Work Measurement Methods

Haleh Byrne
Product Lead – Industrial Engineering
North Carolina State University
Industrial Extension Service
Campus Box 7902
Raleigh, NC 27695-7902

1-800-227-0264
www.ies.ncsu.edu

Jobs, Innovation, Growth, Stability

"If you're not keeping score, you are just practicing." - Vince Lombardi

NC STATE UNIVERSITY

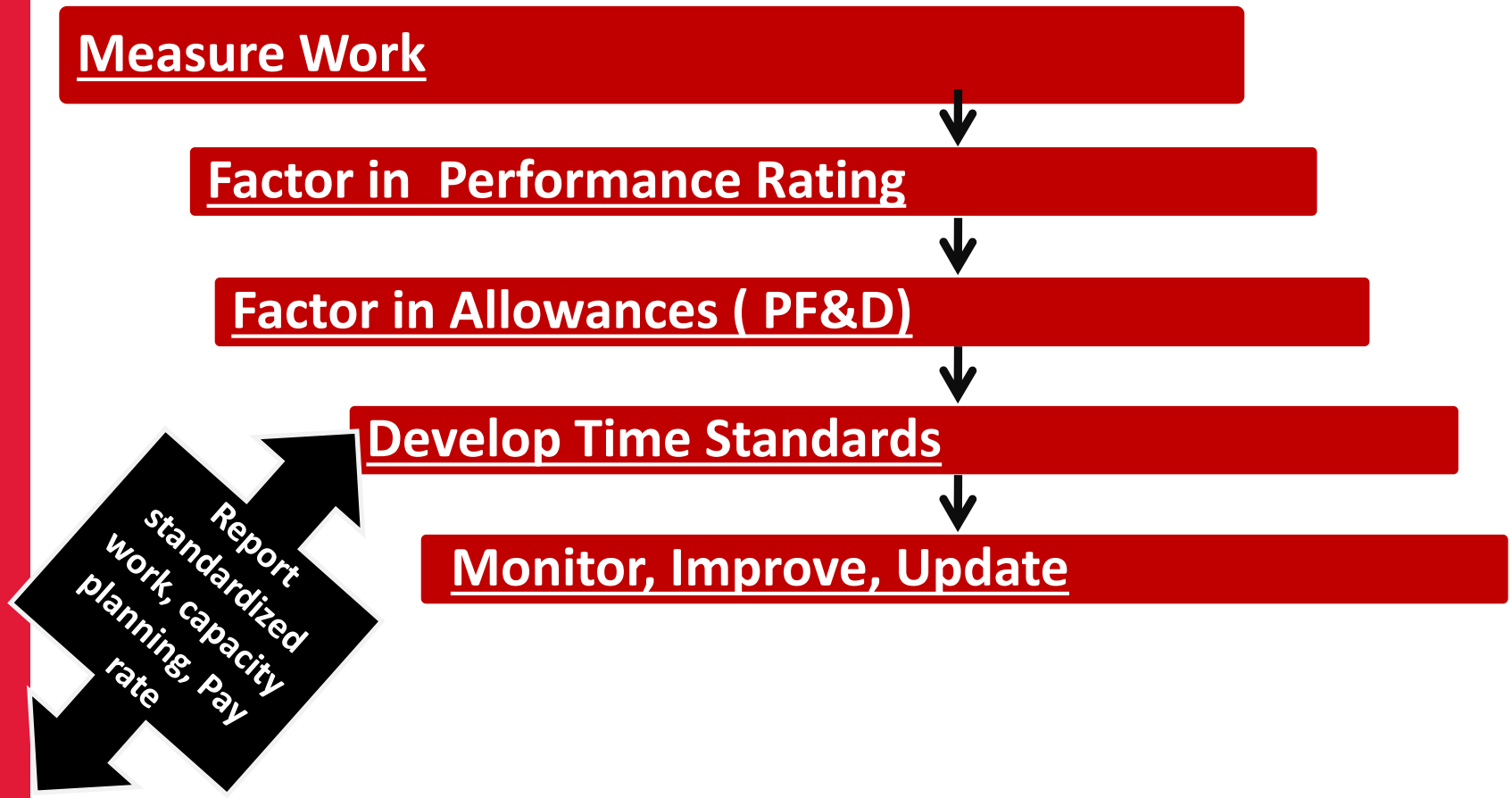
125 YEARS

WHAT IS WORK MEASUREMENT?

Work Measurement is determination of the length of time it should take to complete a job

Systematic determination of the amount of effective physical and mental work in terms of *work units* in a specified task.

General Steps in Work Measurement



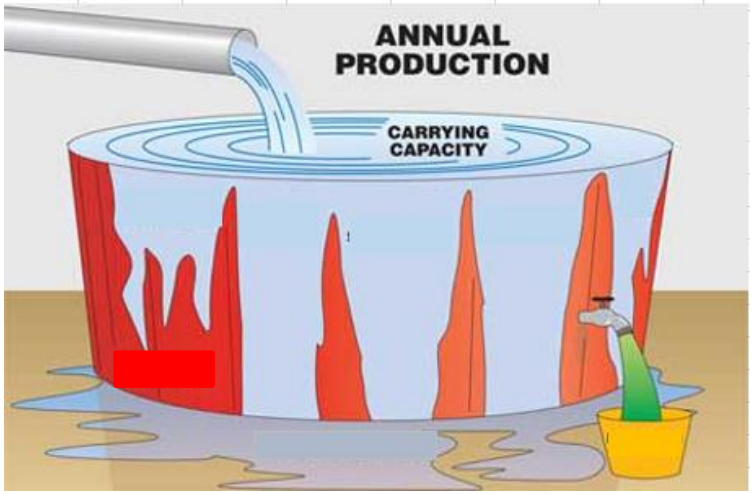
WHERE DO WE USE TIME STANDARDS?

- Product Costing

- Delivery

WHERE DO WE USE TIME STANDARDS?

- Capacity Analysis

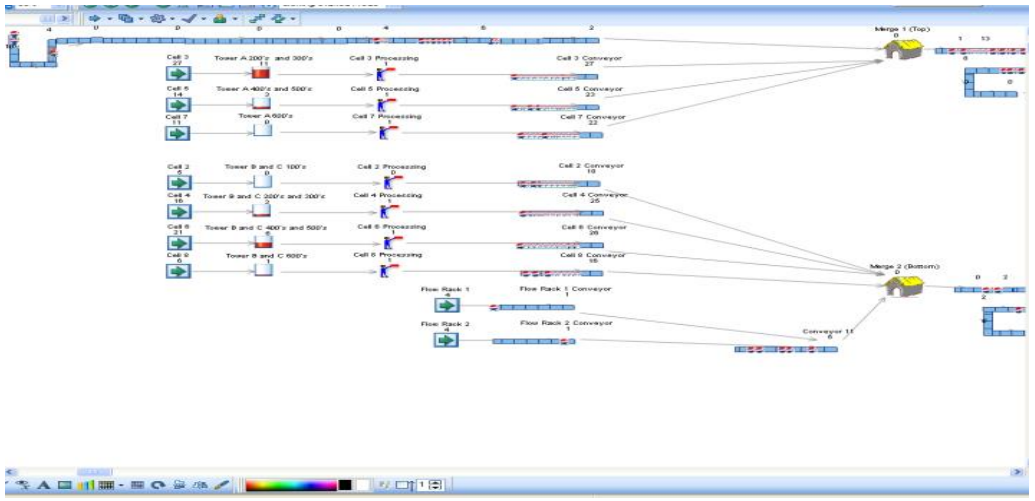


- Equipment Purchase Justification

WHERE DO WE USE TIME STANDARDS?

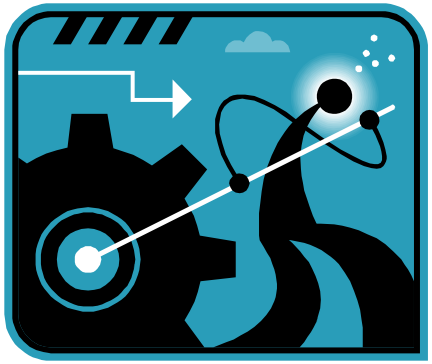
- Efficiency Improvement Scope and Requirement

- System Simulation



WHERE DO WE USE TIME STANDARDS?

- Labor Requirements

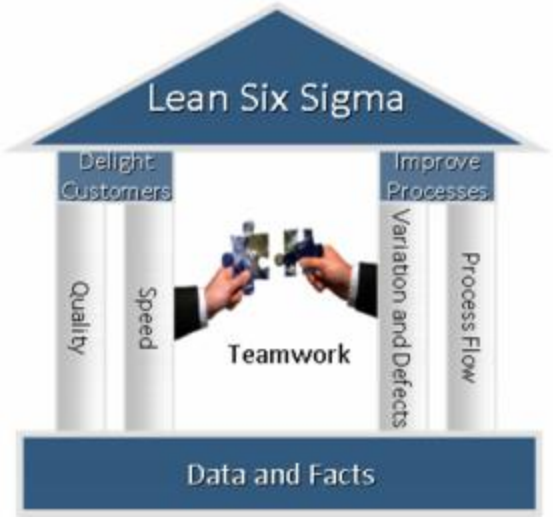


- Determination of Wage Payment Plans

WHERE DO WE USE TIME STANDARDS?

- Benchmarking

- Lean Six Sigma Application



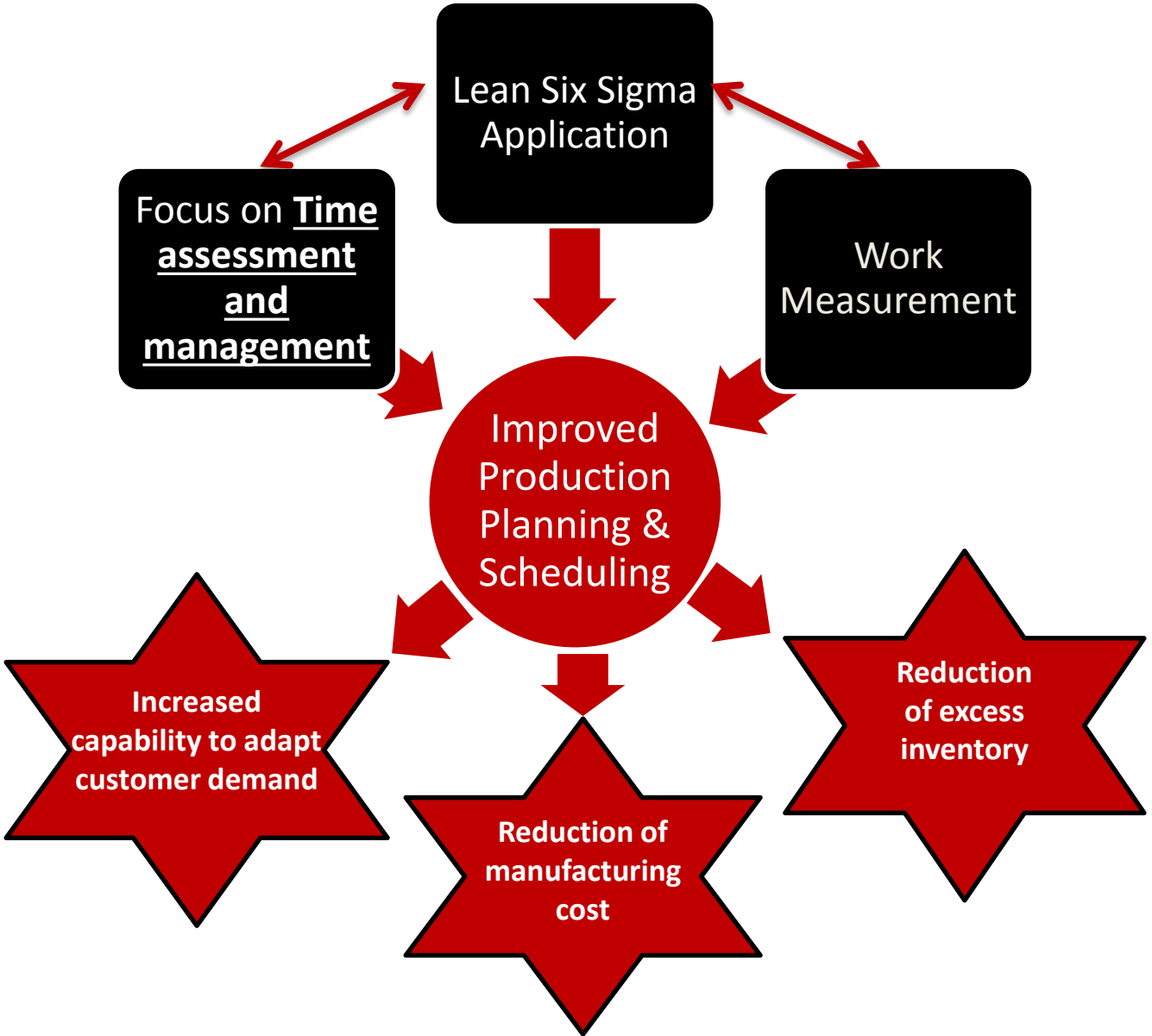
WHERE DO WE USE TIME STANDARDS?

