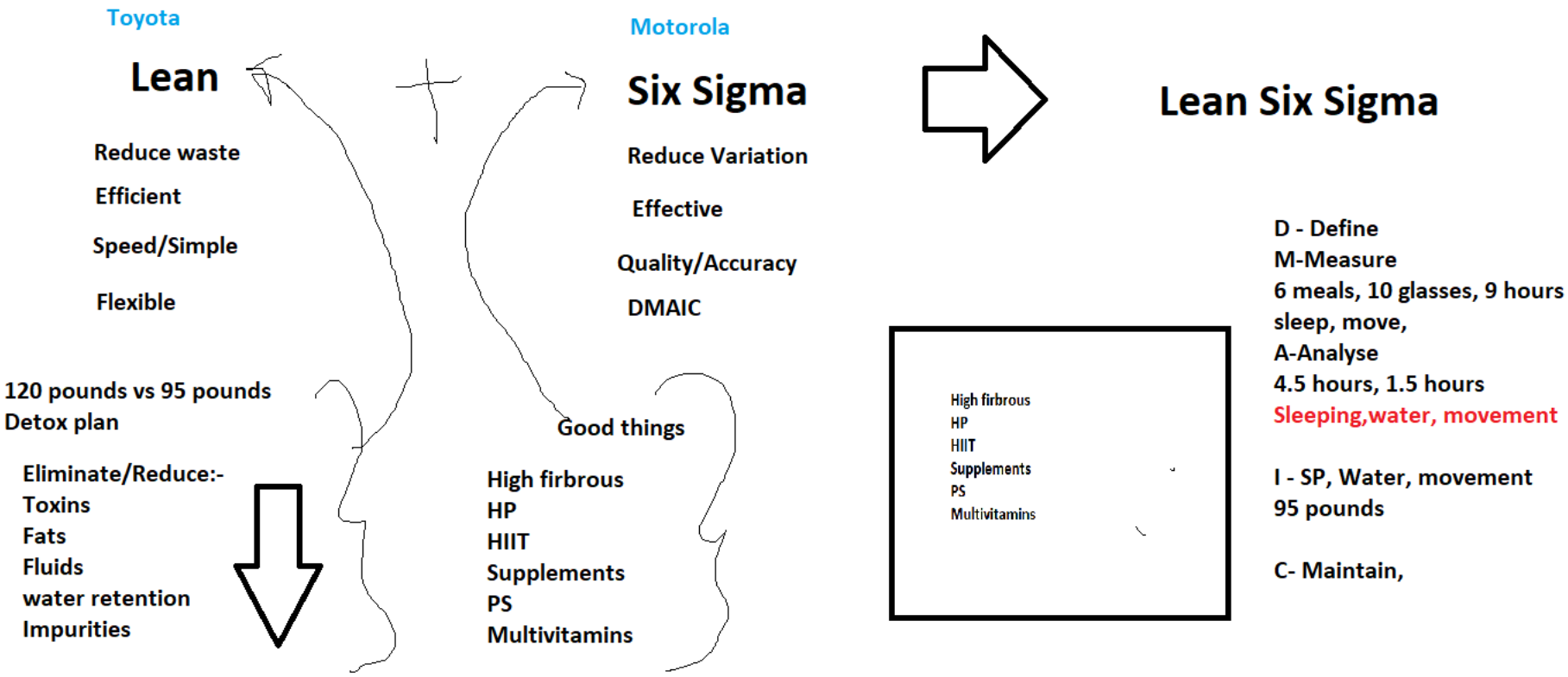

Toyota
Lean
Reduce waste
Efficient
Speed/Simple
Flexible
120 pounds vs 95 pounds
Detox plan
Eliminate/Reduce:-
Toxins
Fats
Fluids
water retention
Impurities
Motorola
Six Sigma
Reduce Variation
Effective
Quality/Accuracy
DMAIC
Good things
High firbrous
HP
HIIT
Supplements
PS
Multivitamins
Lean Six Sigma
High firbrous
HP
HIIT
Supplements
PS
Multivitamins
D - Define
M-Measure
6 meals, 10 glasses, 9 hours sleep, move,
A-Analyse
4.5 hours, 1.5 hours
Sleeping,water, movement
I - SP, Water, movement
95 pounds
C- Maintain,

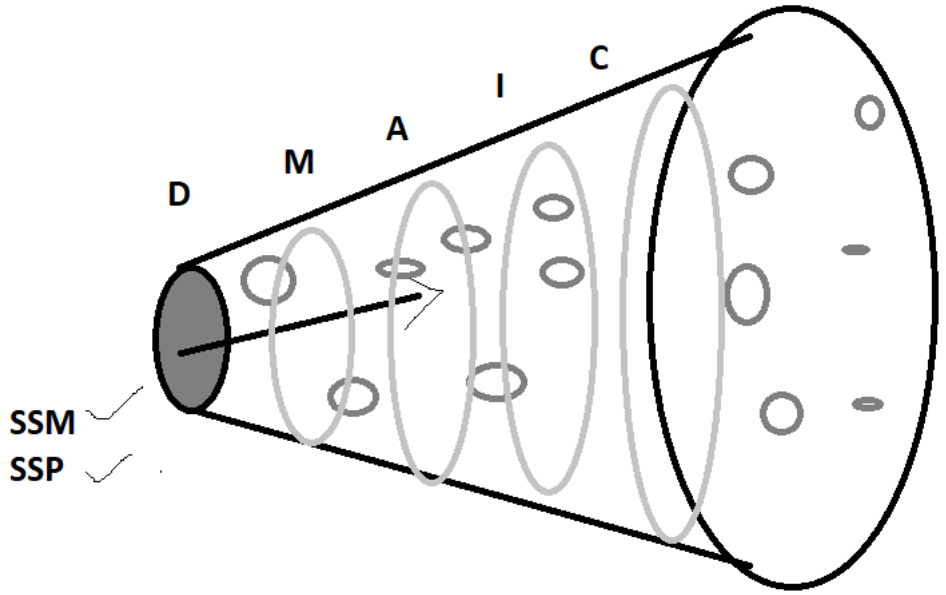
Lean

No Cost
Low Cost
Less Resources
Less Time
Low Risk

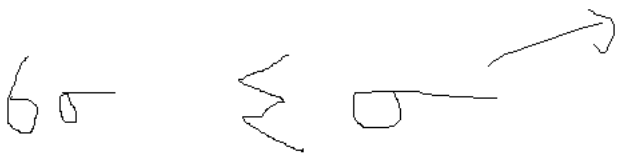
Six Sigma

More Budget
More Time
More Resources
High Risk

disruptive innovation



Six Sigma



6 sigma equates - 3.4 DPMO

18th small greek letter
A a

Defects Per Million Opportunities

3.4 defects in 1 million Opportunities = 6 sigma

Opportunities Means Chances

2000 units * 5 parameters
100000 opportunities, (chances) to make a good product or to make a mistake (defects/errors/rejection/rework)

PROCESS SIGMA TABLE

32%

SIGMA LEVEL	DEFECT RATE	YIELD
2σ	308,770 dpmo	69.10000%
3σ	66,811 dpmo	93.33000%
4σ	6,210 dpmo	99.38000%
5σ	233 dpmo	99.97700%
6σ	3.44 dpmo	99.99966%

3.8

99%

0.019

0-1

Kelly - QD

1 million opportunities

counted

measured

SIGMA LEVEL	DEFECT RATE	YIELD
2σ	308,770 dpmo	69.10000%
3σ	66,811 dpmo	93.33000%
4σ	6,210 dpmo	99.38000%
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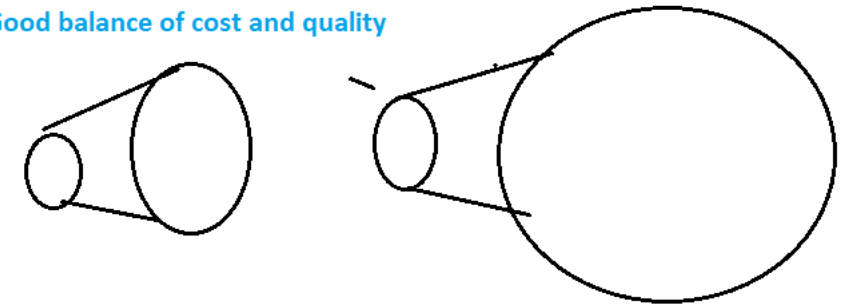
6σ	3.44 dpmo	99.99966%

Good balance of cost and quality

Time

Resources

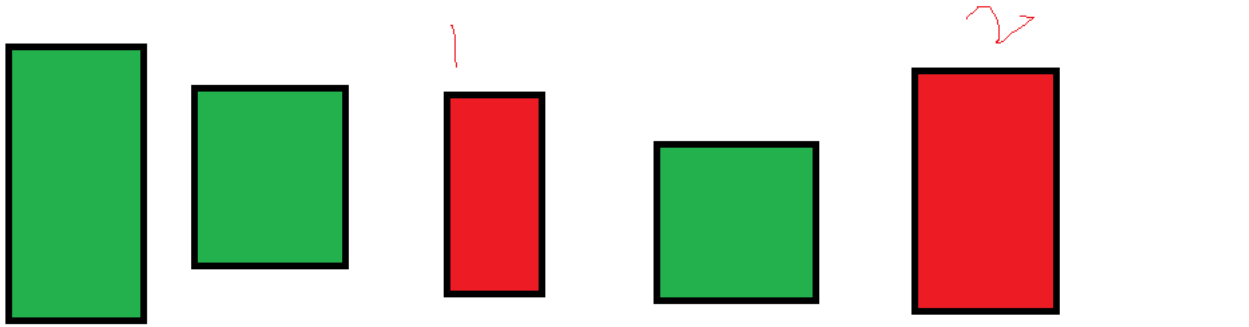
Budget



60 /100 = 60%

What's good enough?

99% Good (3.8 Sigma)	99.99966% Good (6 Sigma)
20,000 lost articles of mail per hour (based on 2,000,000/hr)	7 articles lost per hour
Unsafe drinking water for almost 15 minutes each day	1 unsafe minute every 7 months
5,000 incorrect surgical operations per week	1.7 incorrect operations per week
2 short or long landings daily at an airport with 200 flights/day	1 short or long landing every 5 years
2,000,000 wrong drug prescriptions each year	680 wrong prescriptions per year
No electricity for almost 7 hours each month	1 hour without electricity every 34 years

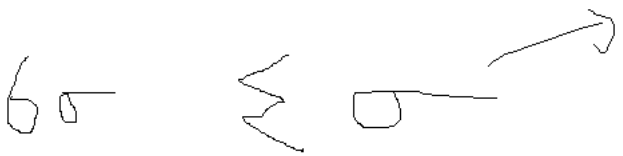


2 torn pages
1 incorrect excercise

2 mismatch mock exams
1 blank page

2 defectives with 6 defects

Six Sigma



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18th small greek letter
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Opportunities Means Chances

2000 units * 5 parameters
100000 opportunities, (chances) to make a good product or to make a mistake (defects/errors/rejection/rework)

Total production = 1200
Total defects = 650
Total defectives = 400
Opportunities = 5 parameters

DPU = 0.54
DPO = 0.108
DPMO = 108,333
Yield = 67%

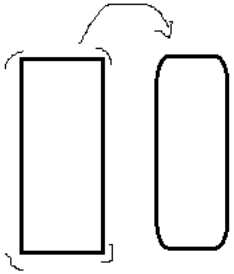
DPU, Defects Per Unit = Total defects / Total units

DPO, Defects Per Opportunity = Total defects / (Total units * number of opportunities)

DPMO, Defects Per Million Opportunities = [Total defects / (Total units * number of opportunities)] * 1000000

