Peter Almström
Technology Management and Economics

Time studies

…or Work studies

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Learning objectives

- After this lecture the student will be able to …
  - Select the correct work study method.
  - Carry out a proper time study.
  - Motivate why performance rating is necessary.
  - Do a work sampling study.
  - Calculate the needed number of observations in a work sampling study.
  - Know when work sampling is applicable.
  - Motivate the use of PTS.
  - Understand the purpose of different PTSs.

Why work studies?

- Standardization
- Improvement work
- Fairness
- Productivity
- Indata

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Determine time standard
(for the core method)

- Estimates
- Historical records
- Work measurement
  - Time study
  - Predetermined time systems
- Must be based on facts – not guesses

Usable time standard

- If the time standard will be used for planning and control, it is not sufficient to only use the norm time for the value adding activities.
- Supportive activities must be studied and standardized as well:
  - Quality control procedures
  - Materials handling, including package materials
  - Set-up work
  - Planning, reporting, etc.
- On top of that is all the extra time - Allowances
  - Personal time
  - Balance losses, waiting time
  - Disturbances

Norm time + Supporting time + Allowances = Standard time

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Why work studies?

- Standardization
- Improvement work
- Fairness
- Productivity
- Indata

Productivity = M × P × U

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Method	Purpose	Pros	Cons
Time study with stop watch	Measure time for work sequences in running production.	Fast and easy to perform. Easy to understand the result.	Requires performance rating depending on the purpose. The analyst interfere the work.
Time study with video	Measure time for work sequences in running production. Method improvement.	Easy to perform. Does not interfere the work. Easy to involve operators.	Requires technology.
Work sampling	Pre-study for improvement projects. Measure the allowance time.	Easy to perform. The only way to measure allowances.	Design and analysis are complicated.
Predetermined time system	Design a norm time. Method improvement. Performance measurement.	The only way to design a manual work time. Objectivity and fairness. Detailed method analysis.	Requires training. Take long time to perform.

History of work studies

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Frederick Winslow Taylor

(1856-1915)

Waste

"We can see our forests vanishing, our water-powers going to waste, our soil being carried by floods into the sea; and the end of our coal and our iron is in sight. But **our larger wastes of human effort**, which go on every day .... are less visible, less tangible, and are but vaguely appreciated."

Taylor (1911)

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What Taylor wanted:

- Increase Productivity (elminate waste)
- High wages and Low labour cost (WIN -WIN)

What Taylor needed to deal with:

- Very low productivity
- Soldiering (taking it easy, working at low performance level)
- Great in-equalities
- Abundance of low-cost labour

The Principles

- *First.* They develop a science for each element of a man's work, which replaces the old rule-of" thumb method.
- *Second.* They scientifically select and then train, teach, and develop the workman, whereas in the past he chose his own work and trained himself as best he could.
- *Third.* They heartily cooperate with the men so as to insure all of the work being done in accordance with the principles of the science which has been developed.
- *Fourth.* There is an almost equal division of the work and the responsibility between the management and the workmen. The management take over all work for which they are better fitted than the workmen, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men.

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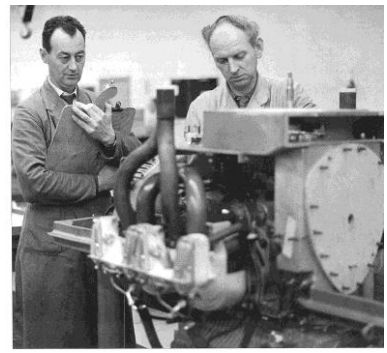
Taylor's followers

- Gilbreth (1911): All human work can be reduced to 17 movements: Therbligs
- Abuse of the system:(1914) US law prohibiting stopwatch time studies in all public businesses.
- Tippet (1927): Work sampling
- Maynard, Schwab and Stegemerten (1948): MTM-1

Time study and Performance rating



Volvo Flygmotor

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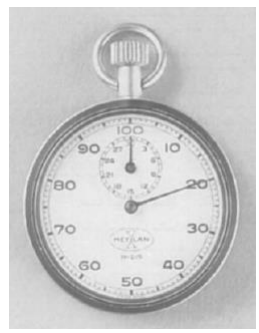
Equipment