- Labor Law Compliance

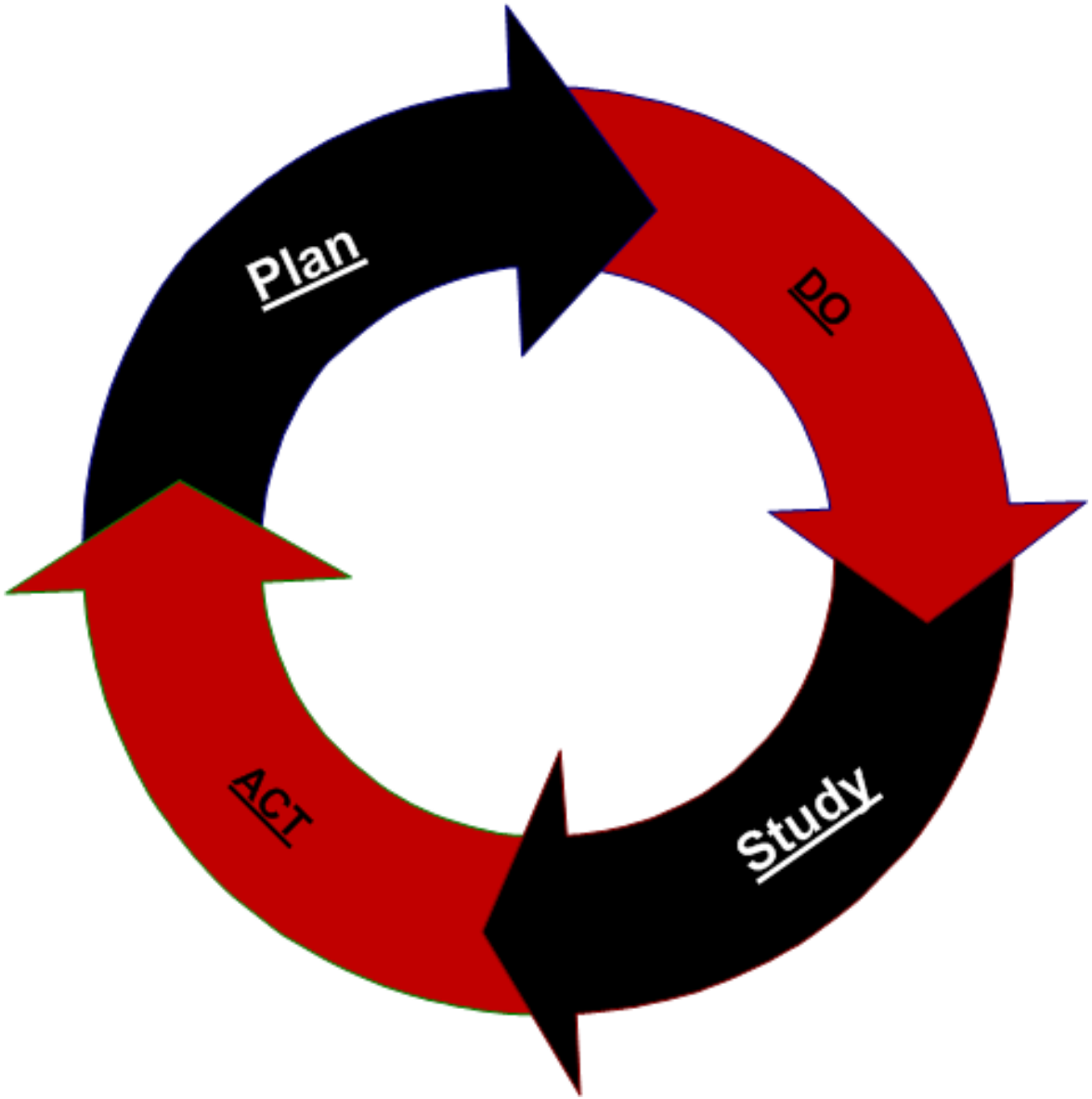
- Union Contract Negotiations


LACK OF CORRECT STANDARD TIMES
• UNPREDICTABLE TIME
• UNPREDICTABLE RESULTS
• INEFFICIENT ALLOCATION OF RESOURCES
• INACCURATE OPERATION COST ESTIMATES

The Whole Picture



Engineering & Lean Six Sigma Approach
PDSA Cycle



PDSA

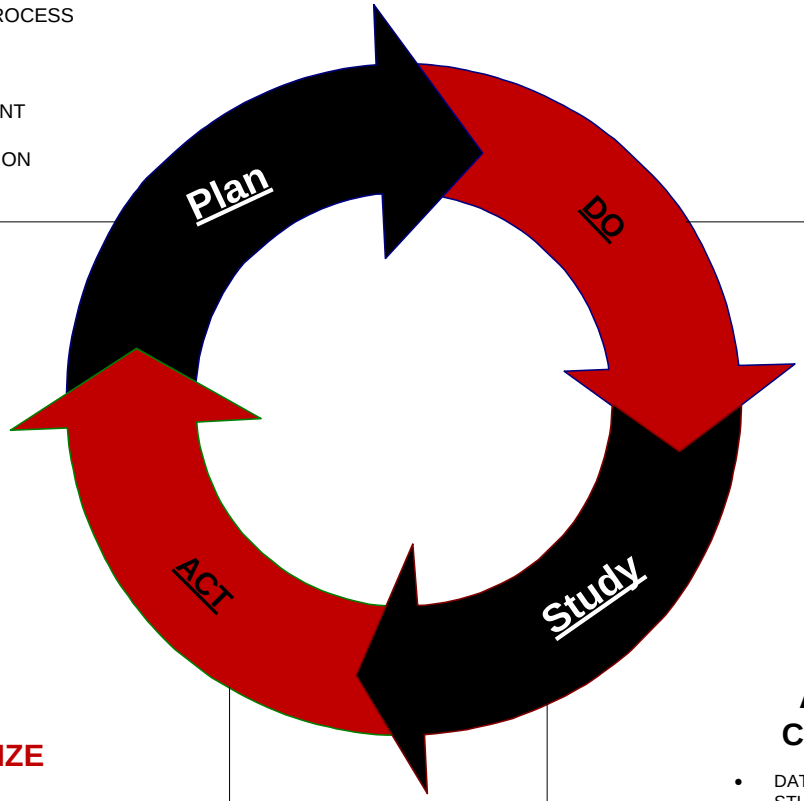
Engineering & Lean Six Sigma Approach for Work Measurement

IDENTIFY SCOPE MODULES

- DEVELOP PROCESS FLOW CHART
- UNDERSTAND THE PROCESS
- DEFINE VARIABLES
- ASSESS NEEDED RESOURCES
- SELECT MEASUREMENT SYSTEM
- PLAN DATA COLLECTION MODULES

MEASURE

- MEASURE WORK- TIME AND MOTION STUDY APPLICATION
- COLLECT/RECORD DATA
- MONITOR OUTPUTS
- CATEGORIZE THE RESULTS



OPTIMIZE

- IDENTIFY OPTIMIZED STATE OF PARAMETERS
- DETERMINE RESOURCE ALLOCATION
- DOCUMENT STANDARIZED WORK FOR FUTURE STATE

ASSESS AND COMMUNICATE

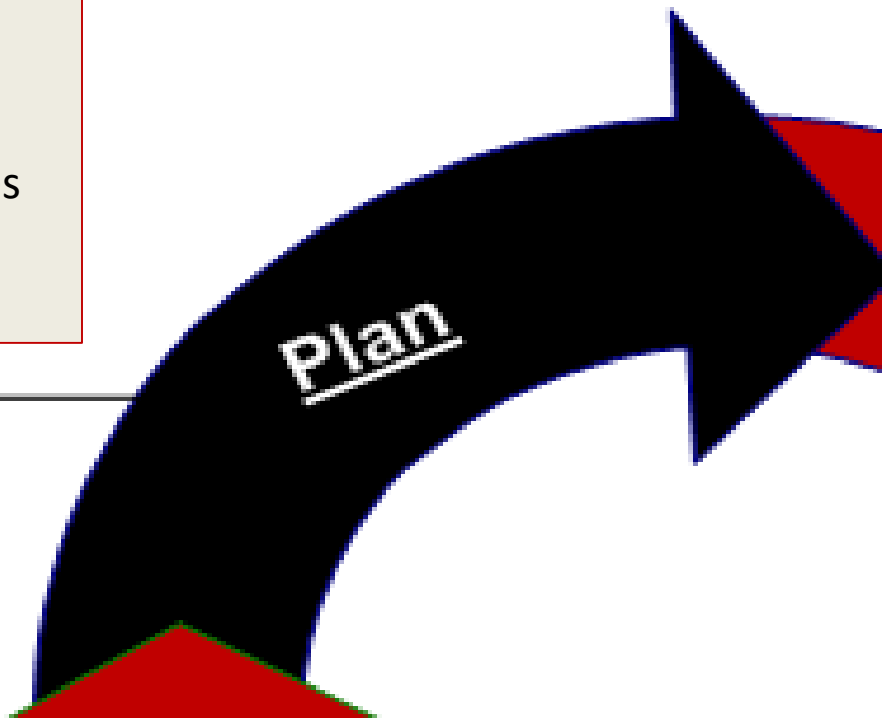
- DATA ANALYSIS – TIME STUDY
- VALIDATE CURRENT APPROACH
- DETERMINE RESOURCE AVAILIBILIY
- COMMUNICATE RESULTS
- BUILD SIMULATION MODEL

NC STATE UNIVERSITY 125 YEARS

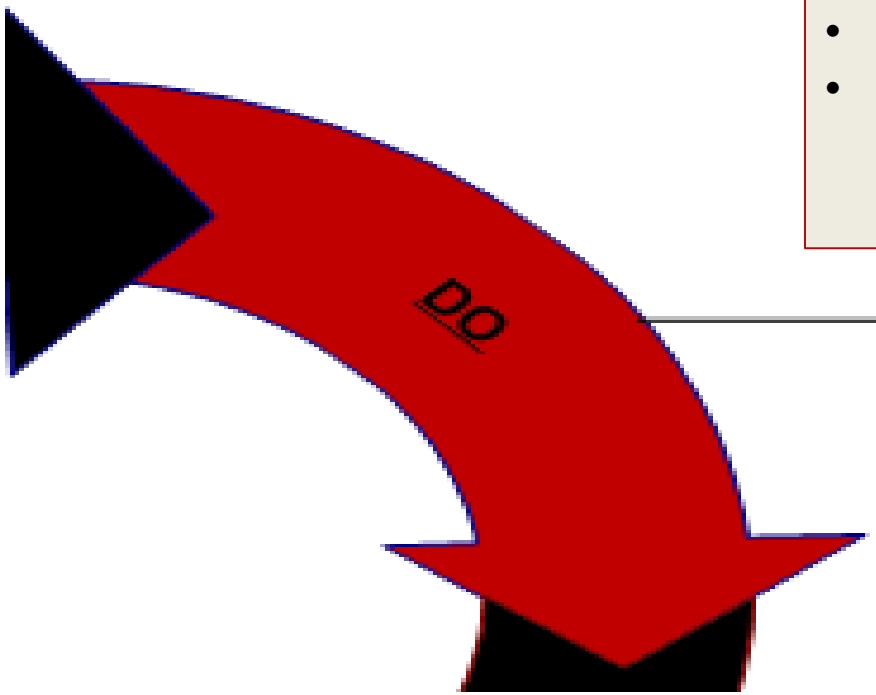
Plan

Identify Scope Modules

- Develop Process Flow Chart
- Understand the process
- Define Variables
- Determine Work Measurement approach
- Assess needed resources
- Create matrix and plan data collection phase and modules



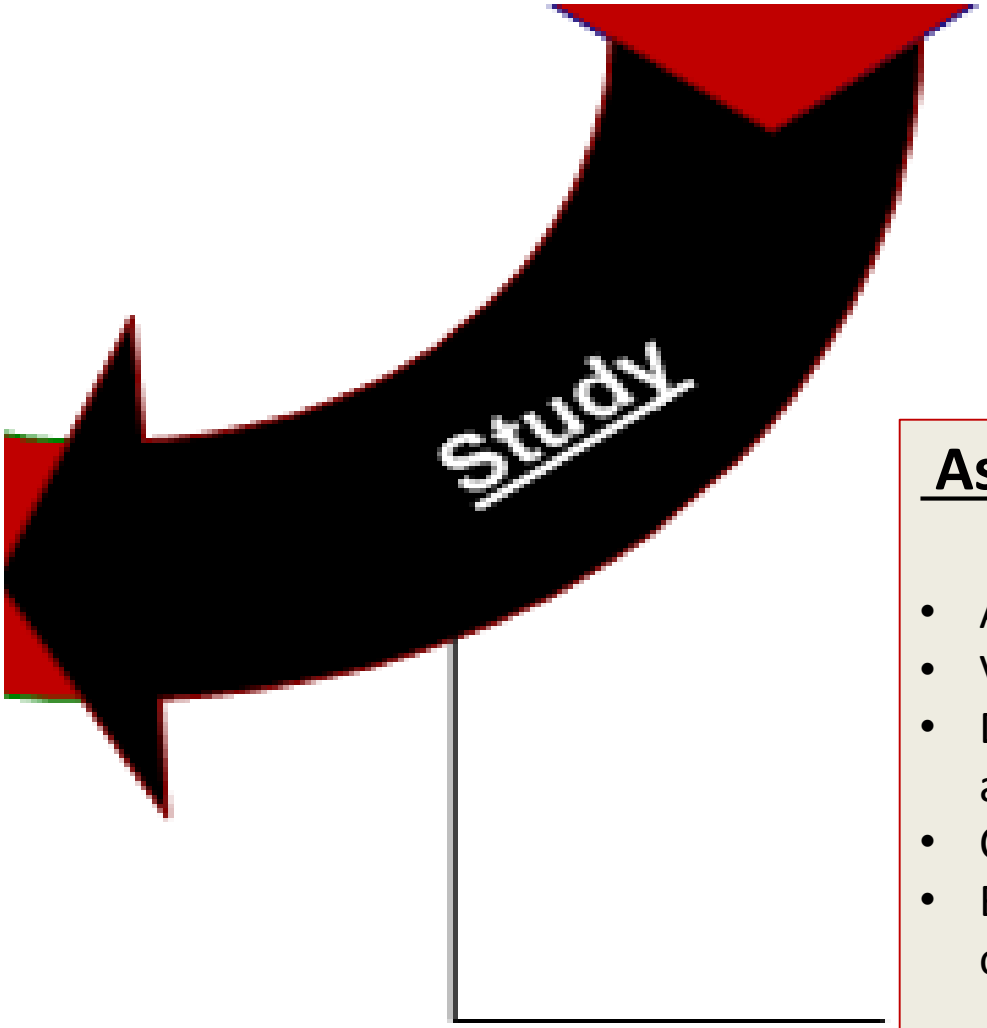
DO



Measure

- Measure Work (time study, work sampling, etc.)
- Collect and record data
- Monitor outputs
- Categorize the results

