Job Design

Chapter 7

Job Design

The act of specifying the contents and methods of jobs.

Job designers focus on

- *what* will be done in a job,
- *who* will do the job,
- *how* the job will be done, and
- *where* the job will be done.

The objectives of job design include productivity, safety, and quality of work life.

Ergonomics is the incorporation of human factors in the design of the workplace. It relates to design of equipment, design of work methods, and the overall design of the work environment.

Current practice in job design contains elements of two basic schools of thought. One might be called the ***efficiency*** school because it emphasizes a systematic, logical approach to job design; the other is called the ***behavioral*** school because it emphasizes satisfaction of wants and needs.

Specialization

Advantages

For management:

1. Simplifies training
2. High productivity
3. Low wage costs

For labor:

1. Low education and skill requirements
2. Minimum responsibilities
3. Little mental effort needed

Disadvantages

For management:

1. Difficult to motivate quality
2. Worker dissatisfaction, possibly resulting in absenteeism, high turnover, disruptive tactics, poor attention to quality

For labor:

1. Monotonous work
2. Limited opportunities for advancement
3. Little control over work
4. Little opportunity for self-fulfillment

Behavioral Approaches to Job Design

Job enlargement. Giving a worker a larger portion of the total task, by horizontal loading. (*horizontal loading)*

Job rotation. Workers periodically exchange jobs. means having workers periodically exchange jobs.

Job enrichment. Increasing responsibility for planning and coordination tasks, by vertical loading. (*vertical loading)*

