Work Measurement and Lean Applications in the Process Industries

Reduce Cost and Improve Flow

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Lean Physics and Operations Modeling Consultant

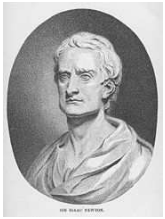
Agenda

- Contributors & Origins of Work Measurement
- Global Economy and Work Measurement
- What's Work ? Lean Principles
- Work Measurement Tools
- Work Measurement Case Studies/Applications Traditional and Non-Traditional
- Improvement Challenges & Survey Results

Contributors and Origins of Work Measurement

The Mayas in Mesoamerican Civilization

Long Time Count
Estimated Current and Historical Dates
2600 B.C.



Issac Newton
1643-1727

W= F d
F = *m a*

Henry Ford
1863-1947

Taiichi Ohno
1912-1990

PROTIME

ProtimeSystems.com

Computer Video-Based Work Measurement
and
Video & Pictorial Instruction Systems
1996

Greece and Egypt
Hour Glass

Fredreric Taylor
1856-1915

Lilian and Frank Gilbreth 1931
Lilian 1878-1972

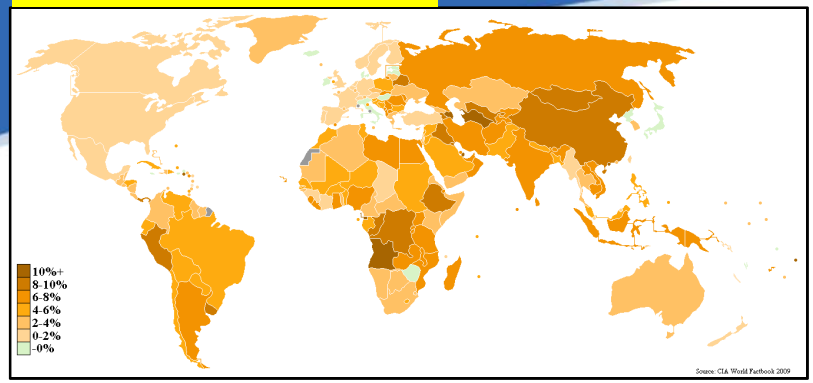
Predetermine Time System (PTS)
1910

MTM

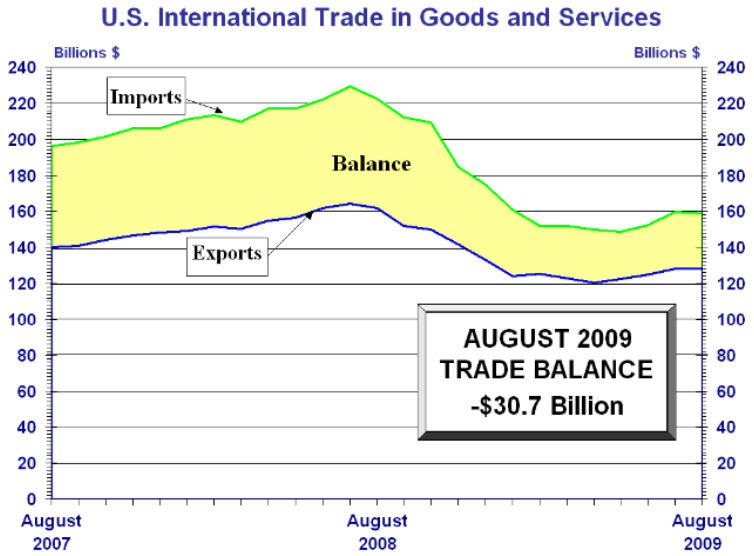
USA-Sweden-Germany
1940
PTS…. And Others
Workfactor, MOST, Modaps

Current Economic Issues and WM

GDP Global Level



Country Level



Product demand unstable (high variability) creating waste of resources

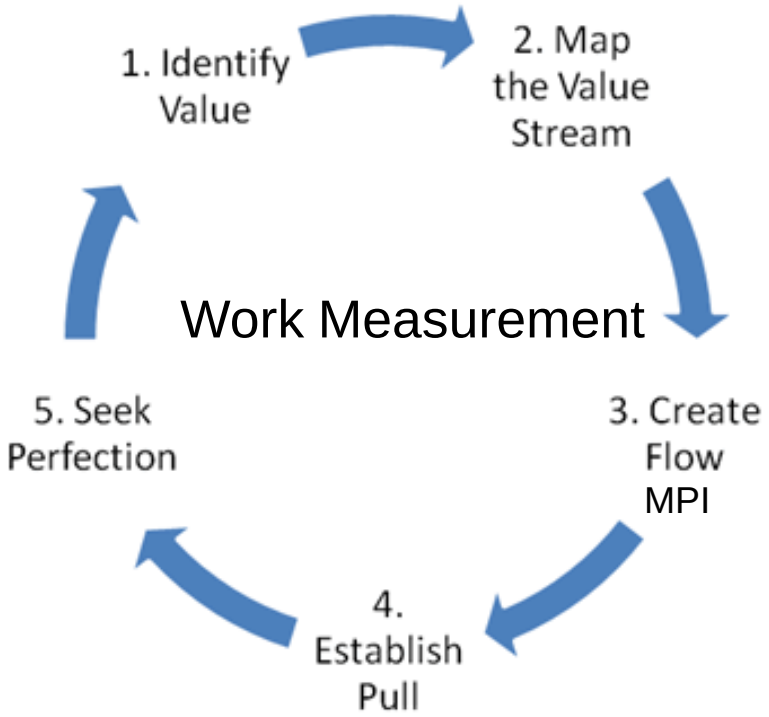
State Level

- **State of CA job growth** fell 5.0% in July 2009 from a year ago; national job growth fell 4.2%.
- **State CA unemployment** averaged 11.9% in July 2009; the national average was 9.4%
- **Personal income** fell 0.2% to $1.5 trillion in Q1 2009 from a year ago.
- **Tax revenue** fell 16.2% in Q1 2009 from the previous year.
- **Exports** fell 22.4% to $48.8 billion in the first five months of 2009 from a year ago.
- **Venture capital investment** in CA fell 63% to $1.4 billion in Q1 2009 from a year ago.

What is Work & Lean Principles

What is Work ?

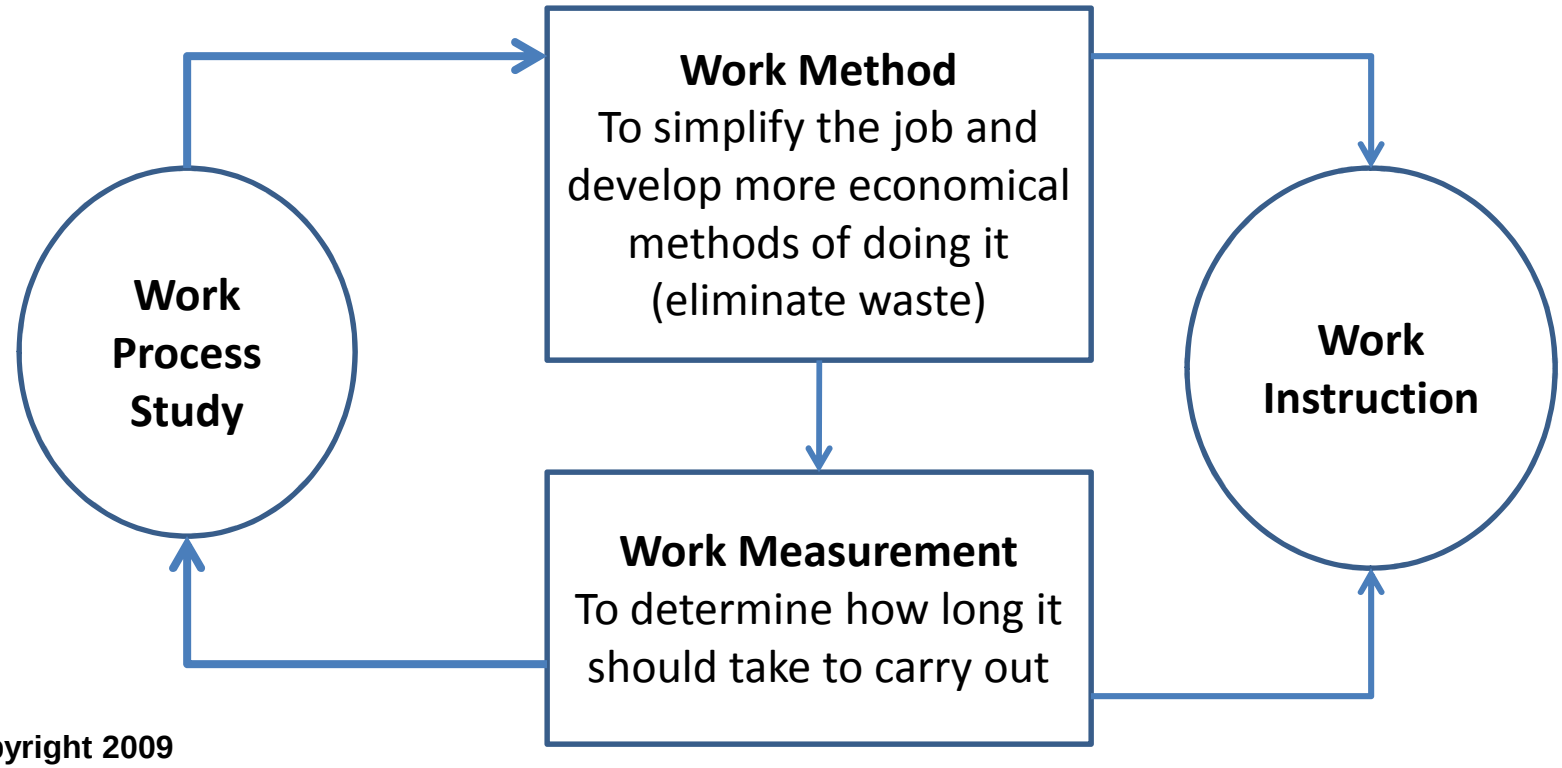
Any activity that consumes resources and creates value or non-value added for the customer



What is Work Measurement ?