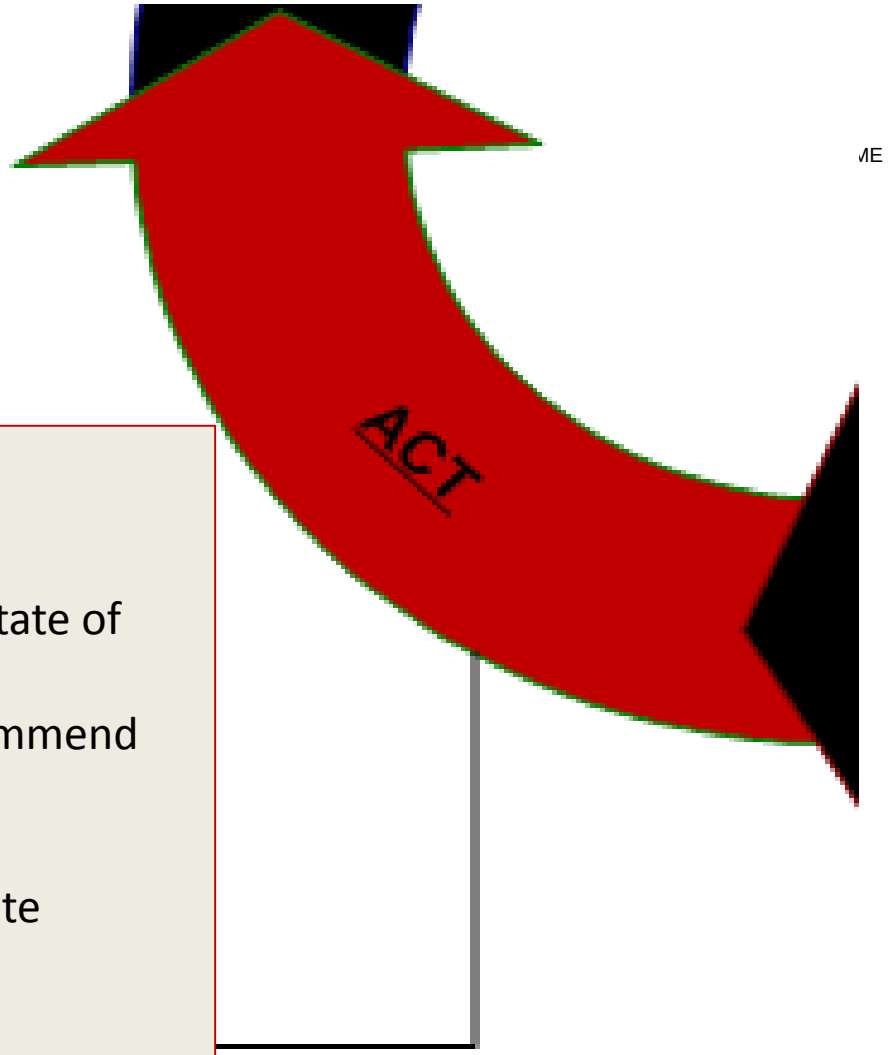
Study Example



Assess and communicate

- Analyze the results
- Validate Current approach
- Determine resources availability
- Communicate results
- Build simulation model (static or dynamic)

Act



Optimize

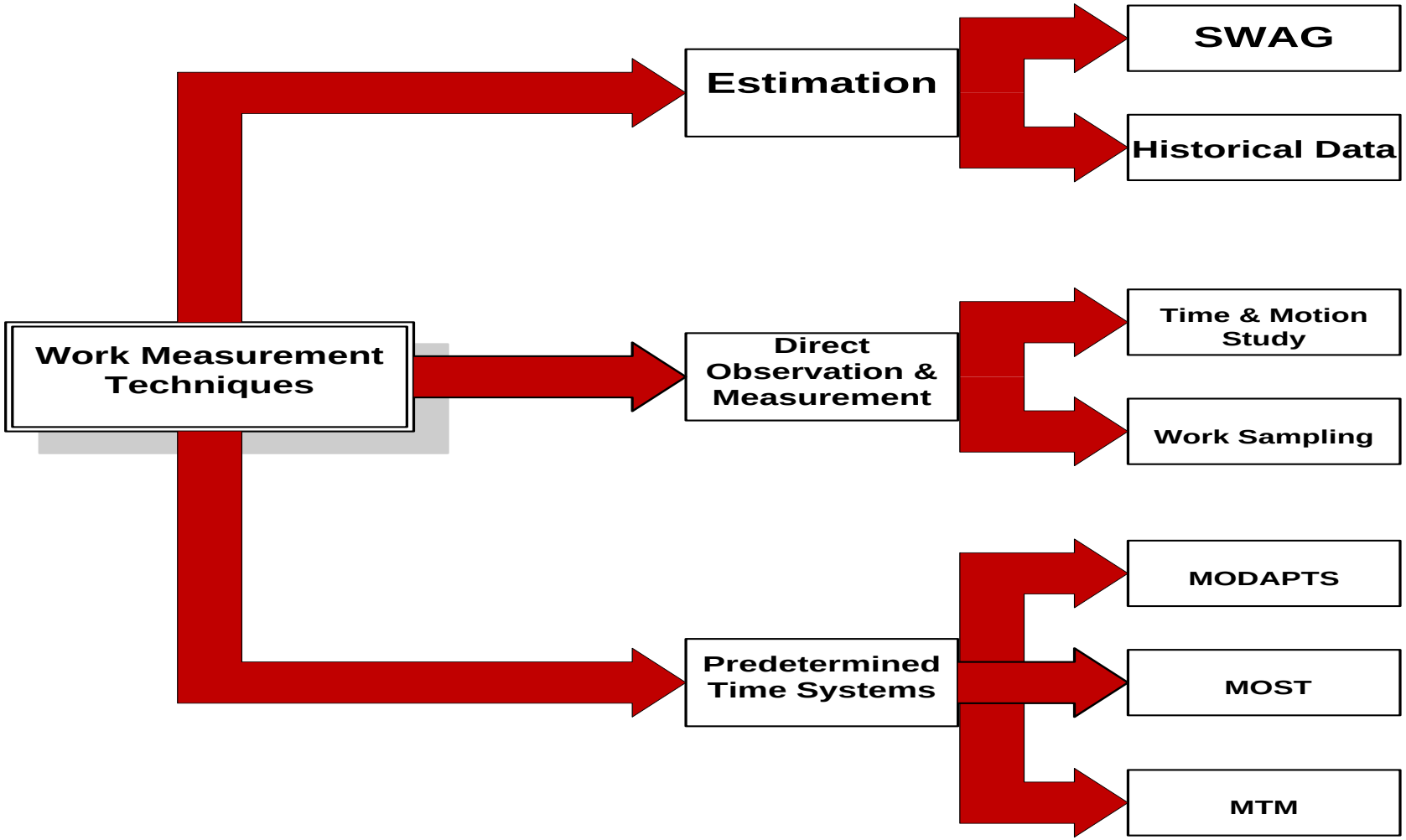
- Identify optimized state of parameters.
- Determine and recommend resource allocation, scheduling, etc.
- Document future state standardized work.

Why Work Measurement?

To:

- **Assess Capabilities**
- **Establish Expectations**

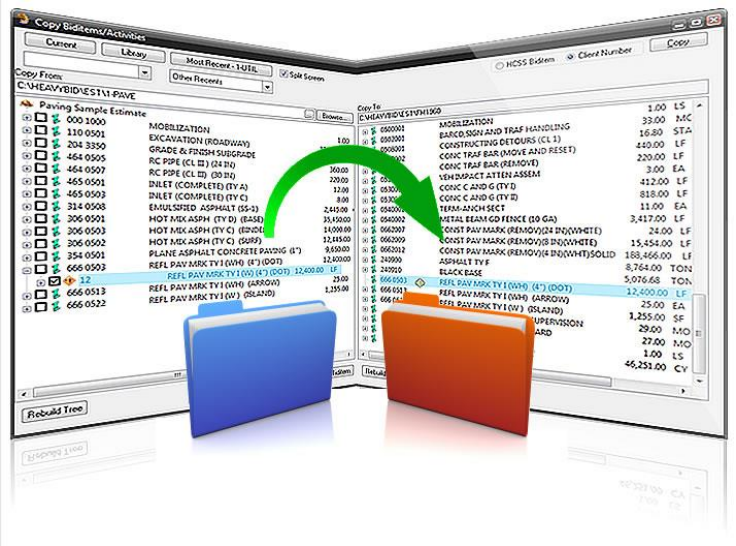
Work Measurement Methods



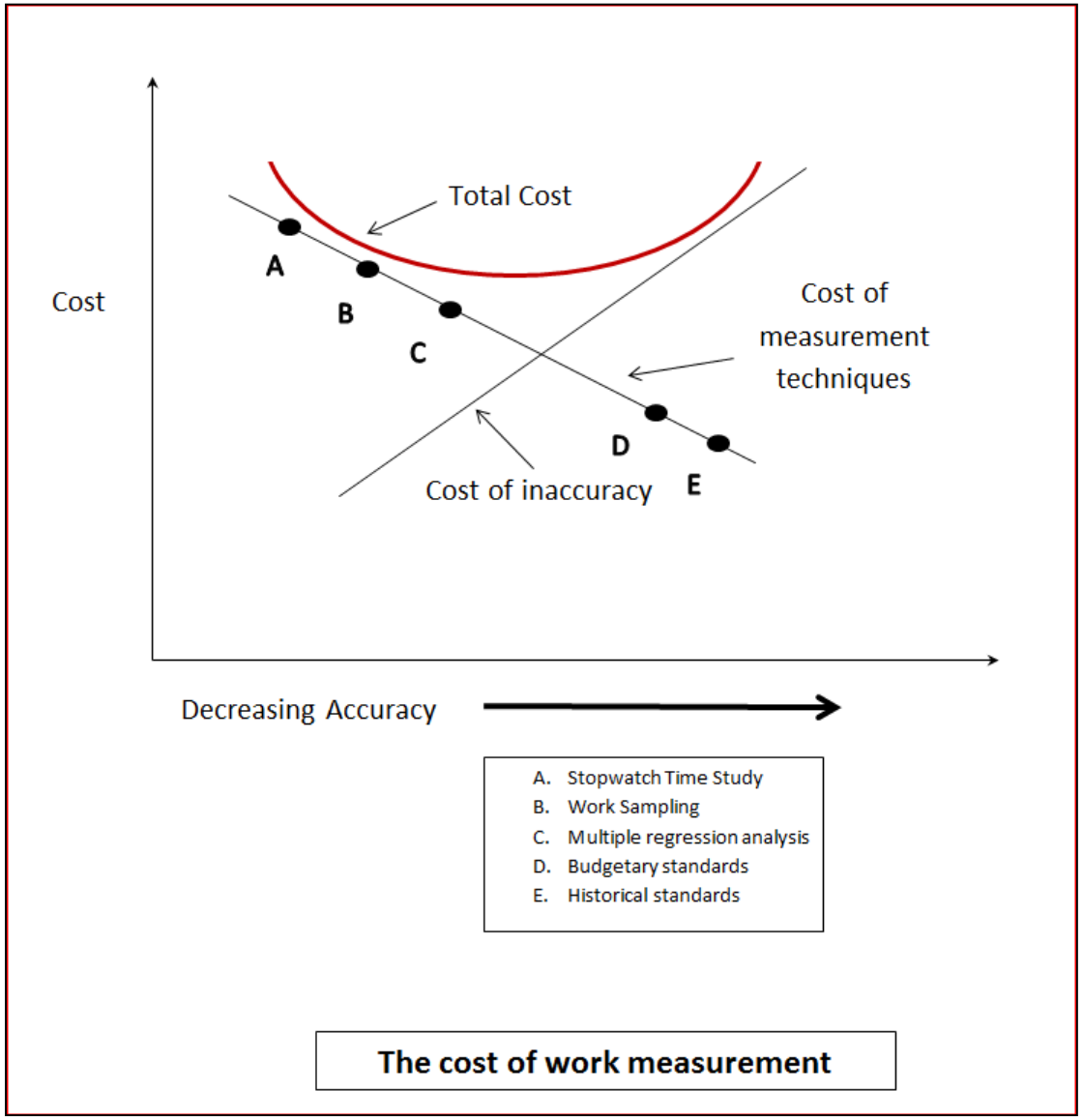
Which Method?