Yeild = (Good units / Total units) * 100

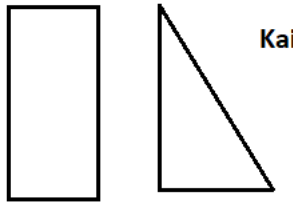
- **TPS- Toyota Prodcution System.**
- **TPS- Thinking People's System**



Kaizen

SMT
TT
MMT
JMT
Janitor
HK

Kaizen
Kai- change/modify
Zen - Good/Better



Kai- Zen

No cost
Low Cost
Less Time
Less Resources

Engagement
Team work
Partnership

Kaizen - https://www.youtube.com/watch?v=wot9DFzFRLU&t=92s&ab_channel=ExpertivityTechnologies

Waste / Muda

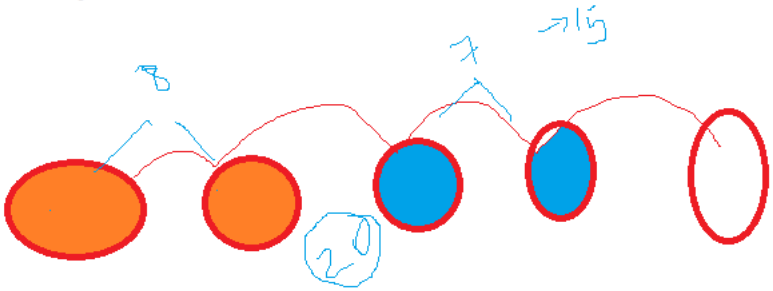
- Mura
- Muri

Defects
Overproduction
Waiting
Non-utilised talents
Excess inventory
Motion
Transportation

DOWNTIME
TIMWOODS
WORMPIIT

T
I
M
W
Overproduction (more units)
Overprocessing (NVA)
D- Defects (Waste)
S- SKILLS

Waste
but not defects



150k - SPM
2-4 months
TL - 10 (50k)

5 S
Sort
Set in order
Standardize
Shine
Sustain
Safety

Cost
Medical
Claim
Loss

5S	Japanese	English
	Seiri	Sort
	Seiton	Set in Order
	Seiso	Shine
	Seiketsu	Standardize
	Shitsuke	Sustain

Need:
1) Daily
2) Weekly
3) Monthly
4) once /twice year

Don't Need:-
Sell it
GIve it to team/dept
Donate
Trash

PROCESS SIGMA TABLE

SIGMA LEVEL	DEFECT RATE	YIELD
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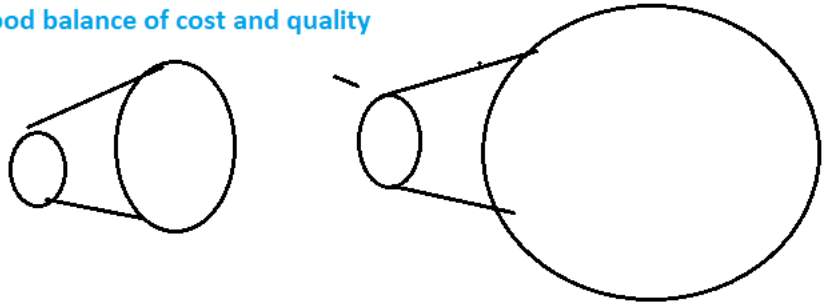


60 /100 = 60%

Define:

VOC- Voice customer (collect VOC)
KPIV and KVOP
Scope the project - SIPOC
Business Case
Project Charter - Problem statement and Goal statement

Pain areas
How much
since when
Financial impact
C-sat /D-sat
Percentage
NOT include RC and solution

SMART Goals

Sources of VOC:-
Scorecard
Surveys
Star rating/reviews
Customer Service Representatives
Claims/Returns/Replacement
Complaint trackers
VOC- internal customer (sales Rep)
Secondary data (SS, Crawler)

Collection of VOC:
Proactive
Reactive

CTQ drill down
Makes the VOC measurable

Types of VOC:-
Unclear and Vague - I didn't like your coffee, Bike, Training
Clear and Complex: Taste, temp, performance, Trainers knowledge,
Clear and Crisp : Bitter, sweet, Less than 70 DC, Poor Mileage, Unsmooth gear shifting, More vibration Engine noise, More examples, communications skills, does not anwer our queries /doubts

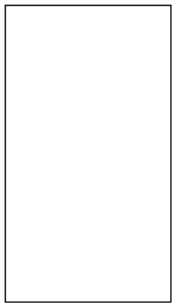
y=f (x)
Sales of Coffee = F(taste)

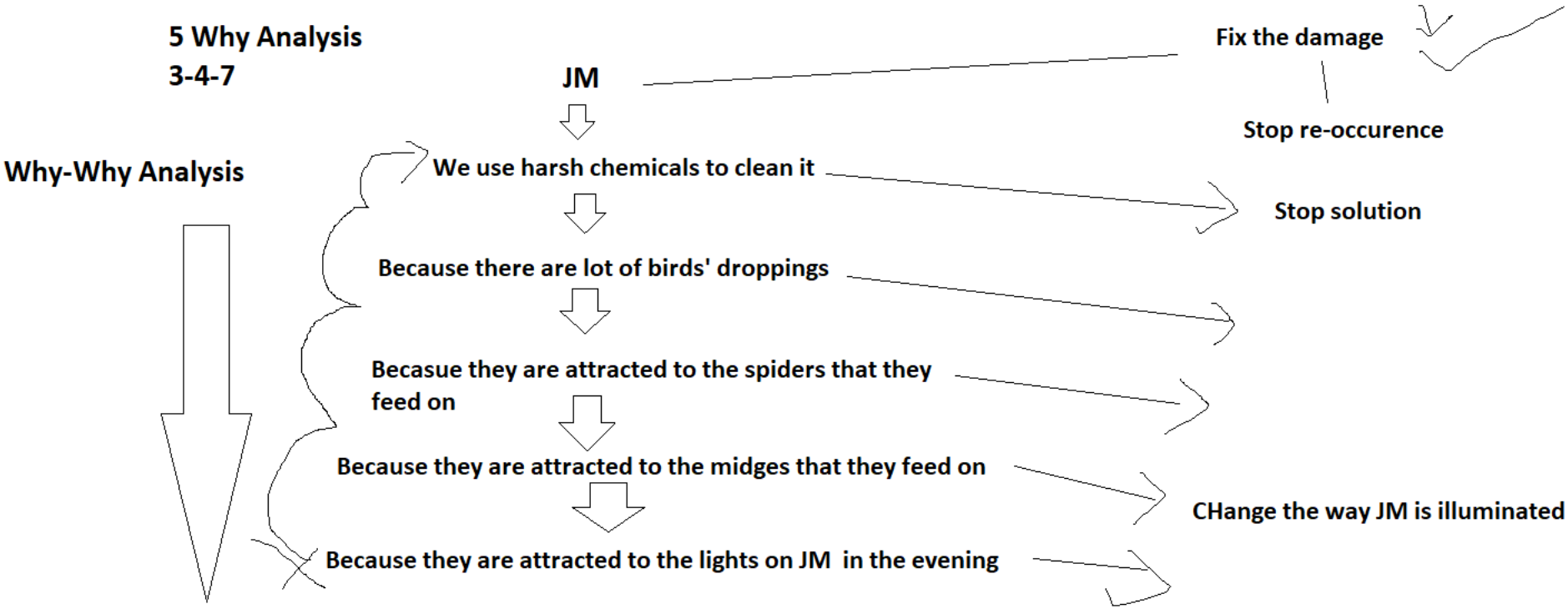
y=f(x1,x2,x3....)
Sales of Coffee = F(taste, color, aroma, price, quantity, hygiene)

It's not about measuring it right
But
To measure the right things

Weight= f(diet, workout, sleep, stress level, disease etc....)

Stomach - Collect data
- Blood test
- Sonography
- CT scan
- X-ray
- Urine test




5 Why Analysis
3-4-7
JM
Fix the damage
Stop re-occurence
Why-Why Analysis
We use harsh chemicals to clean it
Stop solution
Because there are lot of birds' droppings
Becasue they are attracted to the spiders that they feed on
Because they are attracted to the midges that they feed on
CHange the way JM is illuminated
Because they are attracted to the lights on JM in the evening

Vilfredo Preto - Italian economist

Peas pods
Pods Plants
Plants garden
Sales Produce
Sales Customers
Revenue Sales
Issues Cause

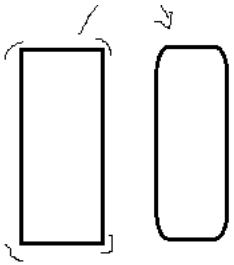
Pareto rule/graph
Vital Few and Trivial many

80:20
70:30
60:40

Time
Resource
Budget

TPS- Toyota Prodcution System.

TPS- Thinking People's System



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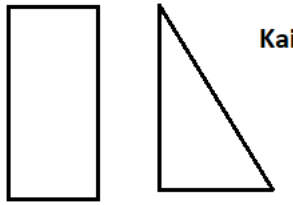


Kai- Zen

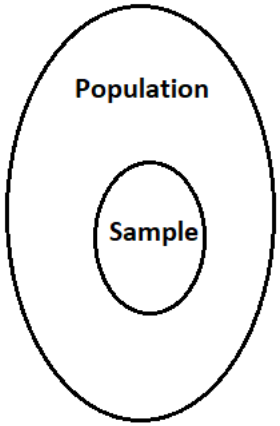
No cost
Low Cost
Less Time
Less Resources

Engagement
Team work
Partnership

Measure:-
How much
SInce When

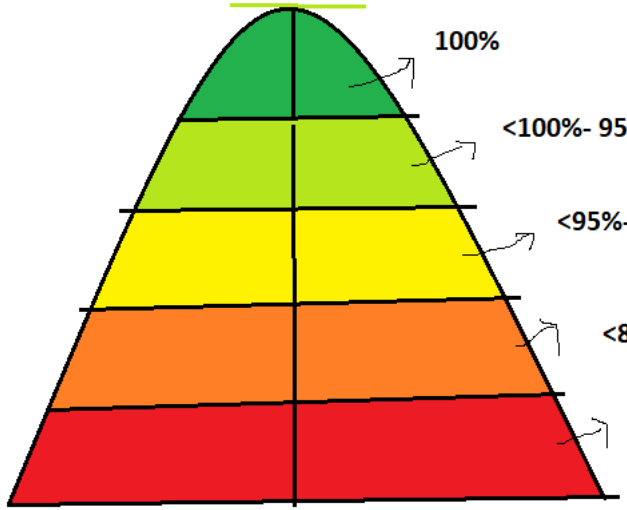
What you can't measure, you can't improve and you can't manage

Types of Data:
Data Collection:
Normal/ non-normal distribution
Base line
As- is VSM (process map)
Process capabilities (cp/cpk)
DPMO - Sigma level (current)
Measure of Central Tendency & DIspersion (mean, median, mode & range, StDev, Variance)