Motivation

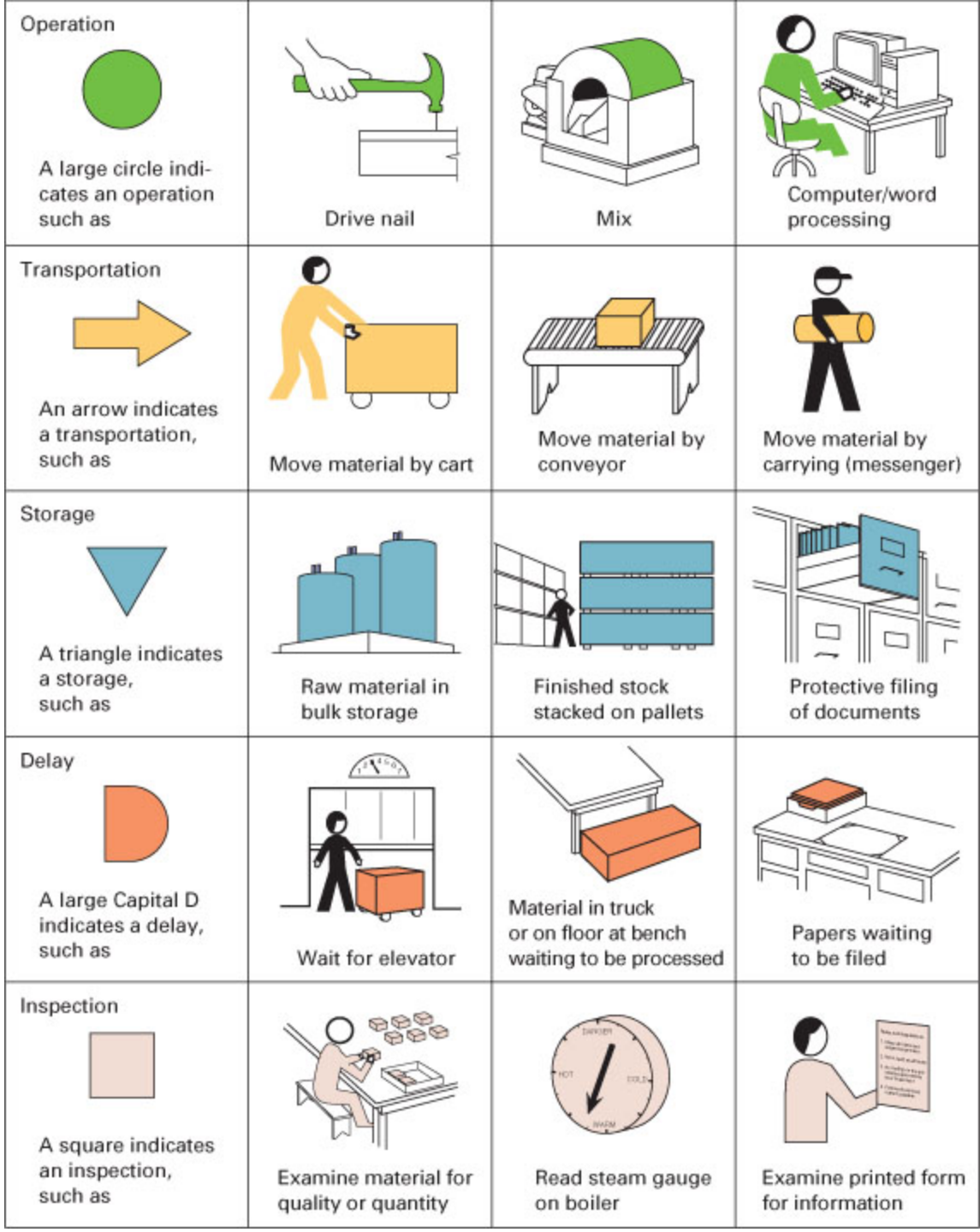
Teams

Methods Analysis

Selecting an Operation to Study
Documenting the Current Method
Analyzing the Job and Proposing New Methods
Installing the Improved Method
The Follow-Up

Analyzing and improving methods is facilitated by the use of various charts such as *flow process charts* and *worker-machine charts*.

Flow process charts are used to review and critically examine the overall sequence of an operation by focusing on the movements of the operator or the flow of materials.



FLOW PROCESS CHART Job Requisition of petty cash	ANALYST D. Kolb	PAGE 1 of 2

Details of method	Operation	Movement	Inspection	Delay	Storage
Requisition made out by department head	●	⇨	□	D	▽
Put in "pick-up" basket	○	⇨	□	◗	▽
To accounting department	○	➡	□	D	▽
Account and signature verified	○	⇨	■	D	▽
Amount approved by treasurer	●	⇨	□	D	▽
Amount counted by cashier	●	⇨	□	D	▽
Amount recorded by bookkeeper	●	⇨	□	D	▽
Petty cash sealed in envelope	●	⇨	□	D	▽
Petty cash carried to department	○	➡	□	D	▽
Petty cash checked against requisition	○	⇨	■	D	▽
Receipt signed	●	⇨	□	D	▽
Petty cash stored in safety box	○	⇨	□	D	▼
	○	⇨	□	D	▽
	○	⇨	□	D	▽
	○	⇨	□	D	▽
	○	⇨	□	D	▽

Product: Bulk Food
Process: Weigh/price

Operator: Customer
Charted by: R.G.

Step	Customer	Time (seconds)	Machine
1	Customer places on scale	0	
		1	
2	Enters product code	2	
3		3	Calculates and displays total price. Dispenses price sticker.
4	Obtains price sticker and removes bag	4	
		5	
5	Places price sticker on bag	6	
		7	

Summary

	Customer		Machine	
	Time (seconds)	%	Time (seconds)	%
Work	7	87.5	1	12.5
Idle	1	12.5	7	87.5

