

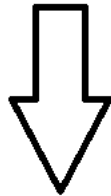
Toyota

Lean

Reduce waste
Efficient
Speed/Simple
Flexible

120 pounds vs 95 pounds
Detox plan

Eliminate/Reduce:-
Toxins
Fats
Fluids
water retention
Impurities



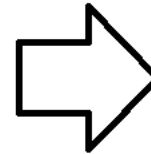
Motorola

Six Sigma

Reduce Variation
Effective
Quality/Accuracy
DMAIC

Good things

High fibrous
HP
HIIT
Supplements
PS
Multivitamins



Lean Six Sigma

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,

High fibrous
HP
HIIT
Supplements
PS
Multivitamins

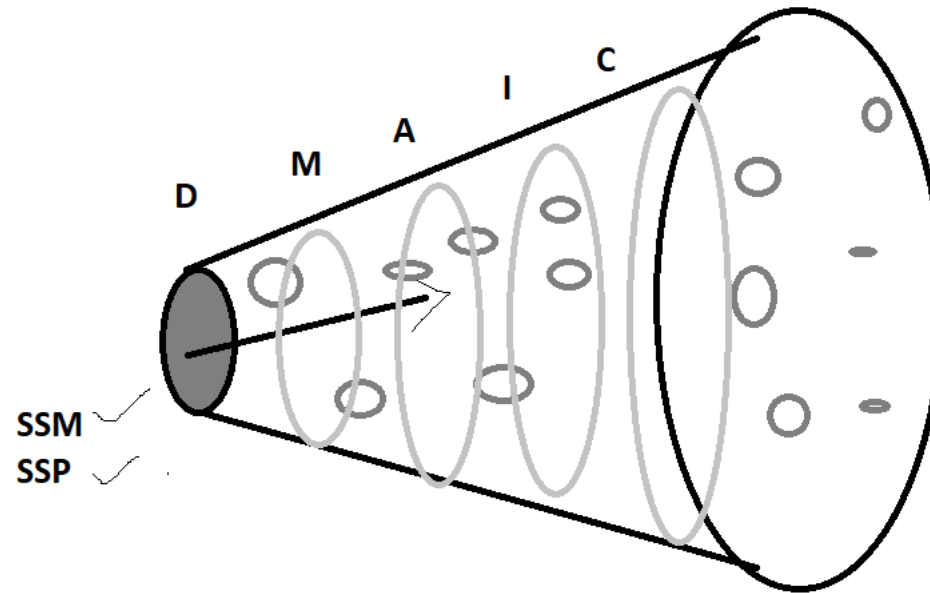
Lean

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

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%

3.8

99%

70

0.019

0-1

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

Kelly - QD

1 million opportunities

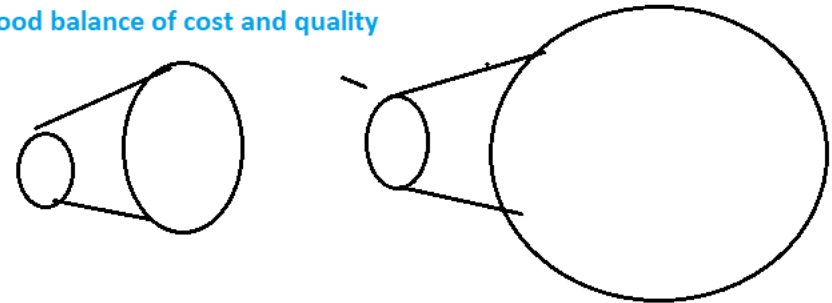
counted

measured

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

Good balance of cost and quality

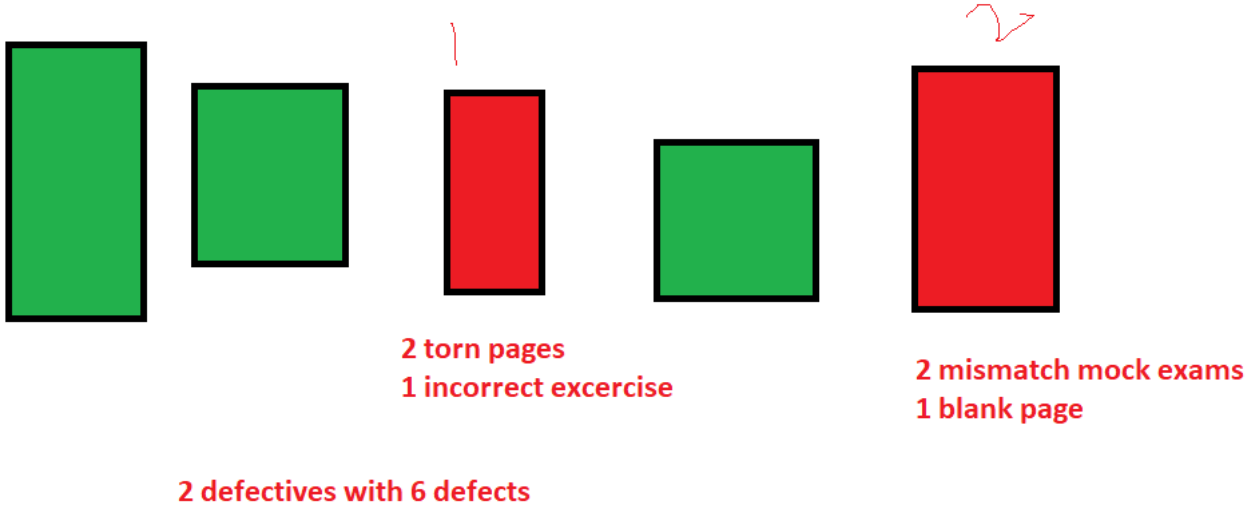
Time
Resources
Budget



$60 / 100 = 60\%$

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



Six Sigma

6 sigma equates - 3.4 DPMO

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)

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

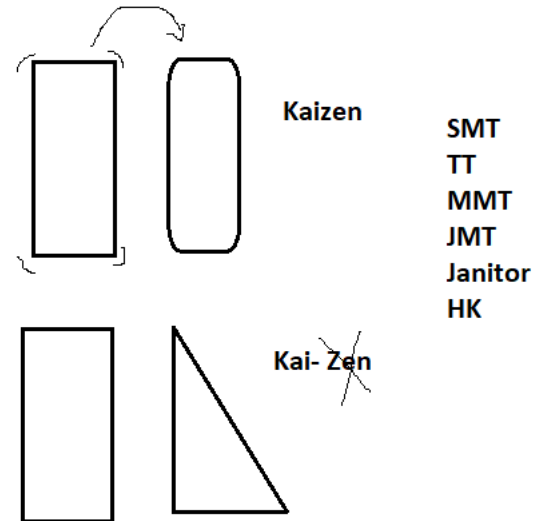
✓ TPS- Toyota Production System.

