

Motion and Time Study

The Goals of Motion Study

- Improvement
- Planning / Scheduling (Cost)
- Safety

Know How Long to Complete Task for

- Scheduling (Sequencing)
- Efficiency (Best Way)
- Safety (Easiest Way)

How Does a Job Incumbent Spend a Day

- Value Added vs. Non-Value Added

The General Strategy of IE to Reduce and Control Cost

- Are people productive ALL of the time ?
- Which parts of job are really necessary ?
- Can the job be done EASIER, SAFER and FASTER ?
- Is there a sense of employee involvement?

Some Techniques of Industrial Engineering

- Measure
 - Time and Motion Study
 - Work Sampling
- Control
 - Work Standards (Best Practices)
 - Accounting – Labor Reporting
- Improve
 - Small group activities

Time Study

- Observation
 - Stop Watch
 - Computer / Interactive
- Engineering Labor Standards (Bad Idea)
- Job Order / Labor reporting data

History

- Frederick Taylor (1900's)
Studied motions of iron workers – attempted to “mechanize” motions to maximize efficiency – including proper rest, ergonomics, etc.
- Frank and Lillian Gilbreth used motion picture to study worker motions – developed 17 motions called “therbligs” that describe all possible work.

TABLE 7-1

Therblig Name	Symbol	Color Designation	Symbol
Search	S	Black	
Select	SE	Gray, Light	
Grasp	G	Lake Red	
Reach	RE	Olive Green	
Move	M	Green	
Hold	H	Gold Ocher	
Release	RL	Carmine Red	
Position	P	Blue	9
Pre-position	PP	Sky Blue	8
Inspect	I	Burnt Ocher	0
Assemble	A	Violet, Heavy	#
Disassemble	DA	Violet, Light	#
Use	U	Purple	U
Unavoidable Delay	UD	Yellow Ocher	
Avoidable Delay	AD	Lemon Yellow	
Plan	PL	Brown	β
Rest to Overcome Fatigue	R	Orange	ℓ

TABLE I—REACH—R

Distance Moved Inches	Time TMU				Hand In Motion		CASE AND DESCRIPTION
	A	B	C or D	E	A	B	
	1/4 or less	2.0	2.0	2.0	2.0	1.6	
1	2.5	2.5	3.6	2.4	2.3	2.3	
2	4.0	4.0	6.9	3.8	3.5	2.7	
3	6.3	6.3	7.3	5.3	4.5	3.6	
4	6.1	6.4	8.4	6.8	4.9	4.3	
5	6.5	7.8	9.4	7.4	5.3	5.0	
6	7.0	8.6	10.1	8.0	5.7	5.7	
7	7.4	9.3	10.8	8.7	6.1	6.5	
8	7.9	10.1	11.5	9.3	6.5	7.2	
9	8.3	10.8	12.2	9.9	6.9	7.9	
10	8.7	11.5	12.9	10.5	7.3	8.6	
12	9.6	12.9	14.2	11.8	8.1	10.1	
14	10.5	14.4	15.6	13.0	8.9	11.5	
16	11.4	15.8	17.0	14.2	9.7	12.9	
18	12.3	17.2	18.4	15.5	10.5	14.4	
20	13.1	18.6	19.8	16.7	11.3	15.8	
22	14.0	20.1	21.2	18.0	12.1	17.3	
24	14.9	21.5	22.5	19.2	12.9	18.8	
26	15.8	22.9	23.9	20.4	13.7	20.2	
28	16.7	24.4	25.3	21.7	14.5	21.7	
30	17.5	25.8	26.7	22.9	15.3	23.2	