What is Work Measurement?

Is the application of techniques designed to **establish the time** for a qualified worker/process to carry out a task at a defined speed



Work Measurement Methodology

1-Select	Work to be studied
2-Record	Relevant data, work elements
3-Examine	Work element breakdown and effective method
4-Measure	Work in each element (time), VA and NVA
5-Define	Work Method (Why, What, Where, When, Who and How)
6-Compile	Work Allowances and determine standard time
7-Install	Std. work instruction training and visual instructions
8-Maintain	Workflow balance and standard work audit

Work Measurement Applications

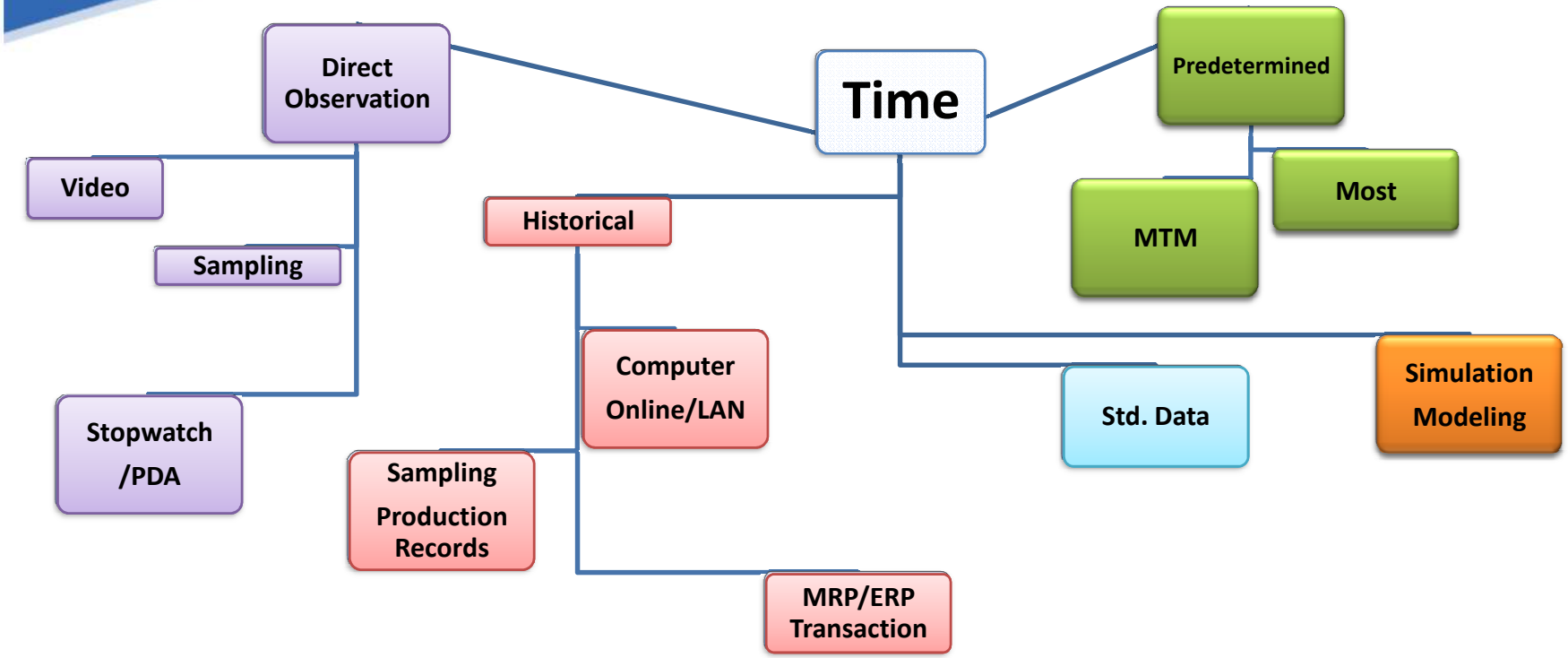
- Value Stream/Process Flow Mapping
- Capacity and Lead Time Analysis
- Production Plan/Production Standards
- Scheduling
- Labor/Staffing Analysis/Labor Standards
- Production Incentives
- Machine Efficiencies (OEE)
- Costing
- Product Design
- Layout Planning
- Ergonomics
- Inventory Planning/ERP
- Information Systems
- Simulation Modeling
- Flow Manufacturing & Service
- Learning Curves and Training
- Productivity/Efficiency & Effectiveness

TIME

The Work Flows of :

- Material
- People
- Machine
- Information
- Service
- Layout
- Cash
- Environment

Work Measurement Techniques



Work Measurement Approach

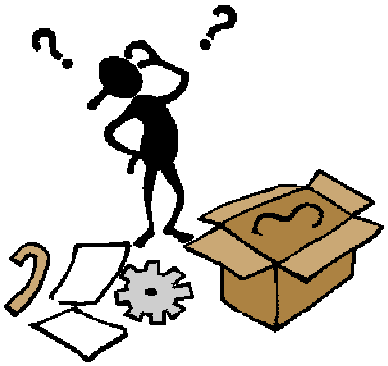
Engineer Based Standards

1. Engineer Conducts Work Measurement
2. Engineer Compiles Standard
3. Engineer Develops Std Work Instruction
4. Management Enforces Standard
5. Operators Follow Instructions

Team Video Based Standards

1. Engineer /Supv. Facilitates Study
2. Cross Functional Team Conducts Work Measurement (Including Operators)
3. Team Develops Std Work Instruction (Including Operators)
4. Management provides training, removes barriers and motivate operators
5. Operators are accountable to sustain
6. Operators are motivated to improve standards
7. Engineer/Mgt. installs the control systems and operating mechanisms

Work Measurement (7 Workflows)



1-Does the **Material flow** ?
Move from one value adding processing step right to the next value adding step

2-Do the **Operators flow** ?
Is the operator's work repeatable and consistent within each cycle ?
Can the operator perform efficiently from one value adding work element to the next ?

3-Do **Machines/Equipment/Tools flow** ? Are the machines or equipment adding value to the product/service ?

4-Does **Information flow** ?
Is there a plan and schedule that maximizes flow
Does everyone know the hourly production target ?
How quickly are problems and abnormalities noticed?
What happens when there are problems and abnormalities ?

5-Does the **Service or Mgt Business Support Function flow** ?
Are the service functions in the company flowing efficiently and supporting mfg. flow

6-Does the **Layout (facility) flow** ?
Are the material, operators, equipment and information flowing efficiently

7-Does the **Cash flow** ?
What is the material idle time (cash in-idle), WIP, TH, CT and inventory turn over

Beyond 5S/Ergonomics-Human Factors

PFD Allowances

Personal
Fatigue
Delays

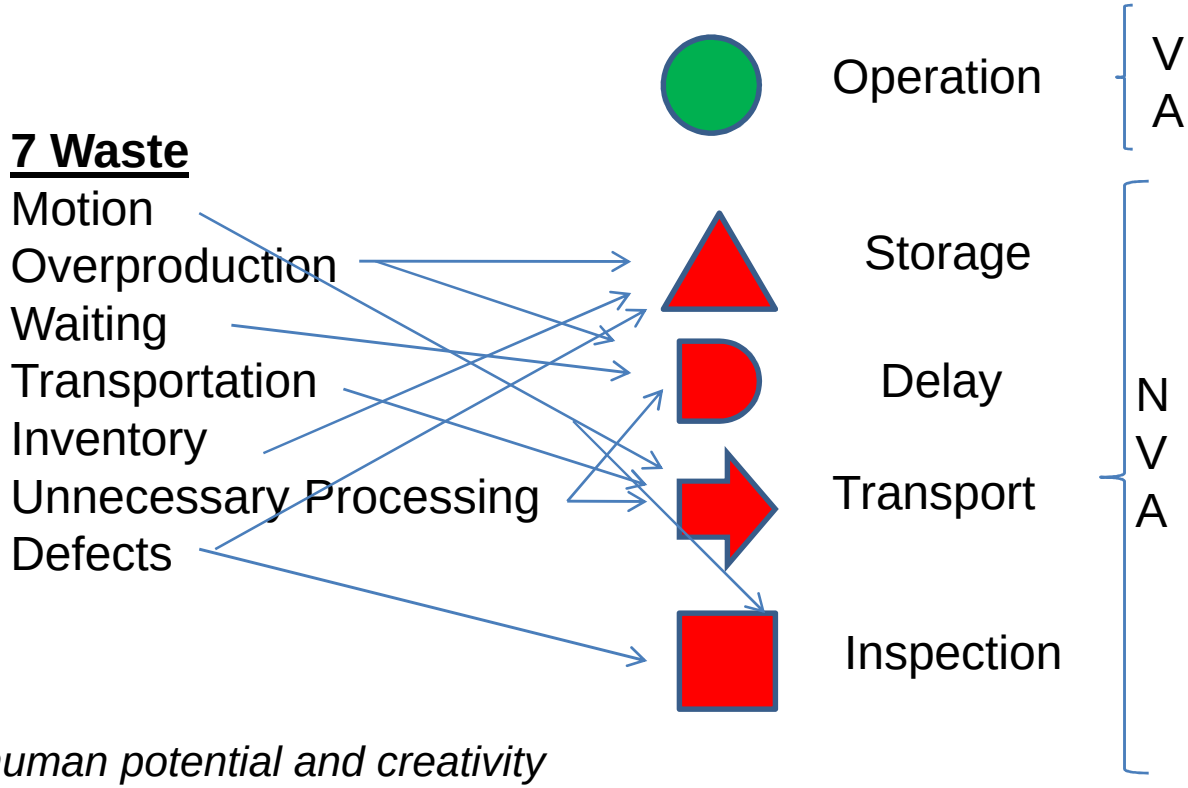
- **Arrangement and Storage of Tools**
- **Lighting**
- **Color**
- **Noise & Vibration**
- **Climate & Ventilation**
- **Toxic Substances**
- **PPE**
- **Work Time and Rests**
- **Facilities**

The 5 Work Symbols and 7 Waste

What is Work ?