✓ TPS- Thinking People's System

Kaizen
Kai- change/modify
Zen - Good/Better

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

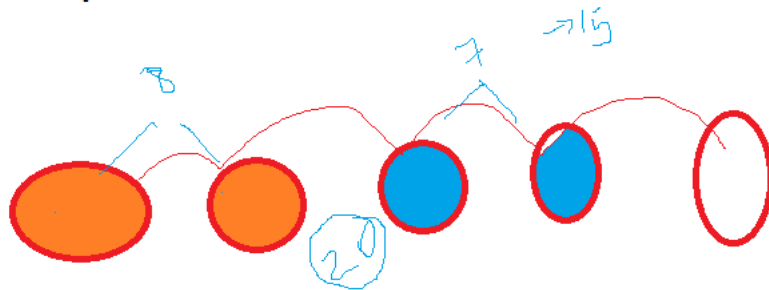
Defects
Overproduction
Waiting
Non-utilised talents
Excess inventory
Motion
Transportation

DOWNTIME
TIMWOODS
WORMPIIT

T
I
M
W

Waste
but not defects

Overproduction (more units)
Overprocessing (NVA)
D- Defects (Waste) →
S- SKILLS →



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

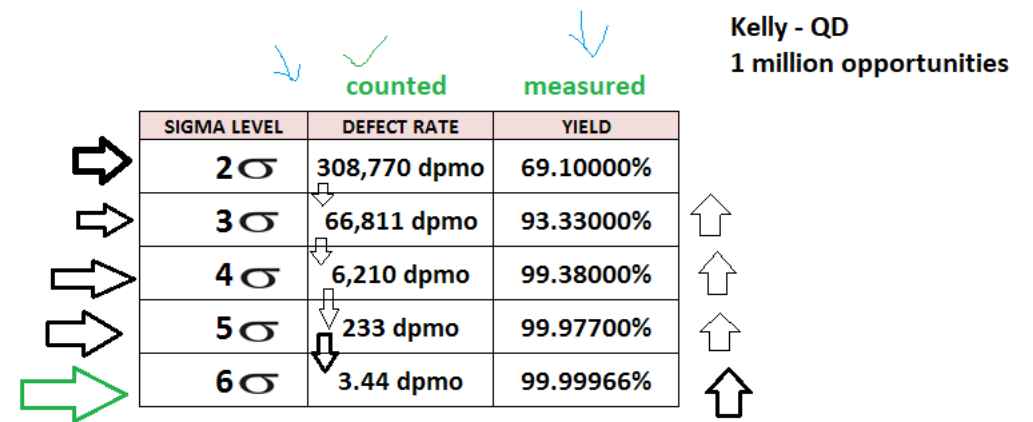
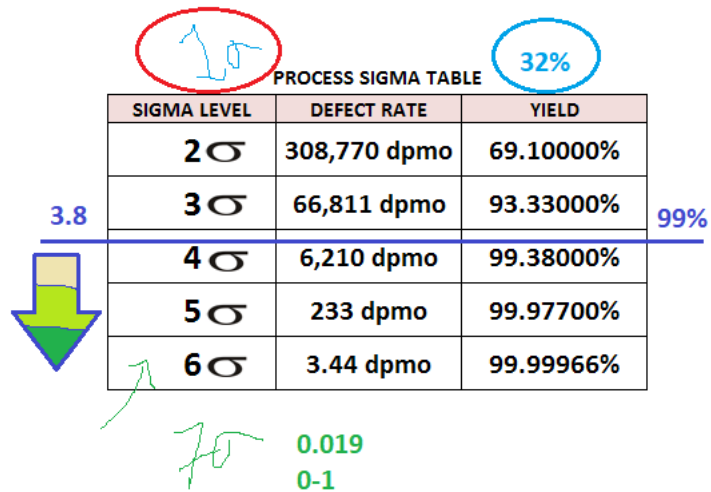
Don't Need:-

Sell it

Give it to team/dept

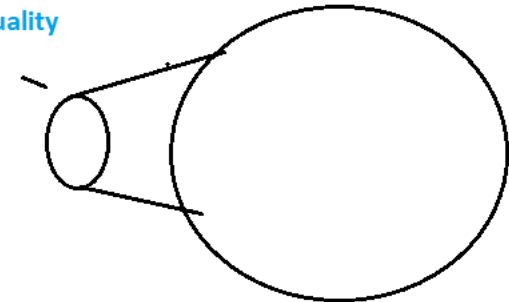
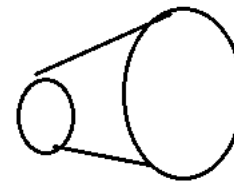
Donate

Trash



Good balance of cost and quality

Time
Resources
Budget



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 answer our queries /doubts

$$y=f(x)$$

Sales of Coffee = F(taste)

$$y=f(x_1,x_2,x_3....)$$

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

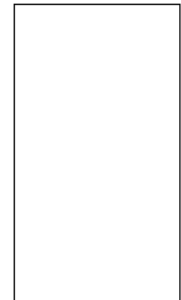
Blood test

Sonography

CT scan

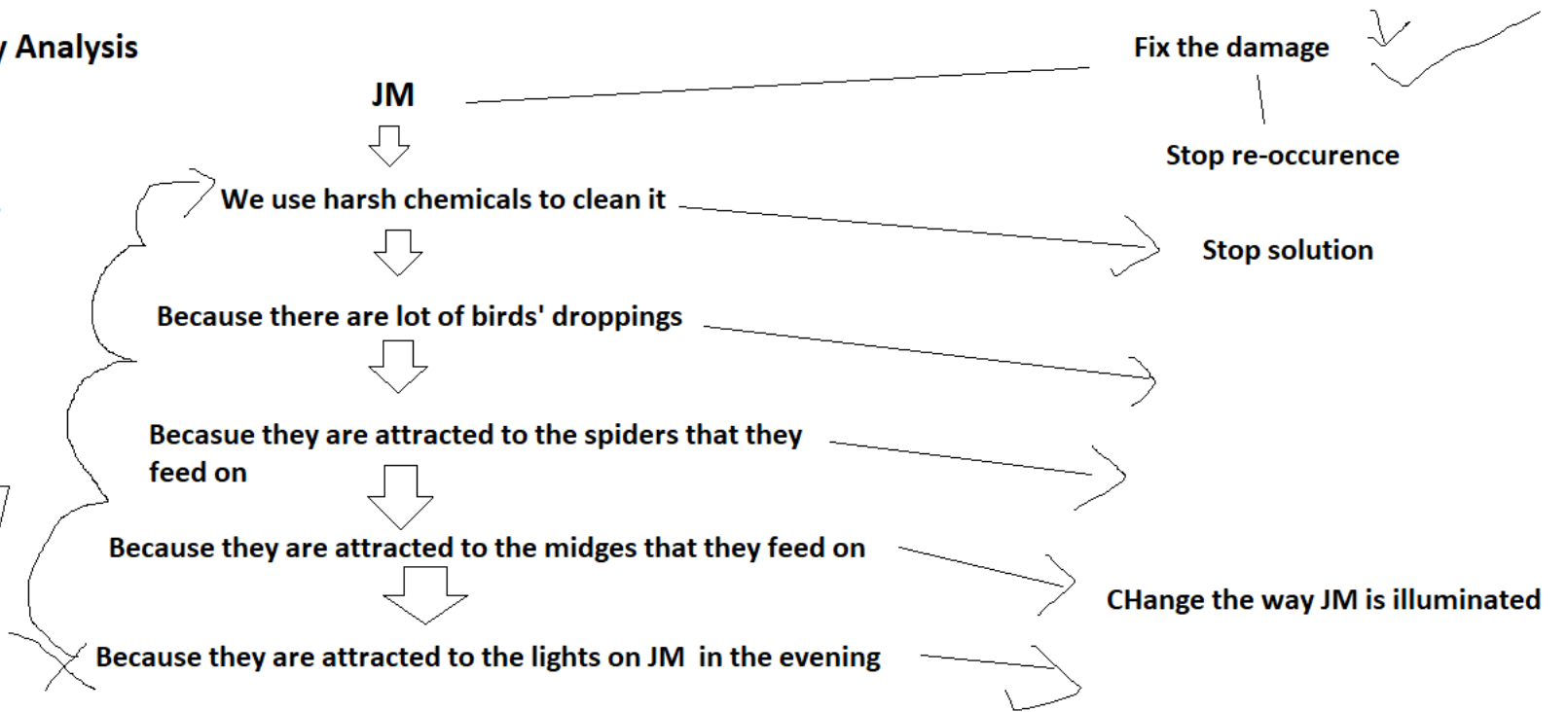
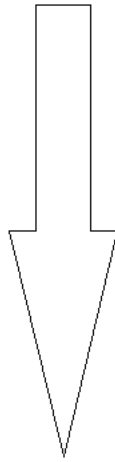
X-ray

Urine test



5 Why Analysis
3-4-7

Why-Why Analysis



Vilfredo Preto - Italian economist



Pareto rule/graph
Vital Few and Trivial many

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

80:20

70:30

60:40

Time
Resource
Budget

✓ TPS- Toyota Prodcution System.