VOLUME	CYCLE TIME	RECOMMENDED TECHNIQUE
1000'S	LONG	Work Sampling
	MEDIUM	Work Sampling, Time & Motion Study
	SHORT	PTSS
100'S	LONG	Work sampling, Time & Motion Study
	MEDIUM	Time & Motion Study, Work Sampling
	SHORT	PTSS , Time & Motion
10'S	LONG	SWAG, Work sampling, Historical Data
	MEDIUM	SWAG, Historical Data
	SHORT	Time & Motion Study

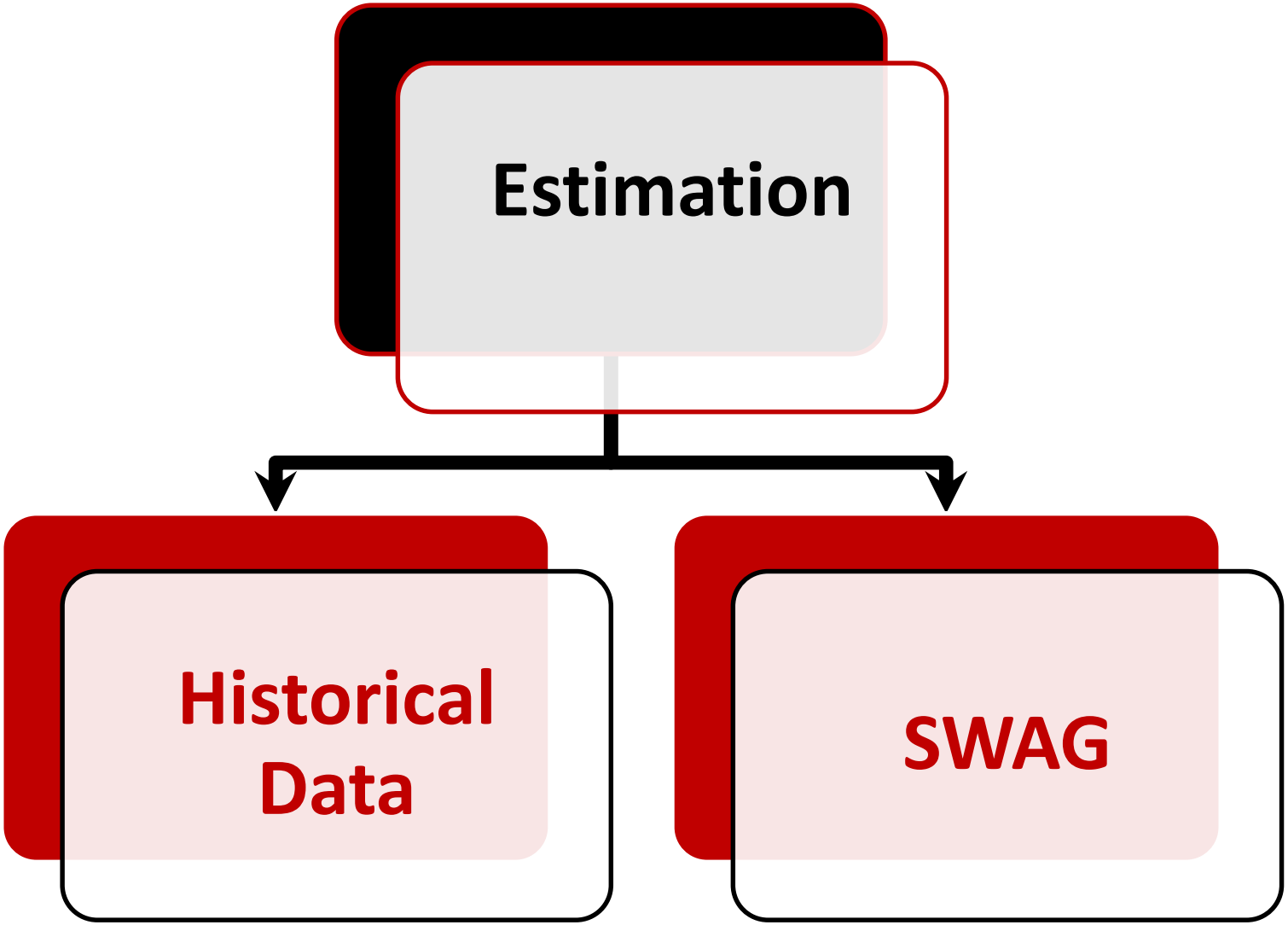
- “My employer has a implemented a lean initiative over 4 years ago, yet has only a very rudimentary time study. Actually, it is only a conversion from (inaccurate) pay rates to time.
- The result is waste has not been reduced from our manufacturing operations.”– IIE Blog



The Cost of Work Measurement



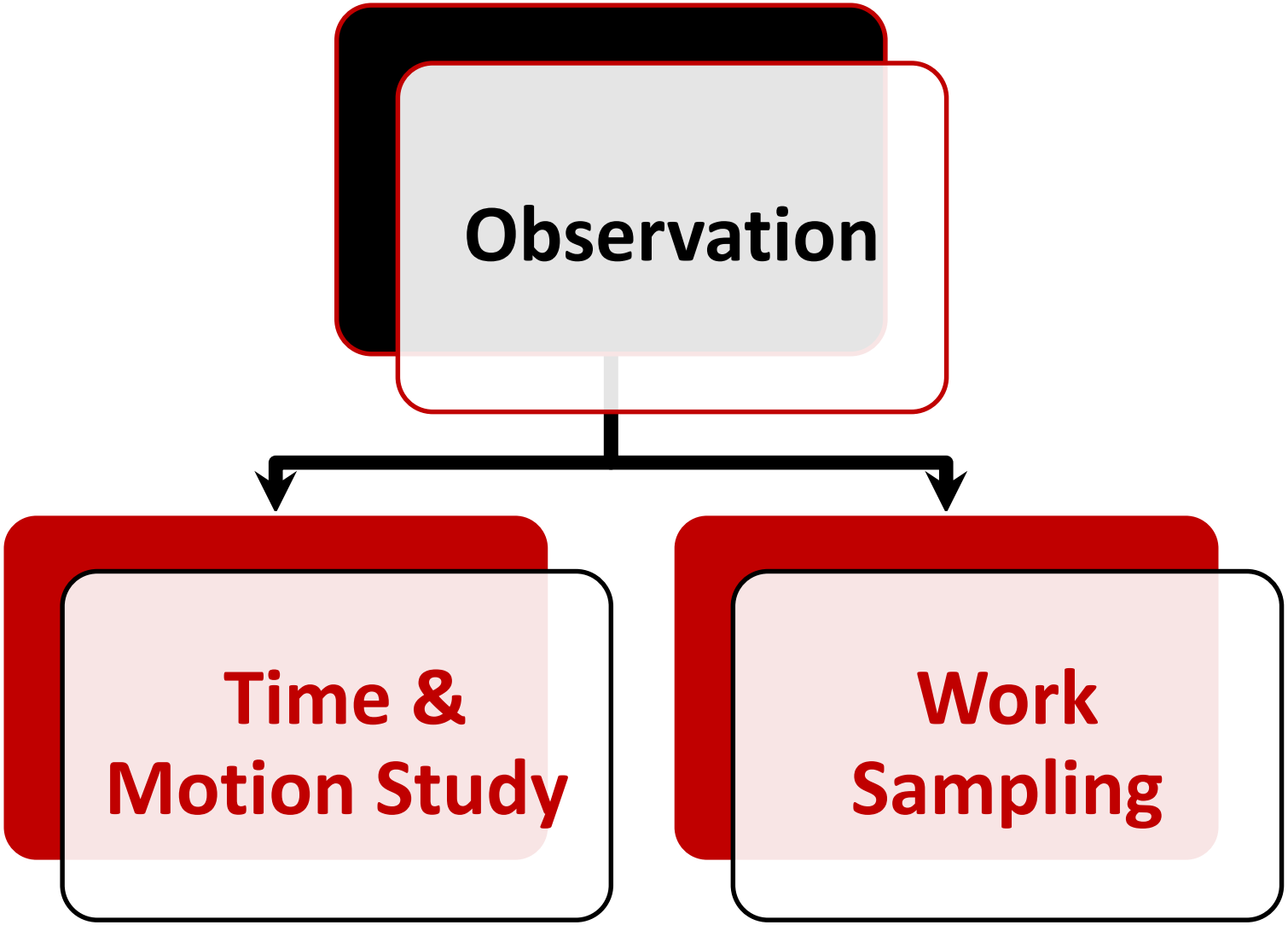
The cost of work measurement


Estimation
Historical Data
SWAG

Estimation

- Available
- Quick
- No need for formalized work measurement program
- Less costly

- Subjective
- Not a good source for time standards
- Inflated time due to delay and non-optimal performance
- Difficult to set higher goals
- Difficult to update standards