Any activity that consumes resources and creates value or non-value added for the customer

5 Work Symbols



"8" Tap into human potential and creativity

Process Flow and The 5 Work Symbols

Process Flow Analysis

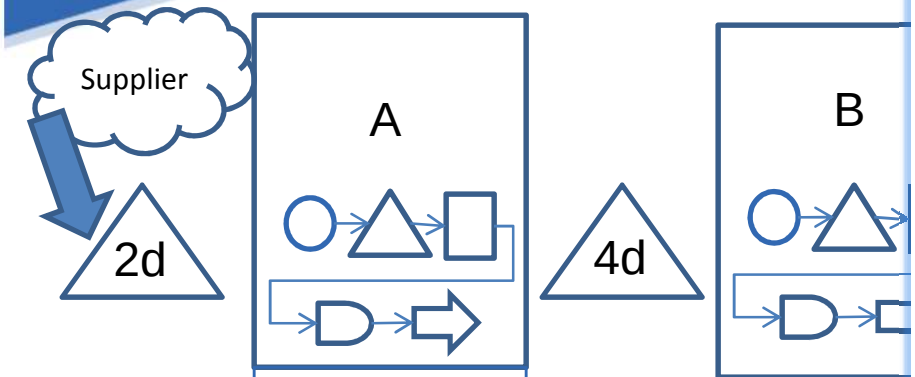
Process Description: XXXXXX

Date: XX-XX-XX Material People Machine Information

	No.	Task Description	Cum. Time (min)	Interval Time (min)	Distance (Ft)	Operation	Transport	Storage	Delay	Inspection
	1	Get tube and place to bender	5	5	6		5			
	2	Get bent tube & place to assy	10	5	1		5			
	3	Get connector	15	5	5		5			
	4	Get hose & place	20	4	3		4			
	5	Start assembly cycle	24	5	0	5				
	6	Walk and bring finished piece	29	7	6		7			
	7	Attach to convolute	36	4	0	4				
	8	Start assembly cycle	40	6	0	6				
	9	Place to tester fixture	46	6	3		6			
	10	inspect part	52	5	0					5
	11	Attach to Coiler	57	5	0	5				
Current		**Total**	**57**		24	20	32	0	0	5
Current		**Steps Count**	**12**			5	6			1
Current		**Work Flow Cycle Efficiency**	**35%**							
Proposed		**Total**								
Proposed		**Steps Count**								
Proposed		**Work Flow Cycle Efficiency**								

This tool is used to measure service or manufacturing processes, collecting information using sticky notes to build the VSM

Work Measuremer at VSM Level



CT= 400 m

C/O= 160 m

TBF = 4 D

TTR = 2 H

Yield = 92%

HCT = 8 FT

EPEI = 4

VA = 300 m

VA = 200 m

VA = 300 m

PROTIME 4.3.2

Operations/Routing

Part No XYZ-CURRENT VSM

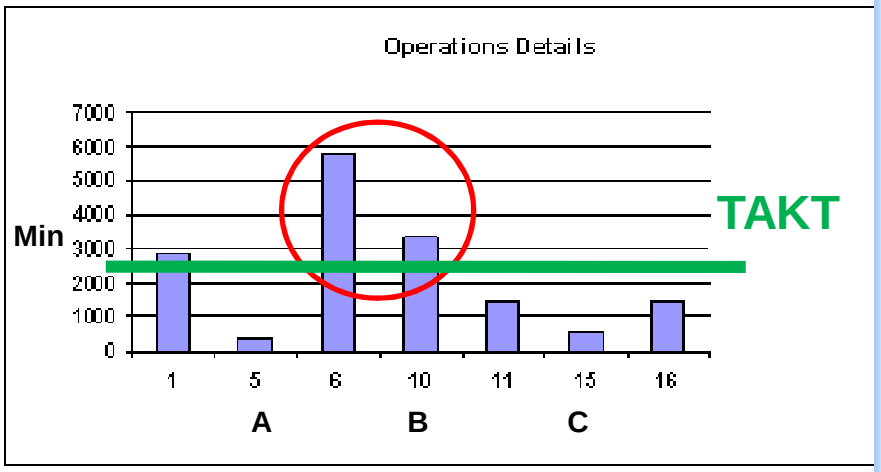
Description Coil Painting

Date 3/15/2009

Hrs/Unit 275.8790

$/Unit $4,654.84

Balance 128.60%

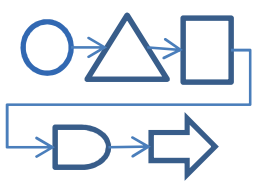


Op No	OpDescription	Elem ID	Hrs
1	Store	1A	48.3840
5	Prep Coils	A	6.6730
6	Store	1B	96.7680
10	CoatCoils	B	61.4000
11	Store	1C	24.1920
15	Pack Coils	C	11.2700
16	Store	1C	24.1920

Work Measurement (Labor Unrestricted)

Current State

Assy1



CT= 30 S

C/O= 0 m

TBF = 0 D

TTR = 0 H

Yield = 92%

HCT = 1 FT

VA = 10 S

PROTIME v5.0 STUDENT - [Element Details]

File Edit View Data Entry Reports Tools Window Help

ELEMENT DETAILS

Search Element ID

Element ID | Work Content Graph | Statistics | Picture | Media Clip | Excel

Elem ID: ASSY1
Name: Housing Assy
Last Update: 5/10/2009
Dept: 30
Engineer: MA
Last Cost: $2.00

Standard Leve
1 Predetermined-MTM
2 Video-Stopwatch
3 Historical
4 Exercise

Memo

Total Cycle Min: 0.4133
Total Std Min: 0.4990
Units/Hr: 120
Labor $/hr: 17
$/Unit: $0.14
PFD: 15%
Batch/Lot Size: 1
Level: 105%
Total TMU: 689

No	Element Details	Code I	Code II	Fr/Sec	Line Total
1	Pick up part	PT	0	3	84
2	Move to table	PT	0	2	56
3	Assemble Housing	PT	0	10	280
4	Inspect Assembly	PT	0	7	196
5	Move part to bin	PT	0	2	56
99	Refill container every 100 pcs (60 s)	PT	0	0.6	16.8
			0	1	

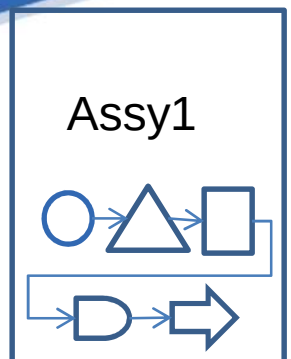
Time
3
2
10
7
2
tainer

Time
60

ators
3%
0 S
.20/hr
10

Work Measurement (Labor Unrestricted)

Future State



CT= 17.3 S

C/O= 0 m

TBF = 0 D

TTR = 0 H

Yield = 92%

HCT = 1 FT

VA = 12 S

PROTIME v5.0 STUDENT - [Element Details]

File Edit View Data Entry Reports Tools Window Help

ELEMENT DETAILS

Search Element ID: ASSY1

Element ID | Work Content Graph | Statistics | Picture | Media Clip | Excel

Elem ID: ASSY2
Name: Housing Assy (future state)
Last Update: 6/10/2009
Dept: 30
Engineer: MA
Last Cost: $0.14

Standard Leve
1 Predetermined-MTM
2 Video-Stopwatch
3 Historical
4 Exercise

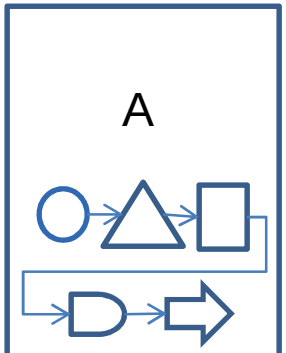
Memo

Total Cycle Min: 0.2520
Total Std Min: 0.2911
Units/Hr: 206
Labor $/hr: 17
$/Unit: $0.08
PFD: 10%
Batch/Lot Size: 1
Level: 105%
Total TMU: 420

No	Element Details	Code I	Code II	Fr/Sec	Line Total
1	Pick up part	PT	0	2	56
2	Move to table	PT	0	1	28
3	Assemble Housing and Inspect	PT	0	12	336
			0	1	

Work Measurement (Labor Restricted) Operator and Machine

Restricted Work
Is work in which the output is limited by factors outside the control of the worker