✓ TPS- Thinking People's System

Kaizen

Kai- change/modify

Zen - Good/Better

No cost

Low Cost

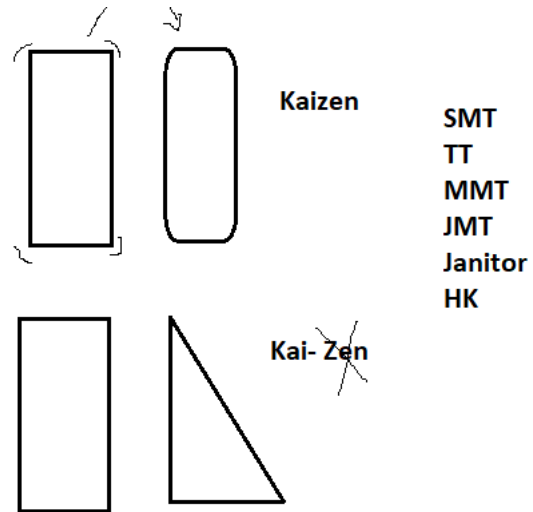
Less Time

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

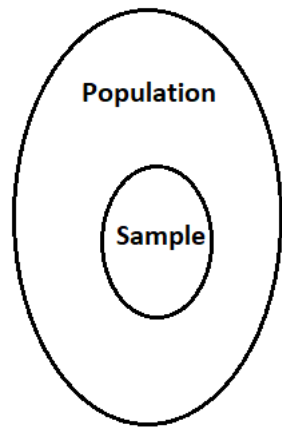
As- is VSM (process map)

Process capabilities (cp/cpk)

DPMO - Sigma level (current)

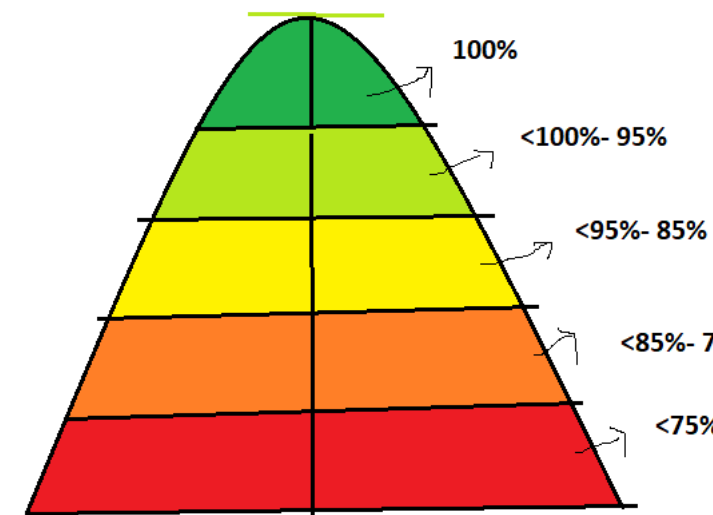
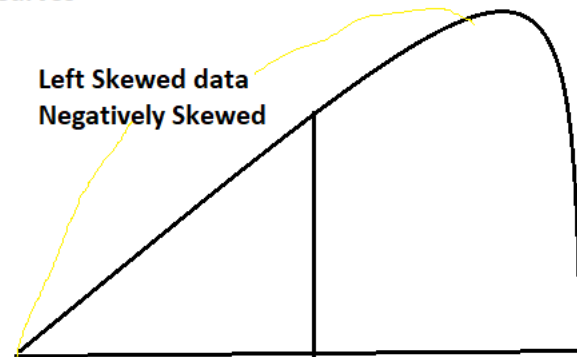
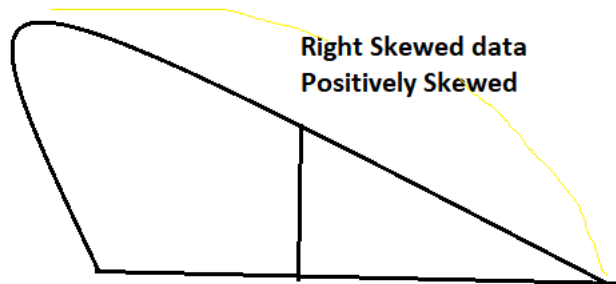
Measure of Central Tendency & Dispersion

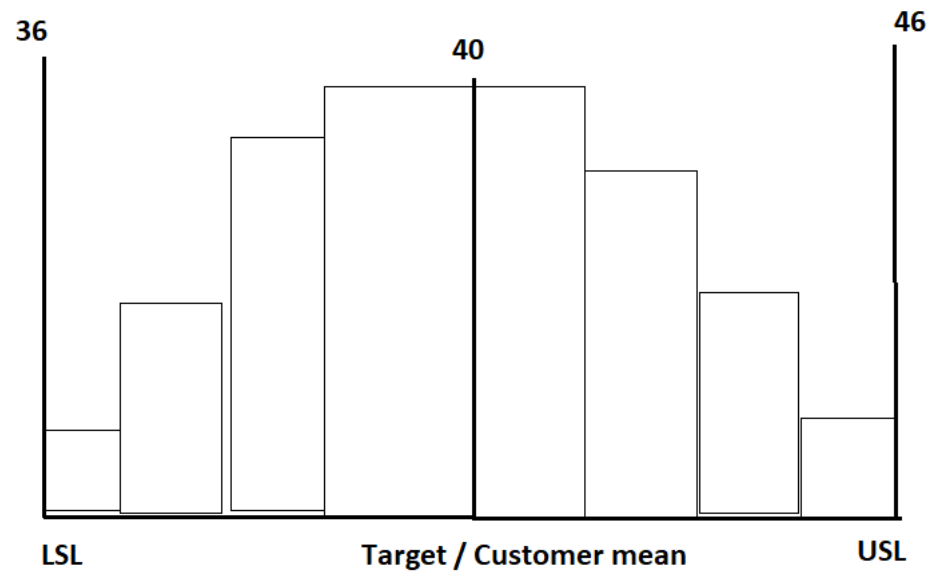
(mean, median, mode & range, StDev, Variance)