Equipment

ZT 730	ZT 865	PC	Pocket PC

Projektema.se

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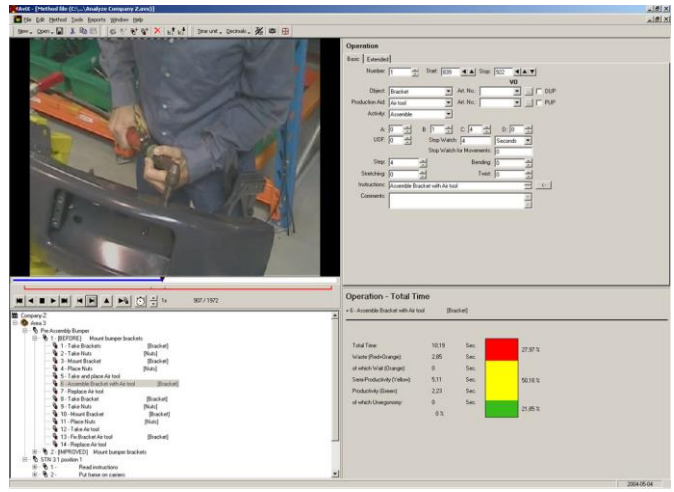
AviX Method



Time Study Form

- R - Rating (performance)
- W – Watch time
- OT – Observed time
- NT – Normal time

Time Study Observation Form — Study No.: 2-85 — Operation: DIE CA

Element No. and Description		1 REMOVE PART FROM DIE, LUBRICATE DIE, INSPECT				2 PLACE PART IN FIXTURE, TRIM ASIDE PART					
Note	Cycle	R	W	OT	NT	R	W	OT	NT	R	W
	1	90	90	30	270	90	113	23	207		
	2	100	40	27	270	100	61	21	210		
	3	90	92	31	279	90	25	23	207		
	4	85	50	35	298	100	70	20	200		
	5	100	98	28	280	100	318	20	200		
	6	110	43	25	275	110	61	18	198		
	7	90	92	31	279	90	416	24	216		
	8	100	44	28	280	85	68	24	204		
	9	90	500	32	288	90	23	23	207		
	10	110	49	26	286	105	68	19	200		
	11										
	12										
	13										
	14										
	15										
	16										

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Number of observations

- 10 cycles as rule of thumb.
- Plot times in histogram and determine if normal distributed.
- Use the average or median time.

Performance rating

…of people

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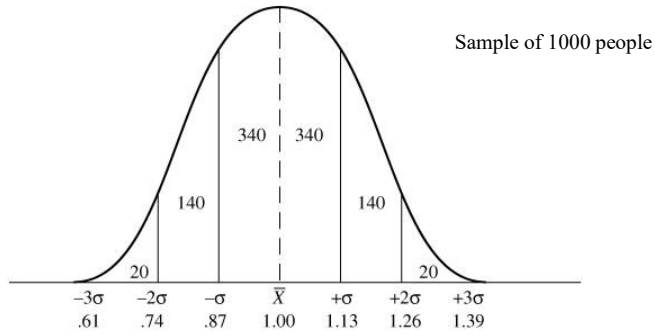
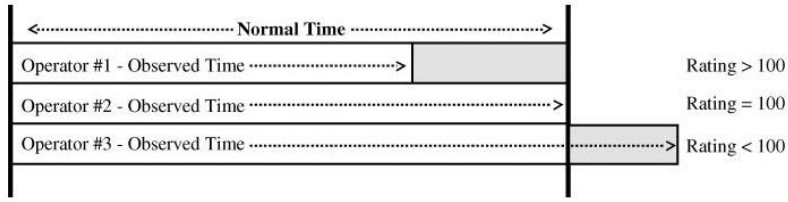
Standard performance



Rating methods

- Rating of each element or for whole task?
- Analyst need talent to do consistent ratings
- Speed vs. Precision



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Performance rate depends on…

- Difficulty of work task
- Precision requirement
- Environment issues (too hot, too cold etc.)
- Skill, training

Rating methods

1. Synthetic rating, i.e. using PTS
2. Speed rating

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Synthetic rating

- Use predetermined times
  - Performance = predetermined time / observed time
- The best method!

Speed rating

- Trained to see the speed, use benchmarks
- Need experience
- Prerequisites
  - Experience of the type of work performed.
  - Use of predetermined (synthetic) time for benchmark of at least two elements.
  - Select operator who is close to normal performance.
  - Use mean value of three or more independant studies.

