Operations Management

Ref book:
OM by Stevension
FE – Industrial Engineering Specific

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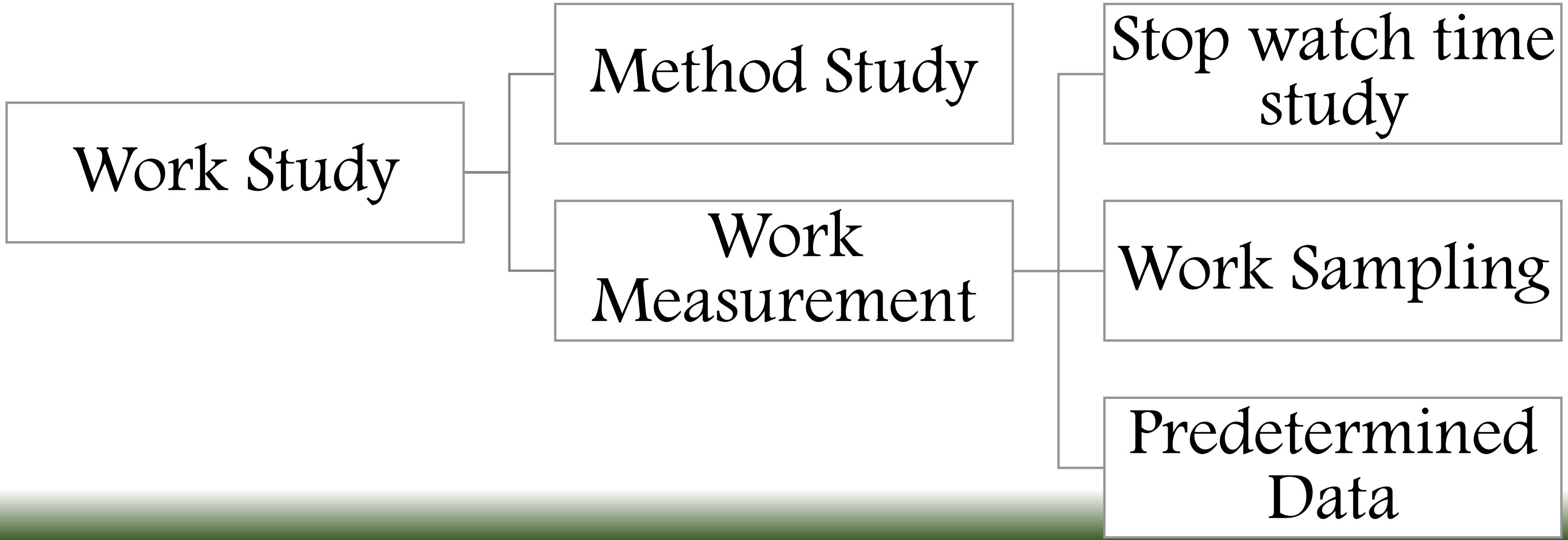
Outline of Work Study

A. Methods analysis (e.g., charting, workstation design, motion economy)
B. Time study (e.g., time standards, allowances)
C. Predetermined time standard systems (e.g., MOST, MTM)
D. Work sampling
E. Learning curves

Work study

- Work study may be defined as the analysis of a job for the purpose of finding the preferred method of doing it and also determining the standard time to perform it by the preferred (or given) method. Work study, therefore, comprises of two areas of study: method study (motion study) and time study (work measurement).



A. Methods analysis (e.g. motion economy)

- **motion study:** Systematic study of the human motions used to perform an operation.

B. Time study (e.g., time standards, allowances)

- Work measurement: determining how long it ought to take to perform a job
- 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

The basic steps in a time study are:

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

B. Time study (e.g., time standards, allowances)

- Observed Time: The average of recorded time

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

OT = Observed time, $\sum x_i$ = Sum of recorded time, n = number of observation

- Normal Time: OT adjusted for worker performance

$$NT = OT * PR$$

NT = normal time, OT = Observed time, PR = Performance rating

- Standard Time: NT plus an allowance

$$ST = NT * AF$$

B. Time study (e.g., time standards, allowances)

An industrial engineer conducted a time study of an assembly operation with the times given. The engineer gave a performance rating of 115. The allowance factor is 10% of job time. The standard time for this operation is most nearly:

A. 2.96
B. 3.20
C. 3.56
D. 3.92

Observation	Time
1	3.10
2	3.05
3	3.10
4	3.08
5	3.12
6	3.15
7	3.12
8	3.08
9	3.05
10	3.10

$OT = \frac{\sum x_i}{n}$ => 30.95/10 = 3.095

$NT = OT * PR$ => 3.095*1.15 = 3.559

$ST = NT * AF$ => 3.559*1.10 = 3.915

A time study analyst timed an assembly operation for 30 cycles, and computed the time per cycle, which was 18.75 minutes. The analyst assigned a performance rating of .96,<11;'(& decided that an appropriate allowance was 15 percent~ Assume the allowance factor is based on the *workday*. *De*termine the following: the observed time, the normal time (NT), and the standard time (ST).

$$OT = \text{Average time} = 18.75 \text{ minutes}$$

$$NT = OT \times \text{Performance rating} = 18.75 \text{ minutes} \times .96 = 18 \text{ minutes}$$

$$AF = \frac{1}{1 - A} = \frac{1}{1 - .15} = 1.176$$

$$ST = NT \times AF = 18 \times 1.176 = 21.17 \text{ minutes}$$

C. Predetermined time standard systems (e.g., MOST)

- **MOST** stands for Maynard operation Sequence technique. It is one of the important work measurement technique used for decisions making.