CT= 1.36 m

C/O= 1 m

TBF = 4 D

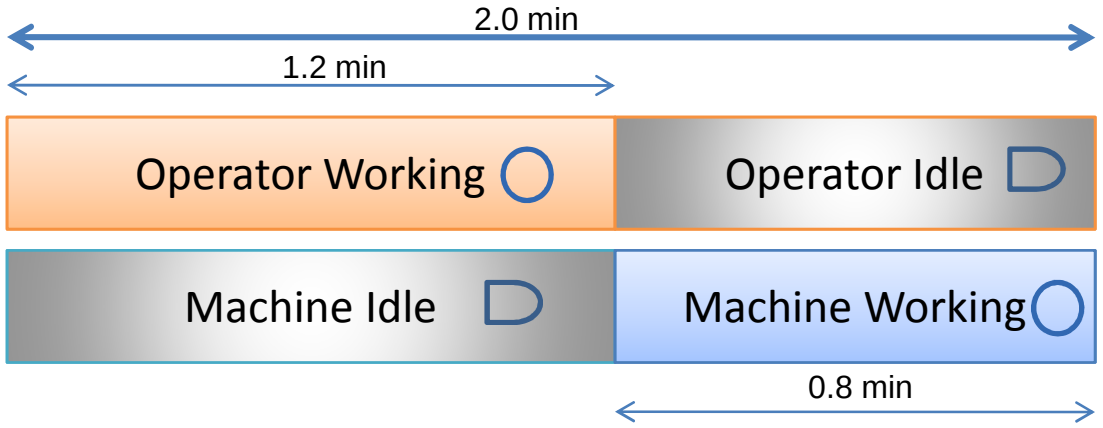
TTR = 2 H

Yield = 92%

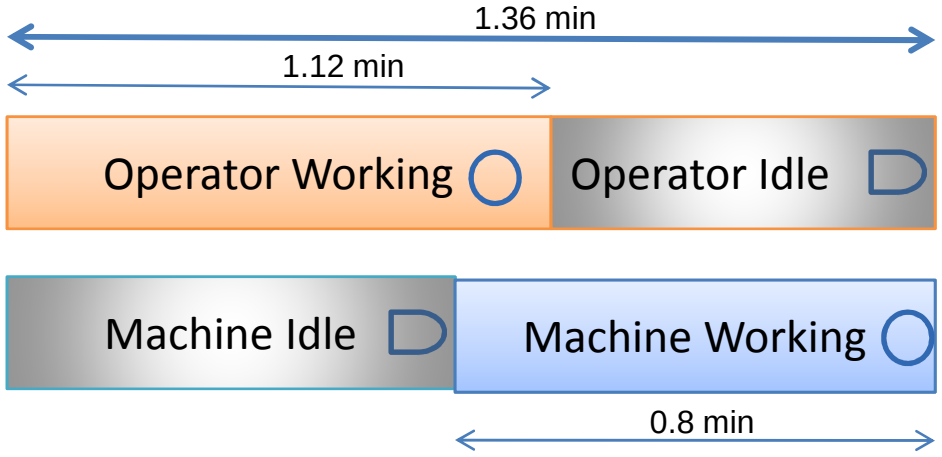
HCT = 8 FT

VA = 0.8 m

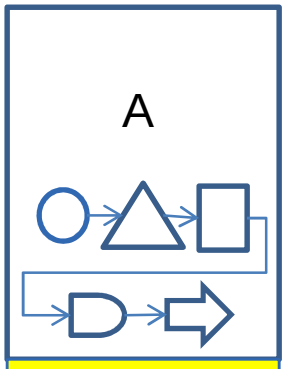
Current



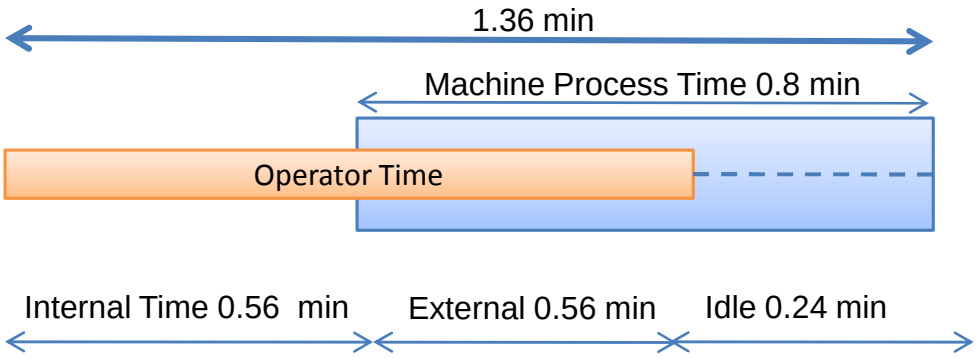
Future



Work Measurement (Labor Restricted) Operator and Machine «Pump Diagram»



CT= 1.36 m
C/O= 1 m
TBF = 4 D
TTR = 2 H
Yield = 92%
HCT = 8 FT
VA = 0.8 m



Summary

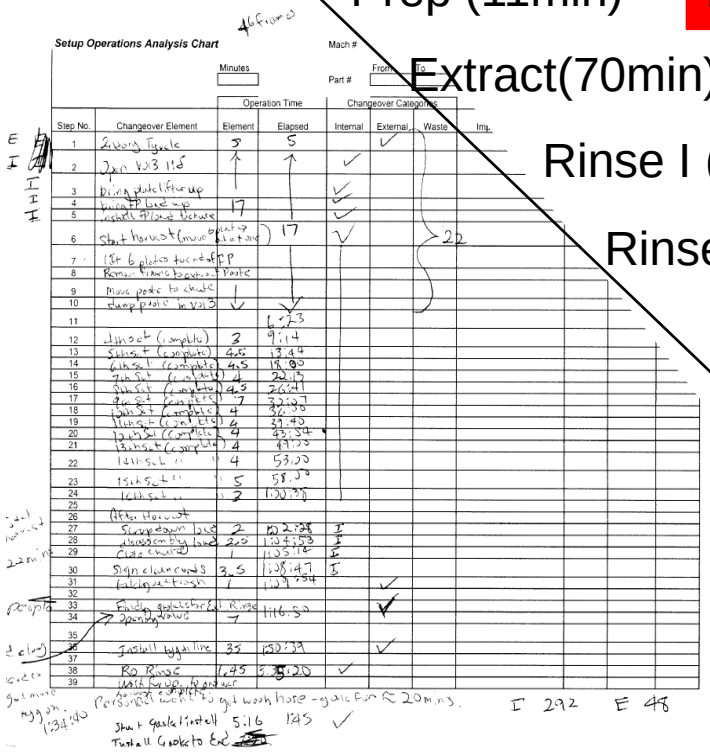
Status	Operator	Machine
• Idle Time • Working Time • Total Cycle • Utilization	• 0.24 min • 1.12 min • 1.36 min • 82% (1.12/1.36)	• 0.56 min • 0.80 min • 1.36 min • 59% (0.8/1.36)

Work Measurement (Setup Time) Operators and Machine « Pump Diagram »

Observed
CT = 648 Min

Setup

Run Time



Prep (11min) External

Extract(70min) Internal-Reduce

Rinse I (50min) Int-Reduce

Rinse II (60min) Int-Reduce

MC Breakdown (200 min) Eliminate

Remove Gasket (80min) Int-Reduce

Clean Gasket (30 min) Int-Reduce

Install Gasket (145 min) Int-Combine

Work Measurement (Setup Time) Operators and Machine « Pump Diagram »

Capacity Gain = 416 min

Observed = 648 min

Reduced = 232 min

PROTIME v5.0 STUDENT - [Element Details]

File Edit View Data Entry Reports Tools Window Help

ELEMENT DETAILS

Search Element ID: ASSY1

Element ID | Work Content Graph | Statistics | Picture | Media Clip | Excel

Elem ID: SETUP1
Name: Setup Extruder
Last Update: 5/15/2009
Dept: 40
Engineer: MA
Last Cost: $56.00

Standard Leve
1 Predetermined-MTM
2 Video-Stopwatch
3 Historical
4 Exercise

Memo

Total Cycle Min: 648.1440
PFD: 15%
Total Std Min: 745.3656
Batch/Lot Size: 1
Units/Hr: 0
Level: 100%
Labor $/hr: 45
$/Unit: $559.02
Total TMU: 1,080,240

No	Element Details	Code I	Code II	Fr/Sec	Line Total
5	Prep equipment	INT	0	660	18480
10	Extract	INT	0	4200	117600
15	Rinse	INT	0	3000	84000
20	Rinse II	INT	0	3600	100800
25	~~MC Breakdown~~	INT	0	11820	330960
30	Remove gasket	INT	0	4800	134400
35	Clean gasket	INT	0	1800	50400
40	Install gasket	INT	0	8700	243600
			0	1	

External
Reduce
Reduce
Reduce
Eliminate
Reduce
Reduce
Combine

Record: 57 of 57

Type Relevant Information; Tools/Safety, General Work Method, Etc.