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Speed Benchmarks

- 100 performance is equal to:
  - Dealing a deck of cards (52 cards) into 4 piles in 30 seconds.

  or
  - Walking 3 miles/h = 4.83 km/h = 1.34 m/s

Work sampling

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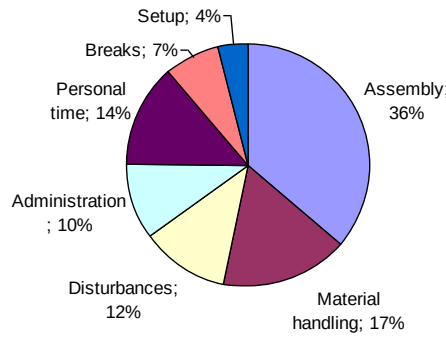
Work sampling



Alternative names

- Work sampling
- Activity sampling
- *Sv. Frekvensstudie*

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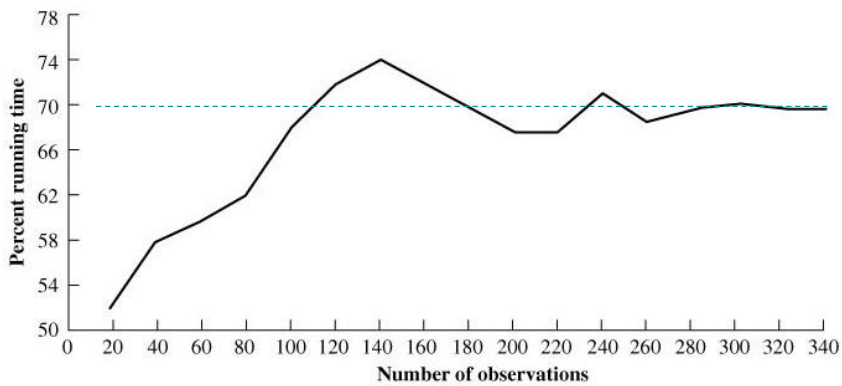
Fast to tune in on mean value



Work sampling applications

- Manual work
- Machine work
- Material (buffer) level
- Administrative work

- Overview study
- Allowances

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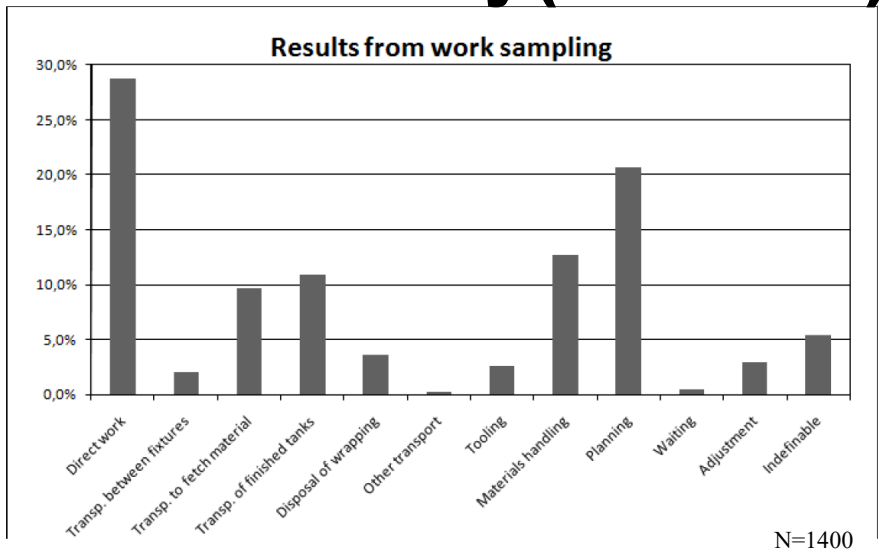
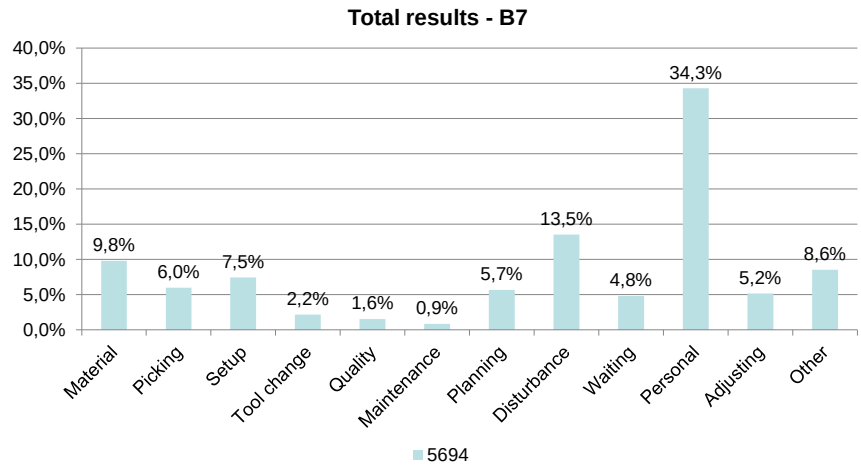
Manual assembly (in stations)

