Lean Metrics and Data Types

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Learning Objectives

Upon successful completion of this module, the student should be able to:

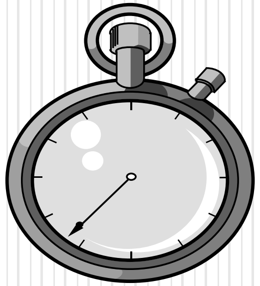
- Describe Data Types
- Understand Little's Law
- Understand Lean Tool Box
- Understand Takt Time and Chart
- Understand Defects per Million Opportunity (DPMO)

Data Types

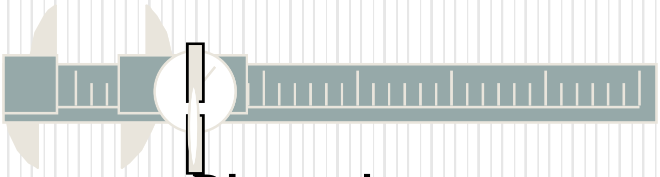
- Information often comes in qualitative form
- Project information collected in quantitative terms:
  - Whether something happened or not
    - Attribute (discrete) data – Count data
  - Specifics about what happened
    - Variable (continuous) data – Measurement data

Data Types

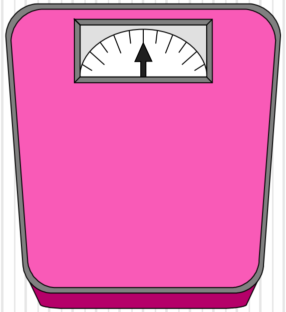
Variable (continuous) Data – characterizes a product or process feature in terms of a parameter such as size, weight or time



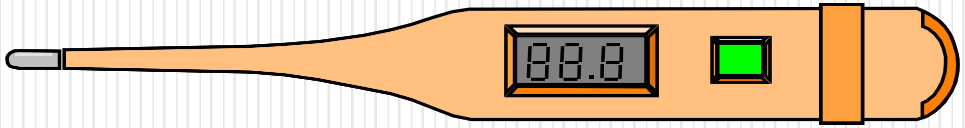
Time



Dimensions



Weight



Temperature

Variable data gives more information than just knowing if the part was good or bad

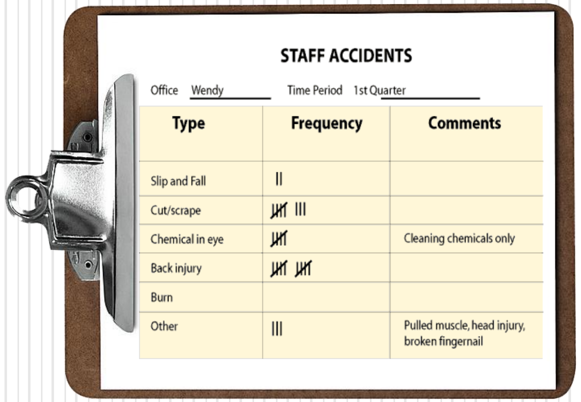
Data Types

Attribute (discrete) Data – the number of times something happens or fails to happen. It is measured as the *frequency* of occurrence. It is also data that falls into categories such as production line, operating shift and plant.

Defect

Defective

Examples of Attribute Data	
Number of Defects	Pass / Fail
Complaint Resolution	Go / No-Go
On-Time Delivery	



STAFF ACCIDENTS

Office Wendy Time Period 1st Quarter

Type	Frequency	Comments
Slip and Fall	||	
Cut/scrape	𝍸 |||	
Chemical in eye	𝍸	Cleaning chemicals only
Back injury	𝍸 𝍸	
Burn		
Other	|||	Pulled muscle, head injury, broken fingernail

Attribute data <u>cannot</u> be meaningfully subdivided into more precise increments

Little's Law:
Lean's Mathematical Foundation

$$\text{Process Cycle Time} = \frac{\text{Work In Process (WIP)}}{\text{Average Completion Rate (ACR)}} = \frac{\text{Things}}{\text{Speed}}$$

Example:

- The Procurement Department Processes (12) Orders per Hour
- There is a Backlog of (89) unprocessed orders
- A 90th order is put into the queue
- How long must the 90th order wait to be processed?