PROTIME v5.0 STUDENT - [Element Details]

File Edit View Data Entry Reports Tools Window Help

ELEMENT DETAILS

Search Element ID: SEUP2

Element ID | Work Content Graph | Statistics | Picture | Media Clip | Excel

Elem ID: SEUP2
Name: Setup Extruder (Future State)
Last Update: 6/20/2009
Dept: 40
Engineer: MA
Last Cost: $559.00

Standard Leve
1 Predetermined-MTM
2 Video-Stopwatch
3 Historical
4 Exercise

Memo

Total Cycle Min: 231.8400
PFD: 15%
Total Std Min: 266.6160
Batch/Lot Size: 1
Units/Hr: 0
Level: 100%
Labor $/hr: 45
$/Unit: $199.96
Total TMU: 386,400

No	Element Details	Code I	Code II	Fr/Sec	Line Total
5	Prep equipment	EXT	0	660	0
10	Extract	INT	0	3800	106400
15	Rinse	INT	0	2000	56000
20	Rinse II	INT	0	2800	78400
30	Remove gasket	INT	0	3800	106400
35	Clean gasket and Install gasket	INT	0	1400	39200
			0	1	

Work Measurement (Single Machine) « OEE »

OEE = Availability x Performance x Quality

Availability (Downtime Loss) = Operating Time / Planned Production Time

Performance (Speed Loss) = Ideal Cycle Time / (Operating Time / Total Pieces)

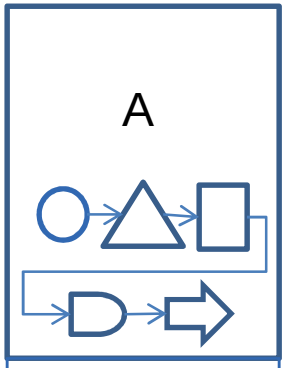
Quality (Quality Loss) = Good Pieces / Total Pieces

OEE Factor	Shift 1	Shift 2
Availability	90%	95%
Performance	95%	95%
Quality	99.5%	96%
OEE	85.1%	86.6%

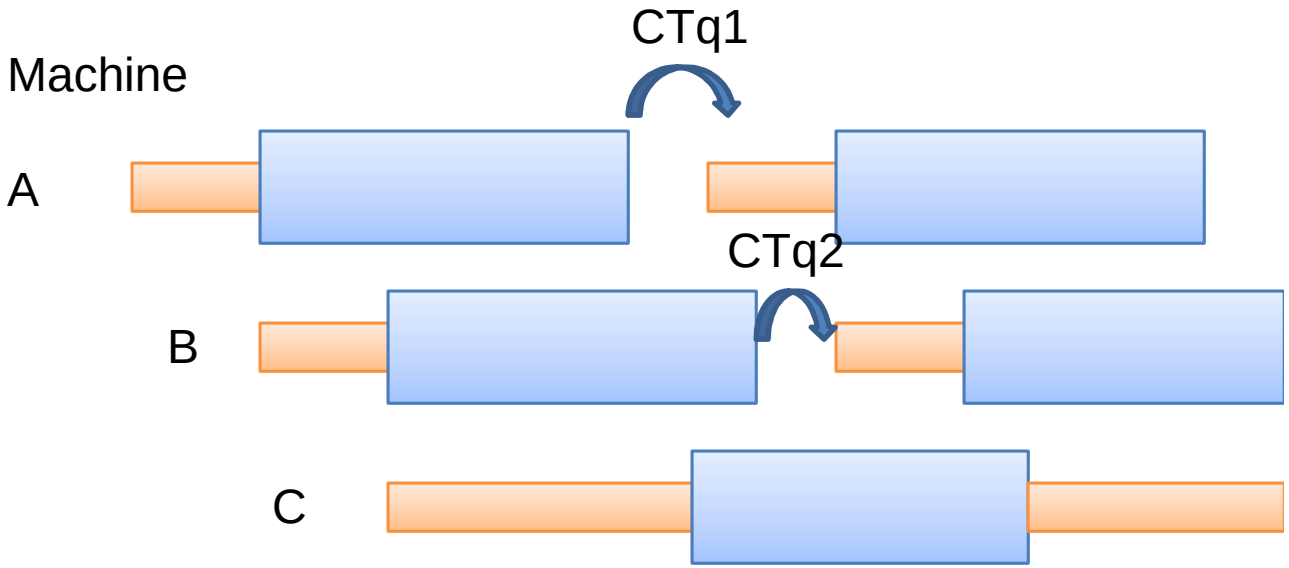
Note: Availability (TBF and TTR)

Work Measurement (Multiple Machine) « Waterfall Diagram »

Multiple Machine and Operator Work
Is work which requires the worker/team to attend two or more machines/equipment



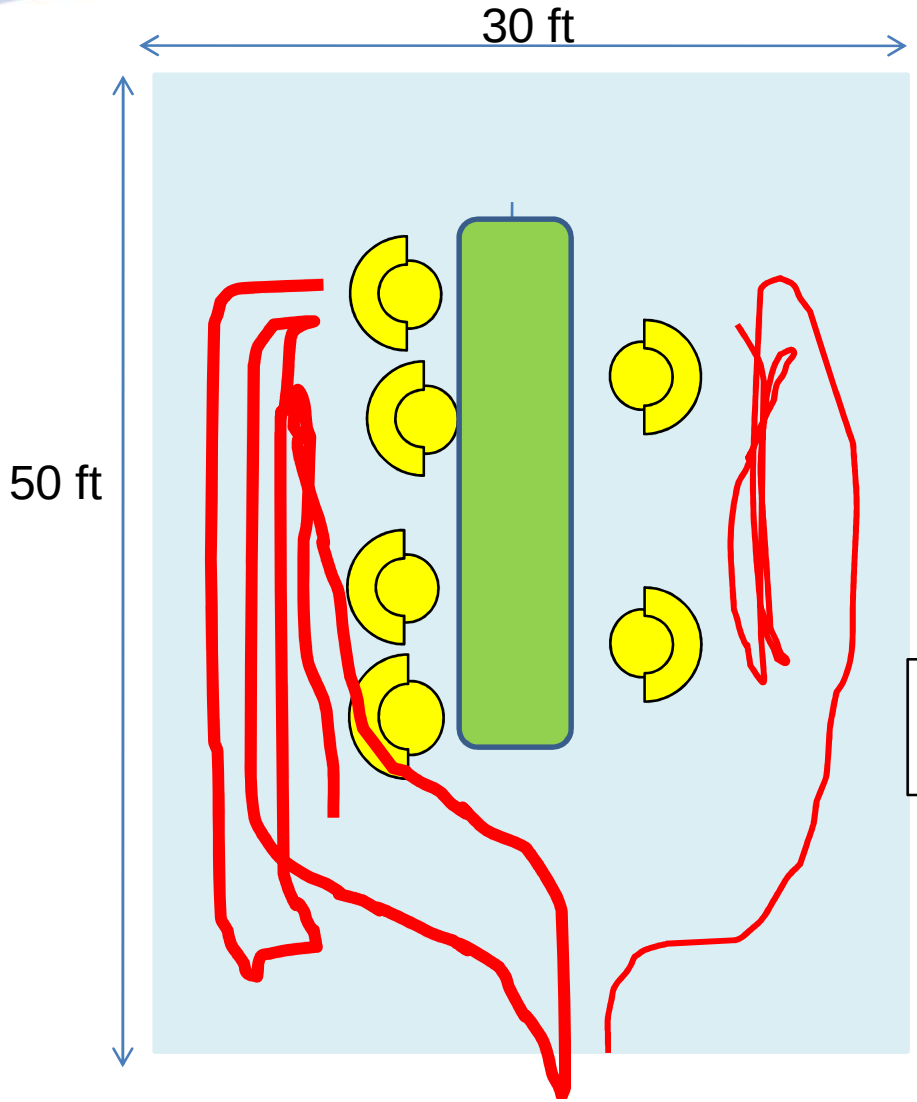
CT= 1.36 m
C/O= 1 m
TBF = 4 D
TTR = 2 H
Yield = 92%
HCT = 8 FT
VA = 0.8 m



CT= SetupTime + Process Run Time + Ctq

Work Measurement (People Flow) « Spaghetti Diagram »