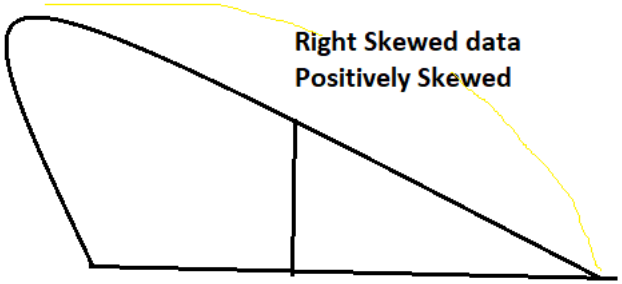


Normal

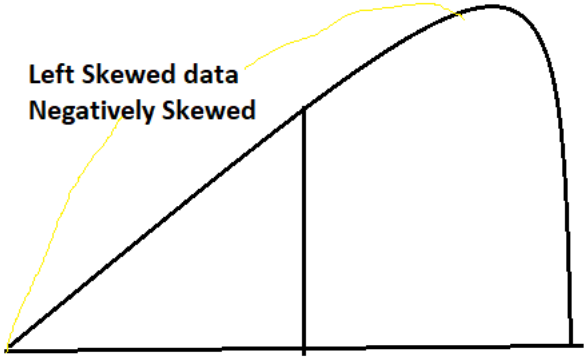
Normal Curve
Bell Curve



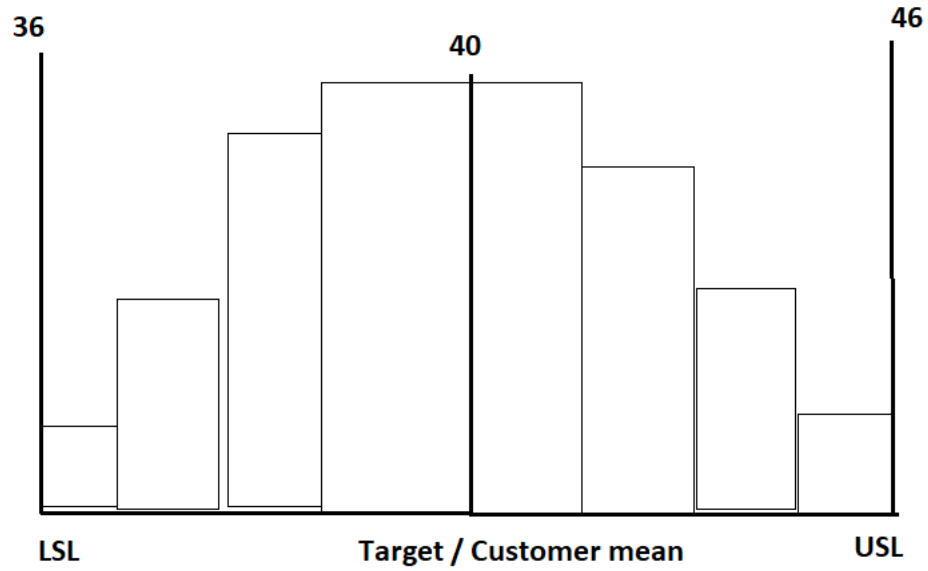
Non-Normal Curves



Right Skewed data
Positively Skewed



Left Skewed data
Negatively Skewed

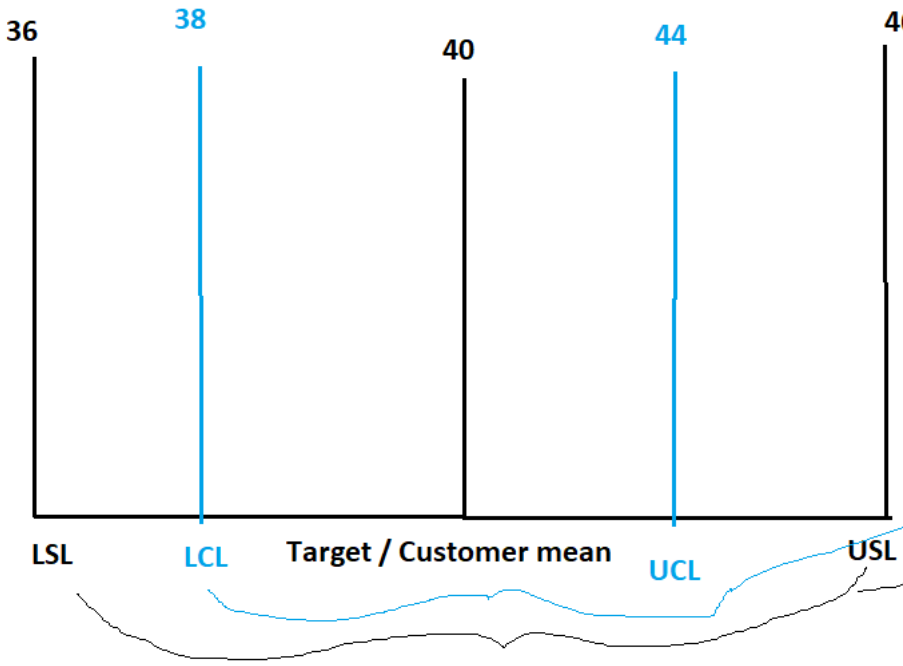


Kelly - Client - 1000 shirts

M - 40

36 - 46

David - manufacture (garments)



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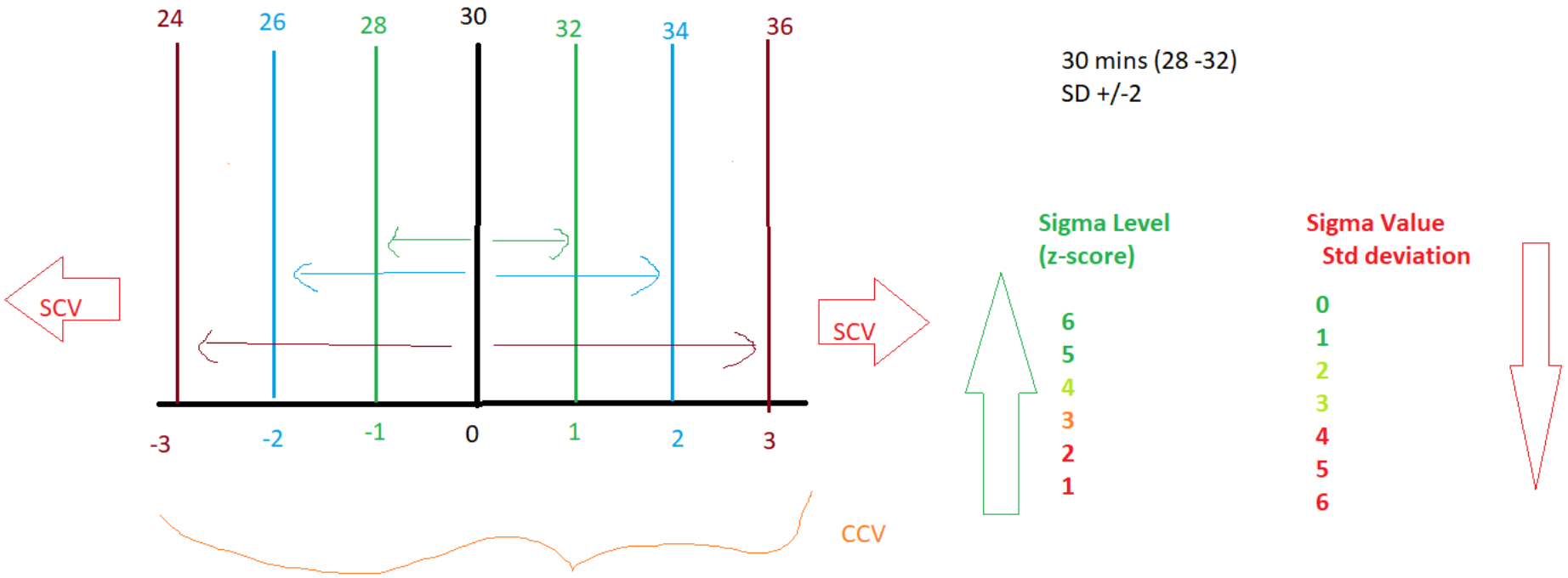
20 tailors

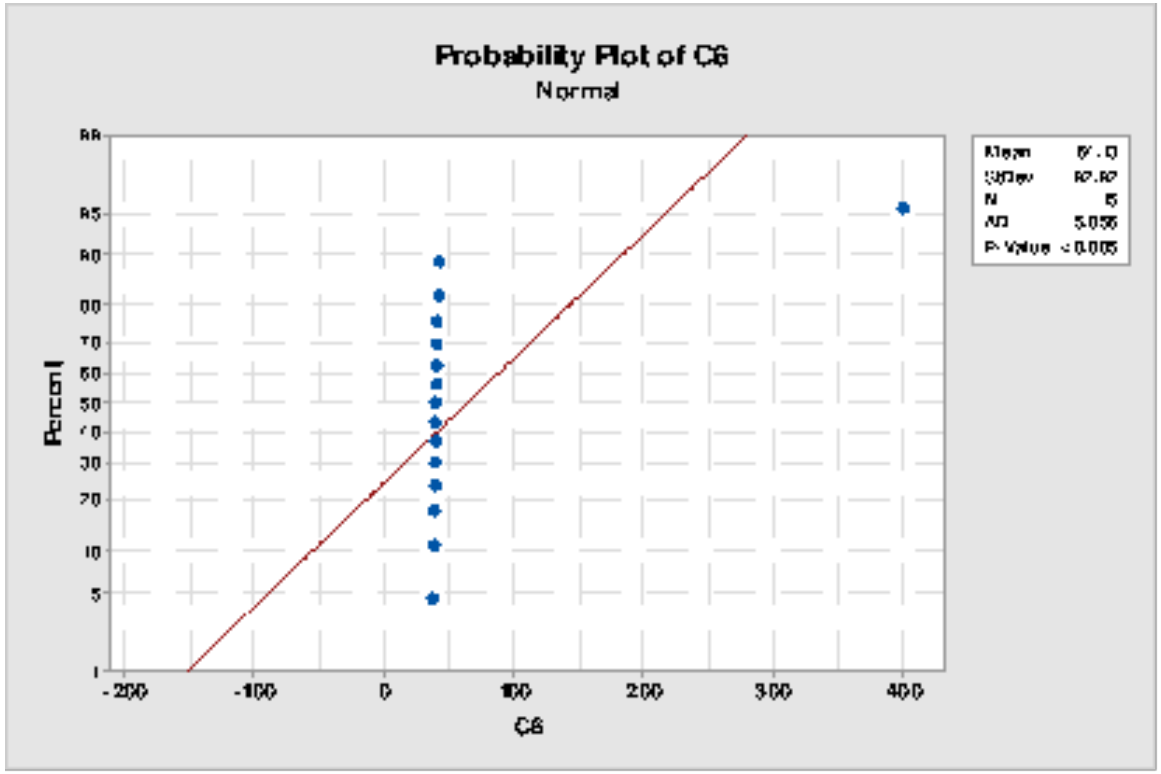
VOP- Process Control Limits

SPC control charts

VOC
Specification Limits
Tolerence Level
Freedom of variance

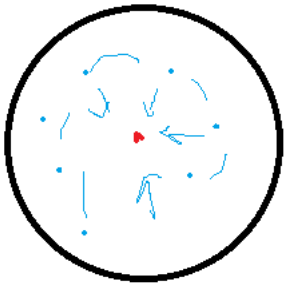
cp / cpk

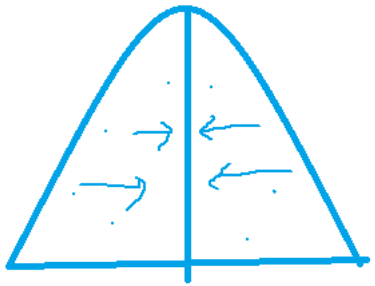

24
26
28
30
32
34
36
-3
-2
-1
0
1
2
3
SCV
SCV
CCV
30 mins (28 -32)
SD +/-2
Sigma Level
(z-score)
6
5
4
3
2
1
Sigma Value
Std deviation
0
1
2
3
4
5
6


Probability Plot of C6
Normal
Percent
C6
-200
-100
0
100
200
300
400
1
5
10
20
30
50
70
80
90
95
99
Mean
StDev
N
AD
P-Value
< 0.005

