TIME STUDY

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I. OVERVIEW

A. Definition:

Time study is a direct observation technique used to determine the time required for a qualified, well-trained person who is working at a normal pace to perform a defined task.

B. The end result of time study is the standard time (sometimes called the allowed time) to perform a job or task. A job (or task) usually consists of several steps, called work elements. In most cases, time study is performed at the elemental level.

For a specific work element, computation of a standard time involves three distinct steps:

1. Timing the element: Measuring the **Observed Time (OT)**

2. Performance Rating the element: Adjusting the observed time to correct for unusually slow or fast performance by the worker. The result of this adjustment is called the **Normal Time (NT)**:

   NT = OT x Performance Rating

3. Determining Allowances: Time study is usually performed over a relatively short duration and does not consider the fact that a worker will experience interruptions and other delays over the course of a workday and will require breaks for personal needs and recovery. Allowances are added to the Normal Time compute the **Standard Time** (ST):

   ST = NT + Allowances

C. Time study emphasizes observation and measurement. The two most common applications of time study are:

1. Establishing Work Standards

2. Methods Improvement: Using time study to identify the “best” work method prior to establishing a standard.

As a general rule, methods improvements are implemented and learned BEFORE any time study data are collected for the purpose of establishing work standards.

II. EQUIPMENT

A. Analog Stopwatches (rarely used today, but available in the laboratory for students who don't like using digital watches

1. Conventional time study watch: Time is measured in decimal minutes (0.01 minute)

   a. Standard watch gears
   b. Main hand moves relatively slowly. It is easy to learn how to read and record a time while the watch is running.

2. Decimal minute watch (0.001 minute units)

   a. Moves fast — 10X the speed of a normal "second" hand
   b. Good for short elements where precise measurements are needed
   c. Impossible to accurately read while running so the hand must be stopped in order to record an observation

3. Decimal hour (0.0001 hour units)

   a. Requires no conversions to compute expected hourly production from standard time (Production = 1/ST)
   b. Does not move at an easily-read speed — 1 sweep of hand equals 0.6 minute.

B. Digital stop watches (available in laboratory)

1. Can do everything an analog stopwatch can do, plus:

   a. Freeze "splits" — LCD display can be temporarily frozen while clock continues to run. This makes it easier to read and record time values. Some boards have two displays: one runs continuously (total elapsed time) while second can be frozen for a split time.
   b. Allow the analyst select time units — pick between decimal minutes or decimal hours.

   Note: The stopwatches used in the IOE 463 lab can be set to measure in seconds, decimal minutes, or decimal hours. It is important that you check the watch to assure that decimal minutes are selected. For recording purposes, you should only use two digits to the right of the decimal.

C. Event recorders ("Pocket" PCs and Palm® devices). See Fig. 9-5 on p. 382 of text.

1. A touch screen (or keys) on unit is programmed to represent specific work elements. An internal clock measures the interval between screen taps or keystrokes

2. Data are automatically entered into a spreadsheet format to automate the process of computing results (e.g., calculating means and standard deviations of each work element.)

D. "Passive" Event Recorders (automated performance measurement systems)

1. No visible watch, internal clock automatically records time of specific machine functions.

2. Information stored for real-time performance monitoring or subsequent analysis

3. Examples:

   a. Grocery scanners/cash registers: monitor time to scan groceries and handle customer payments
   b. Customer service: Directory assistance operators, airline reservationists, telemarketers, etc.: monitor time to pick up "ringing" phone, time to service customers. Can also be combined with sales data.
   c. Production tools in manufacturing facilities

4. Generally disliked by workers ("Big brother is always watching"). May become an issue in collective bargaining.

E. Video

1. Establishes permanent record of work activities. Selection of camera angle (position) can be challenging since you want to be angle to see the worker throughout the entire work cycle.

2. Videotape be digitized and played back frame-by-frame on a personal computer. Computer clock tracks time associated with each frame. Analyst can move the video forward and backward to select and mark specific frames (e.g., break points between work elements). Computer assigns time value to frame and computes results.

3. In addition to time study applications, videos can be used for group or individual training. In this application, video can be used to demonstrate specific skills and "tricks" used by experienced workers to perform the more difficult requirements of the job.

4. Historically, film and video have been opposed by organized labor; however this resistance has greatly decreased during the last decade due to implementation of participative management and the use of video for ergonomic improvements.

5. Note: If you are working as an "outsider", it is essential to obtain informed consent (signed permission) prior to taking any video. Otherwise, you may find yourself as a defendant in a lawsuit.

F. Data Collection Forms

1. Little standardization — Most organizations have custom designed forms.

2. Virtually all forms are structurally similar to a spreadsheet. Time study templates can be designed for personal computers using spreadsheet software (e.g., Excel®) to automatically compute statistics and prepare the time study report.

III. PREPARATION FOR TIME STUDY

A. Know the standard method.

1. Prior to taking any measurements, the analyst should be thoroughly acquainted with the standard method and assure that it is being used

   a. Check industrial engineering archives to see if prior standard method exists.

b. Compare current method to existing method and note changes (if any). To avoid future problems, it is important that methods improvements be documented and agreed upon prior to any timing.

c. Where possible, critique current method to develop an improved work method. If improvements can be made, they should be implemented and the operator should be given sufficient time to learn the new method prior to data collection for time study.

2. During the methods improvement phase the operator should be aware of what you are doing. Keep in mind that there is potential for disagreement. Methods improvement will result in a tighter time standard, possibly resulting in loss of income and/or jobs.