$$\text{7.5 Hours} = \frac{\text{90 Orders in Process}}{\text{12 Orders per hour}}$$

Lean tools reduces waste in process and increases the completion rate

* *Developed by Dr. John D.C. Little in 1961 while on faculty at Case Western Reserve University in Cleveland*

Little's Law:
Variation in Math Formula

$$\text{Process Cycle Time (PCT)} = \frac{\textbf{\textit{Work in Process (WIP)}}}{\textbf{\textit{Average Completion Rate (ACR)}}} = \frac{\textbf{\textit{Things}}}{\textbf{\textit{Speed}}}$$

$$\text{Process Cycle Time (PCT)} = \frac{\textbf{\textit{WIP}}}{\textbf{\textit{Exit Rate}}}$$

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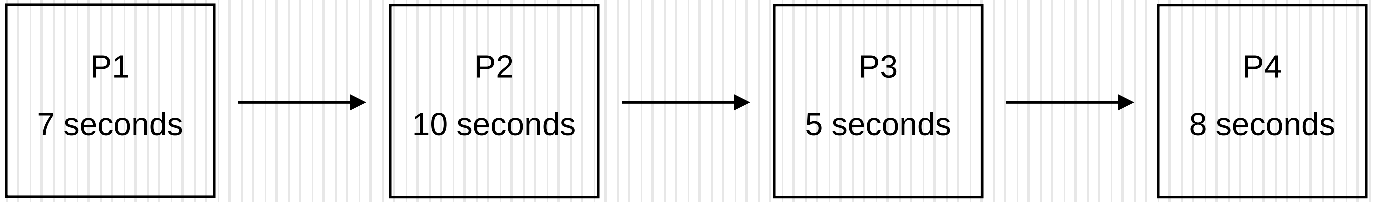
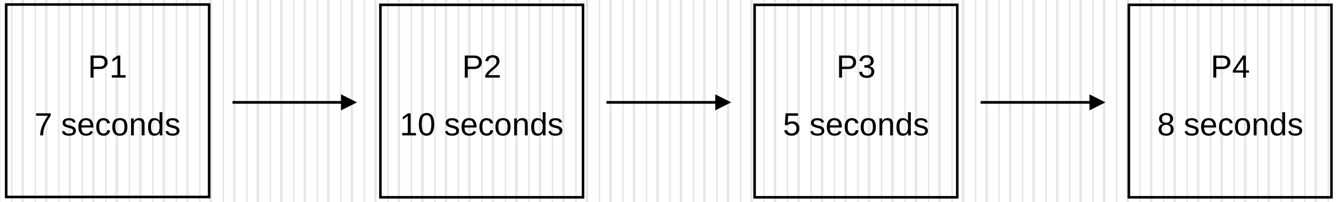
LSS Metrics Toolbox

- Constraint Cycle Time (CCT)
  - Longest time in a process at any given step



= P2 = 10 Seconds

- Total Cycle Time (TCT)
  - Time it takes for one piece to move all the way through a set of processes (or value stream(s)), from start to finish, as defined by your boundaries.



= 7+10+5+8 = 30 Seconds

Lean Metrics Toolbox

- Defects Per Unit (DPU)
  - Represents the number of defects divided by the number of products.
  - DPU= $\frac{Defects}{Products\ (Units)}$ **DPU =** $\frac{5\ Defects}{10\ Units}$ **= .5**
- Yield (Y)
  - Percentage of a process step that is free of defects.
- Y = e^{-DPU} **Y =** $e^{-(0.5)}$ **= .61 = 61%**
  - Defects Per Unit (DPU)
    - = -ln(Y) **Y = -ln(.60653)**

Lean Metrics Toolbox

- Rolled Throughput Yield (RTY)
  - Is the probability that a single unit can pass through a series of process steps free of defects.
    Y = product of process step yields. Y=X1* X2 * X3* Xn

P1		P2		P3		P4
Yield = 26%	→	Yield = 35%	→	Yield = 95%	→	Yield = 99%
TCT = 7 Sec		TCT = 10 Sec		TCT = 5 Sec		TCT = 8 Sec
VAT = 4 Sec		VAT = 3 Sec		VAT = 4 Sec		VAT = 2 Sec