Observation
Time & Motion Study
Work Sampling

Time & Motion Study History

Business efficiency technique combining

Time Study work

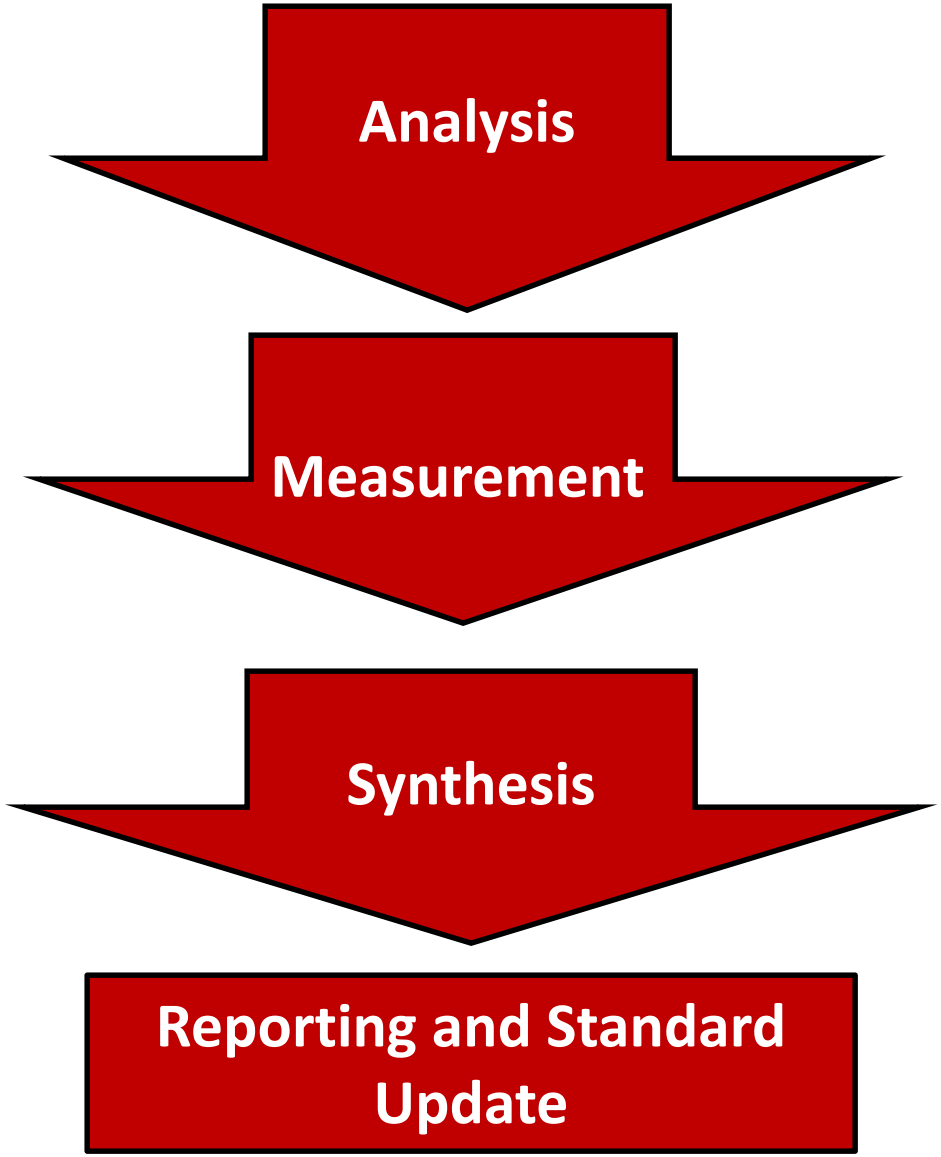
(of Fredrick Winslow Taylor **)**

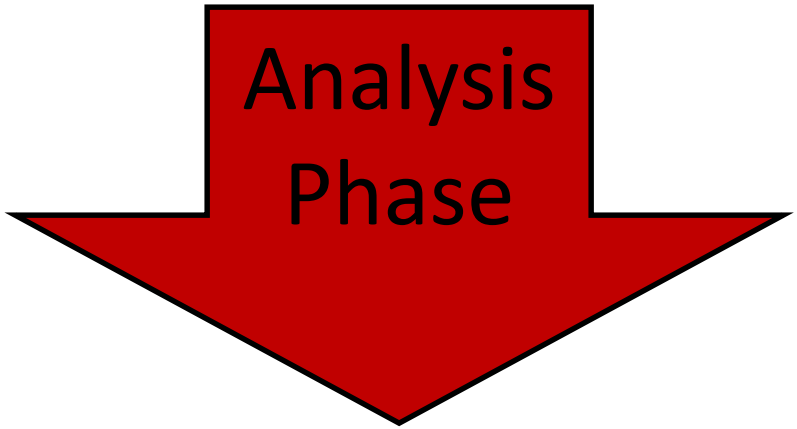
&

Motion Study work

(of Frank and Lillian Gilbreth**)**

Phases of a time study



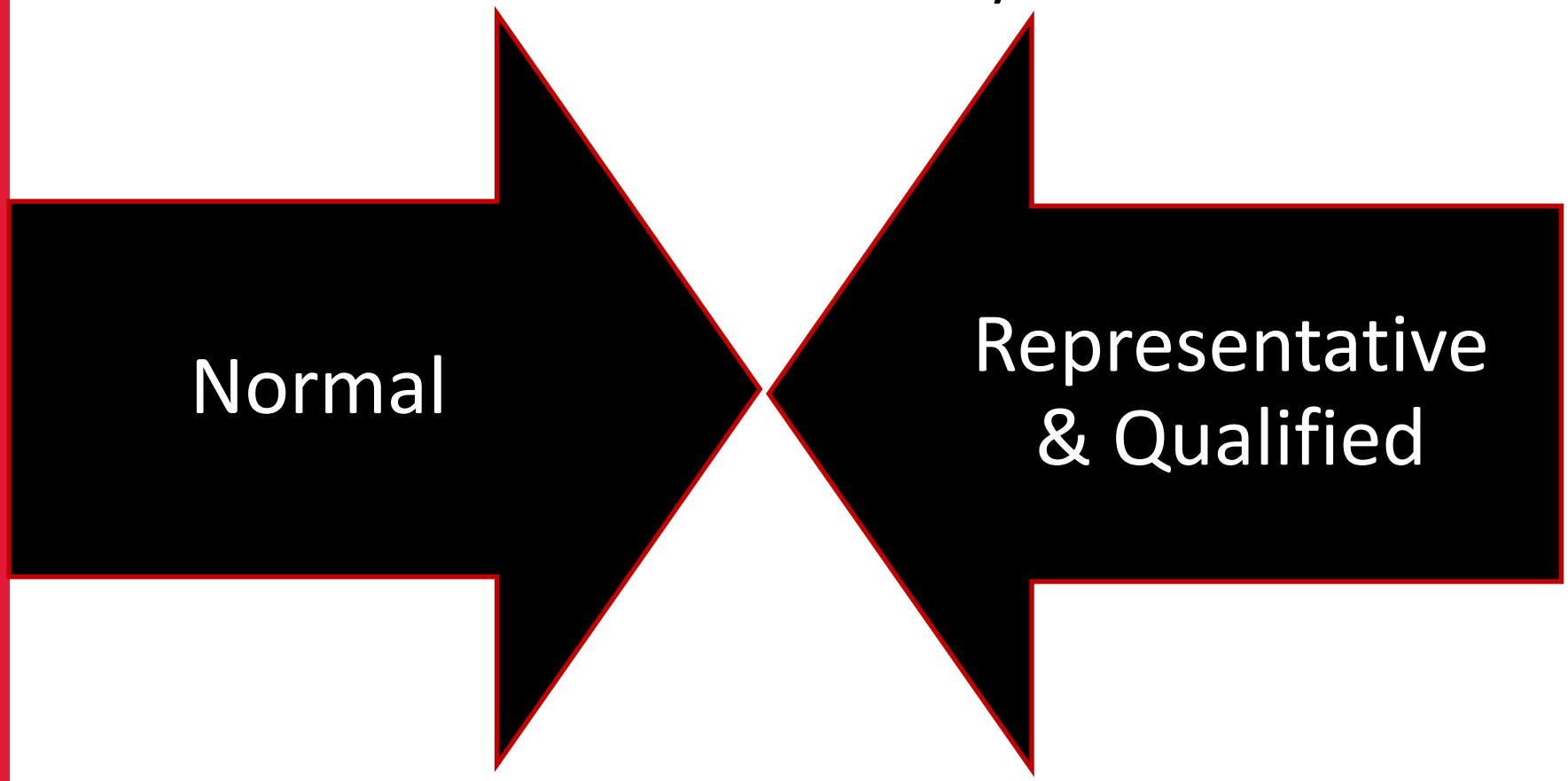


Obtain & record the following:

- Operator
- Working Conditions
- Methods
- Break Down the tasks to elements

Operator

Who do we study?



Normal Operator

- Adapted to the work and has sufficient experience.
- Has coordinated mental and physical abilities.
- Maintains proper use of equipment and tools related to the job.
- Is cooperative.
- Performs a pace best suited for continuous performance.

(Adverse)Working Conditions

Missing tools and equipment

Inadequate Climate

Mental workload

Visual fatigue

Low level of worker participation

Inadequate equipment and workstation

NC STATE UNIVERSITY
125 YEARS

Elements

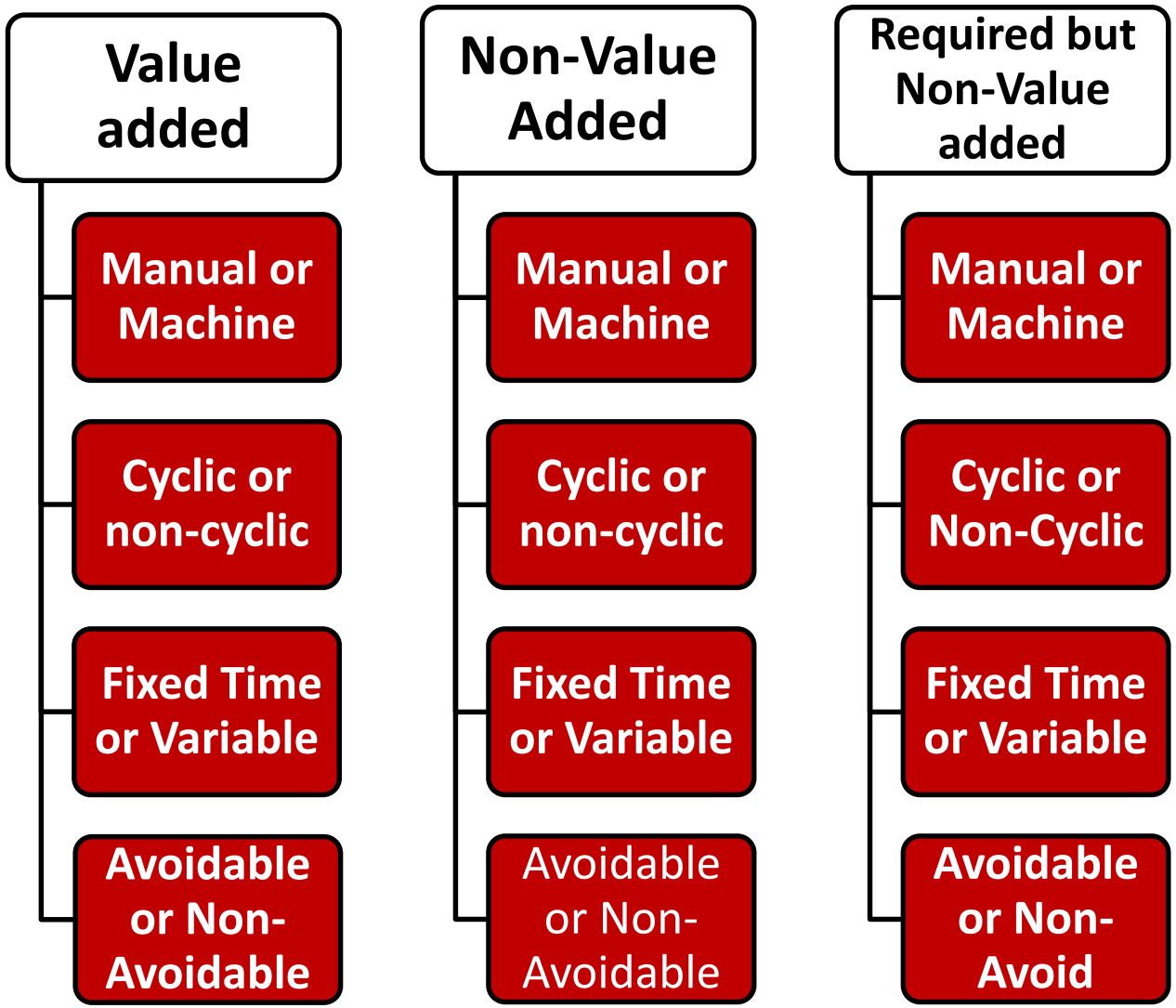
- An **element** is a distinct part of a specified job.

- A **work cycle** is the sequence of elements which are required to perform a job.

What is the Rule of Thumb?

- The elements must be *long enough* to be accurately timed .
- The *proper method* should be used.
- Human and machine must be *separated*.
- The *end point* of each element should be consistently *detected*.

Elements Categories



Time Study Work Sheet

Work Center		Engineer	
Operation		Location	
Part Number			
Machine Number			
Operator			

Observation

Date	Time		Element	Category			TYPE				Operator Rating	Readings										Total	Frequency	Average
	Start	Stop		V	NV	R	M/MC	C/N	F/V	A/VN		1	2	3	4	5	6	7	8	9	10			

Basic Time	
PF &D	
Std Time	

Key	
V	Value added
NV	Non value added
R	Required but non value added
M/MC	Manual or Machine
C/N	Cyclic or Non Cyclic
F/V	Fixed or Variable
A/VN	Avoidable or non avoidable

Takt Time: Available Time / Required Output

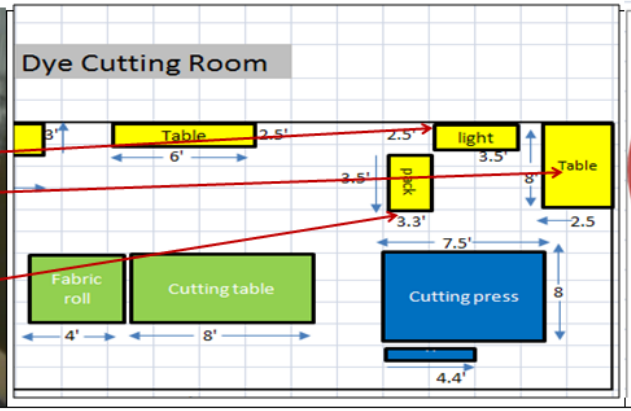
# of operators (operations or machine): Takt Time/ Basic Time

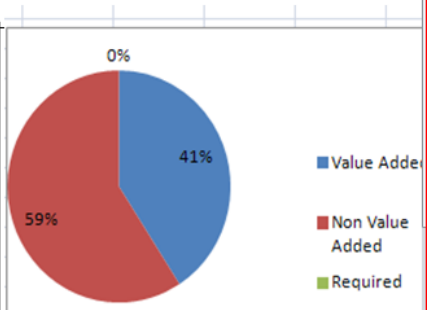
Notes:

Example

scription : **Inspection**

Workstation picture





Work Element	Total work	Time				Modify scale interval : 1 — Cycle Time in second — Modify scale max : 60
		Wait	Manual	Auto	Walk	
Inspect fabric and package	27.22		27.22			
Talk dicuss fabric	1.85	1.85				
Make box	0.432		0.432			
cutter come to talk	0		0			
wait	4.112	4.112				
Talk	.674	.674				
count fabric	8.430		8.430			
Fabric defect	0.806		0.806			
Talking and adjusting the fabric	6.783	6.783				
talking about fabric	2.110	2.110				
Record data and print off the label	2.300		2.300			
walk and get fabric from table	.306	.306				
check new fabric roll	.296		.296			
tape box	1.070		1.070			
put box on pallet	0		0			
take box to warehouse	.493		.493			