Measure of Central Tendency

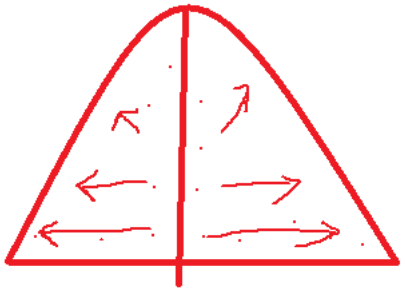
Mean, Median, Mode

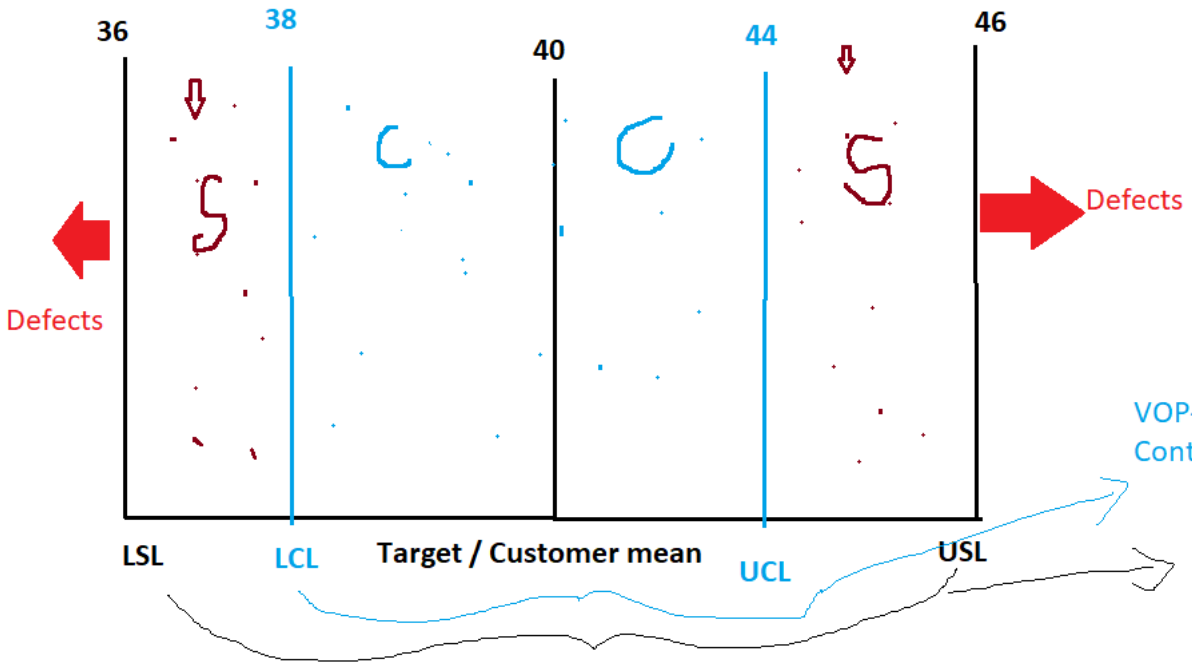




Measure of Dispersion

Range, Variance, Standard Deviation





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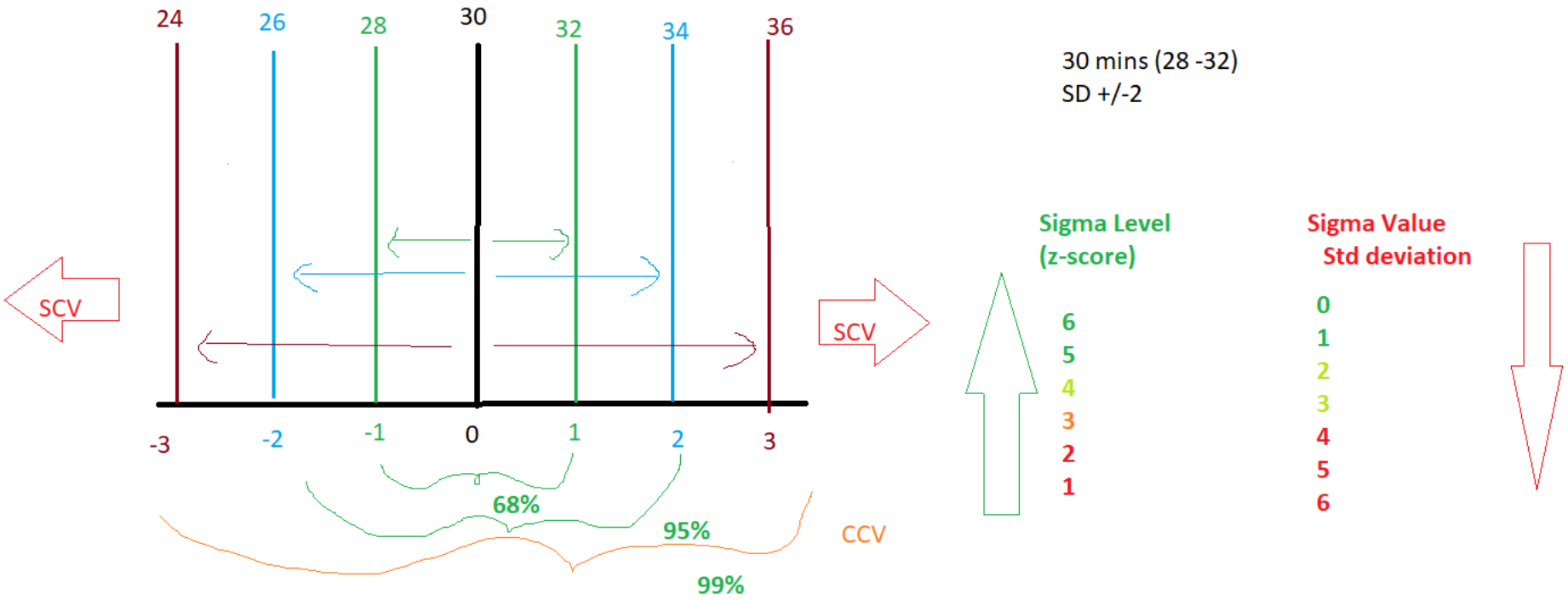
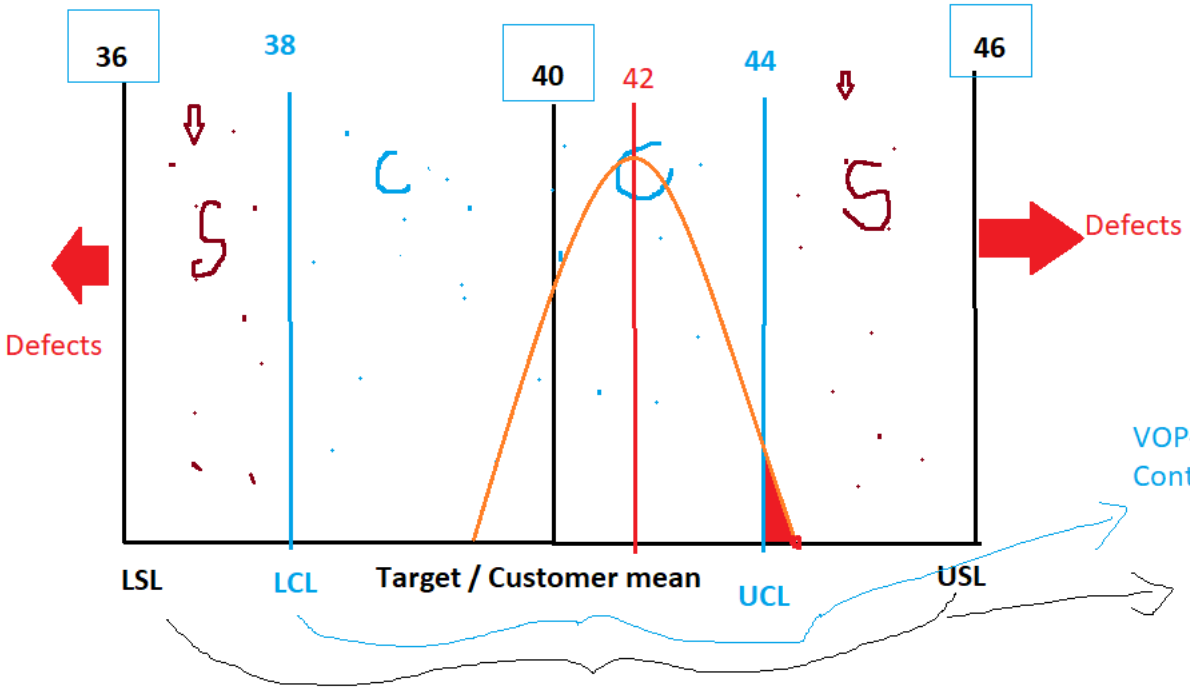

24
26
28
30
32
34
36
SCV
SCV
-3
-2
-1
0
1
2
3
68%
95%
99%
CCV
30 mins (28 -32)
SD +/-2
Sigma Level
(z-score)
6
5
4
3
2
1
Sigma Value
Std deviation
0
1
2
3
4
5
6

Data Normality

1) Histogram (bell curve)
2) Mean=Median=Mode
3) A_D test

3) A_D test
Anderson Darling Normality Test
Wilbur **Anderson** and Donald **Darling**

p-value, 0.05
More than 0.05, normal
Lesser than 0.05, non-normal



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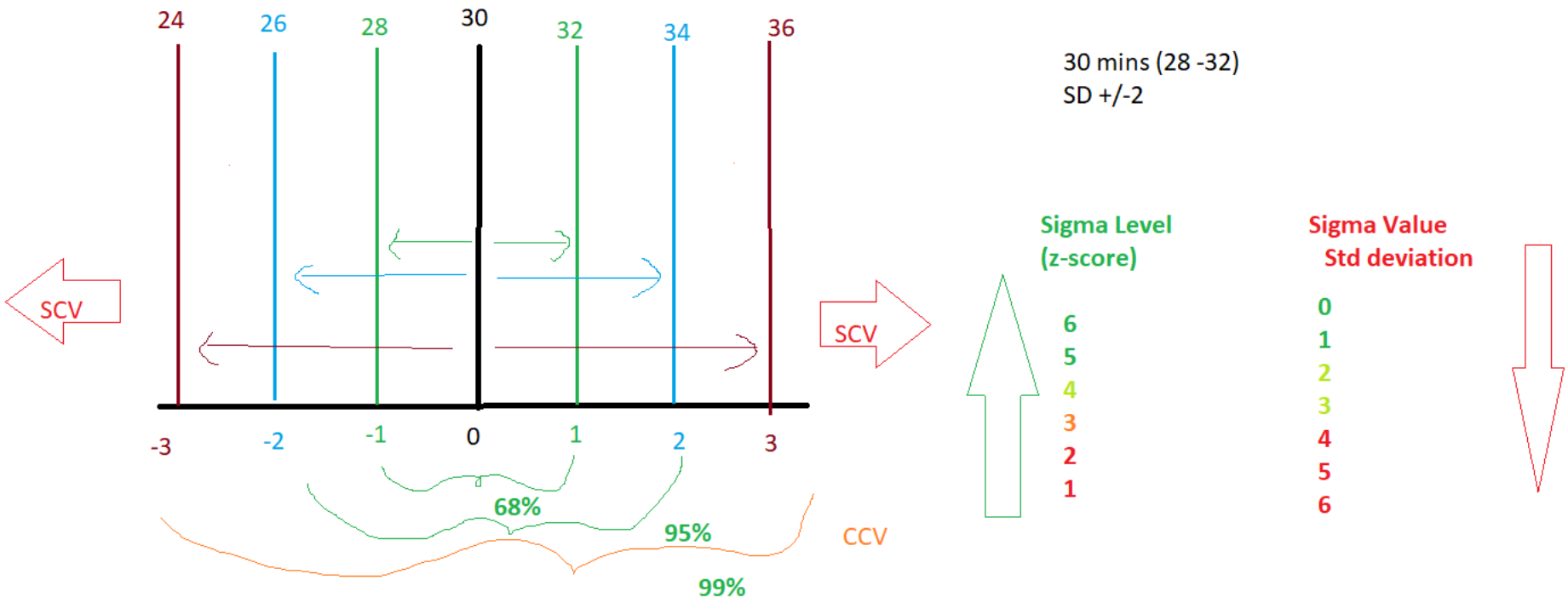