Y = .26 * .35 * .95 * .99 = .09 = 9%

- Process Cycle Efficiency (PCE)
  - Process Efficiency
  - PCE = $\frac{\boldsymbol{Value\ Added\ TIme\ (VAT)}}{\boldsymbol{Total\ Cycle\ Time\ (TCT)}}$

PCE = $\frac{\mathbf{4+3+4+2}}{\mathbf{7+10+5+8}} = \frac{\mathbf{13}}{\mathbf{30}}$ **= .43 = 43%**

PCE is a powerful measure because it shows customer focused Value-Added going into a product or service relative to cycle time

Takt Time & Customer Demand

- Takt means “Baton” and is German concept for time, measure, rhythm
  - Orchestra conductor integrates and harmonizes symphony via baton
  - Conductor’s baton balances rhythm of entire symphony & its sections
  - Think “Metronome”

- Takt in services and/or products is determined by customer demand

Takt Time and Customer Demand

- Formula:

$$\text{Takt} = \frac{\text{Time Available to Create Thing Desired}}{\text{Number of Things Required}}$$

$$\text{Takt} = \frac{\text{Time Available}}{\text{Demand}}$$

  - Time Available is Actual Labor Time
  - Actual Labor Time = (Duty Day) – (Breaks) – (Lunch) – (Meetings)
    - NOTE: Units of “Time” must be in identical units
  - Demand is what the customer requires (product)
- Key Point: Demand Is Specified By Customer

Takt Time Practical Example, 1 of 2

- Let's calculate Takt Time based upon the following scenario

- Situation: Gwennie is a Green Belt candidate at We-R-Designs, Inc. a small business drafting company. A draftsman works an 8-hour shift, 5 days each week. The draftsman is given a 1 hour lunch period, two 20-minute breaks each day, a standing 10-minute meeting each morning to discuss the day ahead, and attends a daily mandatory 1-hour review. We-R-Designs must deliver 6 designs per week to satisfy the customer's new building program demand. What is the Takt time?

- How will you determine what unit of "Time" to use?

- Weeks?	- Hours?	- Seconds?
- Days?	- Minutes?	- Months?

Why?

Produce <u>exactly</u> what the customer requires just in time.

Processes producing ahead or behind Takt Time are Wasteful!

Takt Time Practical Example, 2 of 2

- Calculate Available Time
  - 5 Days per week at 8 hours per day is 40 Hours
  - 40 Hours times 60 minutes is 2,400 minutes per week
  - Less 5 daily lunches at 60 minutes each for 300 minutes per week
  - Less 2 daily breaks of 20 minutes each, or 40 minutes, for 200 minutes per week
  - Less a 10-minute morning kick-off meeting each of 5 days or 50 minutes per week

2,400	Initial Time
- 300	Lunch
2,100	After Lunch
-200	Breaks
1,900	After Breaks
-50	Meetings
1,850	Time Available

$$\text{Takt} = \frac{\text{Time Available}}{\text{Demand}}$$

$$= \frac{1{,}850}{6} = 308.3 \text{ Minutes}$$

$$= \frac{308.3}{60} = 5 \text{ Hrs, } 8 \text{ Mins}$$

Need to produce 1 Design every 5 Hours and 8 Minutes

Takt Time and Production Rate

Use Takt Time when describing the output of a given Step / Task

Takt Time = Customer Demand
(stated in time per unit)
Example: Takt Time = 10 sec / unit

Takt Time =

$$\frac{\text{Production Time Available}}{\text{Number of Units to Produce}}$$

Use Production Rate when referring to Customer Demand

Production rate = Customer Demand
(stated in units per time)
Example: Production Rate = 6 units/min

Production Rate =

$$\frac{\text{Number of Units to Produce}}{\text{Production Time Available}}$$

Takt is a German word indicating the beat or meter of music

Takt Time and Production Rate Example

Scenario

Customer requires 10 Legos to be manufacture each day.
Available working time each day is 5 Minutes.

