1	-1	-1	1	1	1	-1	3.4591
1	-1	-1	-1	-1	1	1	3.2046
-1	1	-1	-1	1	-1	1	-1.4078
1	1	-1	1	-1	-1	-1	10.9332
-1	-1	1	1	-1	-1	1	12.0250
1	-1	1	-1	1	-1	-1	14.3038
-1	1	1	-1	-1	1	-1	12.7647
1	1	1	1	1	1	1	27.7887

Reliability

The Red circles denote the important points:

20% of the failure are less than **215**

Last 10% of the failure are higher than **54,936**



Reliablity

N=14000 T=20 K1=340376;K2=680751

Chi- square with 40 DF P=0.025 24.43

Chi square with 40 DF P=0.975 59.34

K3= K2/59.34 =11,472.0

K4= K2/24.43 =27,865.4

K5= 1/K4 =0.00003588

K6= 1/K3 =0.00008716 K7= 5000

K8= 0.646719 K9= 0.835743

So as this is not good as the highest is just 0.84 (which means that with 95% certainty the equipment will fail 2 out of 10 times), we will change time to 10 hours (which is very aggressive but we want to check how safe we can get)

K10= 0.999129 K11= 0.999640**So as we can see that there is always 99.9% or more certainty that the equipment would not fail, which is almost certain that the setup is very robust.**

SPC

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{4}$$

$$R = x_{max} - x_{min}$$

$$\bar{\bar{x}} = \frac{\bar{x}_1 + \bar{x}_2 + ... + \bar{x}_8}{8} = 104.225$$

$$\bar{R} = \frac{R_1 + R_2 \Lambda + R_8}{8} = 56.75$$

Number	**1**	**2**	**3**	**4**	**5**	**Avg**	**R**
Data	50	45	76	93	39	60.6	54
Number	**6**	**7**	**8**	**9**	**10**	**Avg**	**R**
Data	140	100	110	76	50	95.2	90
Number	**11**	**12**	**13**	**14**	**15**	**Avg**	**R**
Data	110	69	58	64	76	75.4	52
Number	**16**	**17**	**18**	**19**	**20**	**Avg**	**R**
Data	116	86	78	69	93	88.4	47
Number	**21**	**22**	**23**	**24**	**25**	**Avg**	**R**
Data	142	129	89	92	103	111	53
Number	**26**	**27**	**28**	**29**	**30**	**Avg**	**R**
Data	238	200	163	159	121	176.2	117
Number	**31**	**32**	**33**	**34**	**35**	**Avg**	**R**
Data	120	128	124	110	113	119	18
Number	**36**	**37**	**38**	**39**	**40**	**Avg**	**R**
Data	112	98	99	110	121	108	23