STANDARDIZED WORK / TIMING

CHANGEOVER	4BPUMA TO 6BEPIC
MACHINE	3507
APPROVED	

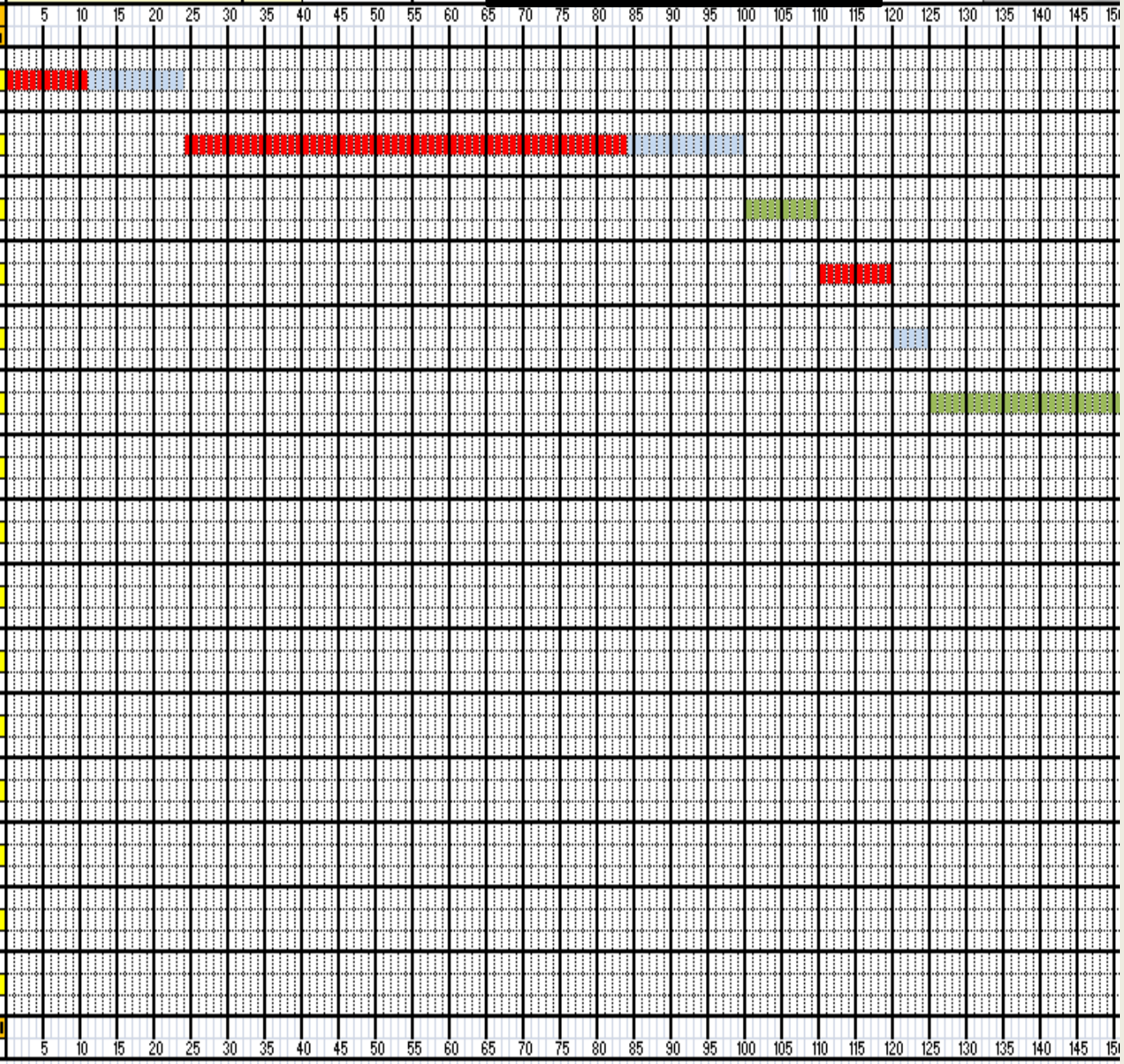
STANDARDIZED WORK COMBINATION TABLE

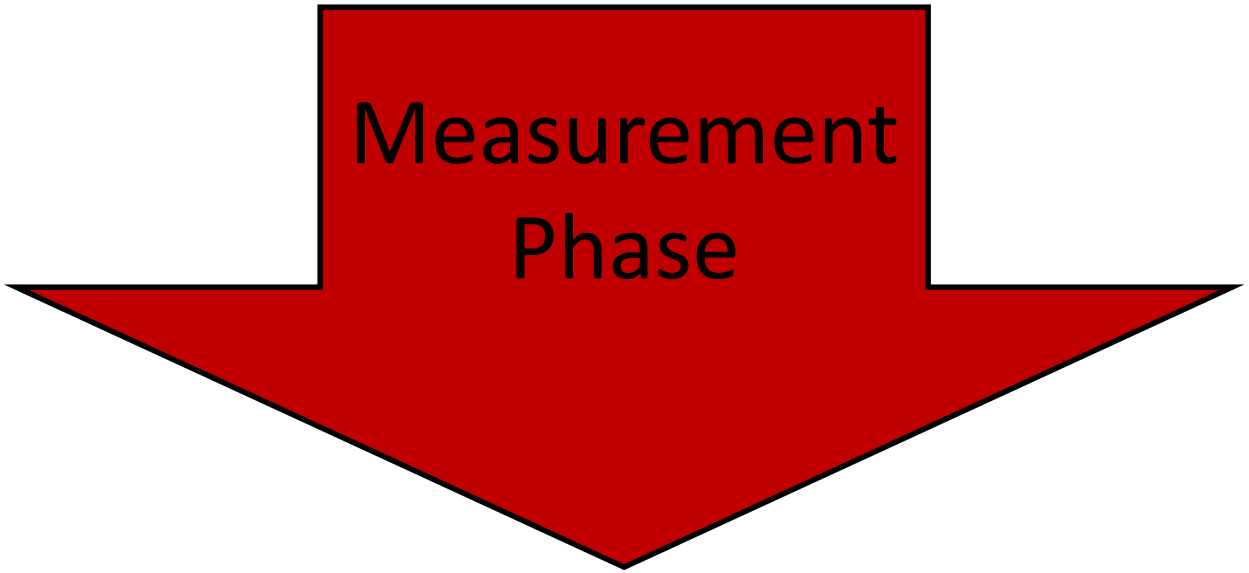
Date	08/29/11
Takt Time	NA
Area	B-BLOCK

[redacted]

IES

No.		TIME Man	Auto	Walk	Total
1	CONSOLE OPERAITONS	11		13	24
				Cumulative:	24
2	TOOL CHANGE (17R,18R,30R,32R, 34R,10L,11L,14L,17L,18L,28L)	60		16	76
				Cumulative:	100
3	RUN QUALIFIER		10		10
				Cumulative:	110
4	INSPECT/ADJUST	10			10
				Cumulative:	120
5	SEND TO CMM			5	5
				Cumulative:	125
6	WAIT FOR CMM RESULTS		55		55
				Cumulative:	180
7	RUN UPON APPROVAL				0
				Cumulative:	180
8					0
				Cumulative:	180
9					0
				Cumulative:	180
10					0
				Cumulative:	180
11					0
				Cumulative:	180
12					0
				Cumulative:	180
13					0
				Cumulative:	180
14					0
				Cumulative:	180
15					0
				Cumulative:	180
		Man	Auto	Walk	Total
	TOTALS	81	65	34	180





- Observe/record the tasks
- Rate operator performance

How do we determine sample size?

- Statistical method
- Conventional method

Statistical Method of Sample Size

- Accuracy desired
- Confidence desired
- Data variability

Formula

$$n = \left(\frac{40 \sqrt{n' \Sigma x^2 - (\Sigma x)^2}}{\Sigma x} \right)^2$$

Provide an example

where

n = sample size we wish to determine
n' = number of readings taken in the preliminary study
Σ = sum of values
x = value of the readings.

Conventional Method for Sample Size

TABLE 28.2

Minimum number of cycles to study (Westinghouse and General Electric).

IF	AND WESTINGHOUSE ELECTRIC VALUES (WESTINGHOUSE, 1953)			OR GENERAL ELECTRIC VALUES (SHAW, 1978)
Time/piece or cycle is over	Activity/yr is under 1,000	Activity/yr is from 1,000 to 10,000	Activity/yr is over 10,000	Activity/yr is any value
.002 h (under)	60	80	140	200
.002	50	60	120	175
.003	40	50	100	125
.004	35	45	90	100
.005	30	40		
.008	25	30		
.012	20	25		
.020	15	20		
.035	12	15		
.050	10	12		
.080	8	10		
.120	6	8		
.200	5	6		
.300	4	5		
.500	3	4		
.800	2	3		
1.000	2	3		
2.000	1	2		

TABLE 28.3

Minimum number of cycles to study (Niebel, 1992).

IF CYCLE TIME, min (h)	AND ACTIVITY IS LESS THAN 1,000/yr	1,000 to 5,000/yr	5,000 to 10,000/yr	Over 10,000/yr
<1 (.017)	40	45	50	60
1 to 2 (.017 to .033)	25	30	35	40
2 to 5 (.033 to .083)	18	20	22	25
5 to 10 (.083 to .167)	15	16	18	20
10 to 20 (.167 to .333)	9	10	11	12
20 to 40 (.333 to .667)	7	8	9	10
40 to 60 (.667 to 1.0)	5	6	7	8
>60 (1.0)	3	4	5	6

There are all kinds of factors that have to be considered!!!!!!!

Don't just take any observed time.

Performance Rating

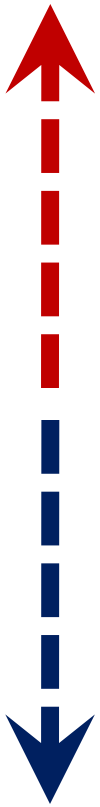
- Westinghouse system
- Synthetic rating
- **Pace rating**
- Objective rating

How Do We Performance Rate the Operator?

Faster Operator 110%

Normal Operator : 100%

Slower Operator 90%



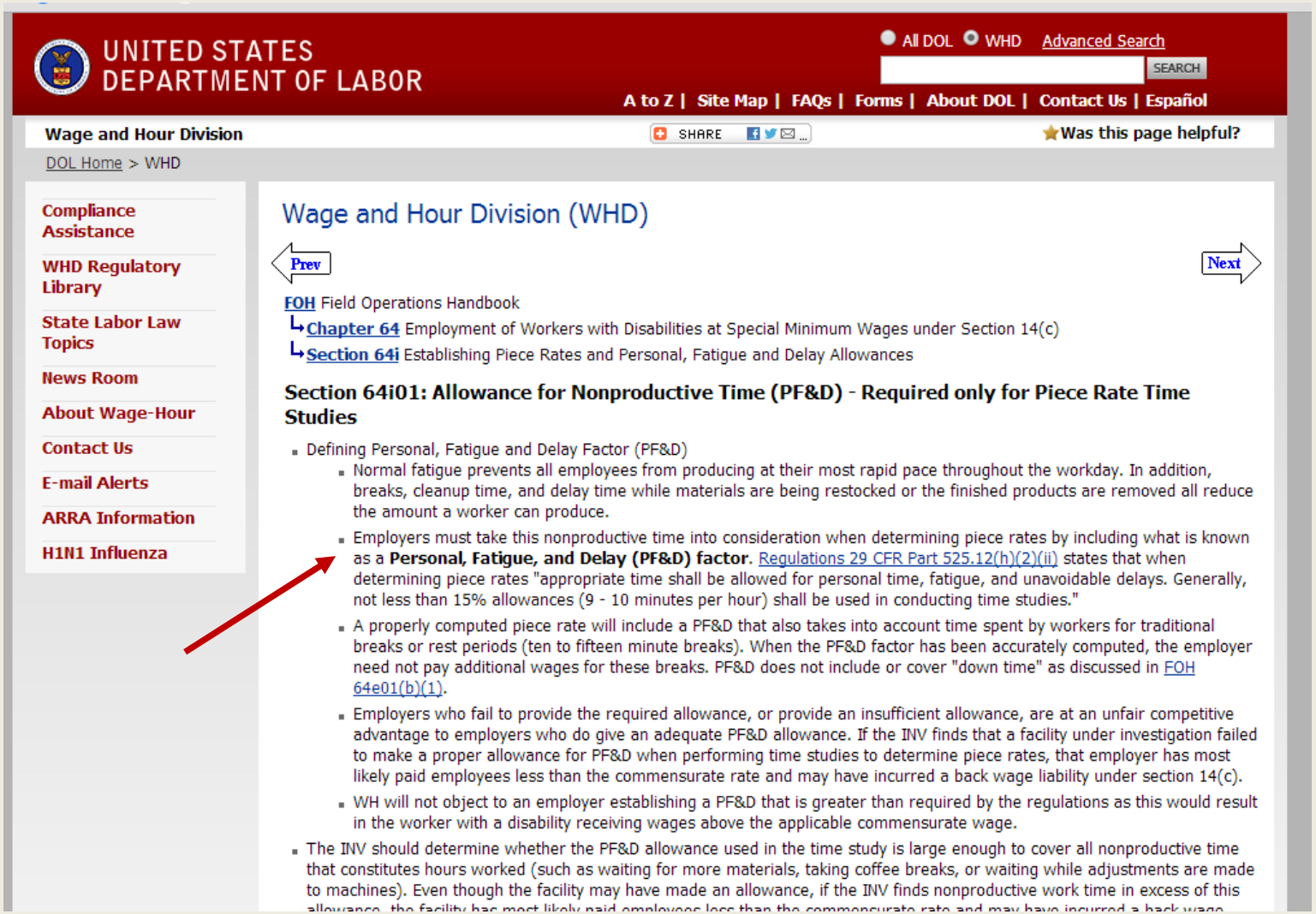
Allowances

Personal

Fatigue

Delays

- Avoidable
- Non-Avoidable



UNITED STATES DEPARTMENT OF LABOR

All DOL WHD Advanced Search SEARCH

A to Z | Site Map | FAQs | Forms | About DOL | Contact Us | Español

Wage and Hour Division SHARE Was this page helpful?

DOL Home > WHD

- Compliance Assistance
- WHD Regulatory Library
- State Labor Law Topics
- News Room
- About Wage-Hour
- Contact Us
- E-mail Alerts
- ARRA Information
- H1N1 influenza

Wage and Hour Division (WHD)

Prev Next

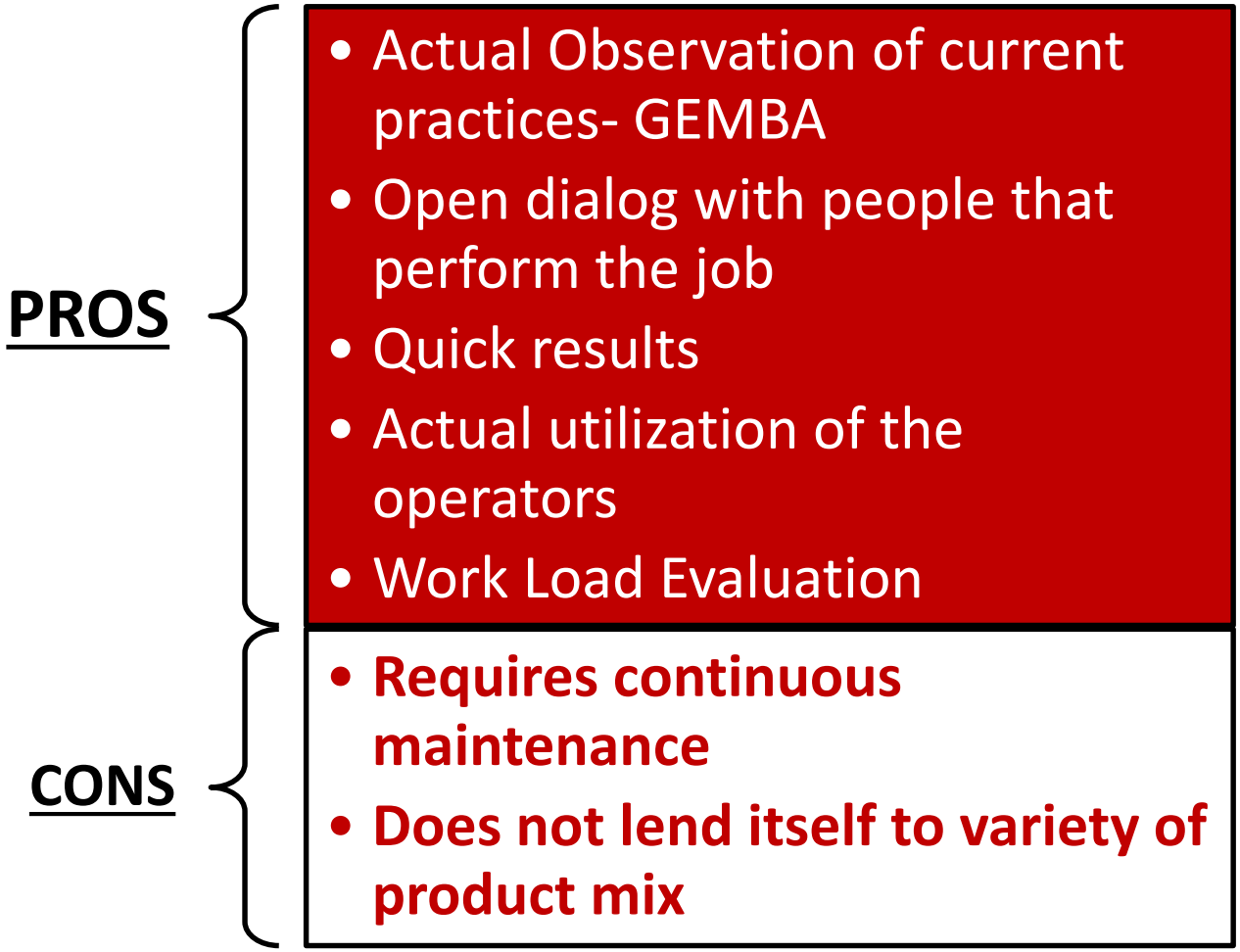
FOH Field Operations Handbook
- Chapter 64 Employment of Workers with Disabilities at Special Minimum Wages under Section 14(c)
- Section 64i Establishing Piece Rates and Personal, Fatigue and Delay Allowances