Takt Time

Takt Time = $\frac{Time\ Available}{Customer\ Demand}$

Takt Time = 5 Minutes / 10 Legos

Takt Time = .5 minutes per Lego

Takt Time = .5 *60 = 30 Seconds per Lego

Production Rate

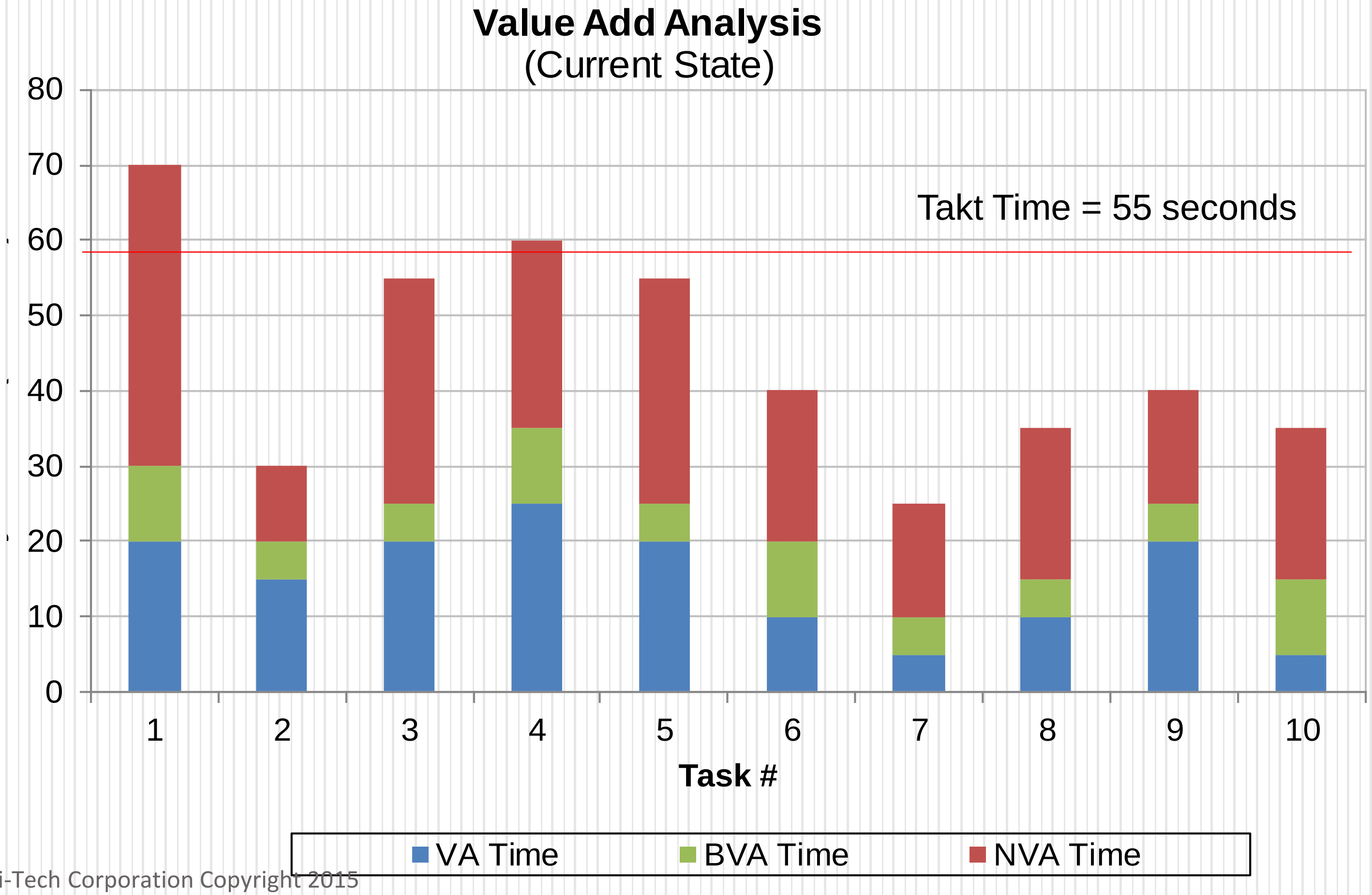
Production Rate = $\frac{Customer\ Demand}{Time\ Available}$