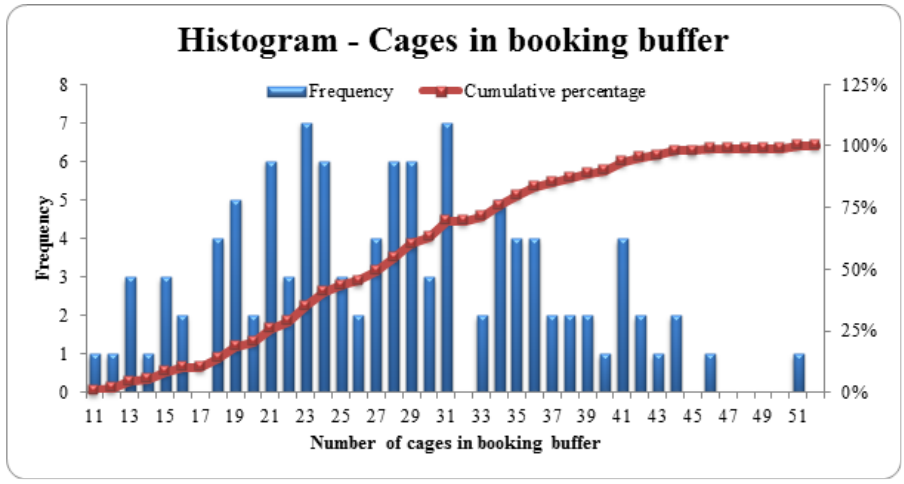


Machine operators



Bergman and Wickström, 2013

Sampling of buffer size



Belin & Hedman, 2010

How to achieve random sampling

- Random intervals
- Random objects with fixed intervals
  - Requires study of >1 object
- Use real random figures.

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Advantages of Work Sampling in comparison with Time study

- More cost efficient (5-50% of time study)
- Qualified analyst not required
- Study can be interrupted
- Less effect on the operators
- More easily accepted by the operators

Disadvantages of Work Sampling in comparison with Time study

- Time study permits a finer breakdown of activities
- No method study
- Averages of groups, no individual differences
- Risk of doing too few samples

How to make a study

1. Determine purpose
2. What objects?
3. What activities?
4. Pre-study
5. Number of samples
6. Carry out study and analyse

Work sampling theory

$$N = \frac{z^2 p(1-p)}{e^2}$$

N=Number of observations
p=Probability of a single occurrence
e=Acceptable limit of error = σ

With 95% confidence interval z=1,96

$$N = \frac{1{,}96^2 p(1-p)}{e^2}$$

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Absolute and relative error

- e is dependent on p
- What you can say after a work sampling study is that:

  "Activity X represent YY% of total time ±e% with 95% confidence"

- Example:

  "Assembly represent 54% of total time ±4% with 95% confidence"

  $\frac{4}{54}$ = 7% relative error

  "Cleaning represent 4% of total time ±4% with 95% confidence"

  $\frac{4}{4}$ = 100% relative error

Examples

Number of observations needed when 10% relative error is acceptable

$$Smallest\_activity = 20\% \Rightarrow N = \frac{1{,}96^2 0{,}20(1-0{,}20)}{0{,}02^2} = 1537$$

$$N = \frac{1{,}96^2 0{,}10(1-0{,}10)}{0{,}01^2} = 3457$$

$$N = \frac{1{,}96^2 0{,}05(1-0{,}05)}{0{,}005^2} = 7299$$

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Example

Number of observations needed when 10% relative error is acceptable

$$N = \frac{1{,}96^2 0{,}01(1-0{,}01)}{0{,}001^2} = 38031$$

Example

Number of observations needed when 5% relative error is acceptable

$$N = \frac{1{,}96^2 0{,}05(1-0{,}05)}{0{,}0025^2} = 29196$$

30000 observations, two samples/minute = 6 weeks fulltime

Self-observation

- Especially for indirect (mobile) work
- Advantage: no extra people needed
- Disadvantage: a disturbance, less accurate
- Technology needed