Motion Study

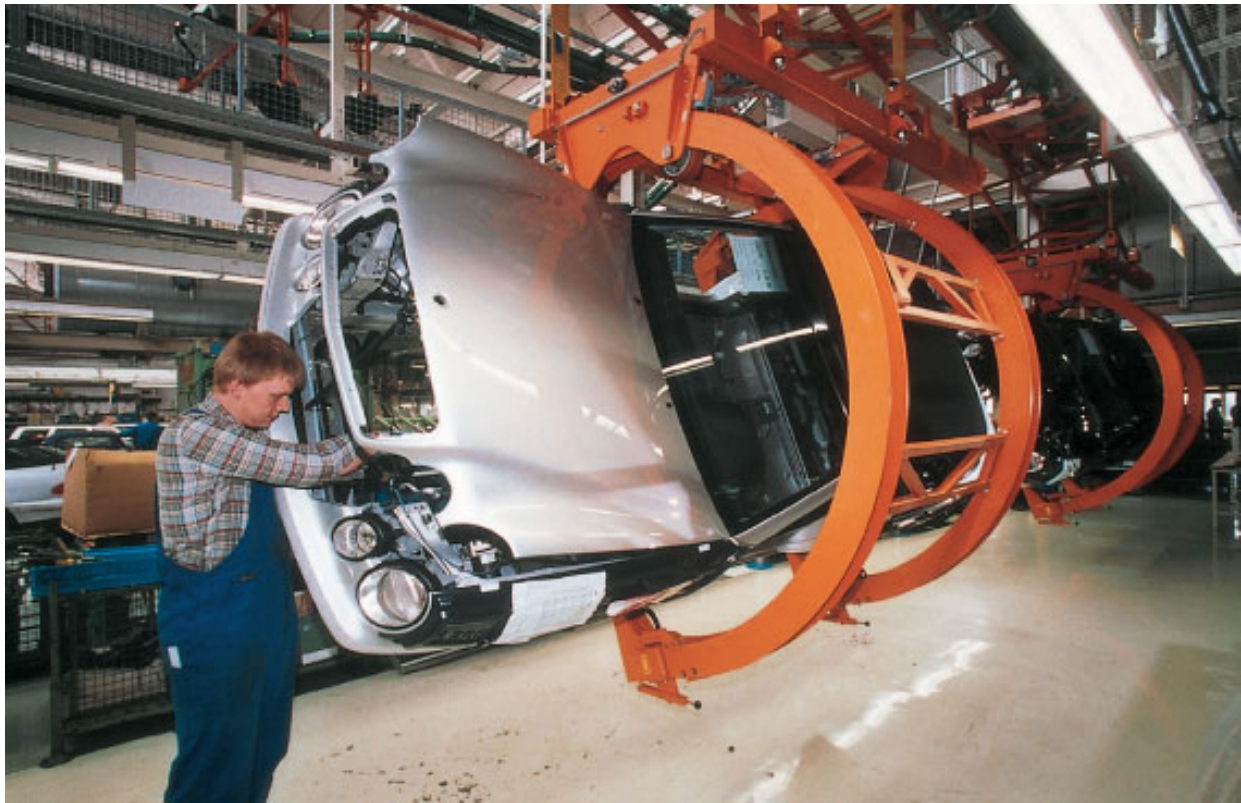
Systematic study of the human motions used to perform an operation.

Motion study principles

The use of the human body.

The arrangement and conditions of the workplace.

The design of tools and equipment.



Therbligs are basic elemental motions.

Search implies hunting for an item with the hands and/or the eyes.
Select means to choose from a group of objects.
Grasp means to take hold of an object.
Hold refers to retention of an object after it has been grasped.
Transport load means movement of an object after hold.
Release load means to deposit the object.

Some other therbligs are *inspect*, *position*, *plan*, *rest*, and *delay*.

Micromotion study. Use of motion pictures and slow motion to study motions that otherwise would be too rapid to analyze.