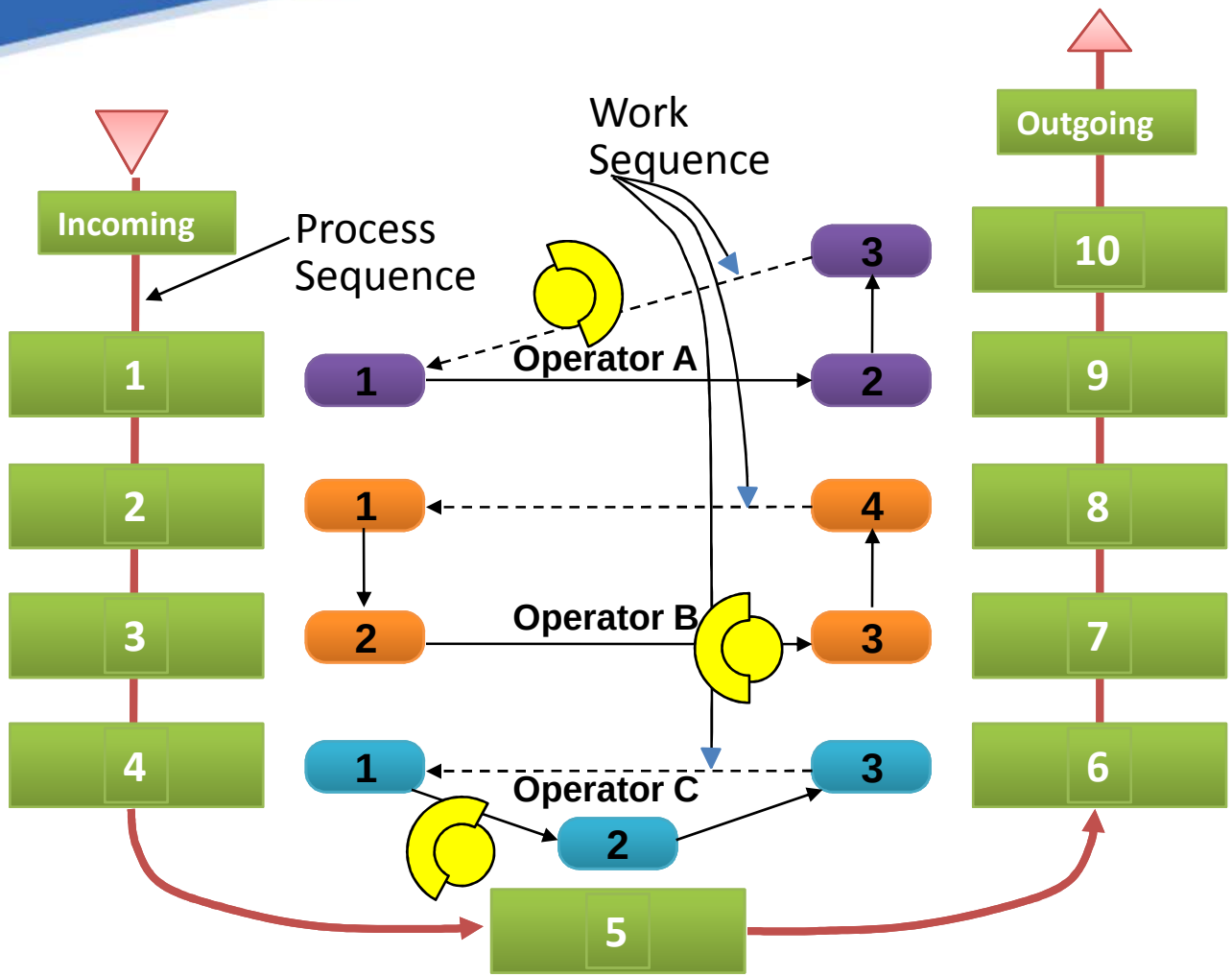
Process Layout: 6 People -Crew



3 Op to unload printing frames and remove gaskets

3 Op to change inks and spray pins

Work Measurement (People Flow)



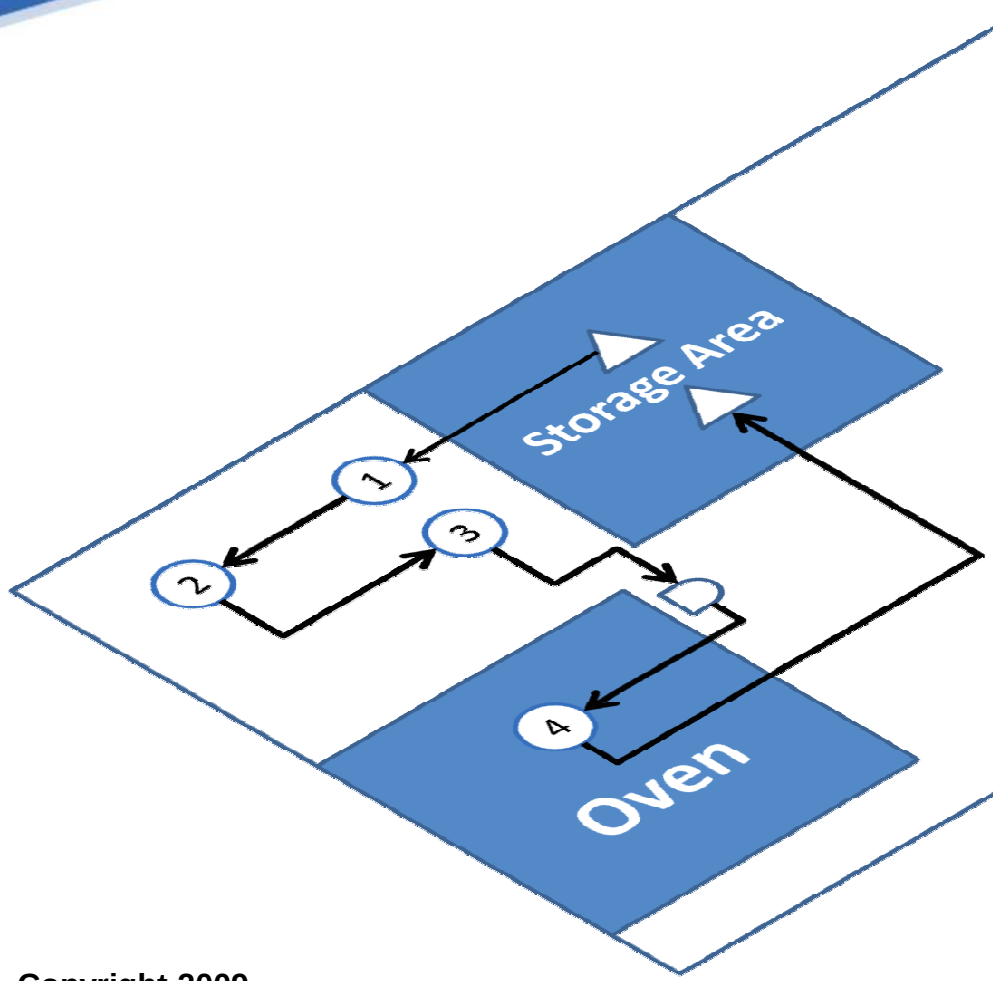
Work Measurement (Material-Facility Flow)

Process Description: Coat Coils

Date: XX-XX-XX (Material) People Machine Information

No.	Task Description	Cum. Time (days)	Interval Time (days)	Distance (Ft)	Operation	Transport	Storage	Delay	Inspection
1	Coils on Storage	5	5				5		
2	To coating machine by truck rack	10	0.1	10		0.1			
3	Coat with glue and emery and place on truck rack 1st	10.1	5	5	5				
4	Dry coil	15.1	4	3	4				
5	Coat with glue and emery and place on truck rack 2nd	19.1	5	0	5				
6	On rack at coating machine	24.1	7	6				7	
7	Rack into drying oven	31.1	0.2	2		0.2			
8	Dry in oven	31.3	6	0	6				
9	Track rack to storage	37.3	0.1	3		0.1			
10	Storage of finished coated coils	37.4	5	0			5		
Current	**Total**	**37.4**		29	20	0.4	10	7	
	Steps Count	**10**			4	3	2	1	
	Work Flow Cycle Efficiency	**53%**	%						
Proposed	**Subtotal**								
	Grand Total		min						
	Work Flow Cycle Efficiency		%						

Work Measurement (Material-Facility Flow)