MSA :-

MSA- https://www.youtube.com/watch?v=k8NLd5linfw

Gage RnR - https://www.youtube.com/watch?v=6sRN1lCTqSM&ab_channel=LEARN%26APPLY%3ALeanandSixSigma

Before data collection , data collection plan , check Measuring system is good (MSA)

Measuring System Analysis

Home - 77
Clinic - 76
Gym - 75

Equipment Variance

Gym:-
A - 75
B - 76
C - 75.5

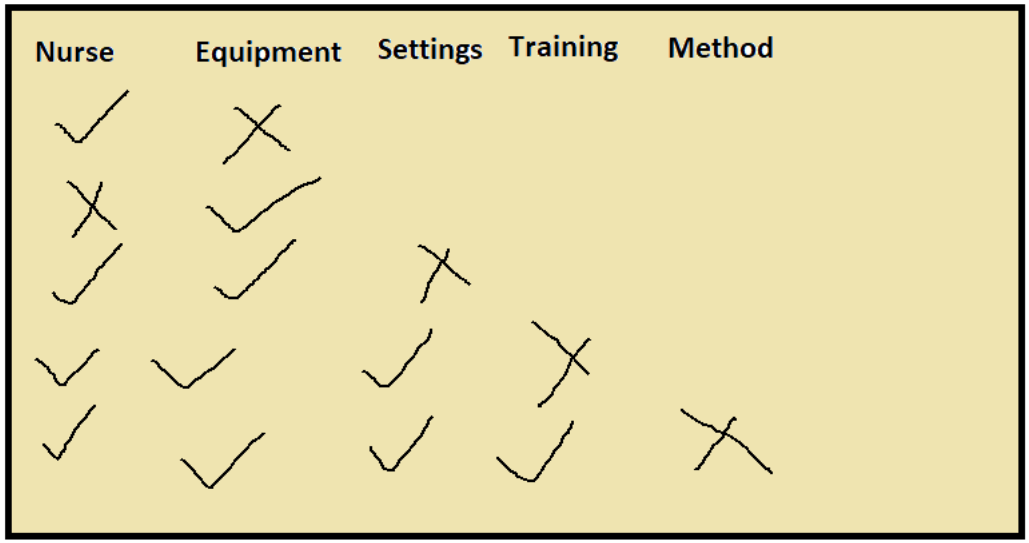
Apraiser Variance

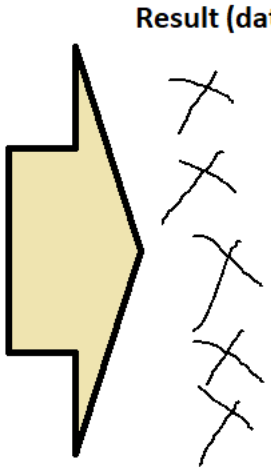
PT:-
1 - 74
2 - 75
3- 75.5

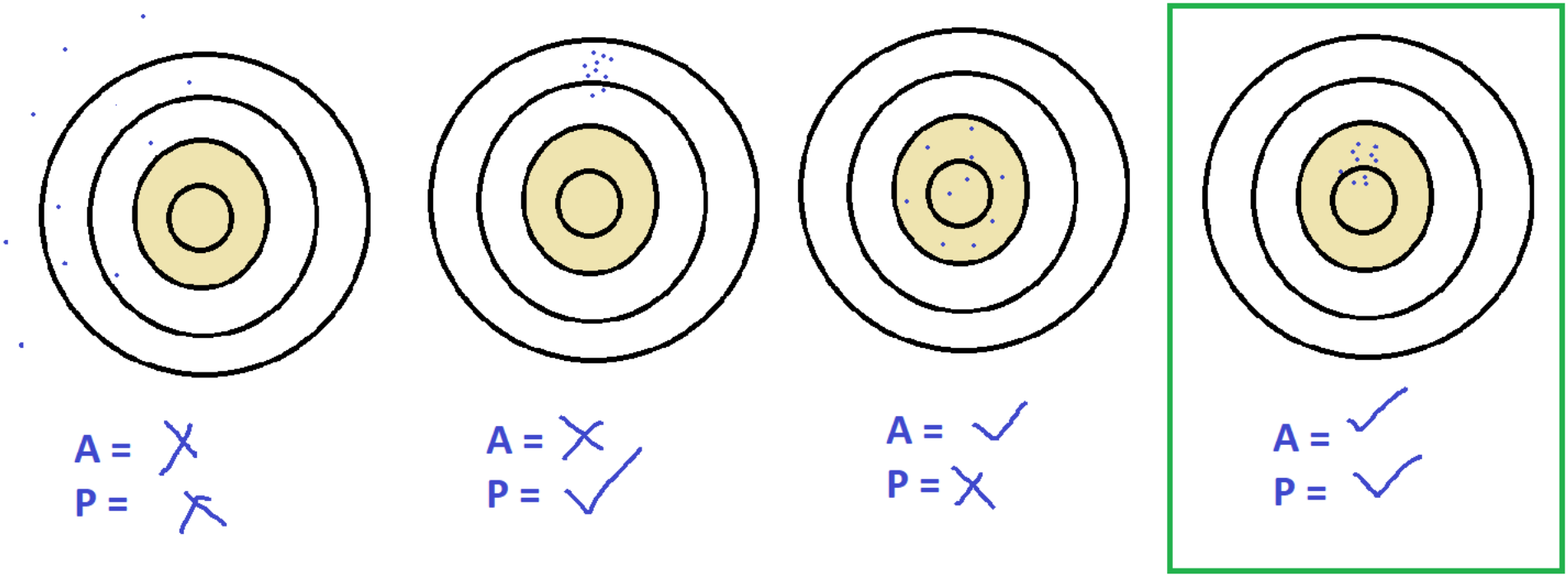
Operator variance

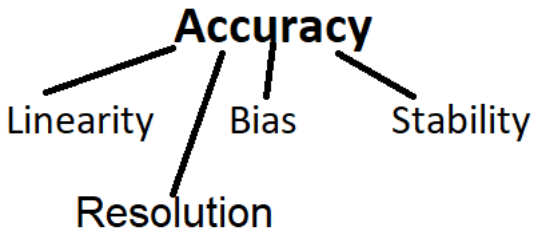
H
W
PR
BMI
Fats %

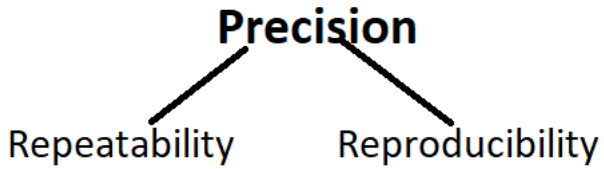
part-to-part variance






A = ✗
P = ✗
A = ✗
P = ✓
A = ✓
P = ✗
A = ✓
P = ✓





cp = (USL- LSL) / (6*SD)

cpk = (Nearest specifcation limit - Mean) / (3*SD)

cp*3 = zst (short term sigma)
cpk*3 = zlt (long term sigma)

	A	B
USL	**44**	**9.2**
LSL	**35**	**8**
Mean	**40**	**8.5**
Std dev	**2.6**	**0.09**
cp	0.577	
cpk	0.513	
zst	1.73	
zlt	1.54	

Sigma Level
1) DPMO + calc
2) cp/cpk *3

➪ Cpu = (Process mean - LSL)/ (3 * Standard deviation)

cpk = min (cpu, cpl)

➪ Cpl = (USL - Process Mean)/ (3 * Standard deviation)

min (0.64 , 0.512)

cpu= (40 - 35) / (3 * 2.6) = 0.641

cpl= (44 - 40) / (3 * 2.6) = 0.5128

SCV Long Term

Annual Revenue

Quarterly Quality score

Monthly Quality score

Weekly sale (50)

Daily sales (24)

Short Term CCV

Monthly , Quarterly

Monthly Quality score , Fortnightly

Weekly QC, Daily QCd

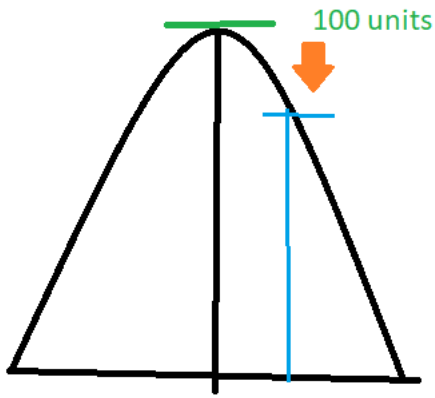
Daily - 12

Hourly sales (3) * 8 =24 sales

100 units
85 units

z-shift = zst - zlt= 1.5

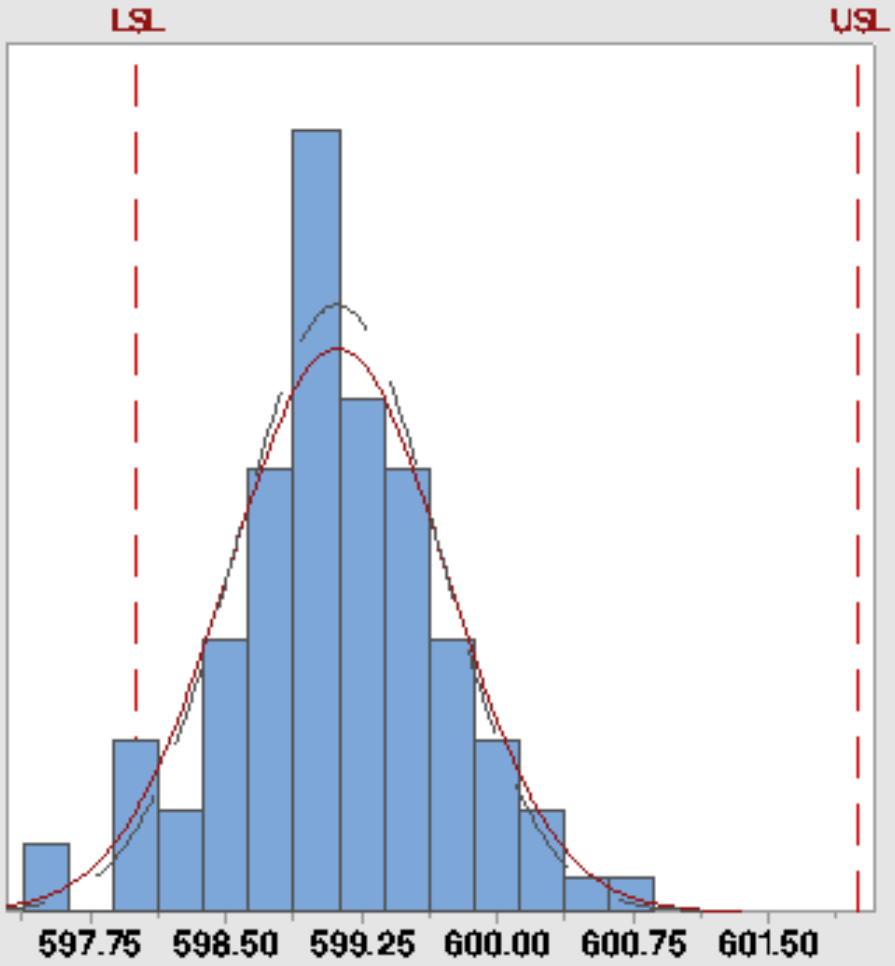
ranges from 1.4 to 1.6 ~ 1.5



	A	B	C	D	D	F
zst = 4 sigma	4	5	3	3.5	4	6
zlt = 1 sigma	3	3	2.5	3	2	3.5
z-shift	1	2	0.5	0.5	2	2.5