TABLE II—MOVE—M

Distance Moved Inches	Time TMU			Hand In Motion B	Wt. Allowance			CASE AND DESCRIPTION
	A	B	C		Wt. (lb.) Up to	Fac-tor	Con-stant TMU	
	1/4 or less	2.0	2.0		2.0	1.7	2.5	
1	2.5	2.9	3.4	2.3	7.5	1.06	2.2	
2	3.6	4.6	5.2	2.9				
3	4.9	5.7	6.7	3.6				
4	6.1	6.9	8.0	4.3				
5	7.3	8.0	9.2	5.0				
6	8.1	8.9	10.3	6.7	17.5	1.17	5.6	
7	8.9	9.7	11.1	6.5				
8	9.7	10.6	11.8	7.2				
9	10.5	11.5	12.7	7.9	22.5	1.22	7.4	
10	11.3	12.2	13.5	8.6				
12	12.9	13.4	15.2	10.0				
14	14.4	14.6	16.9	11.4	27.5	1.28	9.1	
16	16.0	15.8	18.7	12.8				
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				
24	22.4	20.6	25.5	18.4				
26	24.0	21.8	27.3	19.8	42.5	1.44	14.3	
28	25.6	23.1	29.0	21.2				
30	27.1	24.3	30.7	22.7				

TABLE III—TURN AND APPLY PRESSURE—T AND AP

Weight	Time TMU for Degrees Turned										
	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
Small— 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium— 2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large— 10.1 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

APPLY PRESSURE CASE A—10.6 TMU. APPLY PRESSURE CASE B—16.2 TMU

TABLE IV—GRASP—G

Case	Time TMU	DESCRIPTION
1A	2.0	Pick Up Grasp—Small, medium or large object by itself, easily grasped.
1B	3.6	Very small object or object lying close against a flat surface.
1C1	7.3	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter larger than 1/4".
1C2	8.7	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter 1/4" to 3/4".
1C3	10.8	Interference with grasp on bottom and one side of nearly cylindrical object. Diameter less than 1/4".
2	5.6	Regrasp.
3	5.6	Transfer Grasp.
4A	7.3	Object jumbled with other objects so search and select occur. Larger than 1" x 1" x 1".
4B	9.1	Object jumbled with other objects so search and select occur. 1/2" x 1/2" x 1/2" to 1" x 1" x 1".
4C	12.9	Object jumbled with other objects so search and select occur. Smaller than 1/2" x 1/2" x 1/2".
5	0	Contact, sliding or hook grasp.

TABLE V—POSITION*—P

CLASS OF FIT		Symmetry	Easy To Handle	Difficult To Handle
1—Loose	No pressure required	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2—Close	Light pressure required	S	16.2	21.8
		SS	19.7	25.3
		NS	21.0	26.6
3—Exact	Heavy pressure required.	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4

*Distance moved to engage—1" or less.

TABLE VI—RELEASE—RL

Case	Time TMU	DESCRIPTION
1	2.0	Normal release performed by opening fingers as independent motion.
2	0	Contact Release.

TABLE VII—DISENGAGE—D

CLASS OF FIT		Easy to Handle	Difficult to Handle
1—Loose—Very slight effort, blends with subsequent move.		4.0	6.7
2—Close—Normal effort, slight recoil.		7.5	11.8
3—Tight—Considerable effort, hand recoils markedly.		22.9	34.7

TABLE VIII—EYE TRAVEL TIME AND EYE FOCUS—ET AND EF

Eye Travel Time = $15.2 \times \frac{T}{D}$ TMU, with a maximum value of 20 TMU.

where T = the distance between points from and to which the eye travels.
D = the perpendicular distance from the eye to the line of travel T.

Eye Focus Time = 7.3 TMU.

TABLE 19-4 (concluded)