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Work sampling exercise

1. Value adding
   - Writing on the black board
2. Supporting
   - Changeover (change chalk)
   - Planning activity (sit by computer)
3. Not value adding
   - Disturbance (drop chalk)
   - Paid break (walk out)

Predetermined Time Systems and MTM-SAM

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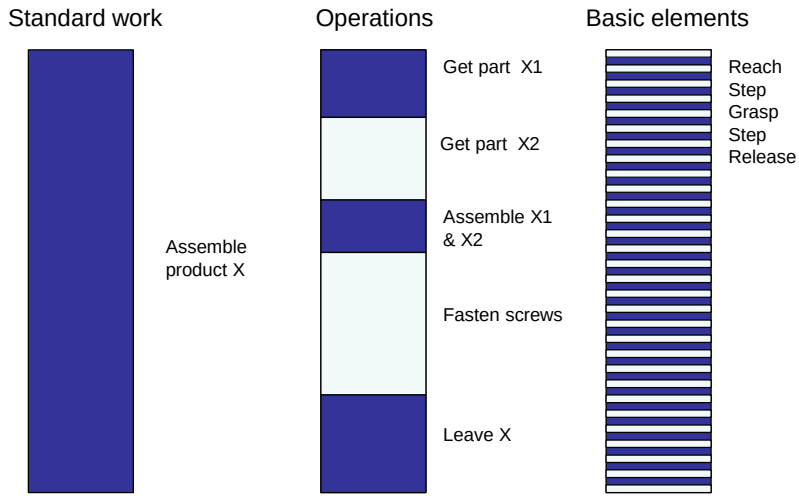
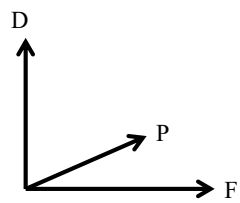


Predetermined time systems

- Other names:
  - Basic motion times
  - Synthetic times
  - Elementary times
  - Predetermined motion time system
  - Swedish: *Elementartidssystem*

Time for an element

- The time for an element depends on:
  - Distance of movement
  - Force (weight, resistance)
  - Precision



Predetermined time application

1. Standard data development
   - Efficient development of standard times
   - Sort of simulation, use in early phases
2. Judgement of ”a fair day’s work”
3. Methods analysis

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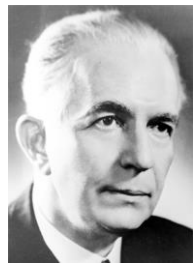
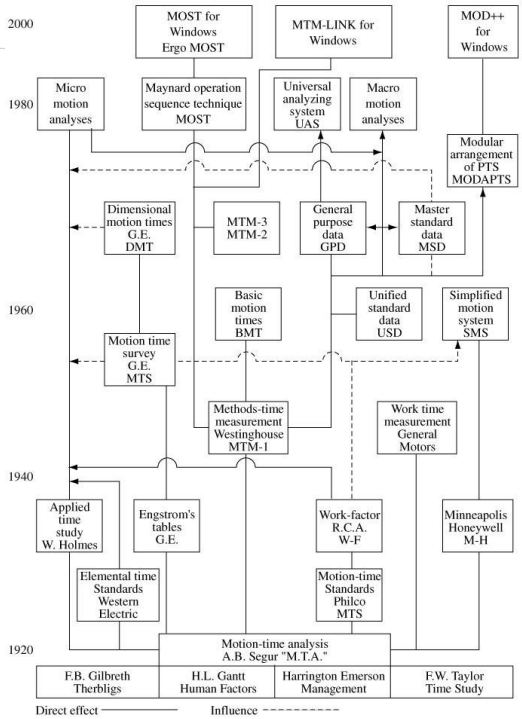
MTM-1