Process Capability Report for Supplier 1

Process Data	
LSL	598
Target	*
USL	602
Sample Mean	599.115
Sample N	100
StDev(Overall)	0.602583
StDev(Within)	0.559239



Overall
Within

Overall Capability	
Pp	1.11
PPL	0.62
PPU	1.60
Ppk	0.62
Cpm	*

Potential (Within) Capability	
Cp	1.19
CPL	0.66
CPU	1.72
Cpk	0.66

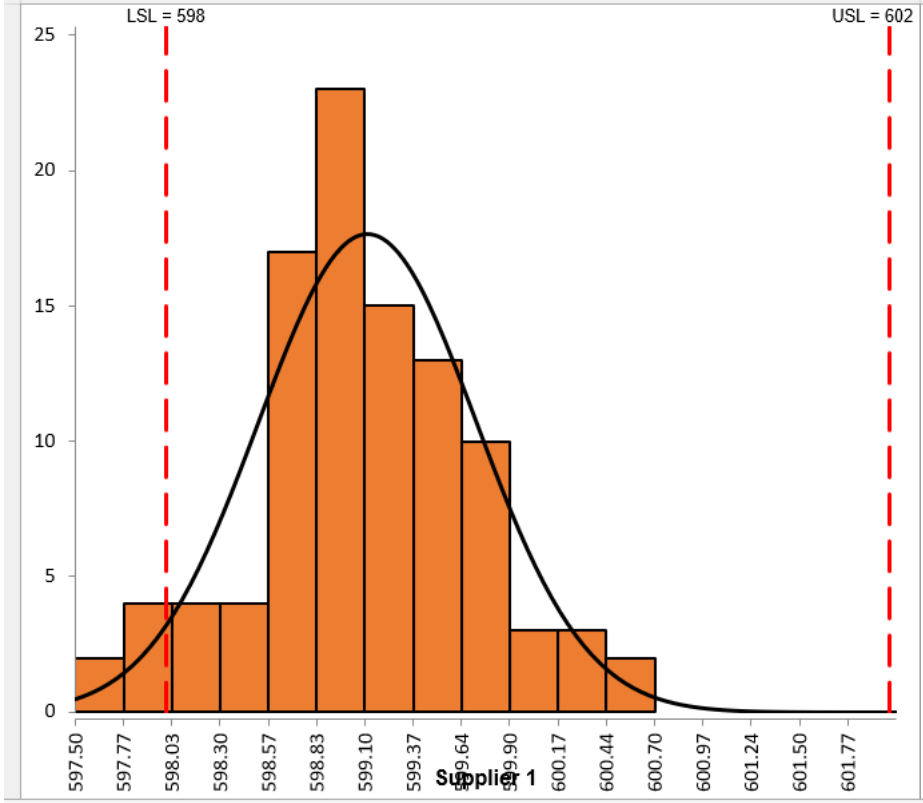
Performance

	Observed	Expected Overall	Expected Within
PPM < LSL	30000.00	32130.26	23088.05
PPM > USL	0.00	0.84	0.12
PPM Total	30000.00	32131.10	23088.18

Process Capability Indices - Continuous Data

(Assumes that data are normally distributed)

Sample Data (user inputs):		
Mean	x-bar	40
Standard Deviation	s	2.6
Upper specification limit	USL	44
Lower specification limit	LSL	35
Results:		
Cp, Pp		0.58
Cpu, Ppu		0.51
Cpl, Ppl		0.64
Cpk, Ppk		0.51



Supplier 1

Count = 100
Mean = 599.12
StDev (Overall) = 0.602583
USL = 602
Target =
LSL = 598

Capability Indices using Overall Standard Deviation
Pp = 1.11
Ppu = 1.60
Ppl = 0.62
Ppk = 0.62
Cpm =

Expected Overall Performance
ppm > USL = 0.8
ppm < LSL = 32130.3
ppm Total = 32131.1
% > USL = 0.00%
% < LSL = 3.21%
% Total = 3.21%

Actual (Empirical) Performance
% > USL = 0.00%
% < LSL = 3.00%
% Total = 3.00%

Process Sigma Level Calculator - Discrete Data

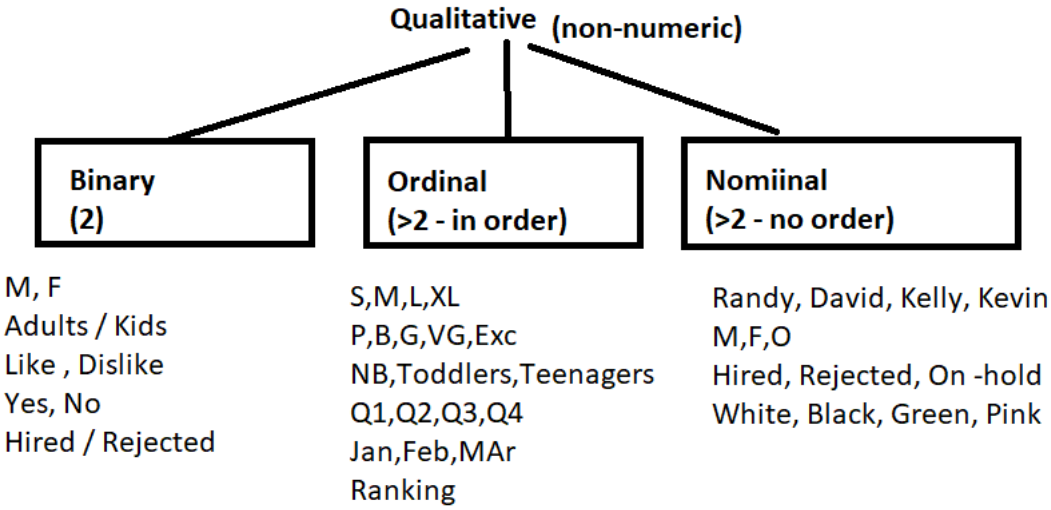
Sample Data (user inputs):		
Number of units	n	1,200
Total number of defects observed	d	650
Number of defect opportunities per unit	o	5
Sigma Shift (typically +1.5)		1.5
Results:		
Defects per Unit	dpu	0.541666667
Defects per Million Opportunities	dpmo	1,08,333.3
Defects per Opportunity	dpo%	10.83%
Yield	yield%	89.17%
Process Sigma Level	sigma	2.735

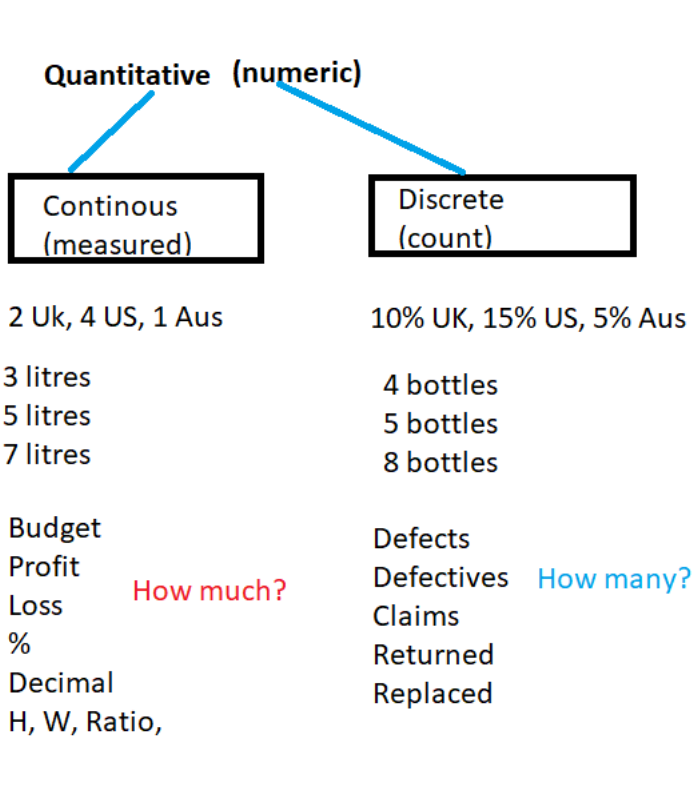
Process Sigma Level Calculator - Continuous Data

(Assumes that data are normally distributed)

Sample Data (user inputs):		
Mean	x-bar	40
Standard Deviation	s	2.6
Upper Specification Limit	USL	44
Lower Specification Limit	LSL	35
Sigma Shift (typically +1.5)		1.5

Results:	
Expected ppm > USL	61967.9
Expected % > USL	6.20%
Expected ppm < LSL	27235.2
Expected % < LSL	2.72%
Expected ppm (overall)	89203.1
Expected yield (overall) %	91.08%
Process Sigma Level	2.846


Qualitative (non-numeric)
Binary (2)
Ordinal (>2 - in order)
Nomiinal (>2 - no order)
M, F
Adults / Kids
Like , Dislike
Yes, No
Hired / Rejected
S,M,L,XL
P,B,G,VG,Exc
NB,Toddlers,Teenagers
Q1,Q2,Q3,Q4
Jan,Feb,MAr
Ranking
Randy, David, Kelly, Kevin
M,F,O
Hired, Rejected, On -hold
White, Black, Green, Pink


Quantitative (numeric)
Continous (measured)
Discrete (count)
2 Uk, 4 US, 1 Aus
3 litres
5 litres
7 litres
Budget
Profit
Loss
%
Decimal
H, W, Ratio,
How much?
10% UK, 15% US, 5% Aus
4 bottles
5 bottles
8 bottles
Defects
Defectives
Claims
Returned
Replaced
How many?

Next week:-

LEAN SOLUTIONS brought to you by: PATRICK ADAMS CONSULTING

Analyze Phase

Please watch these videos for the next class:-

https://www.youtube.com/watch?v=8JOJ_7R_OWY - simple linear regression on excel

https://www.youtube.com/watch?v=HgfHefwK7VQ - multiple linear regression on excel

Scatter Diagram : - https://www.youtube.com/watch?v=1D2gudv591M

https://www.youtube.com/watch?v=SG3_mWwReac

Gemba academy - DEO –https://www.youtube.com/watch?v=tZWAYbKYVjM&t=53s
What is Design of Experiments (DoE)? Example: https://www.youtube.com/watch?v=Srq9Q-yd1Rk

Design of Experiments DOE used in Service and Transactional Businesses as well as Manufacturing.
By John Dennis and Paul Allen
https://www.youtube.com/watch?v=tmEe9GdKBNY&ab_channel=LeanSixSigmaTrainingLtd

Analyse:-

Hypothesis Test

Null is a claim or a belief which does not need any proof

Alternate hypothesis

P-value is more than 0.05, accept the Null
P-value is less than 0.05, Reject the Null

He is innocent until proven guilty

He is innocent - Null Hypothesis
He is not innocent - Alternate Hypothesis

Judge = Proof, photo, witness, camera footage (data)
There is a risk involved in trusting the data.