TABLE IX—BODY, LEG, AND FOOT MOTIONS			
DESCRIPTION	SYMBOL	DISTANCE	TIME TMU
Foot Motion—Hinged at Ankle. With heavy pressure. Leg or Foreleg Motion.	FM	Up to 4"	8.5
	FMP	Up to 6"	19.1
	LM —	Each add'l. inch	7.1 1.2
Sidestep—Case 1—Complete when leading leg contacts floor.	SS-C1	Less than 12"	Use REACH or MOVE Time
		12" Each add'l. inch	17.0 .6
Case 2—Lagging leg must contact floor before next motion can be made.	SS-C2	12" Each add'l. inch	34.1 1.1
Bend, Stoop, or Kneel on One Knee. Arise.	B,S,KOK		29.0
Kneel on Floor—Both Knees. Arise.	AB,AS,AKOK		31.9
	KBK AKBK		69.4 76.7
Sit.	SIT		34.7
Stand from Sitting Position.	STD		43.4
Turn Body 45 to 90 degrees— Case 1—Complete when leading leg contacts floor.	TBC1		18.6
	TBC2		37.2
Walk.	W-FT.	Per Foot	5.3
	W-P	Per Pace	15.0

TABLE X—SIMULTANEOUS MOTIONS

REACH		MOVE		GRASP		POSITION			DISENGAGE		CASE	MOTION					
A, E	B, C, D	A, Bm	B	C	G1A, G2, G6	G1B, G1C	G4	P1S	P1S5, P2S	P1S5, P2S5, P2S			D1E, D1D	D2			
	W	O	W	O	W	O	W	O	F	**	F	D	F	D			
																	A, E
																	B
																	C, D
																	A, Bm
																	B
																	C
																	G1A, G2, G6
																	G1B, G1C
																	G4
																	P1S
																	P1S5, P2S
																	P1S5, P2S5, P2S
																	D1E, D1D
																	D2

= EASY to perform simultaneously.
 = Can be performed simultaneously with PRACTICE.
 = DIFFICULT to perform simultaneously even after long practice. Allow both times.

MOTIONS NOT INCLUDED IN ABOVE TABLE

TURN—Normally EASY with all motions except when TURN is controlled or with DISENGAGE.

APPLY PRESSURE—May be EASY, PRACTICE, or DIFFICULT. Each case must be analyzed.

POSITION—Class 3—Always DIFFICULT.

DISENGAGE—Class 3—Normally DIFFICULT.

RELEASE—Always EASY.







DISENGAGE—Any class may be DIFFICULT if care must be exercised to avoid injury or damage to object.

*W= Within the area of normal vision.
 O= Outside the area of normal vision.
 **E=EASY to handle.
 D=DIFFICULT to handle.

- GET G
- PUT P
- GET WEIGHT GW
- PUT WEIGHT PW
- REGRASP R
- APPLY PRESSURE A
- EYE ACTION E
- FOOT ACTION F
- STEP S
- BEND & ARISE B
- CRANK C

Time Study (Stopwatch Measurement)

1. List work elements
2. Discuss with worker
3. Measure with stopwatch (running VS reset)
4. Repeat for n Observations
5. Compute mean and std dev of work station time
6. Be aware of allowances/foreign element, etc

Activity legend: Typing  Filing  General Work  Telephone  Reception  Personal 
 Minutes of Day: Typing 96.2 Filing 40.2 General Work 186.6 Telephone 59.2 Reception 36.4 Personal 61.4