Normal
Normal Curve
Bell Curve

Non-Normal Curves



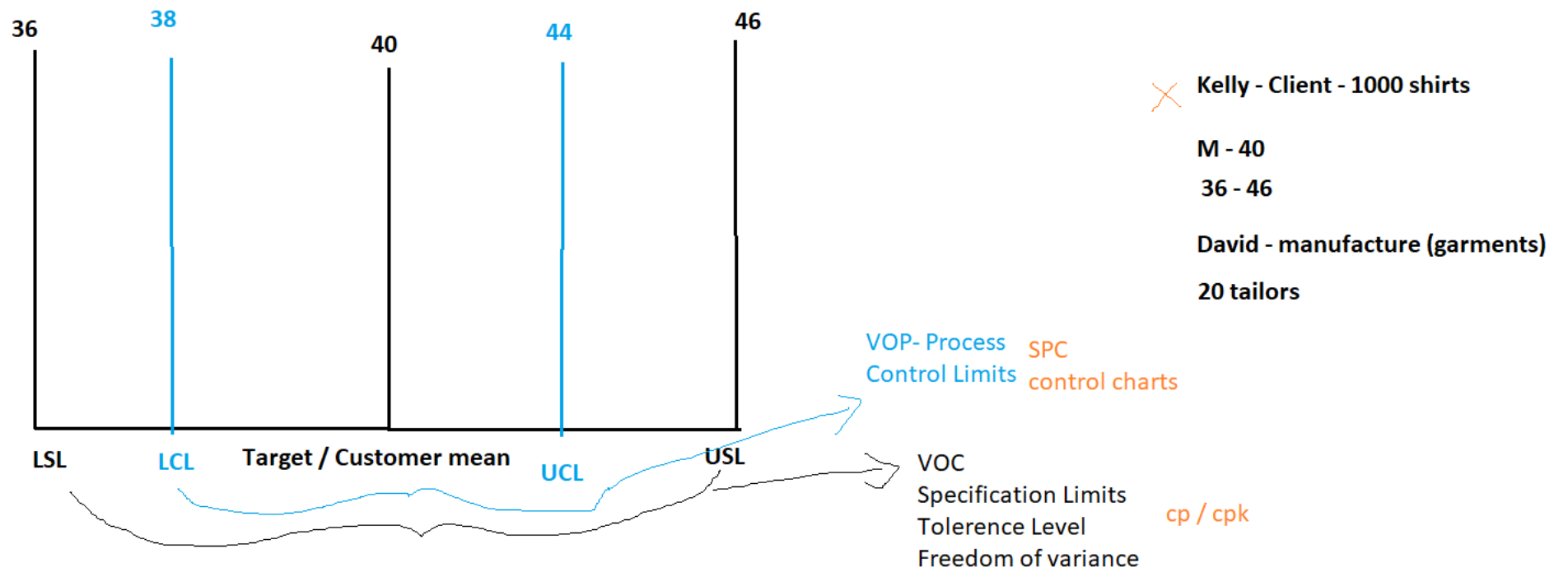


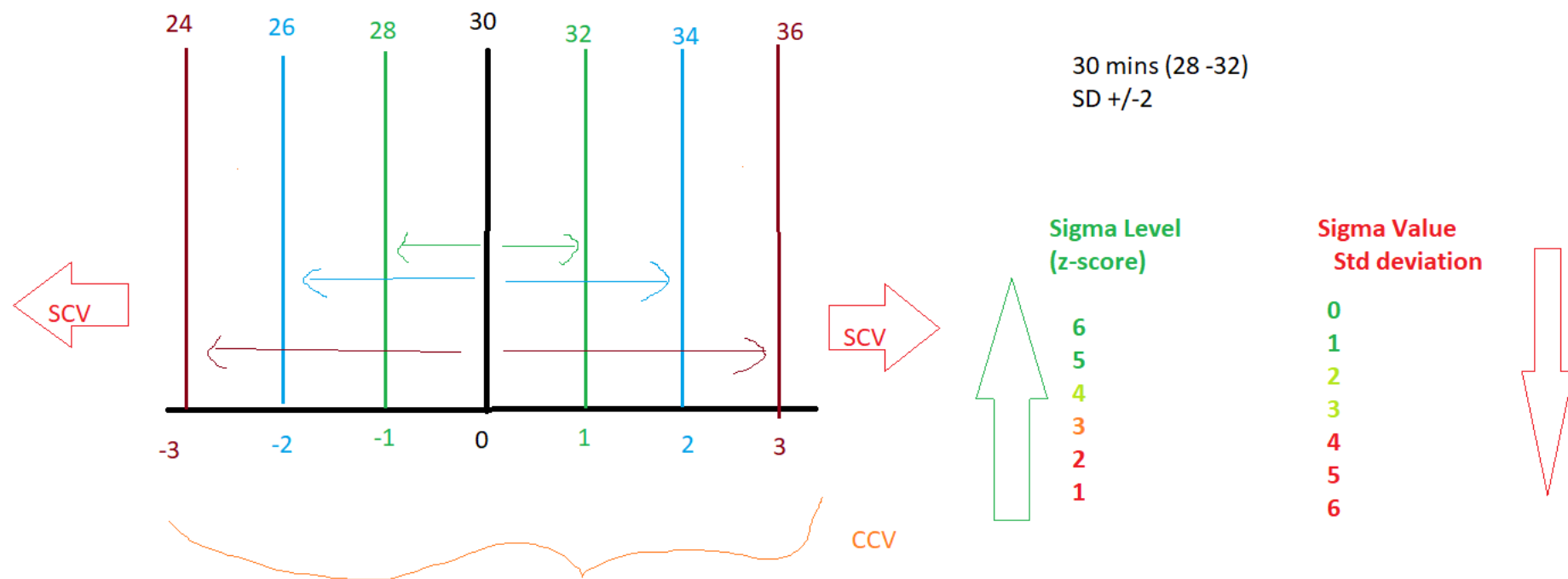
Kelly - Client - 1000 shirts

M - 40

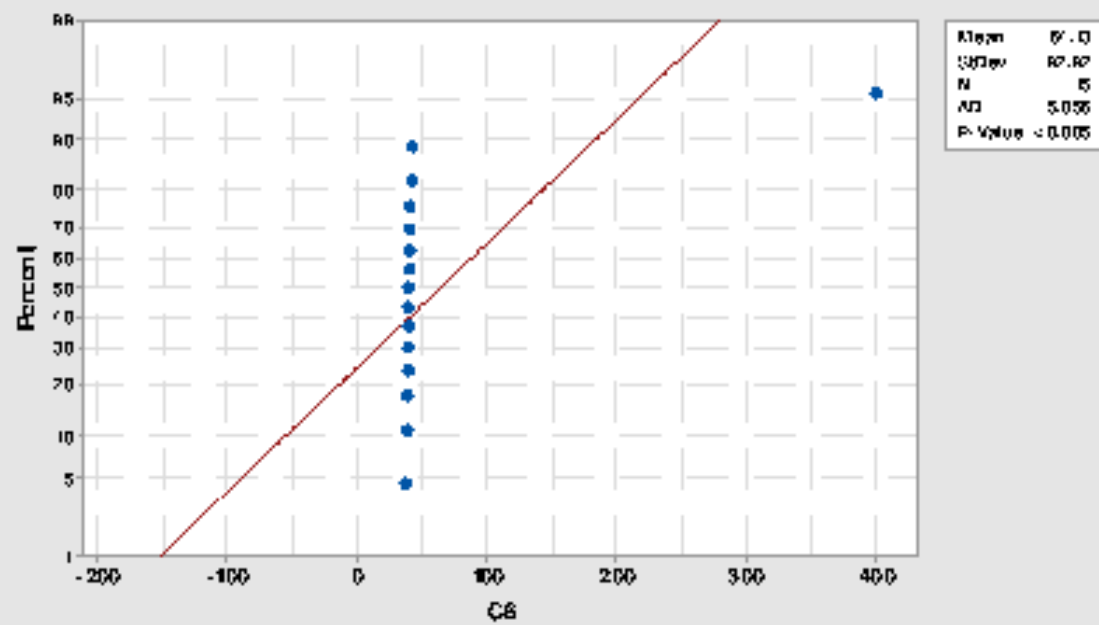
36 - 46

David - manufacture (garments)