Assar Gabrielsson

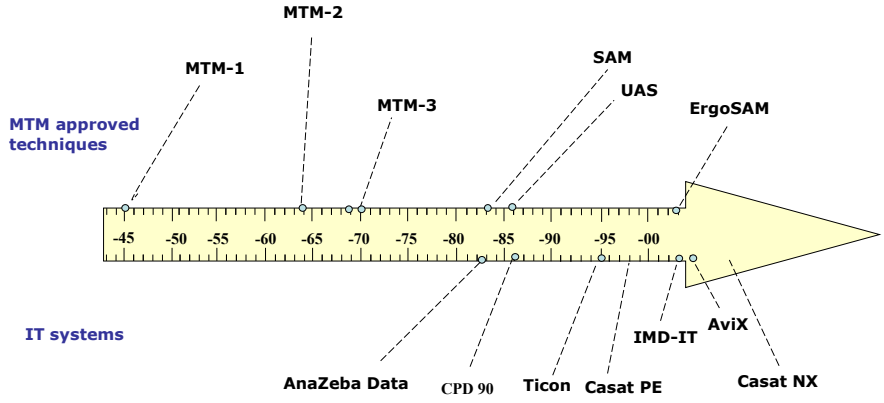
H B Maynard

Fig. 26.—Transport empty (right hand).



Freivalds "Niebel's Methods, standards, and Work Design"

Analysis techniques System development



International MTM Directorate

- Maintaining the standard
- MTM-1 and MTM-2
- Approved high level: UAS and SAM (not MOST !)

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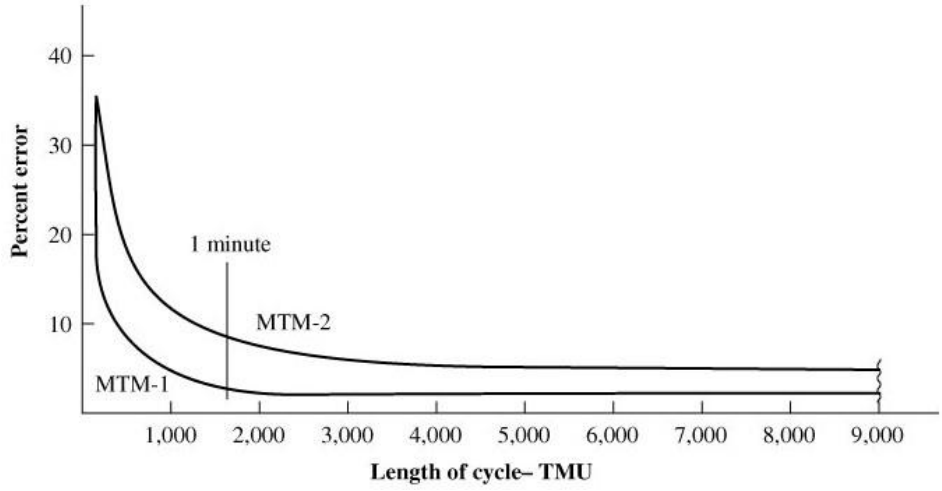
Time Measurement Unit - TMU

TMU	Seconds	Minutes	Hours
1	0,036	0,0006	0,00001
100	3,6	0,06	0,001
28	1		
1667	60	1	



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MTM-1 (Therbligs)

- Reach – R
  - Example: R20B = Reach 20 inches to an object in location that may vary slightly.
- Move – M
  - Distance, weight, and precision affects.
- Turn – T
- Apply pressure - AP

MTM-1 (Therbligs cont.)

- Grasp – G
  - Easy to hard (interference or small size)
- Position – P
- Release – R
- Disengage – D
- Eye travel – ET, Eye focus – EF
- Body, leg, and foot motions