Time of Day

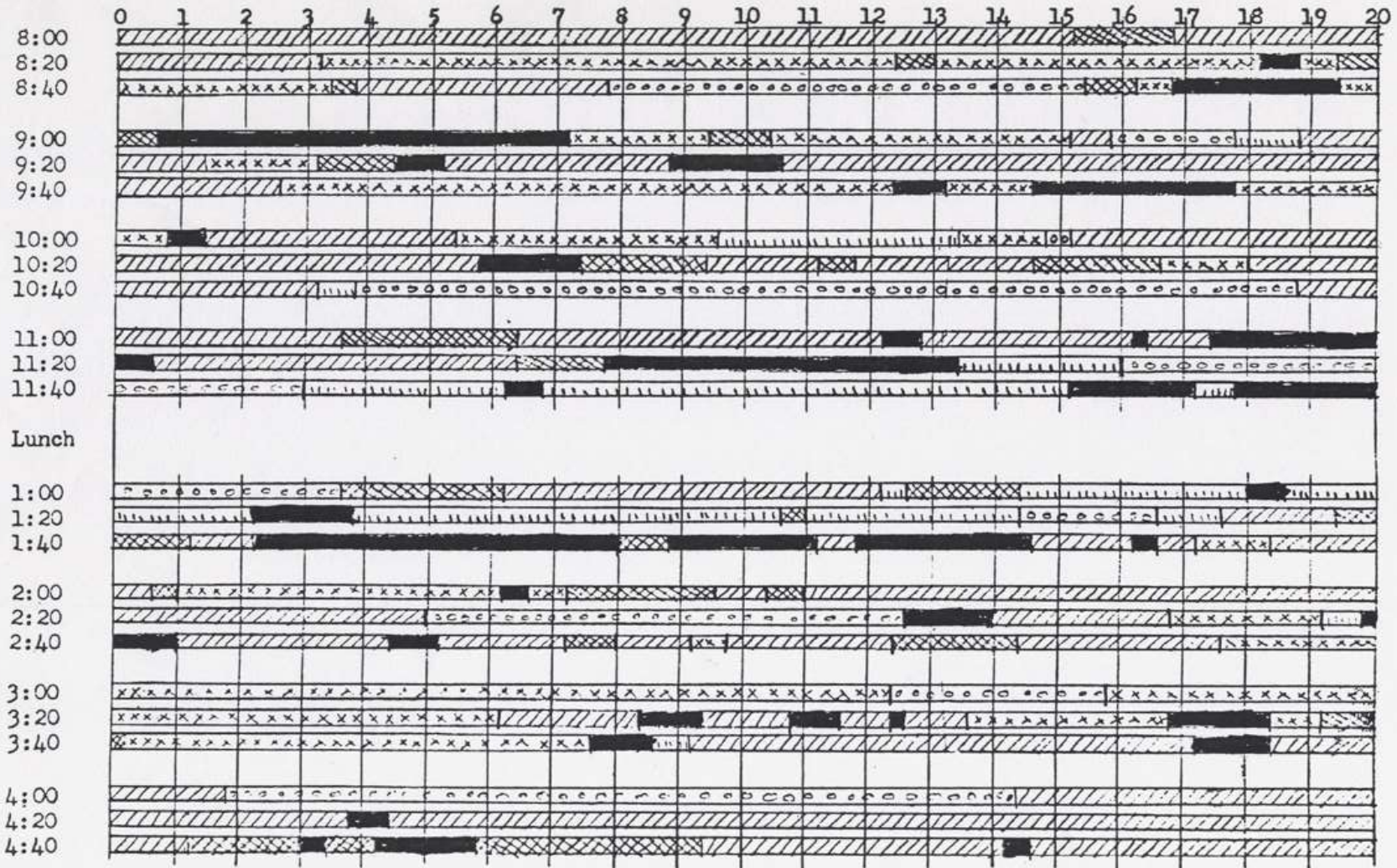


Figure 1. Activity-Timestudy of a Secretary for One Day

Work Sampling

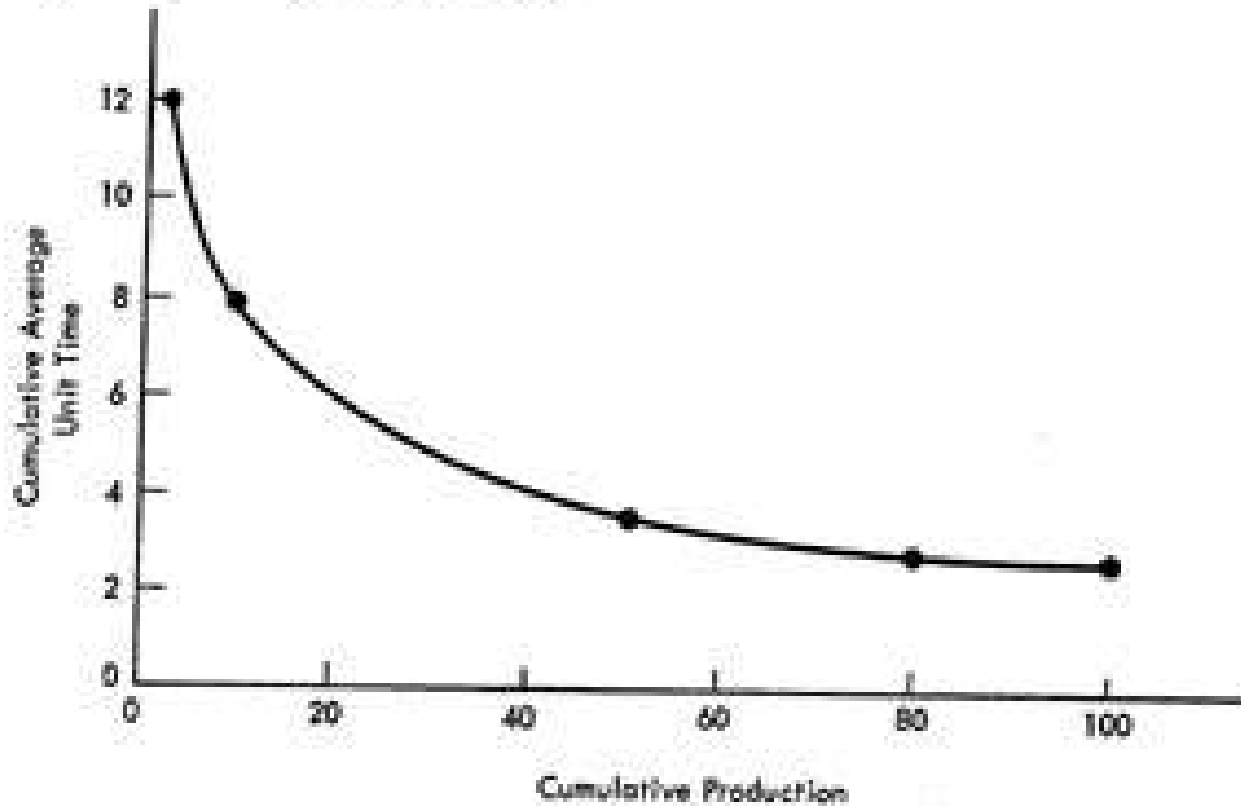
- Determined what is done over typical day
- Random Reporting
- Periodic Reporting

Learning Curve

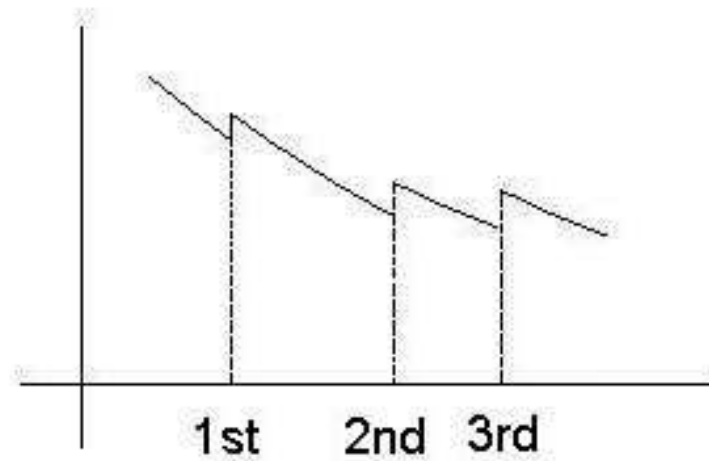
- For repetitive work, worker gains skill, knowledge of product/process, etc over time
- Thus we expect output to increase over time as more units are produced over time to complete task decreases as more units are produced

Traditional Learning Curve

Typical productivity increase graph



Actual Curve



Change, Design, Process, etc

Learning Curve

- Usually define learning as a percentage reduction in the time it takes to make a unit.
- The definition says a doubling of the total number of units made produce a constant decrease in the time per unit
- An 80% learning curve implies a 20% decrease in unit time with each doubling of the number produced (90% implies 10% decrease, 100% implies no improvement)