SIMO CHART

OPERATOR: Ken Reisch
DATE: May 21,
OPERATION: Assembly
PART: Lace Finger
METHOD: Proposed
CHART BY: Joseph Riley

TIME SCALE (winks)	ELEMENT TIME	LEFT-HAND DESCRIPTION	SYMBOL	MOTION CLASS (1 2 3 4 5 6 4 3 2 1)	SYMBOL	RIGHT-HAND DESCRIPTION	ELEMENT TIME	TIME SCALE (winks)
4548	12	Reach for finger	RE		RE	Reach for finger	12	4548
4560	19	Grasp finger	G		G	Grasp finger	19	4560
4579	31	Move finger	M		M	Move finger	31	4579
4610	75	Position and release finger	P RL		P RL	Position and release finger	75	4610
4685	15	Reach for clamp	RE		RE	Reach for clamp	15	4685
4700	15	Grasp clamp	G		G	Grasp clamp	15	4700
4715								4715
7541	12	Grasp assembly	G		G	Grasp assembly	12	7541
	18	Move and release assembly	M RL		M RL	Move and release assembly	18	
7559								7559

SUMMARY

%	TIME	LEFT-HAND SUMMARY	SYM.	RIGHT-HAND SUMMARY	TIME	%
8.56	249	Reach	RE	Reach	245	8.4
7.49	218	Grasp	G	Grasp	221	7.6
12.16	354	Move	M	Move	413	14.2
30.47	887	Position	P	Position	1124	38.6
39.33	1145	Use	U	Use	876	30.1
1.03	30	Idle	I	Idle	0	0.0
.96	28	Release	RL	Release	32	1.1
100.0	2911	TOTALS			2911	100.0

Working Conditions

Temperature and Humidity.

Ventilation.

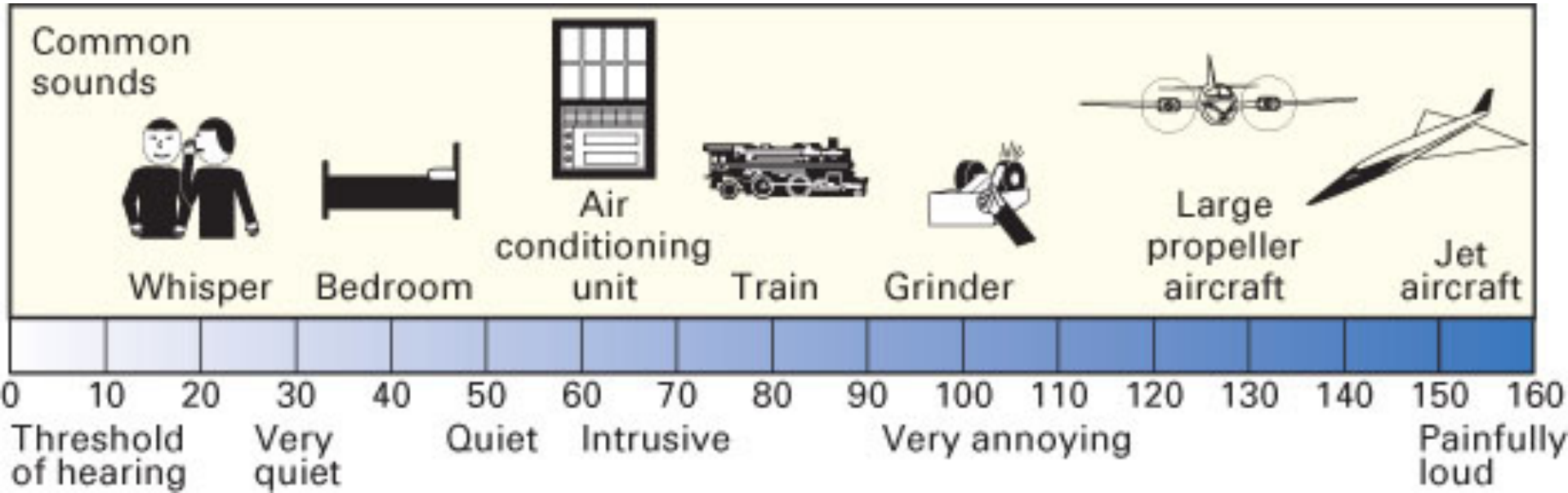
Illumination.