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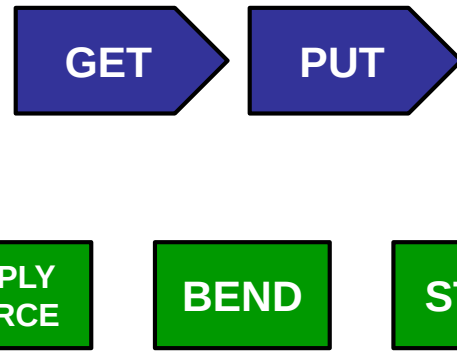
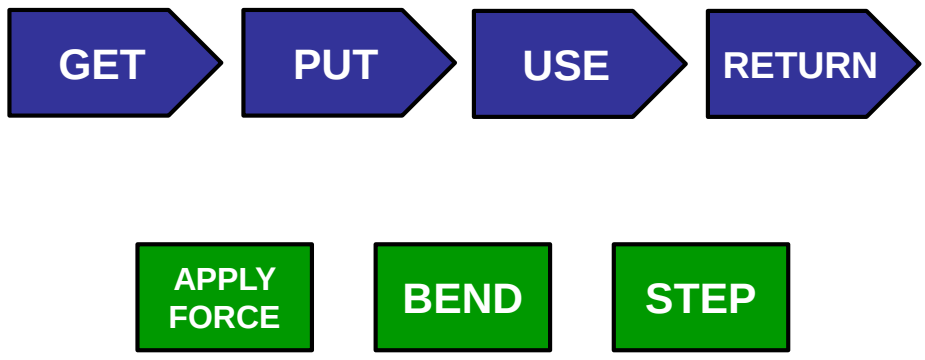
MTM-SAM

Sequential Activity and Method analysis

Sequence - Object handling



Sequence - Tool handling



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SAM Datacard

1 factor	=	5 TMU
1 second	ca	5,6 factors
1 minute	ca	333 factors
1 hour	=	20 000 factors

Motion Length in cm	≤10	>10 to ≤45	>45
Distance Class	10	45	80

Basic Activities		Code	10	45	80
			Factors		
GET	Single	GS	2	4	5
	Handful	GH	8	10	11
PUT	Directly	PD	2	4	5
	Precise	PP	5	7	8
Addition			Code	Fact	
PUT with weight - weight addition			AW	2	

Complementary Activities	Code	Fact
Apply Force	AF	3
Step	S	3
Bend and arise	B	12

Repetitive Activity	Code	10	45	80
To and From	FA	2	5	7

Screw Time per grip		Code	Thread Diameter ≤4	(4)-7	(7)-15	(15)-26
			4	7	15	26
Fingers	Light	SA	2	2	3	3
	Resistance	SB	3	3	4	5
Srew-driver	Light	SC	2	3	4	-
	Resistance	SD	3	4	5	-
Yankee screwdriver		SE	3	3	-	-
Ratchet wrench		SF	3	4	5	7
Combination wrench		SG	6	8	10	12
Allen key		SH	3	4	6	8
T-wrench		SI	6	7	8	10

Repetitive Activities	Code	Fact
HAMMER - per stroke		
Light with wrist	HA	2
Heavy with forearm	HB	4
READ - per term		
Read a term - per term	RA	2
Read, compare terms - per term	RB	7
Read a scale - per scale	RC	8
Control quality on object	RD	3
NOTE - per letter, figure or sign		
Block letters	NA	5
Ordinary writing	NB	3
CRANK - per revolution	CA	3
PRESS BUTTON - per button	PA	2

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SAM Analysis Form

Object	Date	DWG No.
Operation	Issued by	Page of
		Reg.nr

Method description	GET Step S	GS 80	GS 45	GS 10	Add. for Handful -H	PUT Weight >5 kg AW	Step S	PD 80	PD 45	PD 10	Add. for Precision -P	Apply Force AF	USE No.of strokes, grips etc..	No.of places	Time of stroke,prip etc		Apply Force AF	RETURN PUT Weight > 5 kg AW	Step S	PD 80	PD 45	PD 10	Add. for Precision -P	Apply Force AF	Bend+Arise B	Summing up Factors		
	3	5	4	2	6	2	3	5	4	2	3	3	f	n	t	=	3	2	3	5	4	2	3	3	12	F	f	Total
	3	5	4	2	6	2	3	5	4	2	3	3					3	2	3	5	4	2	3	3	12			
	3	5	4	2	6	2	3	5	4	2	3	3					3	2	3	5	4	2	3	3	12			
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	3	5	4	2	6	2	3	5	4	2	3	3					3	2	3	5	4	2	3	3	12			

Calculation:	Total net time (factors)

Method	Purpose	Pros	Cons
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Work sampling	Pre-study for improvement projects. Measure the allowance time.	Easy to perform. The only way to measure allowances.	Design and analysis are complicated.
Predetermined time system	Design a norm time. Method improvement. Performance measurement.	The only way to design a manual work time. Objectivity and fairness. Detailed method analysis.	Requires training. Take long time to perform.