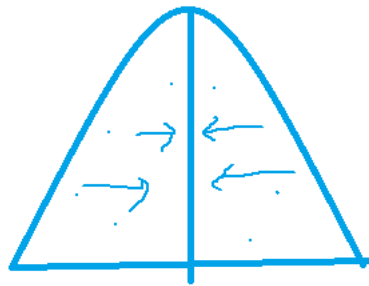
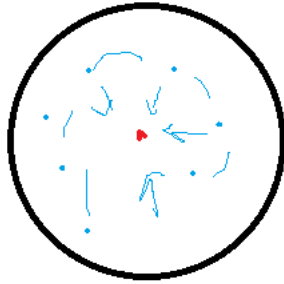


Probability Plot of C6
Normal



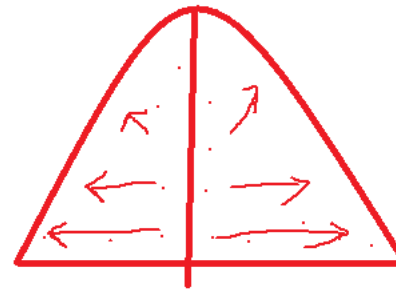
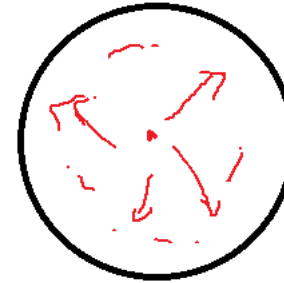
Measure of Central Tendency