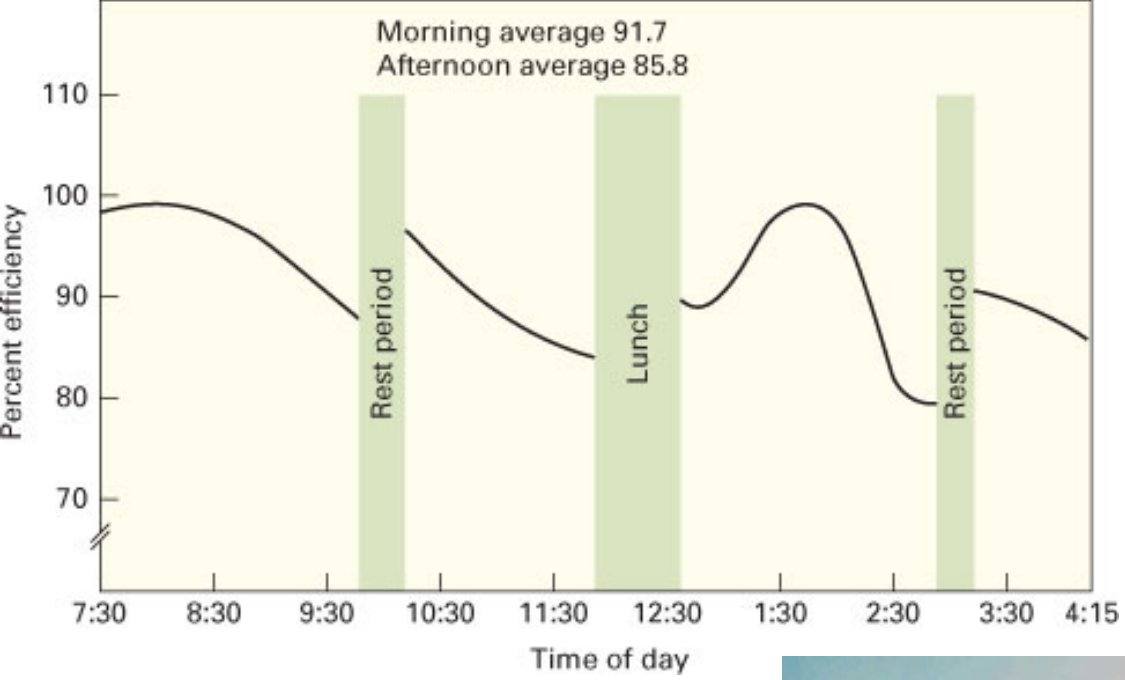
Noise and Vibrations.

Work Breaks.

Safety.

Ethical Issues.




Morning average 91.7
Afternoon average 85.8
Percent efficiency
110
100
90
80
70
Rest period
Lunch
Rest period
7:30
8:30
9:30
10:30
11:30
12:30
1:30
2:30
3:30
4:15
Time of day

Work Measurement

A **standard time** is the amount of time it should take a qualified worker to complete a specified task, working at a sustainable rate, using given methods, tools and equipment, raw material inputs, and workplace arrangement.

- stopwatch time study
- historical times
- predetermined data
- work sampling

Stopwatch Time Study

Stopwatch time study. Development of a time standard based on observations of one worker taken over a number of cycles.

1. Define the task to be studied, and inform the worker who will be studied.
2. Determine the number of cycles to observe.
3. Time the job, and rate the worker's performance.
4. Compute the standard time.

The number of cycles that must be timed is a function of three things: (1) the variability of observed times, (2) the desired accuracy, and (3) the desired level of confidence for the estimated job time.

$$n = \left(\frac{zs}{a\bar{x}}\right)^2$$

where

n = Sample size needed

z = Number of normal standard deviations needed for desired confidence

s = Sample standard deviation

a = Desired accuracy percentage

x = Sample mean

$$n = \left(\frac{zs}{e}\right)^2$$

where

e = Maximum acceptable errror

Desired Confidence (%) Value	z
90	1.65
95	1.96
95.5	2.00
98	2.33
99	2.58

Example

A time study analyst wants to estimate the time required to perform a certain job. A preliminary study yielded a mean of 6.4 minutes and a standard deviation of 2.1 minutes. The desired confidence is 95 percent. How many observations will he need (including those already taken) if the desired maximum error is

a. ±10 percent of the sample mean?

b. One-half minute?