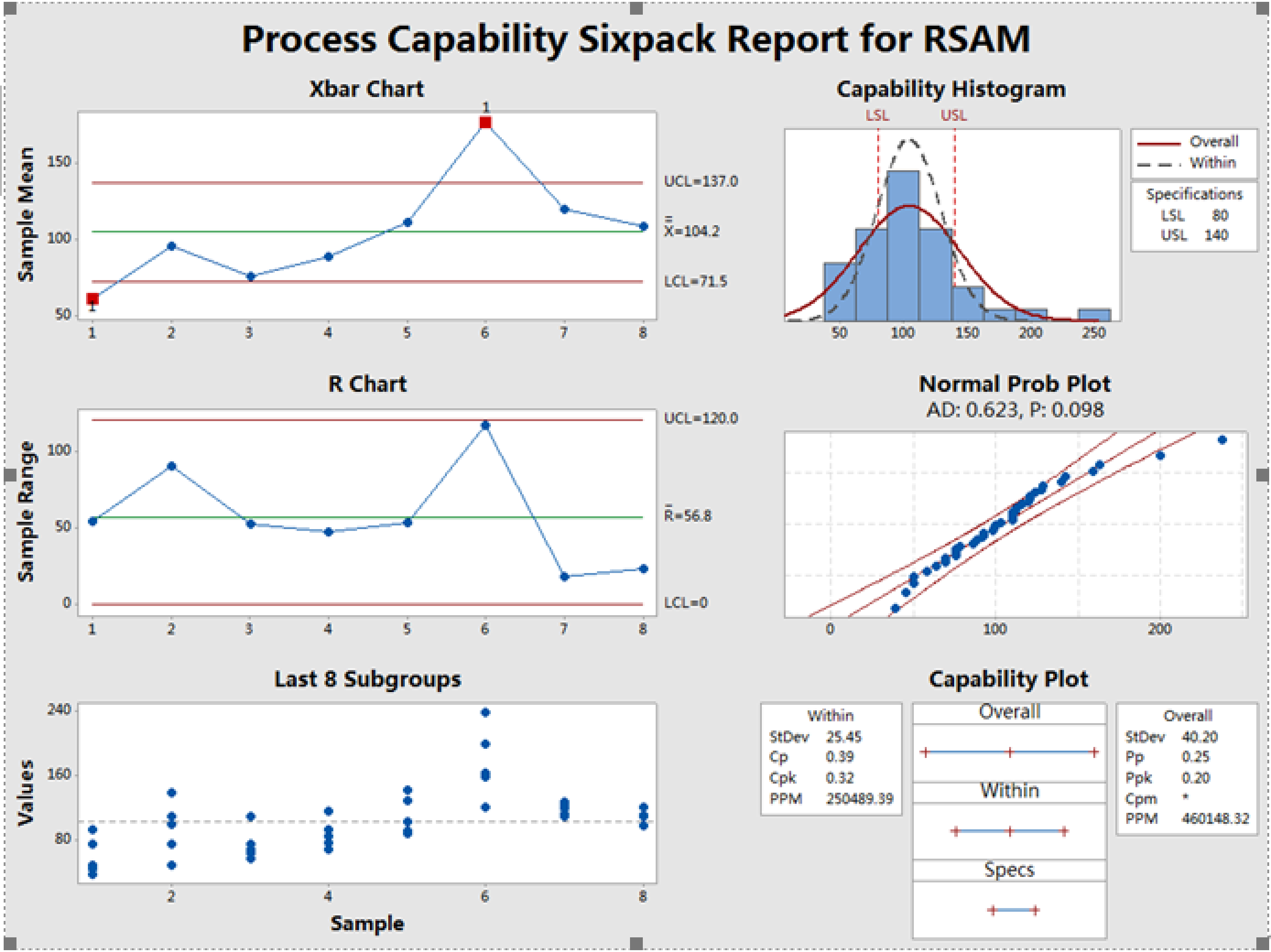
spc

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2\bar{R} = 137.0$$

$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2\bar{R} = 71.5$$

$$UCL_{\bar{R}} = D_4 * \bar{R} = 120.0$$

$$UCL_{\bar{R}} = D_3 * \bar{R} = 0$$



SPC

$$\bar{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{4}$$

$$R = x_{max} - x_{min}$$

$$\bar{\bar{x}} = \frac{\bar{x}_1 + \bar{x}_2 + \ldots + \bar{x}_8}{8} = 109.75$$

$$\bar{R} = \frac{R_1 + R_2 \Lambda + R_8}{8} = 24.75$$

Number	**1**	**2**	**3**	**4**	**5**	**Avg**	**R**
Data	107	114	119	101	110	110.2	18
Number	**6**	**7**	**8**	**9**	**10**	**Avg**	**R**
Data	121	105	107	104	101	107.6	20
Number	**11**	**12**	**13**	**14**	**15**	**Avg**	**R**
Data	118	116	105	103	93	107	25
Number	**16**	**17**	**18**	**19**	**20**	**Avg**	**R**
Data	109	108	98	103	103	104.2	11
Number	**21**	**22**	**23**	**24**	**25**	**Avg**	**R**
Data	132	103	90	93	95	102.6	42
Number	**26**	**27**	**28**	**29**	**30**	**Avg**	**R**
Data	129	110	113	111	98	112.2	31
Number	**31**	**32**	**33**	**34**	**35**	**Avg**	**R**
Data	139	123	109	113	119	120.6	30
Number	**36**	**37**	**38**	**39**	**40**	**Avg**	**R**
Data	128	107	109	112	112	113.6	21