P-value is more than 0.05, CCV , not satistically significant (no impact)
P-value is less than 0.05, SCV , satistically significant (has impact)

Null Hypothesis
Alternate Hypothesis

P-value (0.05)
Risk
Alpha
Beta

Type 1 and 2 error

Sky is blue
Schools have teachers
Teachers are strict
The sun rises in the east
Sun is hot
Temperature in California is 100DC

Analyse:

Collected data in the measure phase. Toll gate Revieo
RCA - Fishbone+ 5 Why anlalyse
Hypothesis Test

Risk	alpha	CI
5%	0.05	95%
4%	0.04	96%
10%	0.1	90%
3%	0.03	97%

How much risk is OK?

New business = 80% profit - 20% loss (risk)
Steel or iron industry = 10% is ok
Pharma / medicines = 10% is not ok
5% is still a risk ...
>3%

Over the decades , statisticians or business leaders or experts have decided that 5-10% risk is ok.
Minimum risk is better.
5% risk is OK
This risk is alpha, which is the p-value

P-value is more than 0.05, CCV , not satistically significant (no impact)
P-value is less than 0.05, SCV , satistically significant (has impact)

P-value is more than 0.05, accept the Null
P-value is less than 0.05, Reject the Null

P-value is more than 0.05, accept the Null
P-value is less than 0.05, Reject the Null

If you reject Null, **Type 1 error** , risk alpha, **producer's risk**
If you accept Null, **Type 2 error**, risk beta, **consumer's risk**

Assumption = Good
Reality = Good
Assumption = Reality
Null Hypothesis , Accept

It wasn't good
If you reject Null
Type 1 error

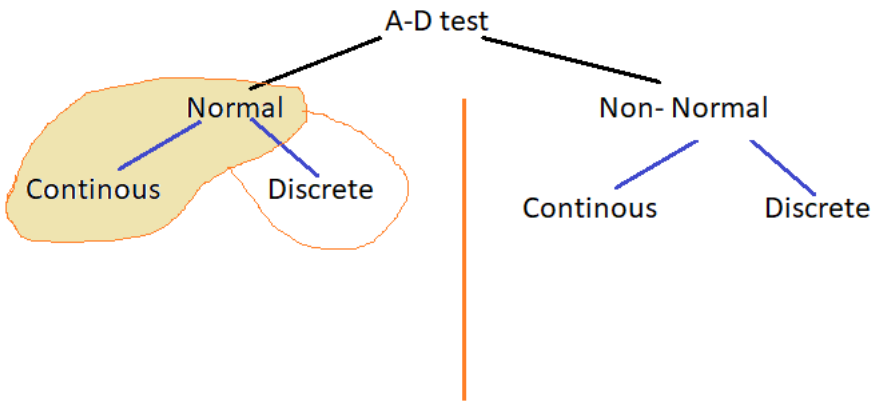
Titanic
Assumption = Good
Reality = Good
Assumption = Reality
It was not good
Producer's risk

Assumption = Good
Reality = Not so good
Assumption ≠ Reality
Alternate Hypothesis , Reject Null

It was good
Failing to reject Null
Type 2 error

Me Time
Assumption = Good
Reality = Not so good
Assumption ≠ Reality

It was good.
Type 2 error
Consumers will watch it
Consumer's risk



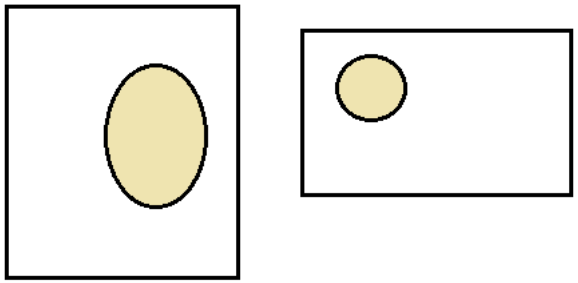
Difference between t and z tests

t-test
Sample size (<30)
both the samples should be equal
12 - 12
08 - 08
21-21
29-29

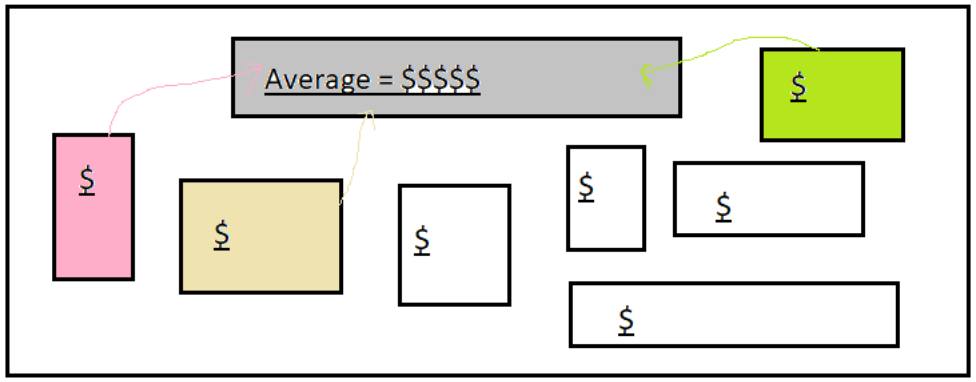
z-test
Sample size (>30)
samples can be equal / unequal
32-32
32-300
48-48
48-340

Difference between 1-sample and 2-sample tests

2 sample tests are when the samples
are compared from 2 different population



1-sample test
When the sample is compared with the **AVERAGE** of the **same** POPULATION



Paired t -test:-

Paired t-test **Before - After**

Pharma - BP patients
1 month course
1tab+1cap+1inj

20 sales reps
cost per head
8 sales rep- training
12 - BAU

Before	After
30	150
32	200
31	30
350	65
150	230
32	56
90	92
15	20

P-value is more than 0.05, CCV , not satistically significant (no impact)
P-value is less than 0.05, SCV , satistically significant (has impact)

P-value is more than 0.05, accept the Null
P-value is less than 0.05, Reject the Null

1 way Anova

		Kelly	David	Kevin
Voice	CS	80%	52%	100%
		75%	62%	100%
		86%	89%	25%
Chat email	Sales	96%	100%	25%
		93%	63%	60%
		95%	100%	98%

2 way Anova

1 way Anova

Detergents

	Det 1	Det 2	Det 3
cold	80%	52%	100%
	75%	62%	100%
	86%	89%	25%
Hot	96%	100%	25%
	93%	63%	60%
	95%	100%	98%

2 way Anova

Parametric tests - Normal
Non Parametric tests - Non-Normal

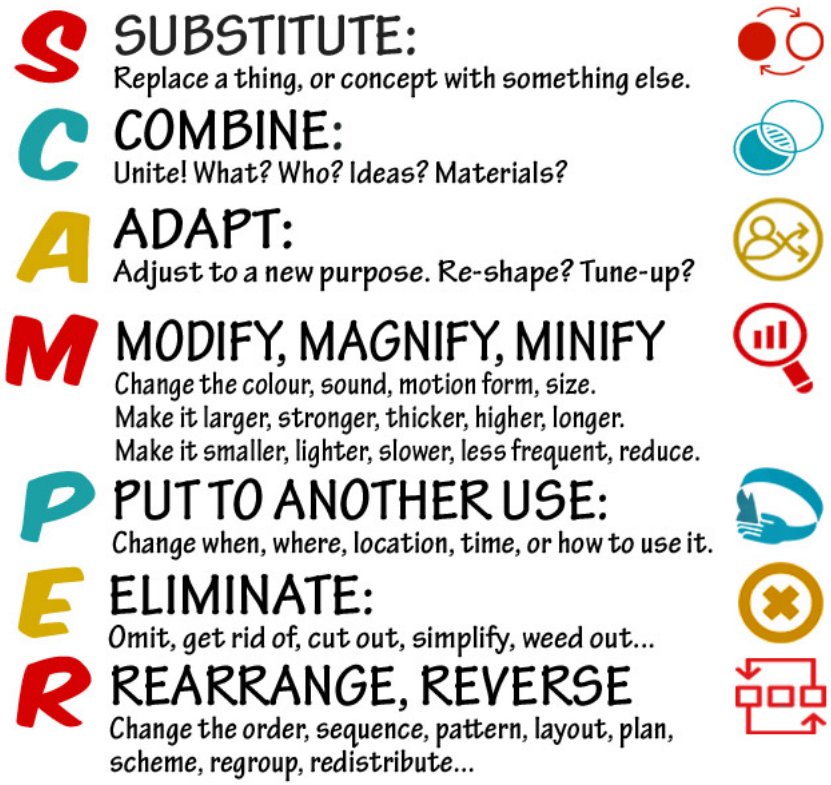
Analyze Phase: Hypothesis Testing with Non-Normal Data

Non-Parametric	*Parametric (normal data)*
1 Sample Sign	One-sample t-test
1 Sample Wilcoxon	Paired t-test
Mann-Whitney	2 sample t-test
Kruskal-Wallis	One-way ANOVA
Mood's Median	One-Way ANOVA
Friedman	Balanced ANOVA

Will discuss more with examples

One- and Two-Sample Proportion: (for pass/fail data)
Chi-Squared (Contingency Tables): (for association)

Improve:-



PICK chart – prioritize the solution.