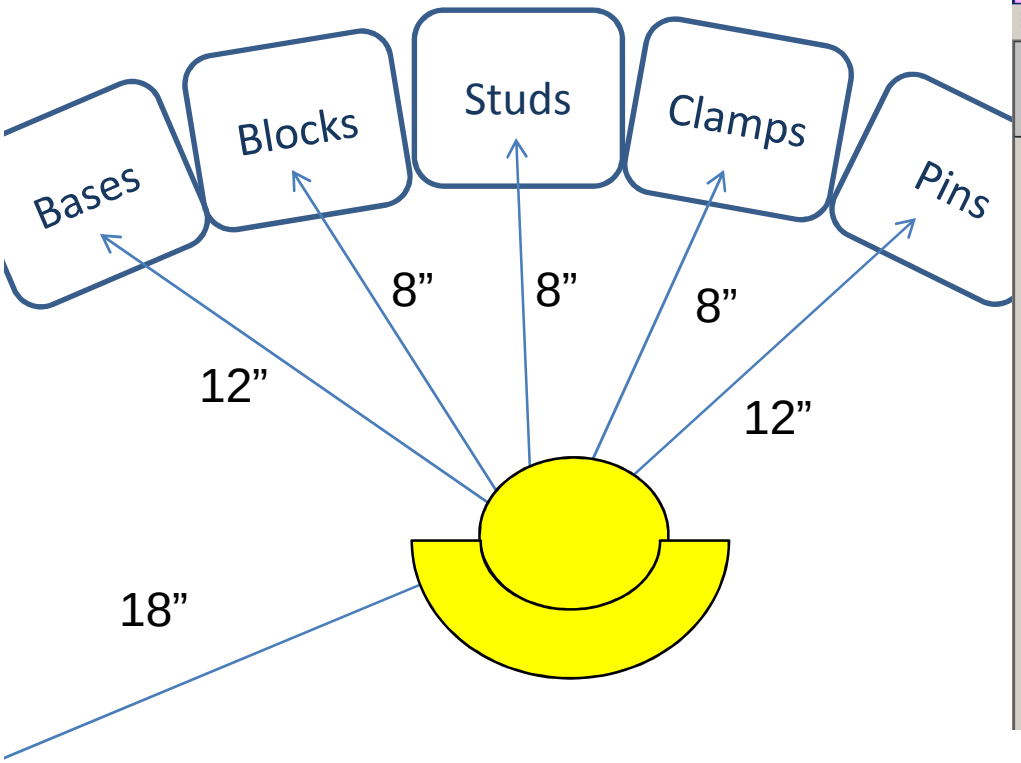


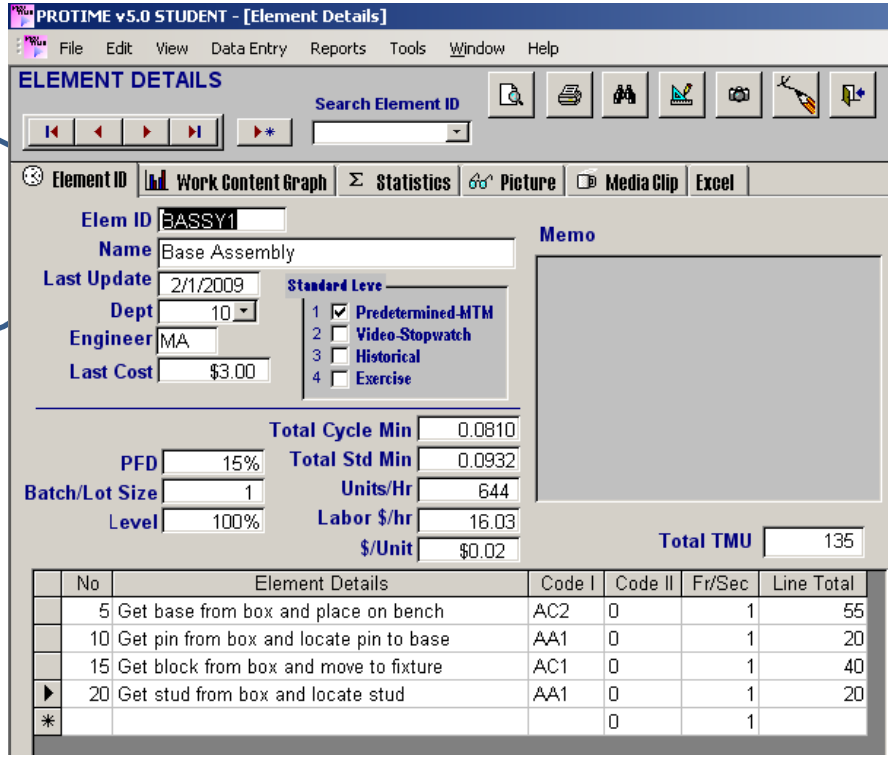
Work Measurement PTS
Predetermined Time Standards

PTS

Are pre-established times for basic human motions and are used to build up the time for a job at a defined level of performance

Base assembly workplace layout





Work Measurement
Work Sampling

WS

Is a method of finding the % of occurrence of a certain activity by statistical sampling and random observations

Sample Size

$$\partial p = \sqrt{\frac{pq}{n}}$$

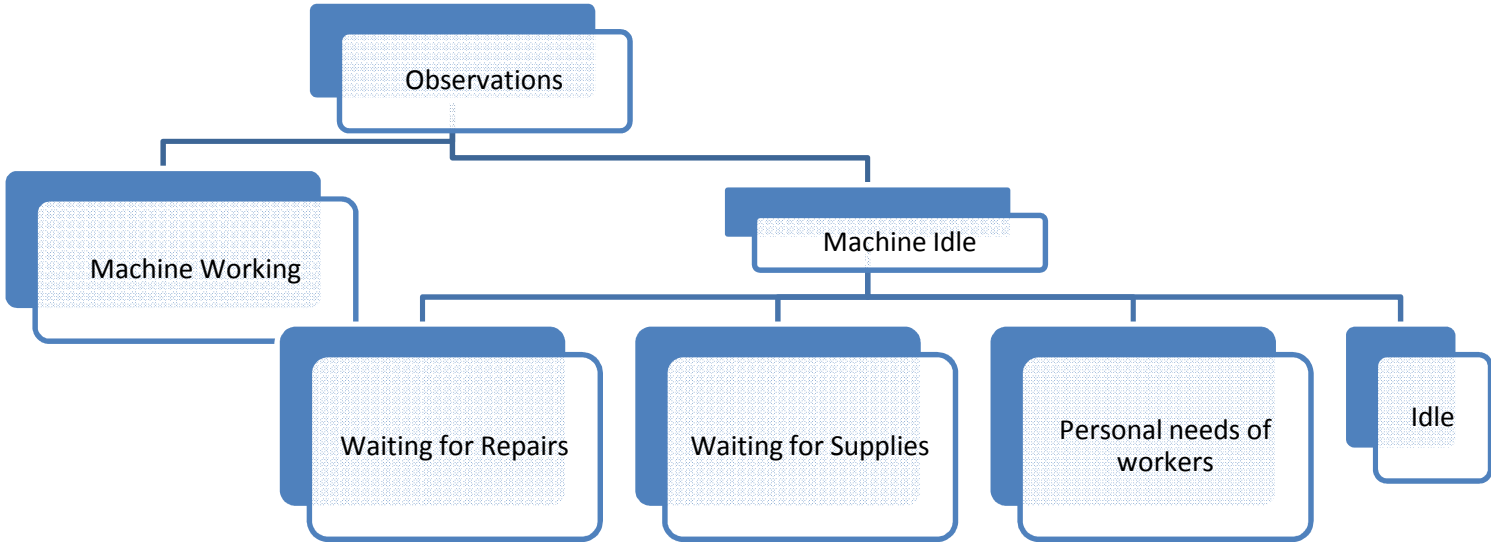
Preliminary Study
100 observations
P = 25 % machine idle
q = 75% working

95% conf level 10% error

$$1.96 \times \partial p = 10$$

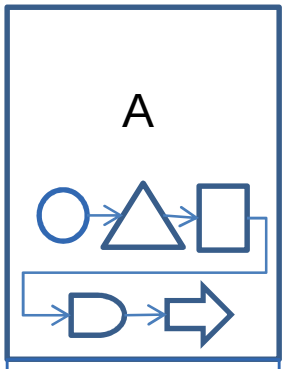
$$5 = \sqrt{\frac{25 \times 75}{n}}$$

n = 75 observations



Numb er of Observations: 75			Total	%
Machine Running		11111 11111 11111 11111 11111 11111 11111 11111 11111 11111 11111 11111 11111 11	62	82.7%
Machine Idle	Repairs	11	2	2.7%
	Supplies	111111	6	8.0%
	Personal	1	1	1.3%
	Idle	1111	4	5.3%
				100%

Work Measurement
Service /Business Function



CT= 1.36 m

C/O= 1 m

TBF = 4 D

TTR = 2 H

Yield = 92%

HCT = 8 FT

VA = 0.8 m

Time To Fill Vacancies
(Intellectual Capital Losses)

Lost Hours of Productive Hourly Employees
Lost Hours of Productive Salary Employees
Lost Hours of Productive Executive Employees

Time To Train New Employees

Time To Process Purchase Orders

Time To Generate Financial Reports

Time and Resources To Service Machinery and Equipment

Time and Resources To Execute a Project

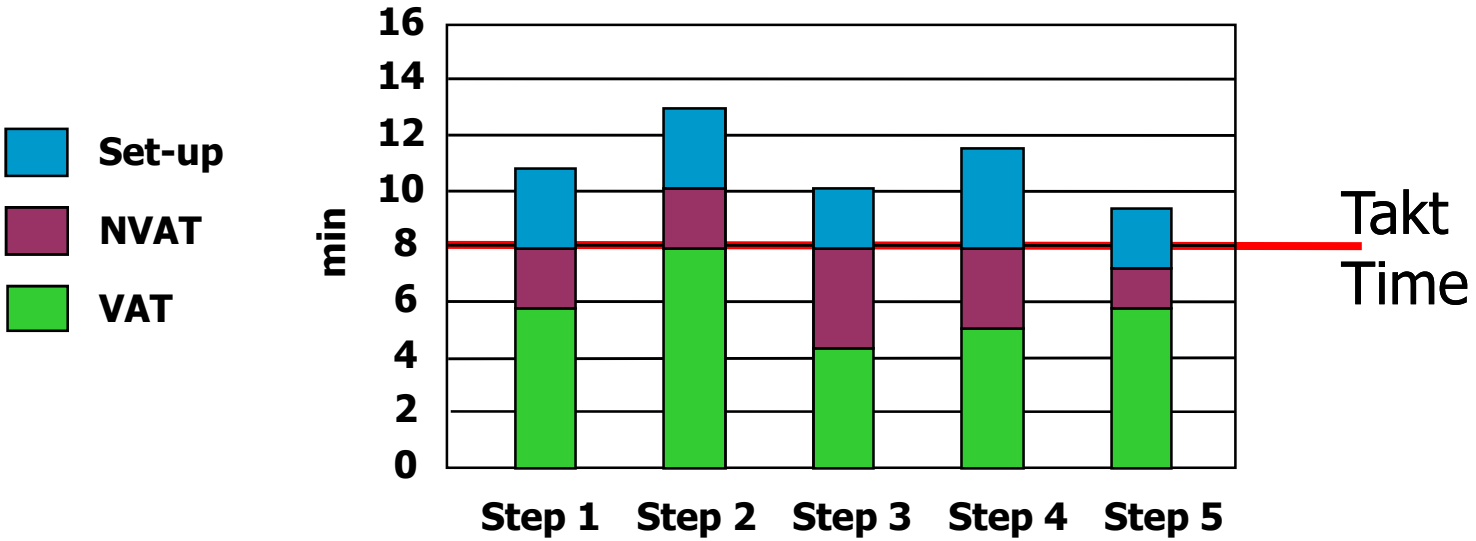
Distributing the Work Load
Line Balancing

a. Reduce NVA time to improve work balance

b. Reduce product cost by removing work time from product

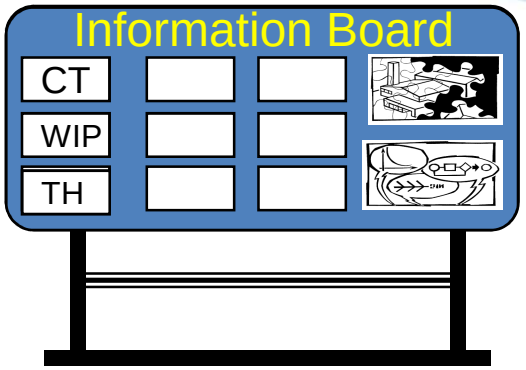
c. Cycle Time and WIP will be reduced

d. Productivity will increase due to more time for VA tasks

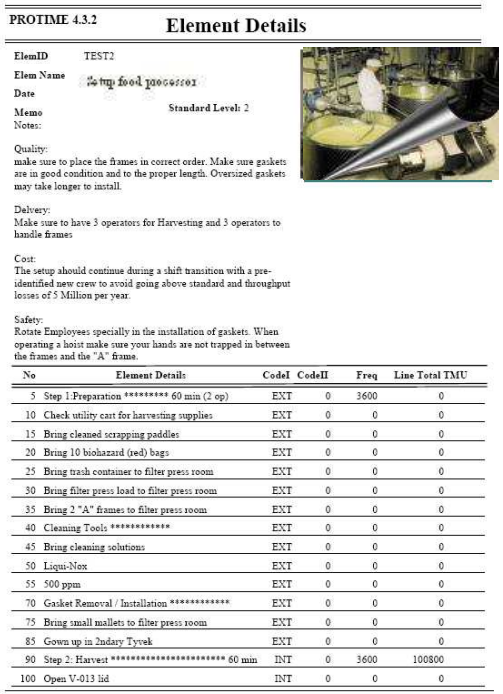


Work Measurement (Information Flow)
Does everyone know the target and the method ?