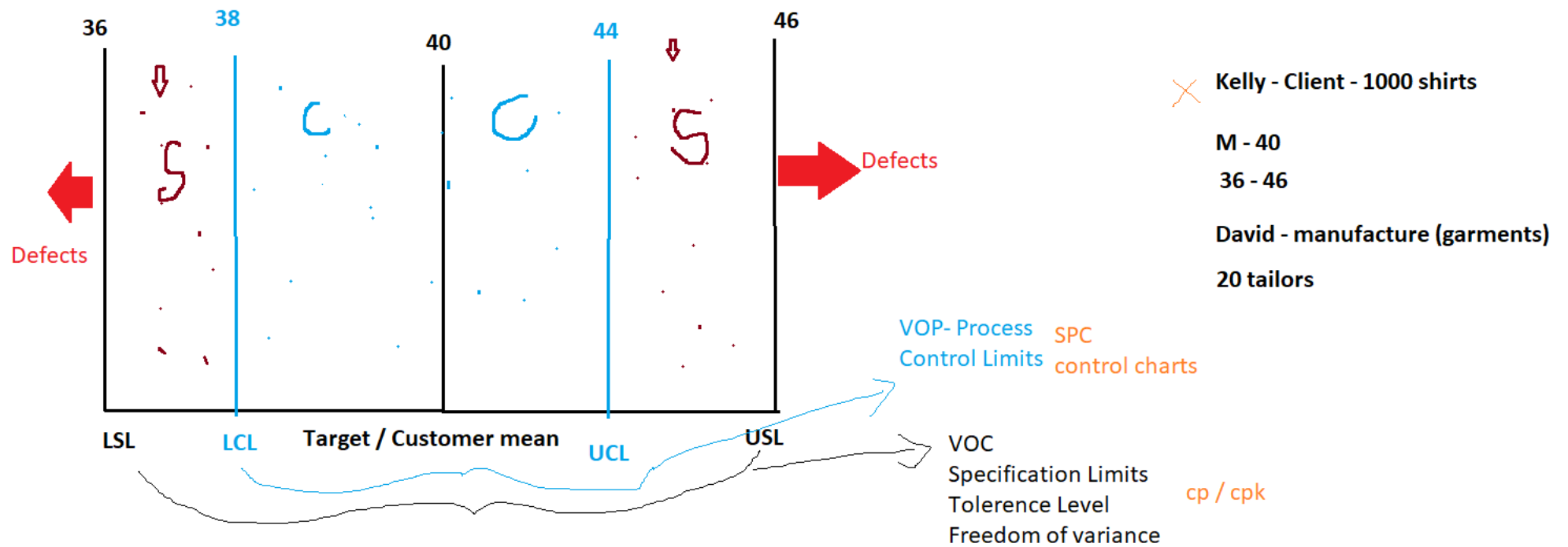
Mean, Median, Mode

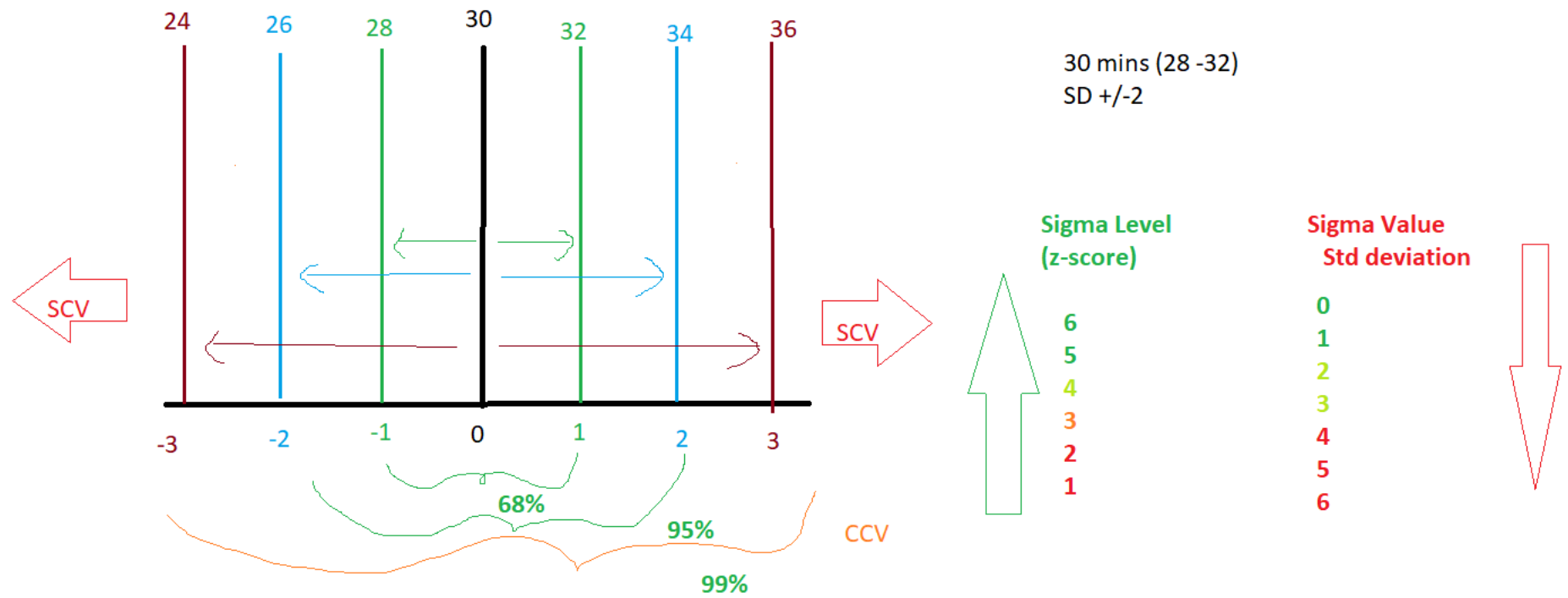


Measure of Dispersion

Range, Variance, Standard Deviation







Data Normality

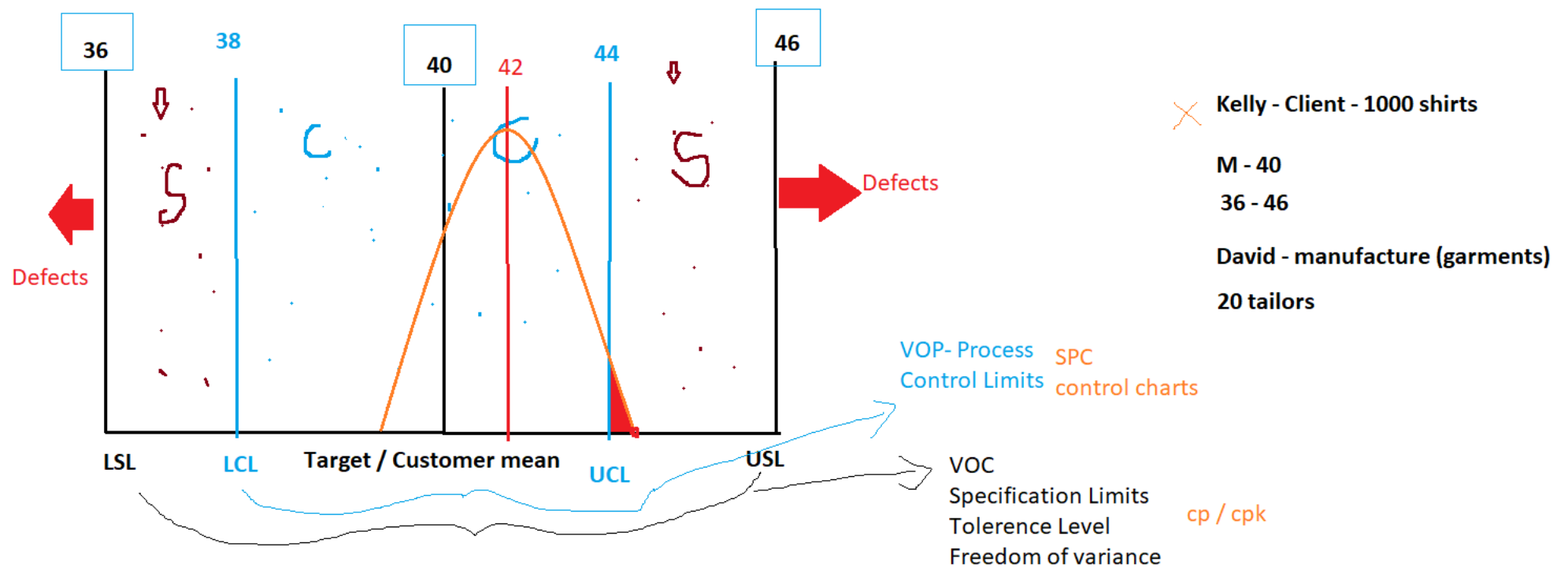
- 1) Histogram (bell curve)
- 2) Mean=Median=Mode
- 3) A_D test

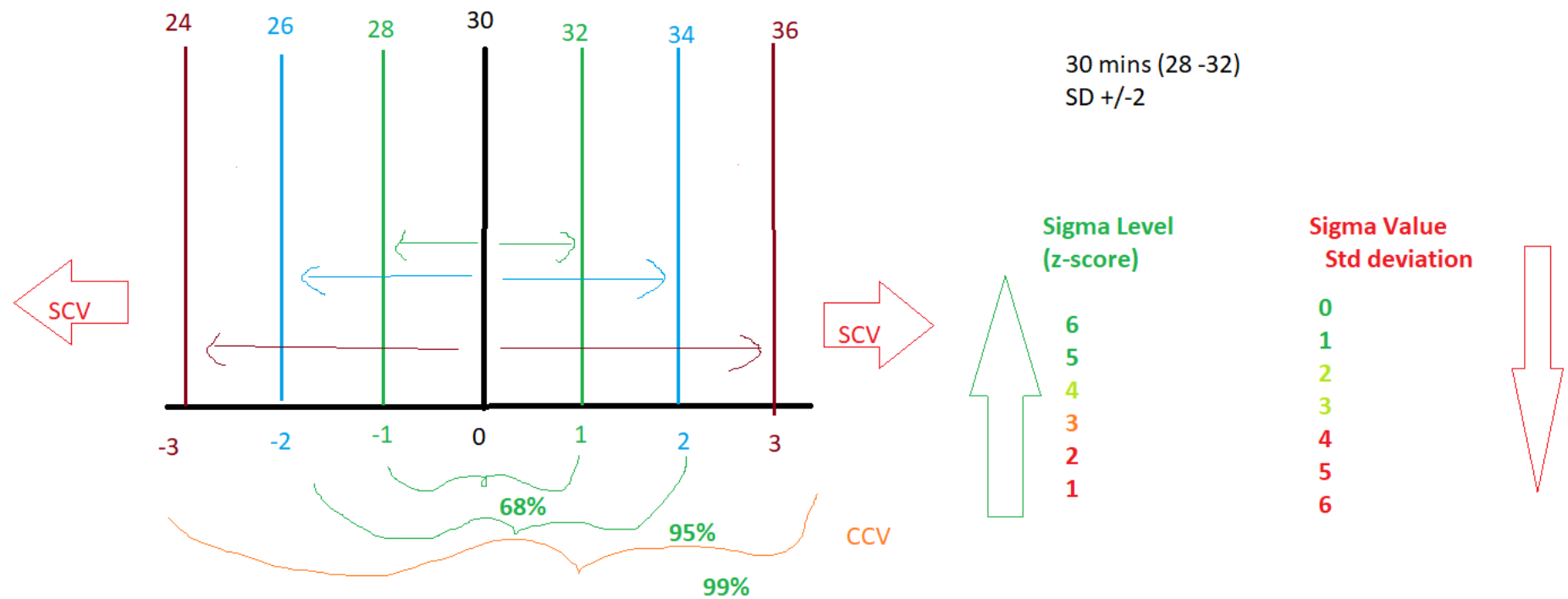
3) A_D test
Anderson Darling Normality Test
Wilbur **Anderson** and Donald **Darling**

p-value, 0.05

More than 0.05, normal

Lesser than 0.05, non-normal





MSA :-

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

Gage RnR - https://www.youtube.com/watch?v=6sRN1ICTqSM&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

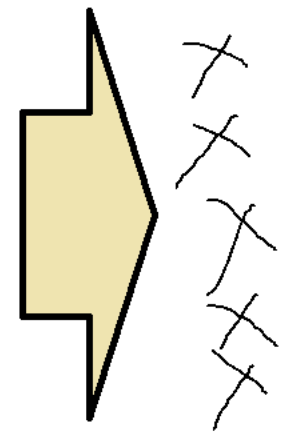
H
W
PR
BMI
Fats %

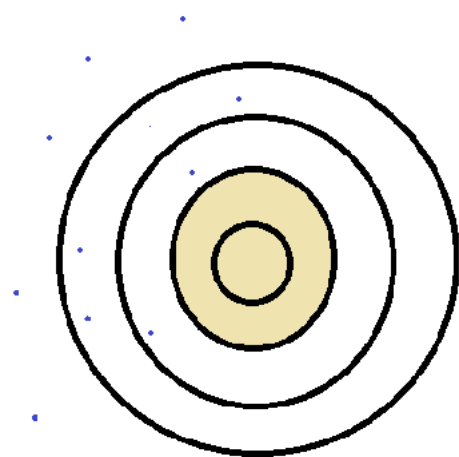
part-to-part
variance

Operator variance

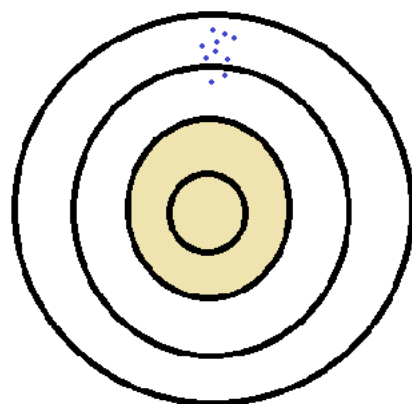
Nurse	Equipment	Settings	Training	Method
✓	✗			
✗	✓			
✓	✓	✗		
✓	✓	✓	✗	
✓	✓	✓	✓	✗