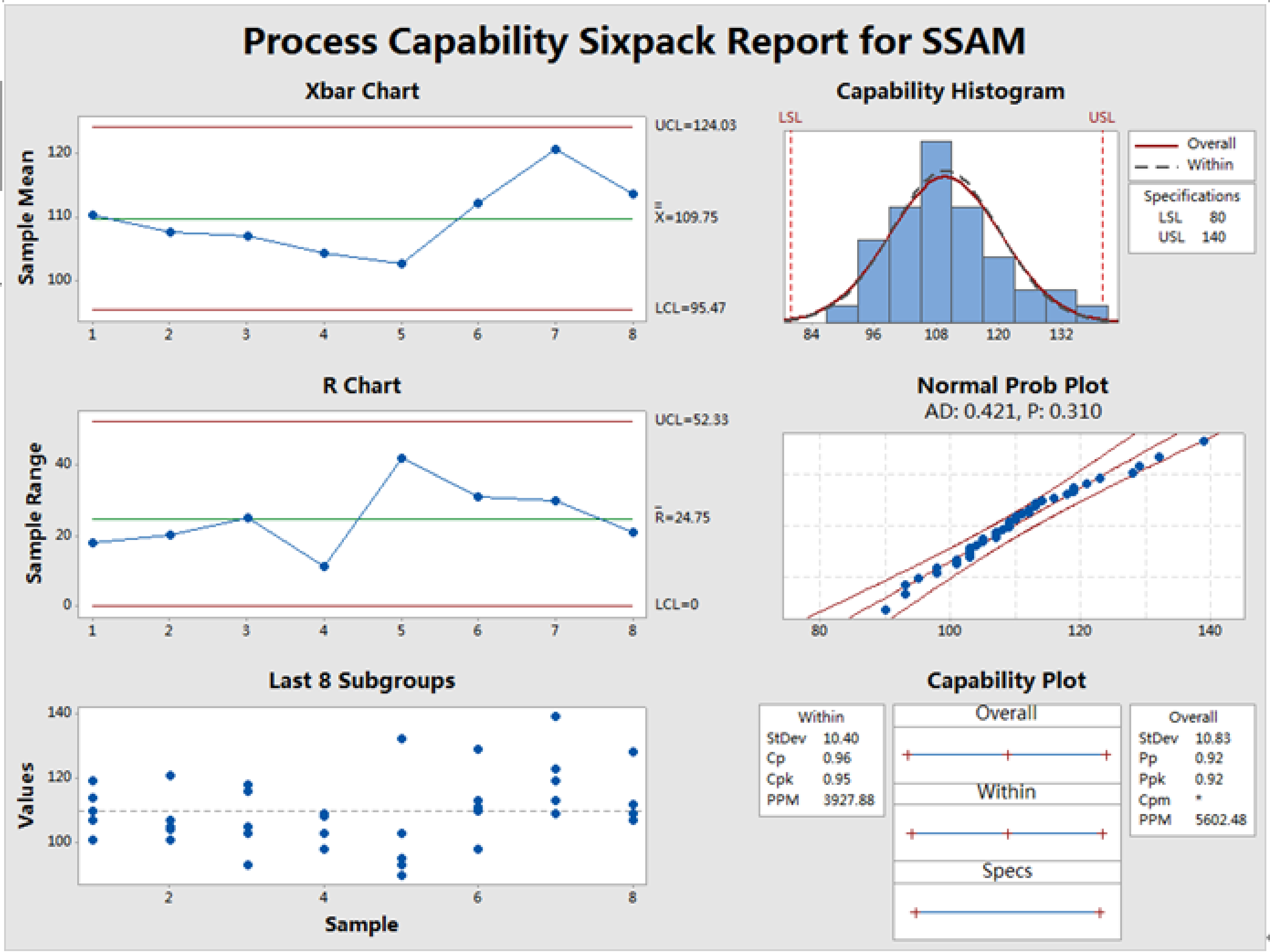
SPC

$$UCL_{\bar{x}} = \bar{\bar{x}} + A_2 \bar{R} = 124.03$$

$$LCL_{\bar{x}} = \bar{\bar{x}} - A_2 \bar{R} = 95.47$$

$$UCL_{\bar{R}} = D_4 * \bar{R} = 52.33$$

$$UCL_{\bar{R}} = D_3 * \bar{R} = 0$$



Conclusion

- The Seismic Spectral Amplitude Measurement (SSAM) is more precise and reliable compared to the Real-time Seismic Amplitude (RSAM) in predicting volcanic eruptions.Therefore, offers a better chance for volcanic eruptions management.
- We also have colaboration with the weather and news channels and the radio as well so we can forecast the eruption and let all the people know in advance.
- The tourists will be stopped during the months of high risk.
- The Evacuation vehicles need to ready to work at a short moment of notice.

THANK YOU!