$s = 2.1$ minutes $\qquad z = 1.96$

$\bar{x} = 6.4$ minutes $\qquad a = 10\%$

$$n = \left(\frac{zs}{a\bar{x}}\right)^2 = \left(\frac{1.96(2.1)}{.10(6.4)}\right)^2 = 41.36 \text{ (round up to 42)}$$

$$e = .5 \qquad n = \left(\frac{zs}{e}\right)^2 = \left(\frac{1.96(2.1)}{.5}\right)^2 = 67.77 \text{ (round up to 68)}$$

Development of a time standard involves computation of three times: the *observed time* (OT), the *normal time* (NT), and the *standard time* (ST).

Observed Time. The observed time is simply the average of the recorded times.

$$OT = \frac{\Sigma x_i}{n}$$

where

OT = Observed time

Σx_i = Sum of recorded times

n = Number of observations

Normal Time. The normal time is the observed time adjusted for worker performance.

$$NT = OT \times PR$$

where

NT = Normal Time

PR = Performance rating

$$NT = \Sigma(\bar{x}_j \times PR_j)$$

where

x_j = Average time for element j

PRj = Performance rating for element j

Standard Time. The normal time does not take into account such factors as personal delays, unavoidable delays, or rest breaks.

$$ST = NT \times AF$$

where

ST = Standard time

AF = Allowance factor

$$AF_{job} = 1 + A \qquad A = \text{Allowance percentage based on job time}$$

$$AF_{day} = \frac{1}{1 - A} \qquad A = \text{Allowance percentage based on workday}$$

	Percent
A. Constant allowances:	
1. Personal allowance	5
2. Basic fatigue allowances	4
B. Variable allowances:	
1. Standing allowance	2
2. Abnormal position allowance:	
a. Slightly awkward	0
b. Awkward (bending)	2
c. Very awkward (lying, stretching)	7
3. Use of force or muscular energy (lifting, pulling, or pushing): Weight lifted (in pounds):	
5	0
10	1
15	2
20	3
25	4
30	5
35	7
40	9
45	11
50	13
60	17
70	22

	Percent
4. Bad light:	
a. Slightly below recommended	0
b. Well below	2
c. Very inadequate	5
5. Atmospheric conditions (heat and humidity)—variable	0–10
6. Close attention:	
a. Fairly fine work	0
b. Fine or exacting	2
c. Very fine or very exacting	5
7. Noise level:	
a. Continuous	0
b. Intermittent—loud	2
c. Intermittent—very loud	5
d. High-pitched—loud	5
8. Mental strain:	
a. Fairly complex process	1
b. Complex or wide span of attention	4
c. Very complex	8
9. Monotony:	
a. Low	0
b. Medium	1
c. High	4
10. Tediousness:	
a. Rather tedious	0
b. Tedious	2
c. Very tedious	5

Example

A time study of an assembly operation yielded the following observed times for one element of the job, for which the analyst gave a performance rating of 1.13 Using an allowance of 20 percent of *job* time, determine the appropriate standard time for this operation.

i Observation	Time, *x* (minutes)	*i* Observation	Time, *x* (minutes)
1	1.12	6	1.18
2	1.15	7	1.14
3	1.16	8	1.14
4	1.12	9	1.19
5	1.15	Total	10.35

$n = 9 \qquad PR = 1.13 \qquad A = .20$

$$OT = \frac{\Sigma xi}{n} = \frac{10.35}{9} = 1.15 \text{ minutes.}$$

tes.

ST = NT × (1 + *A*) = 1.30(1.20) = 1.56 minutes.