Result (data)

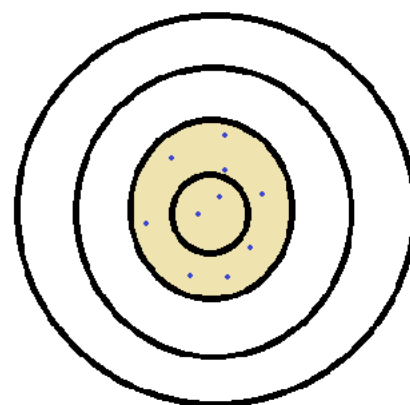




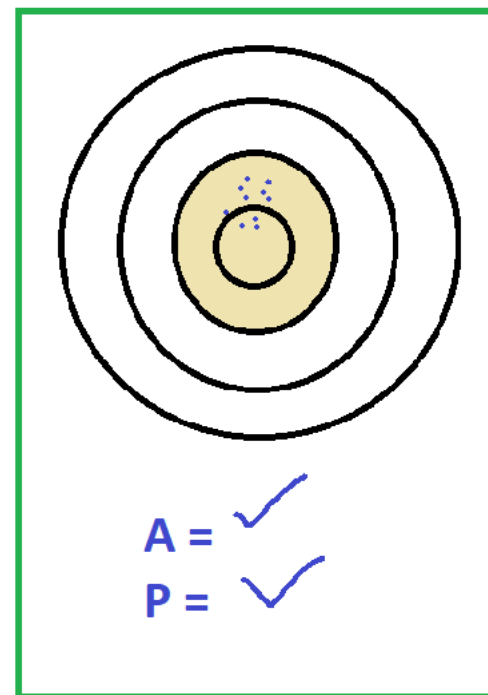
A = ✗
P = ✗



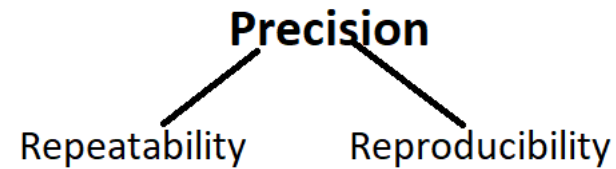
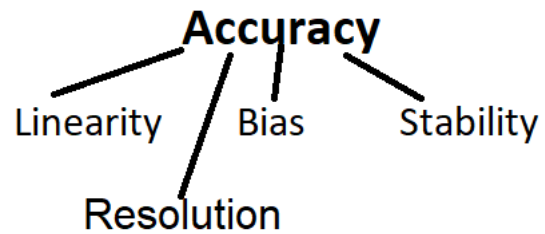
A = ✗
P = ✓



A = ✓
P = ✗



A = ✓
P = ✓



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

$$cpk = (\text{Nearest specification limit} - \text{Mean}) / (3 * SD)$$

$$cp * 3 = zst \text{ (short term sigma)}$$

$$cpk * 3 = zlt \text{ (long term sigma)}$$

Sigma Level

1) DPMO + calc

2) $cp/cpk * 3$

	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	

$$\Rightarrow Cpu = (\text{Process mean} - \text{LSL}) / (3 * \text{Standard deviation})$$

$$cpk = \min (cpu, cpl) \quad \Rightarrow Cpl = (\text{USL} - \text{Process Mean}) / (3 * \text{Standard deviation})$$

$$\min (0.64, 0.512)$$

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

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

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

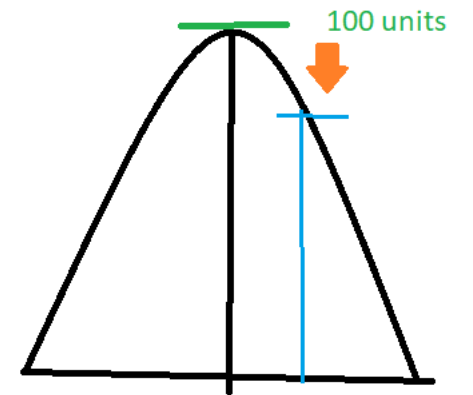
Weekly QC, Daily QCd

Daily - 12

Hourly sales (3) * 8 =24 sales

100 units
85 units

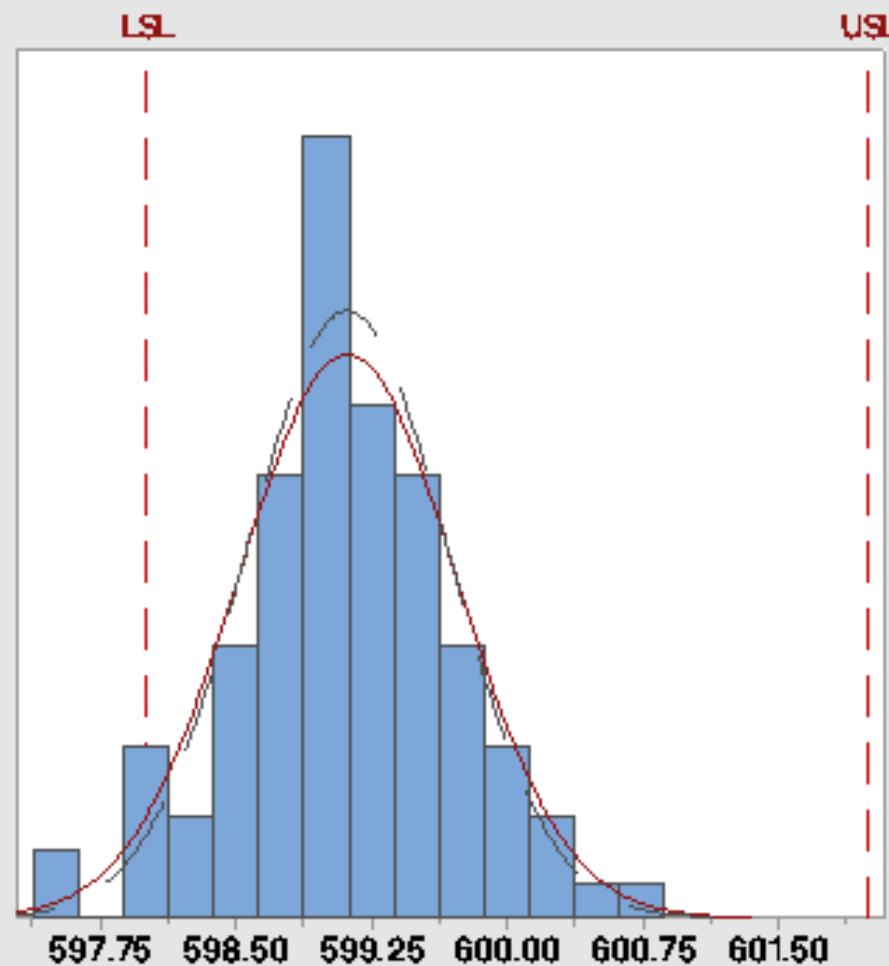
$z\text{-shift} = zst - zlt = 1.5$
ranges from 1.4 to 1.6 ~ 1.5