Production Rate = 10 Legos / 5 Minutes

Production Rate = 2 Legos per minute

Takt Chart with Value-add Analysis

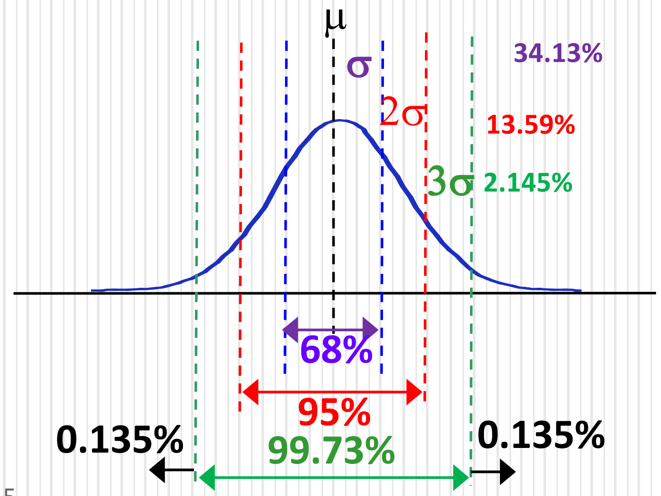
- Tasks that cannot meet 'Takt time' have "Constraints"
- Time it takes to perform constrained tasks must be reduced



Six Sigma Defined

- Sigma describes variability (spread or standard deviation) of data from mean
- Sigma Quality Level measures process performance with respect to customer requirements (specifications) → Higher Sigma = Higher Quality
- Six Sigma methodology provides the ability to "predict" process performance
- Six Sigma methodology provides a benchmark to determine if actions have produced results

Distributions can be linked to probability – making possible predictions of outcome or evaluation of the odds of an occurrence being "unusual"

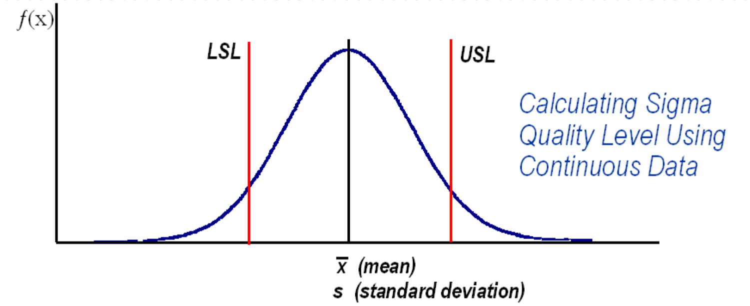


In a normal distribution, the number of standard deviations from the mean tells us the percent distribution of the data and thus the probability of occurrence

Sigma Quality Level Defined

There are two ways to calculate Six Sigma Quality Level (SQL):

- Mean, Standard deviation, and Specification limits



Sigma Quality Level (SQL) = The distance between average performance and specification limits divided by the standard deviation

$$\text{Sigma Quality Level (SQL)} = Min\left[\frac{USL - \bar{x}}{s} \quad or \quad \frac{\bar{x} - LSL}{s}\right]$$

- Defects Per Opportunity

Yield	DPMO	Sigma
99.4%	6,210	4
99.5%	4,660	4.1
99.7%	3,460	4.2
99.9992%	8	5.8
99.9995%	5	5.9
99.99966%	3.4	6

Calculating Sigma Quality Level using Discrete Data

How to Calculate Sigma Quality Level Using DPO

Steps	Equation	Example
1. Determine number of defect opportunities per unit	O	2
2. Determine number of units processed	U	5
3. Determine total number of defects made	D	1
4. Calculate Defects per Opportunity	DPU= $\frac{D}{U\ X\ O}$	DPU= $\frac{1}{5*2}$ = 0.1
5. Calculate Yield	First Pass Yield = (1-DPO) X 100	(1 - 0.1)* 100 = 90
6. Look up the Sigma Quality Level using the Six Sigma Conversion Table (Round Down)	Process Sigma	2.7

Summary

In this lesson we discussed:

- Describe Data Types
- Understand Little's Law
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- Understand Defects per Million Opportunity (DPMO)