CBR = Cost Benefit Ratio
CBA = Cost Benefit Analysis

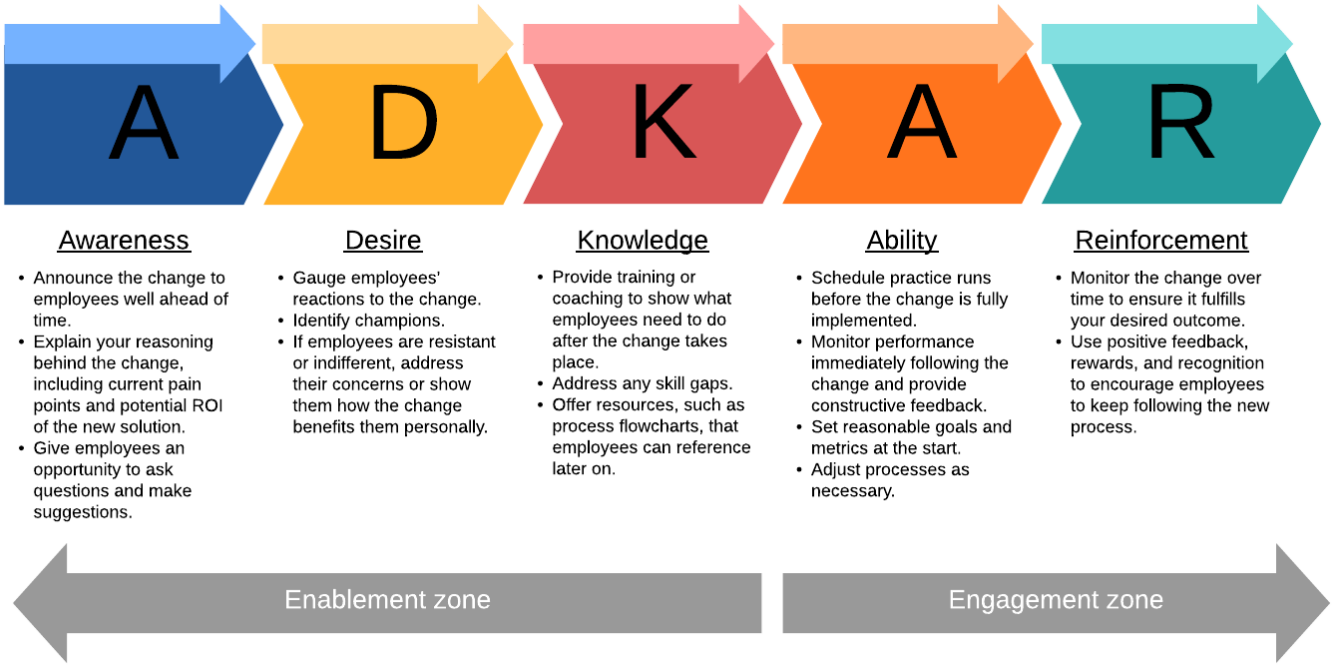
Cost = 100
Benefit = 200

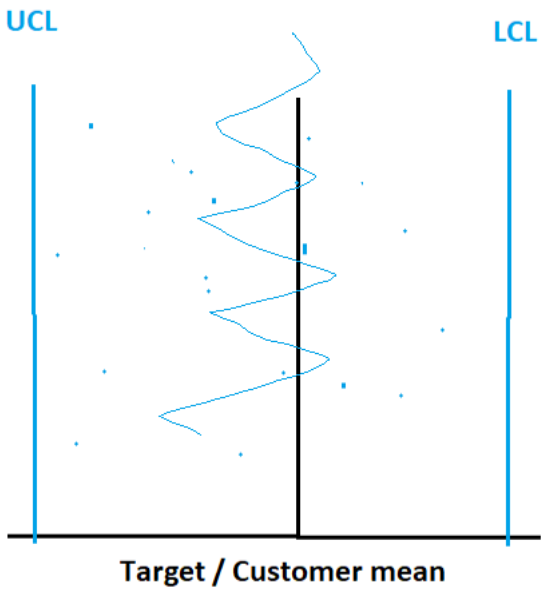
CBR : B/C

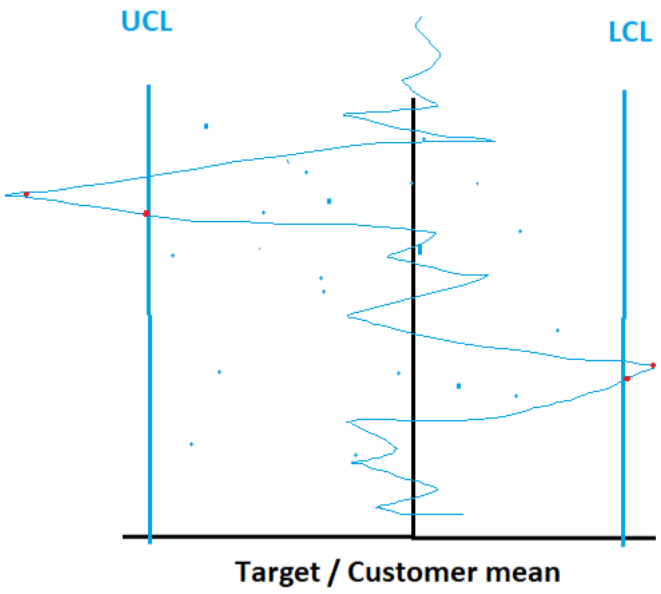
CBR > 1 , do it
CBR < 1 , do it
CBR = 1 , getting approval is difficult.
Check for hidden benefits

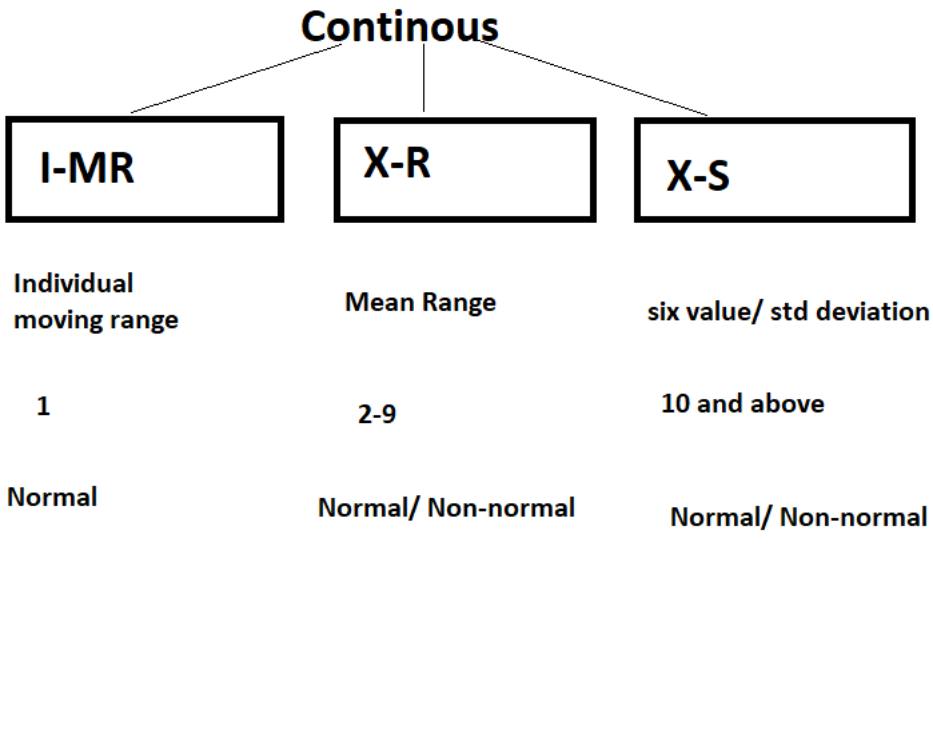
Change Management

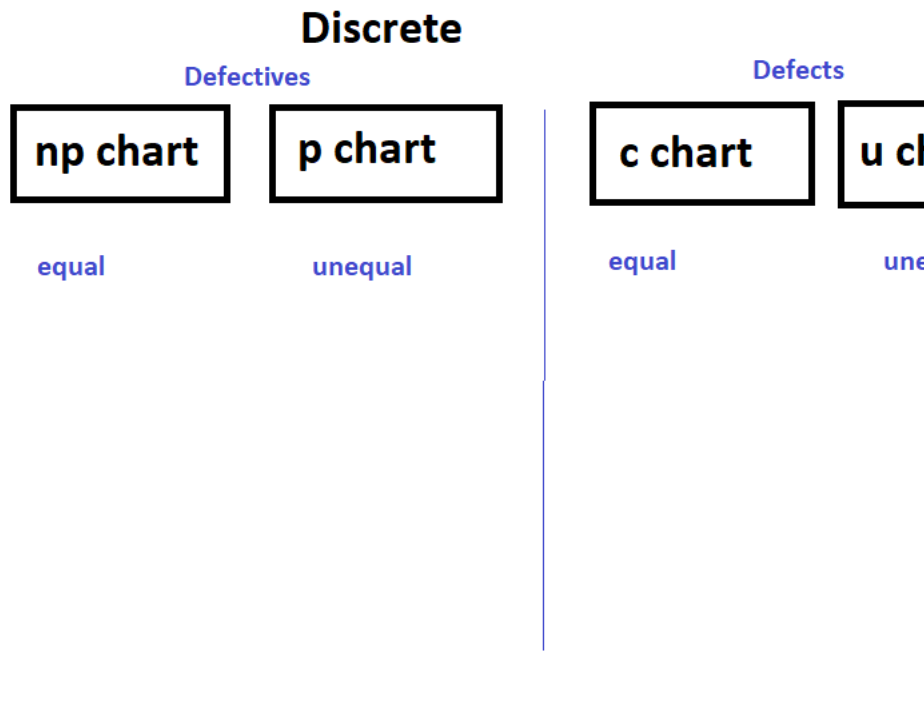
ADKAR

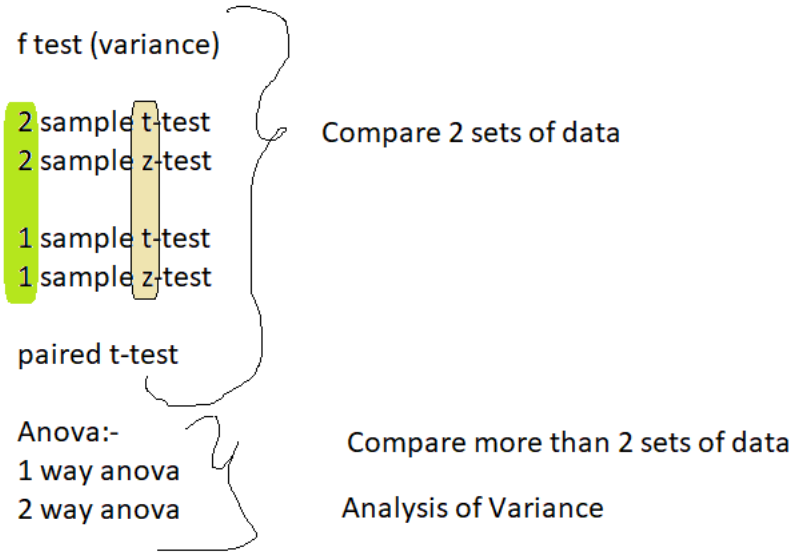

A
D
K
A
R
Awareness
Announce the change to employees well ahead of time.
Explain your reasoning behind the change, including current pain points and potential ROI of the new solution.
Give employees an opportunity to ask questions and make suggestions.
Desire
Gauge employees' reactions to the change.
Identify champions.
If employees are resistant or indifferent, address their concerns or show them how the change benefits them personally.
Knowledge
Provide training or coaching to show what employees need to do after the change takes place.
Address any skill gaps.
Offer resources, such as process flowcharts, that employees can reference later on.
Ability
Schedule practice runs before the change is fully implemented.
Monitor performance immediately following the change and provide constructive feedback.
Set reasonable goals and metrics at the start.
Adjust processes as necessary.
Reinforcement
Monitor the change over time to ensure it fulfills your desired outcome.
Use positive feedback, rewards, and recognition to encourage employees to keep following the new process.
Enablement zone
Engagement zone

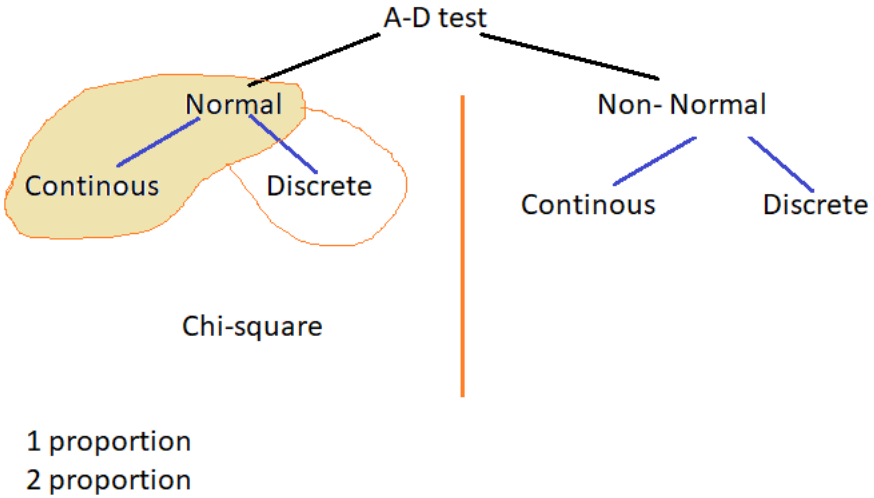

UCL
LCL
Target / Customer mean


UCL
LCL
Target / Customer mean


Continous
I-MR
X-R
X-S
Individual moving range
Mean Range
six value/ std deviation
1
2-9
10 and above
Normal
Normal/ Non-normal
Normal/ Non-normal


Discrete
Defectives
Defects
np chart
p chart
c chart
u ch
equal
unequal
equal
une


f test (variance)
2 sample t-test
2 sample z-test
1 sample t-test
1 sample z-test
paired t-test
Compare 2 sets of data
Anova:-
1 way anova
2 way anova
Compare more than 2 sets of data
Analysis of Variance


A-D test
Normal
Non- Normal
Continous
Discrete
Continous
Discrete
Chi-square
1 proportion
2 proportion