	A	B	C	D	D	F
$zst = 4 \text{ sigma}$	4	5	3	3.5	4	6
$zlt = 1 \text{ sigma}$	3	3	2.5	3	2	3.5
$z\text{-shift}$	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

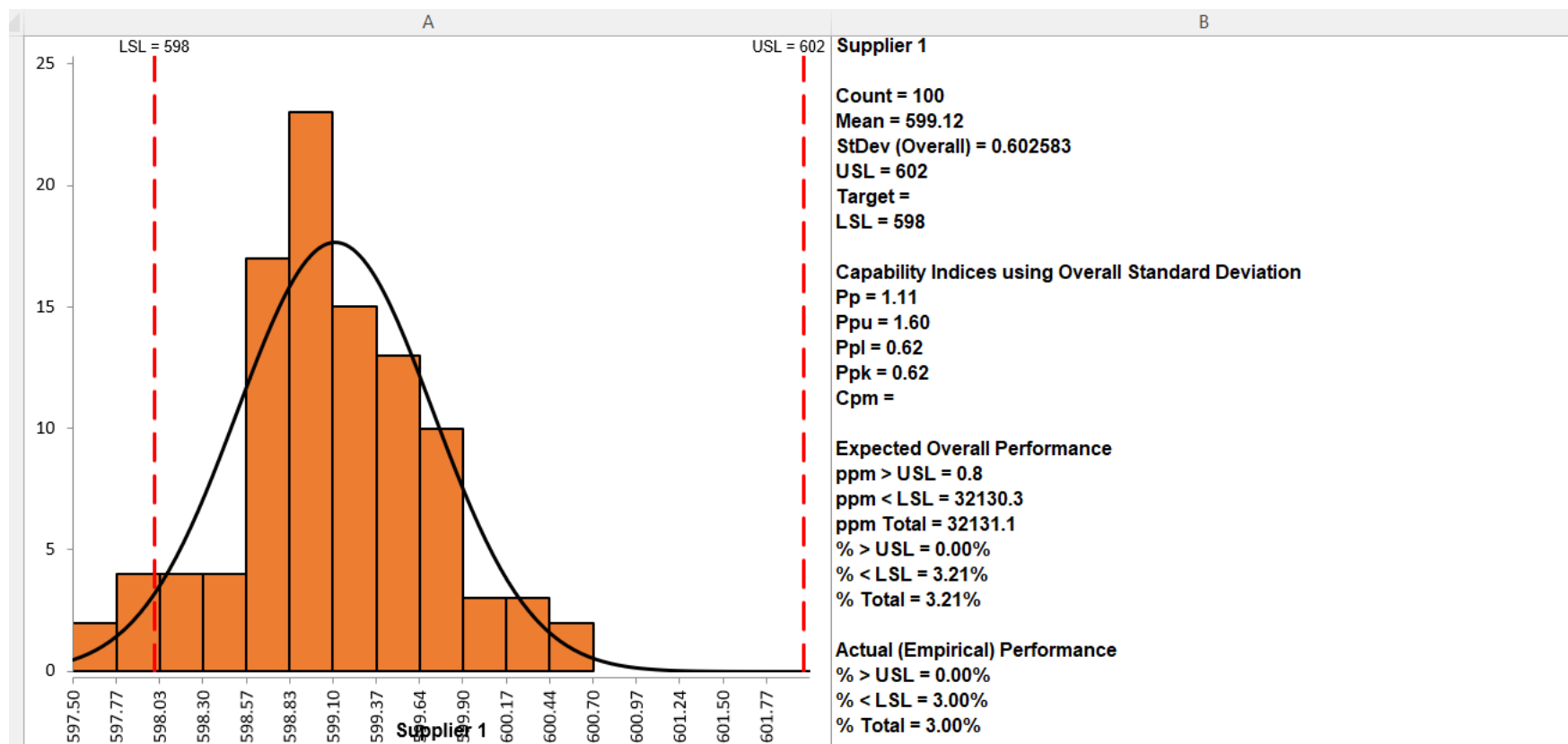
(Assumes that data are normally distributed)

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





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

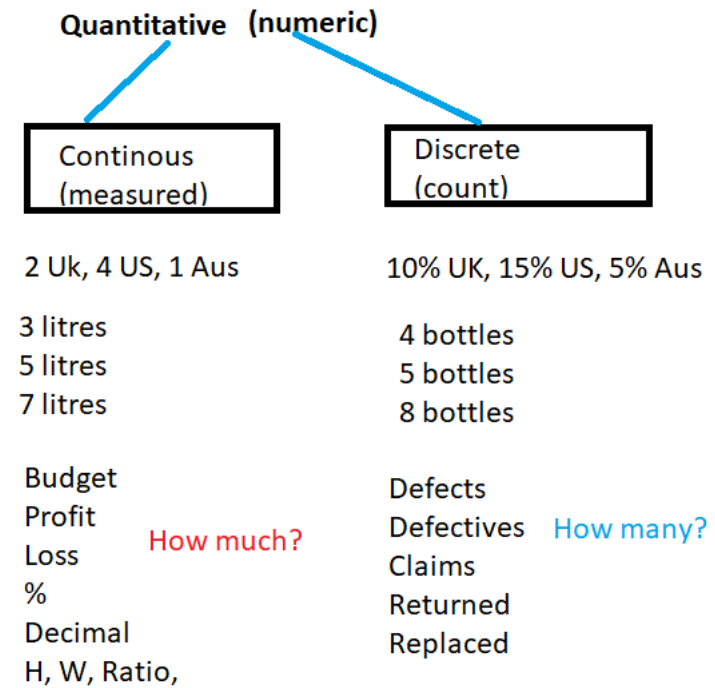
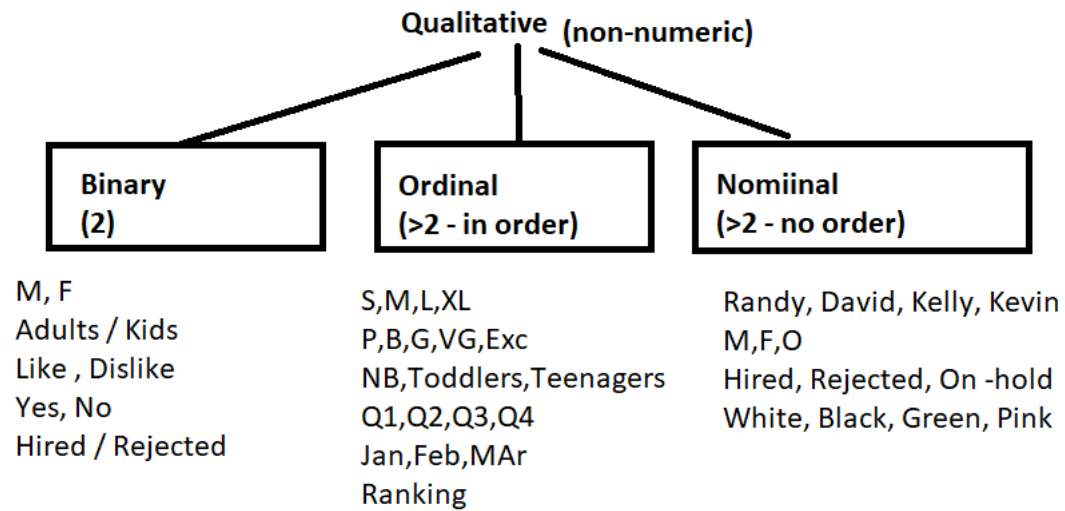
(Assumes that data are normally distributed)

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



Next week:-

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=HgfhfwK7VQ> - 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