Section 64i01: Allowance for Nonproductive Time (PF&D) - Required only for Piece Rate Time Studies

- Defining Personal, Fatigue and Delay Factor (PF&D)
  - Normal fatigue prevents all employees from producing at their most rapid pace throughout the workday. In addition, breaks, cleanup time, and delay time while materials are being restocked or the finished products are removed all reduce the amount a worker can produce.
  - Employers must take this nonproductive time into consideration when determining piece rates by including what is known as a **Personal, Fatigue, and Delay (PF&D) factor**. Regulations 29 CFR Part 525.12(h)(2)(ii) states that when determining piece rates "appropriate time shall be allowed for personal time, fatigue, and unavoidable delays. Generally, not less than 15% allowances (9 - 10 minutes per hour) shall be used in conducting time studies."
  - A properly computed piece rate will include a PF&D that also takes into account time spent by workers for traditional breaks or rest periods (ten to fifteen minute breaks). When the PF&D factor has been accurately computed, the employer need not pay additional wages for these breaks. PF&D does not include or cover "down time" as discussed in FOH 64e01(b)(1).
  - Employers who fail to provide the required allowance, or provide an insufficient allowance, are at an unfair competitive advantage to employers who do give an adequate PF&D allowance. If the INV finds that a facility under investigation failed to make a proper allowance for PF&D when performing time studies to determine piece rates, that employer has most likely paid employees less than the commensurate rate and may have incurred a back wage liability under section 14(c).
  - WH will not object to an employer establishing a PF&D that is greater than required by the regulations as this would result in the worker with a disability receiving wages above the applicable commensurate wage.
- The INV should determine whether the PF&D allowance used in the time study is large enough to cover all nonproductive time that constitutes hours worked (such as waiting for more materials, taking coffee breaks, or waiting while adjustments are made to machines). Even though the facility may have made an allowance, if the INV finds nonproductive work time in excess of this

NC STATE UNIVERSITY 125 YEARS

Direct observation

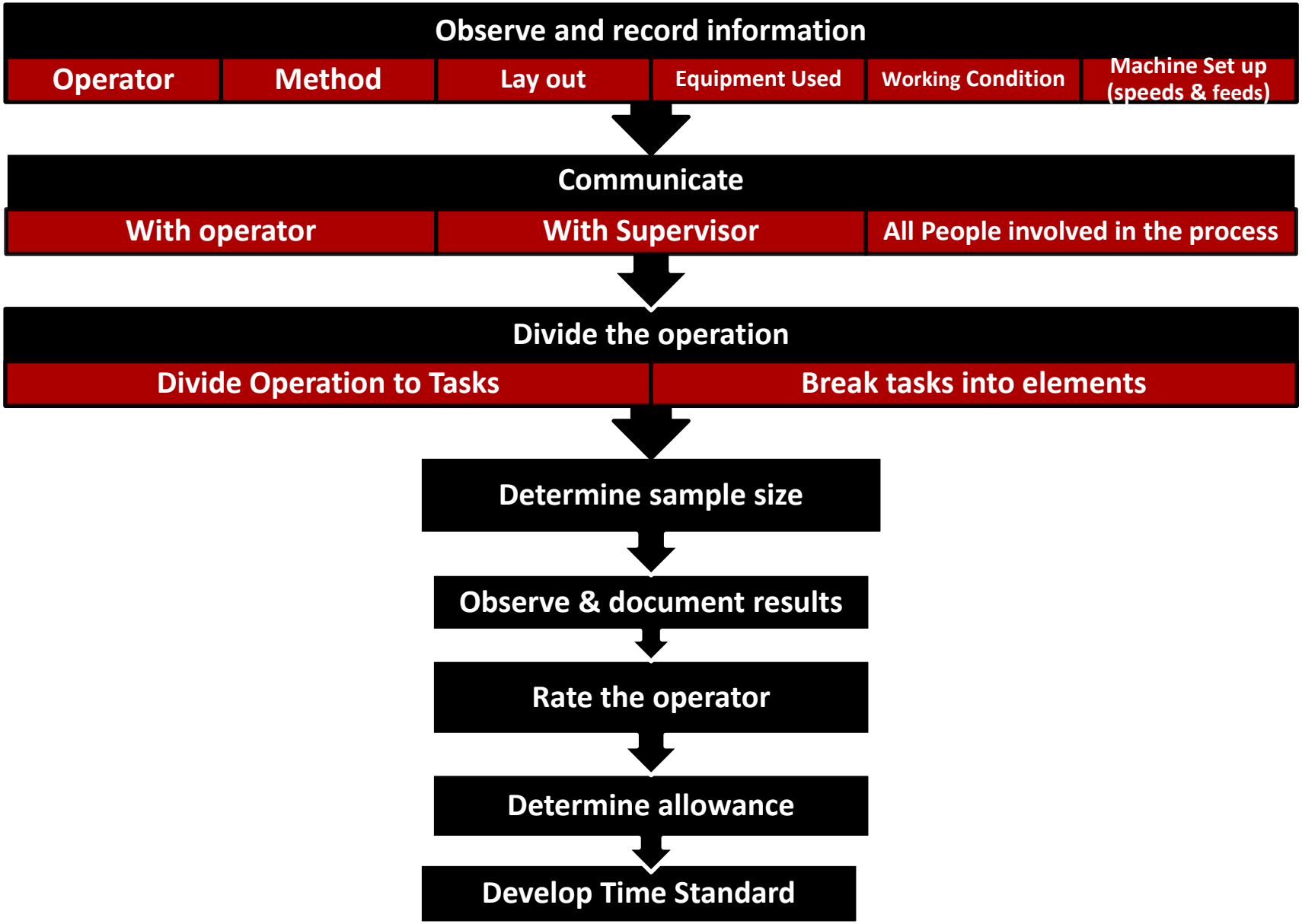


Direct Time Study Devices

Stop Watch

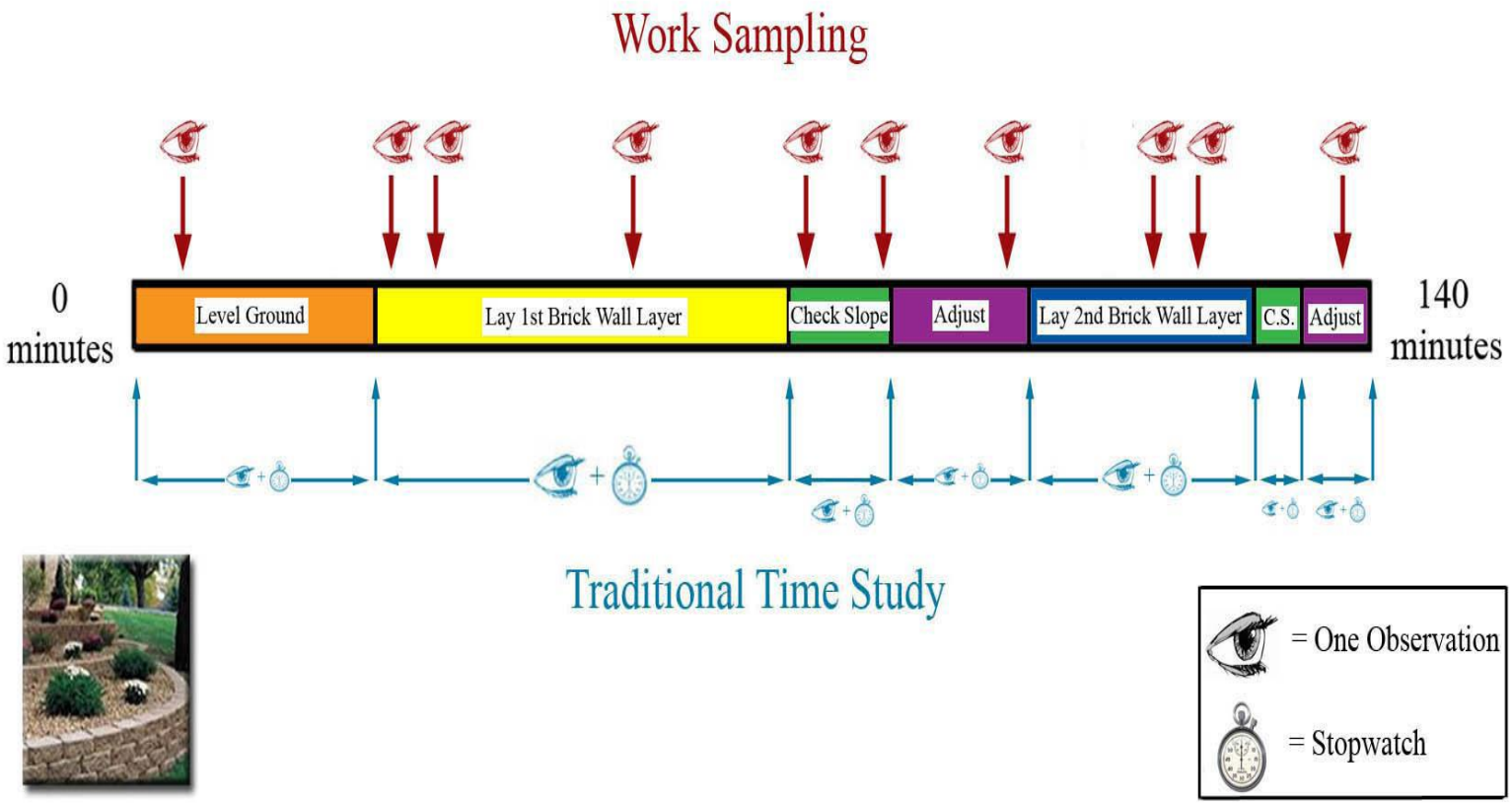
Video Camera

Time Study Steps

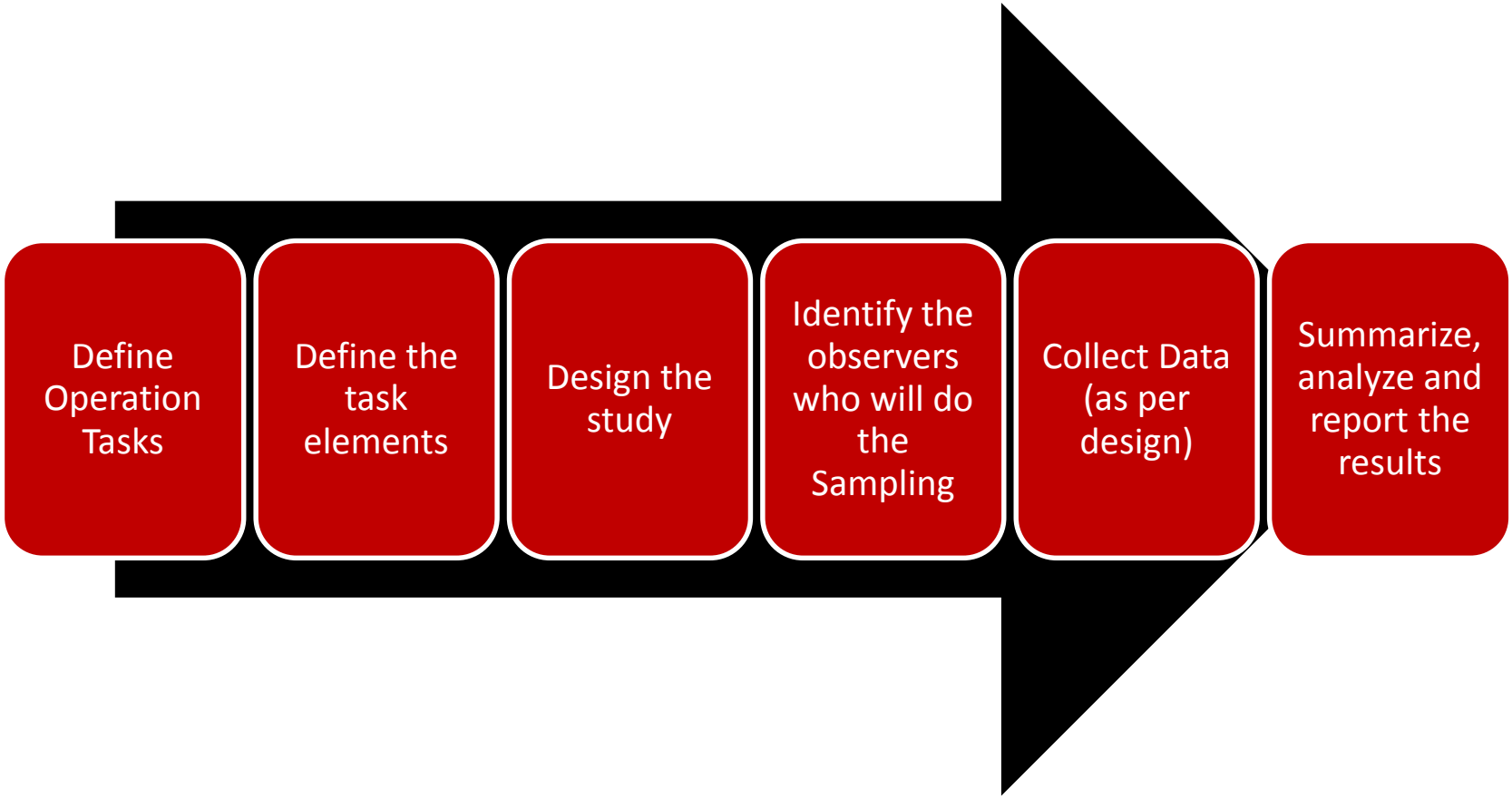


Work Sampling

Observations about work are collected at discrete time intervals, either periodic or random.