C. Predetermined time standard systems (e.g. MTM - Method time measurement)

- the analyst must divide the job into its basic elements (reach, move, turn, disengage), measure the distances involved (if applicable), rate the difficulty of the element, and then refer to the appropriate table of data to obtain the time for that element.
- The standard time for the job is obtained by adding the times for all of the basic elements. Times of the basic elements are measured in time measurement units (TMUs); one TMU equals .0006 minute.

- **Standard Time Determination**
  ST = *NT* × *AF*
  where *NT* = normal time, *AF* = allowance factor

- ***Case 1:*** Allowances are based on the *job time*.
  $$AF_{job} = 1 + A_{job}$$
  A_{job} = allowance fraction (percentage/100) based on *job time*.

- ***Case 2:*** Allowances are based on *workday*.
  AF_{time} = 1/(1 – *A*_day)
  A_{day} = allowance fraction (percentage/100) based on *workday*

1. Predetermined time systems are useful in cases where either (1) the task does not yet exist or (2) changes to a task are being designed and normal times have not yet been established for all elements of the new task or changed task. In such cases no opportunity exists to measure the element time.
2. Unfortunately, there is no scientific basis for predicting element times without breaking them down into motion-level parts. A task consists of elements. An organization may develop its own database of normal element durations, and normal times for new or changed tasks may be predicted if the tasks consist entirely of elements whose normal times are already in the database.
3. But new elements can be decomposed into motions, for which scientifcally predetermined times exist in databases called MTM-1, MTM-2, and MTM-3. These databases and software to manipulate them are commercially available. To use one of them effectively requires about 50 hours of training

D. Work sampling

The technique for estimating the proportion of time that a worker or machine spends on various activities and the idle time

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

The manager of a small supermarket chain wants to estimate the proportion of time stock clerks spend making price changes on previously marked merchandise. The manager wants a 98 percent confidence that the resulting estimate will be within 5 percent of the true value. What sample size should she use?

The procedure of work sampling

1. Clearly identify the worker(s) or machine(s) to be studied.
2. Notify the workers and supervisors of the purpose of the study to avoid arousing suspicions.
3. 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 $p = .50$.
4. Develop a random observation schedule.
5. Begin taking observations. Re-compute the required sample size several times during the study.
6. Determine the estimated proportion of time spent on the specified activity

WORK SAMPLING FORMULAS

$$D = Z_{\alpha/2}\sqrt{\frac{p(1-p)}{n}} \quad \text{and} \quad R = Z_{\alpha/2}\sqrt{\frac{1-p}{pn}}, \text{ where}$$

p = proportion of observed time in an activity

D = absolute error

R = relative error ($R = D/p$)

n = sample size

Source: FE – Industrial Specific

An analyst has been asked to prepare an estimate of the proportion of time that a operator spends on non-value added time, with 90% CL. Based on previous experience, the analyst believes the proportion will be approximately 30%.

a) If the analyst uses a sample size of 400, what is the max possible error?
b) What sample size would the analyst need in order to have the max error to be min $\pm$ 5%

$$\hat{p} = .30 \qquad z = 1.65 \text{ (for 90 percent confidence)}$$

$$a.\quad e = z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = 1.65\sqrt{\frac{.3(.7)}{400}} = .038$$

$$b.\quad n = \left(\frac{z}{e}\right)^2 \hat{p}(1-\hat{p}) = \left(\frac{1.65}{.05}\right)^2 (.3)(.7) = 228.69, \text{ or } 229$$

Time Study		Work Sampling	

Time Study

A. Sample size

$$n = \left(\frac{zs}{a\bar{x}}\right)^2 \quad (7\text{–}1)$$

$$n = \left(\frac{zs}{e}\right)^2 \quad (7\text{–}2)$$

B. Observed time

$$\text{OT} = \frac{\sum x_i}{n} \quad (7\text{–}3)$$

C. Normal time

$$\text{NT} = \text{OT} \times \text{PR} \quad (7\text{–}4)$$

$$\text{NT} = \sum(\bar{x}_j \times \text{PR}_j) \quad (7\text{–}5)$$

D. Standard time

$$\text{ST} = \text{NT} \times \text{AF} \quad (7\text{–}6)$$

E. Allowance factor

$$\text{AF}_{job} = 1 + \text{A} \quad (7\text{–}7)$$

$$\text{AF}_{day} = \frac{1}{1 - \text{A}} \quad (7\text{–}8)$$

Work Sampling

A. Maximum error

$$e = z\sqrt{\frac{\hat{p}(1 - \hat{p})}{n}} \quad (7\text{–}9)$$

B. Sample size

$$n = \left(\frac{z}{e}\right)^2 \hat{p}(1 - \hat{p}) \quad (7\text{–}10)$$

Symbols:

a = Allowable error as percentage of average time

A = Allowance percentage

e = Maximum acceptable error

n = Number of observations needed

NT = Normal time

OT = Observed, or average, time

PR = Performance rating

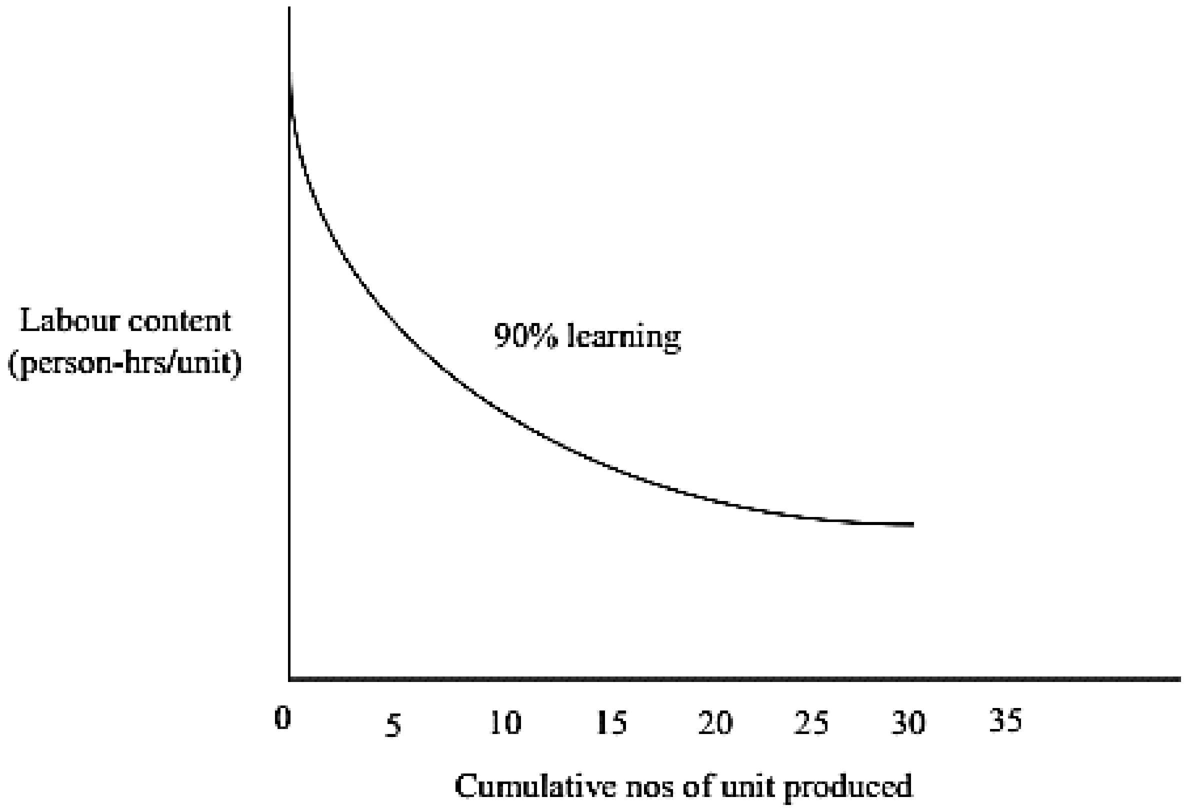
s = Standard deviation of observed times

ST = Standard time

x_i = Time for ith observation (i = 1, 2, 3, . . . , n)

E. Learning curves

- Human performance of activities typically shows improvement when the activities are done on a repetitive basis: The time required to perform a task decreases with increasing repetitions. *Learning curves* summarize this phenomenon



Learning Curve

- The labour content (in person-hrs per unit) requires to make a product, expressed as a function of the cumulative number of units made is called Learning Curve

- the amount of time required to make the nth unit of the product will be

$$T_n = T_1 \times n^a$$

  where T_n = Time to make the nth unit.
  T_1 = Time to make 1st unit.
  a = (ln x/ln 2)
  x = learning rate (expressed as decimal)

- **Given, 80% curve, T_1 = 10 hours, how much it would take to produce 3rd product?**

Applications of Learning Curves

Learning curve theory has found useful applications in a number of areas

1. Manpower planning and scheduling.
2. Negotiated purchasing.
3. Pricing new products.
4. Budgeting, purchasing, and inventory planning.
5. Capacity planning.

LEARNING CURVES

The time to do the repetition N of a task is given by

$$T_N = KN^s, \text{ where}$$

K = constant

s = ln (learning rate, as a decimal)/ln 2; or, learning rate = 2^s

If N units are to be produced, the average time per unit is given by

$$T_{avg} = \frac{K}{N(1+s)}\left[(N+0.5)^{(1+s)} - 0.5^{(1+s)}\right]$$

Source: Fundamental Engineering – Industrial Specific

BoM

- A bill of materials (BOM) describes the components that are required in order to produce a product. The components can be raw materials, semi-finished products, or ingredients.

Product Life Cycle