Standard Elemental Times

Standard elemental times are derived from a firm's own historical time study data.

1. Analyze the job to identify the standard elements.
2. Check the file for elements that have historical times, and record them. Use time study to obtain others, if necessary.
3. Modify the file times if necessary (explained below).
4. Sum the elemental times to obtain the normal time, and factor in allowances to obtain the standard time.

Predetermined Time Standards

Predetermined time standards involve the use of published data on standard elemental times.

	TIME (TMU)				WEIGHT ALLOWANCE			
Distance Moved (inches)	A	B	C	Hand in Motion B	Weight (pounds) up to:	Dynamic Factor	Static Constant TMU	Case and Description
3/4 or less	2.0	2.0	2.0	1.7				
1	2.5	2.9	3.4	2.3	2.5	1.00	0	A. Move object to other hand or against stop.
2	3.6	4.6	5.2	2.9				
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	B. Move object to approximate or indefinite location.
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	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				
24	22.4	20.6	25.5	18.4	42.5	1.44	14.3	C. Move object to exact location.
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				

Work Sampling

Work sampling is a technique for estimating the proportion of time that a worker or machine spends on various activities and the idle time.

$$e = z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

where

z = Number of standard deviations needed to achieve desired confidence

p = Sample proportion (the number of occurrences divided by the sample size)

n = Sample size

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p})$$

Determining the sample size is only one part of work sampling. The overall procedure consists of the following steps:

- Clearly identify the worker(s) or machine(s) to be studied.
- Notify the workers and supervisors of the purpose of the study to avoid arousing suspicions.
- Compute an initial estimate of sample size using a preliminary estimate of p, if available (e.g., from analyst experience or past data). Otherwise, use $p = .50$.
- Develop a random observation schedule.
- Begin taking observations. Recompute the required sample size several times during the study.
- Determine the estimated proportion of time spent on the specified activity.

	1	2	3	4	5	6
1	6912	7264	2801	8901	4627	8387
2	3491	1192	0575	7547	2093	4617
3	4715	2486	2776	2664	3856	0064
4	1632	1546	1950	1844	1123	1908
5	8510	7209	0938	2376	0120	4237
6	3950	1328	7343	6083	2108	2044
7	7871	7752	0521	8511	3956	3957
8	2716	1396	7354	0249	7728	8818
9	2935	8259	9912	3761	4028	9207
10	8533	9957	9585	1039	2159	2438
11	0508	1640	2768	4666	9530	3352
12	2951	0131	4359	3095	4421	3018

Day	Hour	Minute
6	3	47
1	4	15
2	9	24

Day	Hour	Minute
1	4	15
2	9	24
6	3	47

DAY 1

Observation	Time	Busy (✓)	Idle (✓)
1	8:15		
2	9:24		
3	9:02		
4	9:31		
5	9:48		
6	10:05		
7	10:20		
8	11:02		
9	1:13		
10	3:55		

DAY 2

Observation	Time	Busy (✓)	Idle (✓)
1	8:04		
2	9:15		
3	9:24		
4	9:35		
5	10:12		
6	10:27		
7	10:38		
8	10:58		
9	11:50		
10	1:14		

Work sampling compared with stopwatch time study

Advantages

- Observations are spread out over a period of time, making results less susceptible to short-term fluctuations.
- There is little or no disruption of work.
- Workers are less resentful.
- Studies are less costly and less time-consuming, and the skill requirements of the analyst are much less.
- Studies can be interrupted without affecting the results.
- Many different studies can be conducted simultaneously.
- No timing device is required.
- It is well suited for nonrepetitive tasks.

Disadvantages

- There is much less detail on the elements of a job.
- Workers may alter their work patterns when they spot the observer, thereby invalidating the results.
- In many cases, there is no record of the method used by the worker.
- Observers may fail to adhere to a random schedule of observations.
- It is not well suited for short, repetitive tasks.
- Much time may be required to move from one workplace to another and back to satisfy the randomness requirement.