Work Sampling Steps



Observation

- Actual Observation of current practices- GEMBA
- Work load evaluation
- Open dialog with people that perform the job
- Quick results
- Actual utilization of the operators

- Requires continuous maintenance
- Does not lend itself to variety of product mix

PREDETERMINED TIME SYSTEM (PMTS)

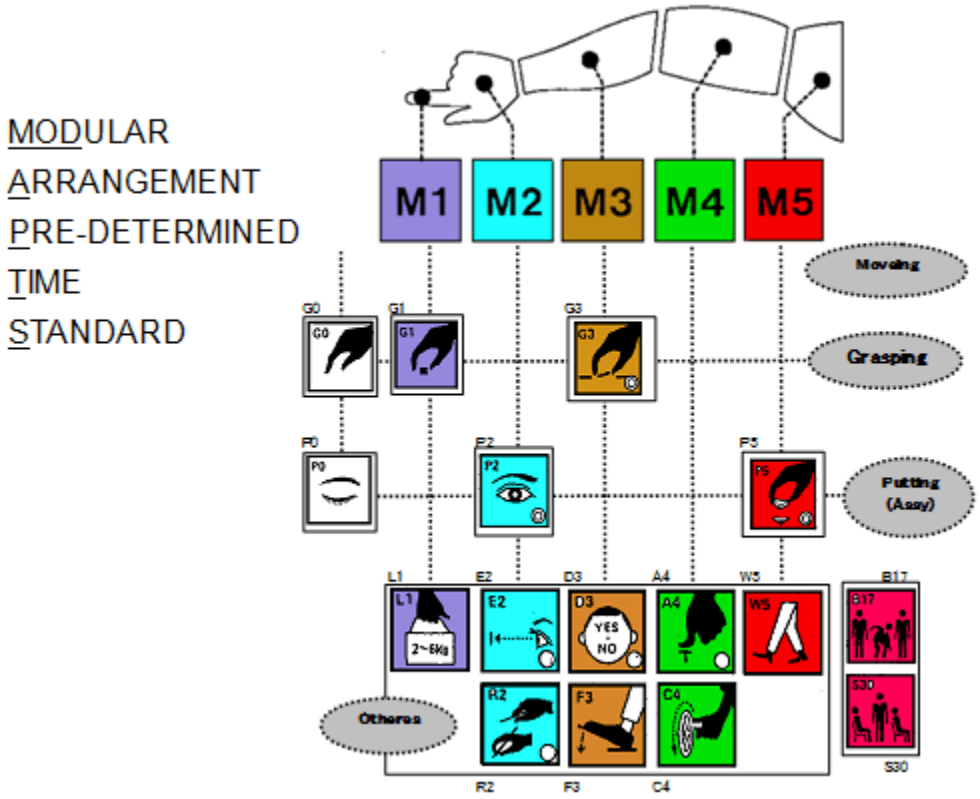
Utilizes a Methods-Time Measurement that is used primarily in industrial settings to determine the standard time for completing an elemental task.

PMTS Procedures

- MODAPTS
- MOST
- MTM

MODAPTS

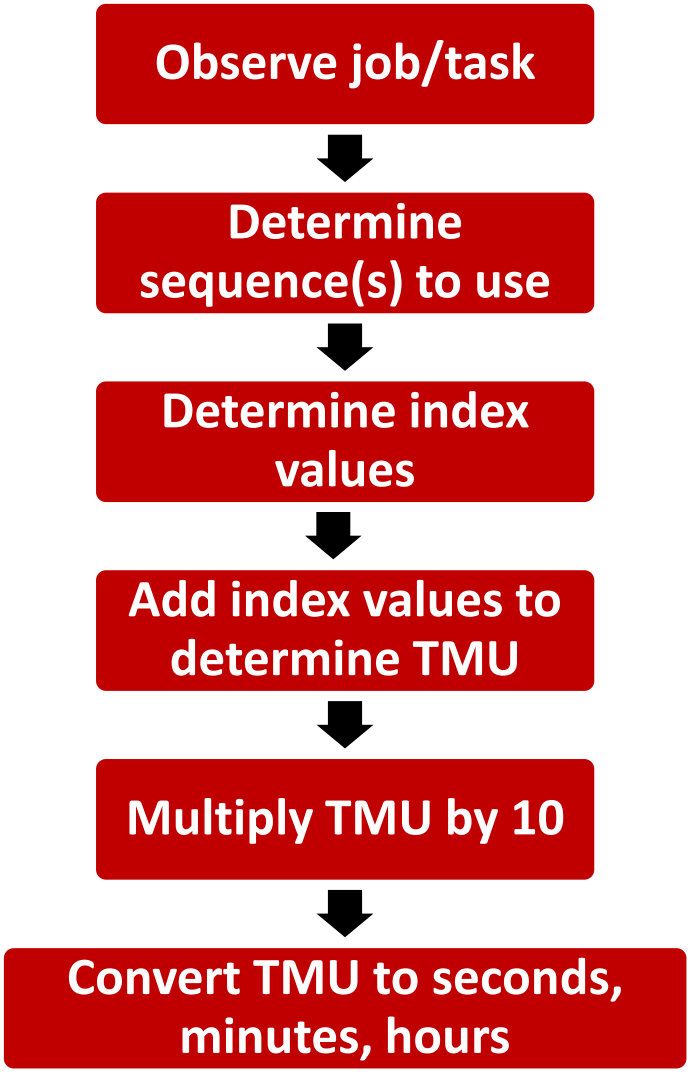
"Modular Arrangement of Predetermined Time Standards"



MOST (Maynard Operation Sequence Technique)

Parameters:	Categories:
• A= Action Distance • B= Body Motion • G= Gain Control • P= Placement	• Reach • Gain • Move • Place • Return

MOST Procedure



MTM (Methods Time Measurement)

MTM Categories

Reach
Move
Turn
Apply Pressure
Grasp
Position
Release
Disengage
Body Motions
Eye Motions

MTM Tables

Grasp times (TMU) given for five types of grasp. Pick

TYPE OF GRASP	CASE	TIME, TMU	DESCRIPTION
PICKUP	1A	2.0	Any size object t
	1B	3.5	Object very smal
	1C1	7.3	Diameter larger t
	1C2	8.7	Diameter 1/4" to
	1C3	10.8	Diameter less tha
REGRASP	2	5.6	Change grasp wi
TRANSFER	3	5.6	Control transferr
SELECT	4A	7.3	Larger than 1" ×
	4B	9.1	1/4" × 1/4" × 1/
	4C	12.9	Smaller than 1/4"
CONTACT	5	0	Contact, Sliding,

Distance Moved (inches)	TIME (TMU) A	B	C	Hand in Motion B	WEIGHT ALLOWANCE Weight (pounds) up to:	Dynamic Factor	Static Constant TMU	Case and Description
¾ or less	2.0	2.0	2.0	1.7				
1	2.5	2.9	3.4	2.3	2.5	1.00	0	
2	3.6	4.6	5.2	2.9				A. Move object to other hand or against stop.
3	4.9	5.7	6.7	3.6	7.5	1.06	2.2	
4	6.1	6.9	8.0	4.3				
5	7.3	8.0	9.2	5.0	12.5	1.11	3.9	
6	8.1	8.9	10.3	5.7				
7	8.9	9.7	11.1	6.5	17.5	1.17	5.6	
8	9.7	10.6	11.8	7.2				
9	10.5	11.5	12.7	7.9	22.5	1.22	7.4	B. Move object to approximate or indefinite location.
10	11.3	12.2	13.5	8.6				
12	12.9	13.4	15.2	10.0	27.5	1.28	9.1	
14	14.4	14.6	16.9	11.4				
16	16.0	15.8	18.7	12.8	32.5	1.33	10.8	
18	17.6	17.0	20.4	14.2				
20	19.2	18.2	22.1	15.6	37.5	1.39	12.5	
22	20.8	19.4	23.8	17.0				C. Move object to exact location.
24	22.4	20.6	25.5	18.4	42.5	1.44	14.3	
26	24.0	21.8	27.3	19.8				
28	25.5	23.1	29.0	21.2	47.5	1.50	16.0	
30	27.1	24.3	30.7	22.7				
Additional	0.8	0.6	0.85		TMU per inch over 30 inches			

PRE-DETERMINED TIME

- Efficient
- Reduced required time
- Method Sensitive
- Objective Approach
- Applicable to Diverse Industries
- Most widely used
- Enables to Develop Standards at planning stage
- Not Sample Size Sensitive
- Detailed Time & Method Study

- Limited to hand, eye and body motions
- Process or machine times may not be established
- Extra allowances are not taken to account
- Not applicable to jobs with a high degree of control
- Not economically feasible for non- repetitive work

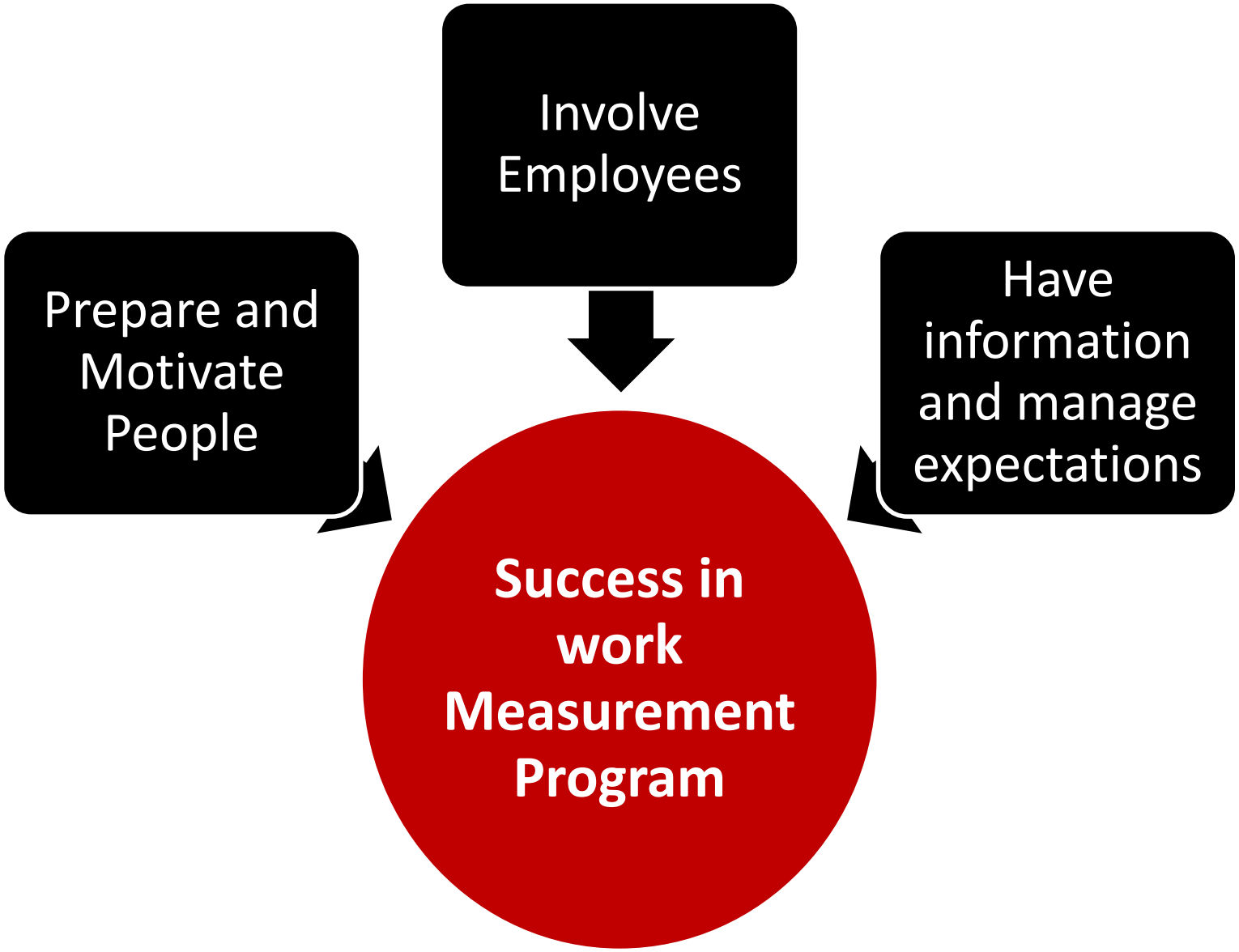
PRE-DETERMINED TIME

- Hard to classify some motions
- Difference in opinion between team members
- Variation in distance measurements
- Repeatability and variation of worker
- Very time-consuming to break up job
- Repetitive to enter in data
- May not match actual times

Time Study - Rules

- Don’t comment to the worker during the task
- Stand (don’t sit) beside the worker
- Write every event (even though it may seems not important)- If not caught on camera
- Have a good position to observe/record
- Stop the study if the worker seems to be under pressure and it affects his/her work

Keys to Success



Benefits of Work Measurement

- **Common Currency** for the evaluation and comparison of all types of work.
- Methods Improvement
- Performance Standard provision
- Allows for additional compensation for better performance
- Cost reduction by focusing on productivity improvement & elimination of waste in the process

"For the strength of the Pack is the Wolf,
and the strength of the Wolf is the Pack"

"Rudyard Kipling"