Video Instruction



Text Instruction



PROTIME 4.3.2

Element Details

ElemID TEST2
Elem Name
Date
Memo
Notes:

Standard Level: 2

Quality:
make sure to place the frames in correct order. Make sure gaskets are in good condition and to the proper length. Oversized gaskets may take longer to install.

Delivery:
Make sure to have 3 operators for Harvesting and 3 operators to handle frames

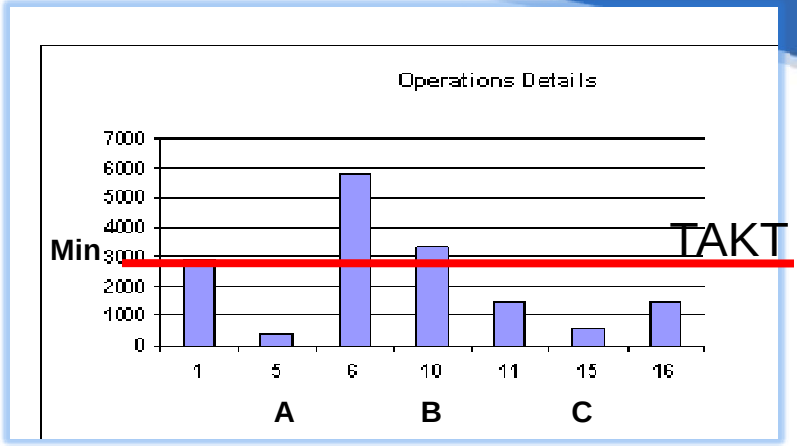
Cost:
The setup should continue during a shift transition with a pre-identified new crew to avoid going above standard and throughput losses of 5 Million per year.

Safety:
Rotate Employees specially in the installation of gaskets. When operating a hoist make sure your hands are not trapped in between the frames and the "A" frame.

No	Element Details	CodeI	CodeII	Freq	Line Total TMU
5	Step 1:Preparation ********* 60 min (2 op)	EXT	0	3600	0
10	Check utility cart for harvesting supplies	EXT	0	0	0
15	Bring cleaned scrapping paddles	EXT	0	0	0
20	Bring 10 biohazard (red) bags	EXT	0	0	0
25	Bring trash container to filter press room	EXT	0	0	0
30	Bring filter press load to filter press room	EXT	0	0	0
35	Bring 2 "A" frames to filter press room	EXT	0	0	0
40	Cleaning Tools **********	EXT	0	0	0
45	Bring cleaning solutions	EXT	0	0	0
50	Liqui-Nox	EXT	0	0	0
55	500 ppm	EXT	0	0	0
70	Gasket Removal / Installation **********	EXT	0	0	0
75	Bring small mallets to filter press room	EXT	0	0	0
85	Gown up in 2ndary Tyvek	EXT	0	0	0
90	Step 2: Harvest ********** 60 min	INT	0	3600	100800
100	Open V-013 lid	INT	0	0	0

Achieving Standard Work

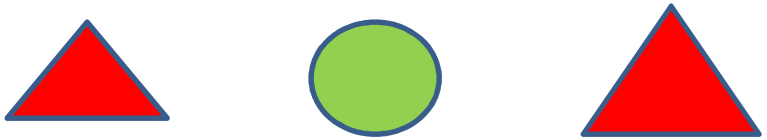
Routine for work to be performed right the first time, every time



Elements of Standard Work

1- Takt (Demand Rate)

2- Standard WIP

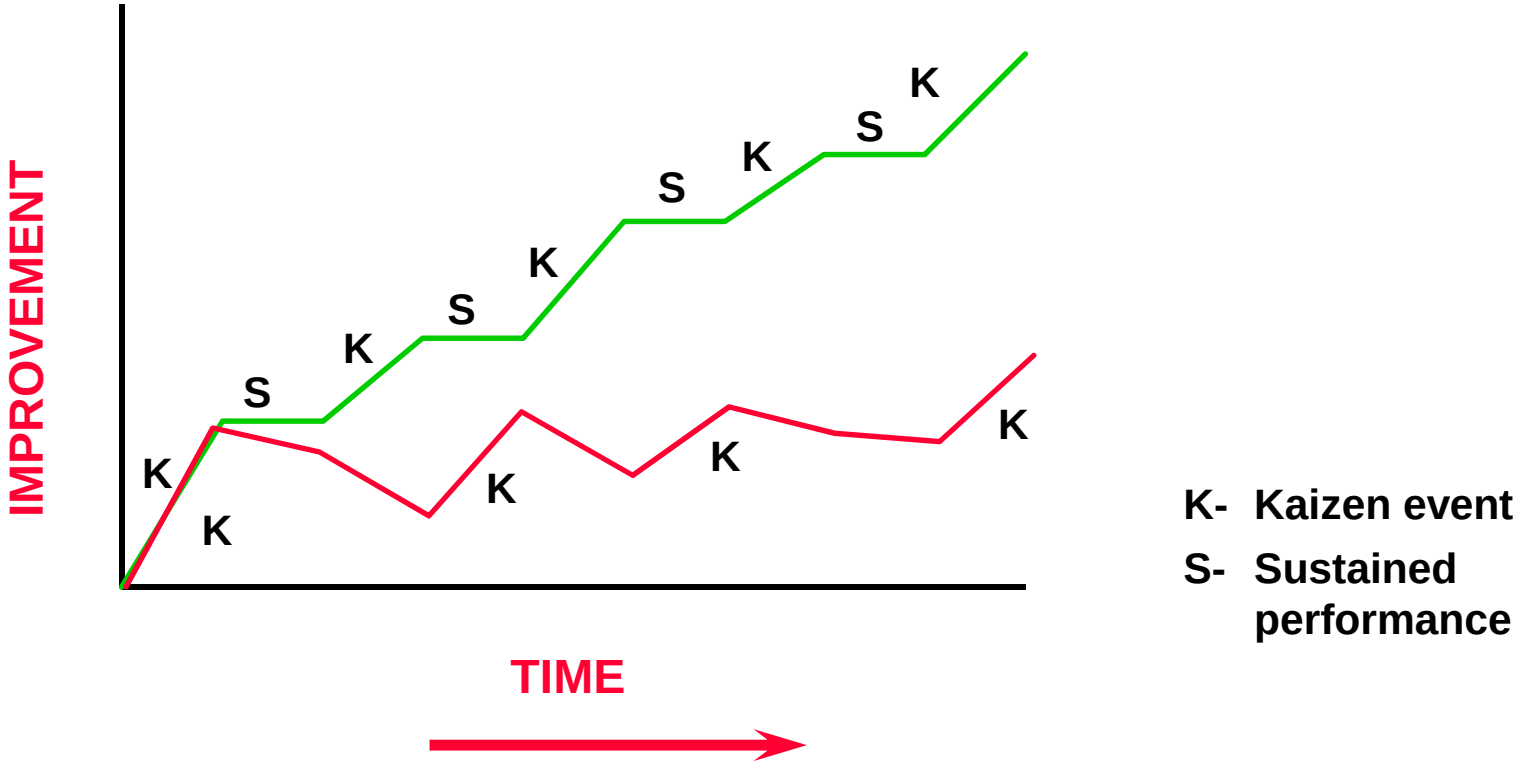


3- Work sequence (Work Instruction, Documentation & Training)

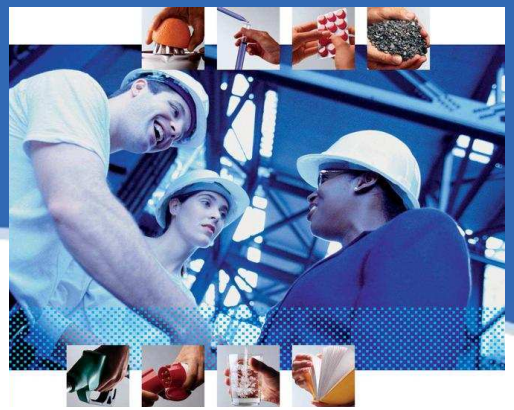
$$WIP = CT \times TH$$

Sustaining and Improving

Standardization Drives Sustainable Results



Q&A



Cannot manage if you don't measure !

Contact IIE Membership
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