B. Inform all parties. If a collective bargaining agreement is in place, there may be rules that spell out who needs to be informed. Typically, the following individuals are informed.

1. Union steward – This individual is responsible for assuring that the standard is fair to workers. He/she will check to see that study is well-documented and includes a complete record of:

   a. Methods
   b. Workstation layout
   c. Environmental conditions
   d. Other issues than can affect time. It is the responsibility of the steward to assure that the standard is reasonable and fair from the standpoint of labor.

2. Supervisor – This individual is responsible for assuring that the standard is fair to both the company and to people he/she supervises.

   a. Formally notifies operator of your intent. It's a good idea for the supervisor to introduce you to the operator. It's not a bad idea for the steward to accompany you to the first meeting with the operator.
   b. Assures that all machines and tools conform to specifications and operate properly during the period of time study.
   c. Assures that the standard method is being used.
   d. The supervisor may share common interests with the workers in his/her area. Supervisors are frequently rewarded if their team exceeds production expectations. A loose standard makes it easier to exceed expectations.

3. Select and inform the operator

   a. Operator must be experienced with using standard method.

   b. Try to find a person who's perform score is somewhere between normal and slightly above average. Most important, however, the selected worker must be consistent. This will make the process of data collection and performance rating much easier.

      i. Avoid selecting a worker who is unusually productive. Performance rating is difficult at high deviations from normal, and it is difficult to achieve proper leveling for a superior operator.
      ii. Below-average workers are also very difficult to study. Poor performers may add unnecessary steps and may not be consistent. This adds to the workload of the time study analyst

and generally decreases the accuracy and precision of the normal time.

iii. The required sample size (number of work cycles timed) increases with cycle-to-cycle variance, so consistency is important.

IV. DATA COLLECTION

GUIDING PRINCIPLES: Data collection activities and documentation should be sufficiently complete to:

- Allow subsequent evaluation of work methods to determine if methods have changed.
- Allow re-creation or replication of the time study at a later date in the event that the standard is contested.

A. Document "Key Facts".

1. **Work Objectives**: Describe in a few words what the operator is expected to do.
2. **Workplace Layout**: A well-dimensioned plan view is essential. Elevation views should also be prepared if needed.
    a. Sketch the workplace showing the location of:
        i. Operator
        ii. Machines/furniture
        iii. Tools
        iv. Raw materials and finished parts
        v. Record critical dimensions such as walking distances, vertical reaches, horizontal reaches. These can be very important for ergonomic evaluations.

    b. Record location in facility
        i. Organizationally (Department, job title, operation, etc.)
        ii. Spatially (column number or bay number)
3. Describe all equipment used (machines, tools, fixtures, jigs, etc.)
    a. Manufacturer
    b. Model number
    c. Size or capacity
    d. Date of manufacture
    e. Serial number
    f. Other
4. Describe the part that is being produced, or the operational step if job is part of a large assembly process. Document part number for cross-reference (this should save you the time required to sketch the part and describe part specifications).
5. Describe materials processed or consumed.
6. Record operator name, badge number, and basic characteristics
    a. Height
    b. Hand dominance
    c. Experience on this job/operation

7. Record environmental conditions

    a. Temperature/humidity
    b. Noise
    c. Lighting
    d. Other

8. Describe any personal protective equipment required to perform the job.

9. Document date, time started, time ended.

10. Sign and print your name.

C. Divide job into elements.

1. If cycle time is short, observe several (5-10) cycles. As you do this, mentally break the job down into elements.

2. Elements should be logical and represent distinct work activities or work objectives, e.g.:

    - Walk to conveyor and grasp wheel
    - Carry wheel to conveyor and place on vehicle
    - Secure wheel with multi-spindle tool.

3. Elements should be discrete with easily recognizable beginning and end points (break points). Where possible use audible cues. This gives the analyst the option to quickly divert his/her visual attention from the job to the stopwatch or data recording sheet without missing a break point.

4. Elements should have duration of at least .05 minute (3 seconds). This is the minimal time required for an experienced analyst to read a running stopwatch and record the time on a data collection sheet.

5. Separate machine functions from operator functions. Note that machine functions cannot be performance rated. Furthermore, if machine actions can be made more efficient, it will not be necessary to re-study the job at a later date.

6. Keep in mind that there is no single "correct" breakdown of a job into work elements. The important thing is that the total cycle time must be accounted for in the elemental description.

D. Timing the operator

1. Snapback method **(Note: This method is rarely used anymore due to the capabilities of electronic stopwatches and event recorders)**:

    a. Start watch at breakpoint (beginning of element) and stop at next breakpoint, read, record and snap back.

    b. Advantages

        i. Less clerical time (no subtraction required to determine elemental elapsed times)

ii. Recording foreign elements, delays, etc. does not interfere with recording regular elements.
iii. Generally easier to record out-of-order elements.

c. Disadvantages

i. Elements are not independent — may lead to tight standards.
ii. If timing successive elements, time may be lost when snapping back.
iii. Analyst may be biased by previous cycles.
iv. Complete study is not recorded, therefore it is easy to overlook foreign elements and interruptions to production. Supervisors and workers do not like this because it may lead to an unreasonably tight standard.
v. No ability to show correlation between cumulative time of study and elapsed clock time. This may result in challenges if union believes that study failed to document activities that should be figured into allowances.

2. Continuous method. Watch runs continuously for duration of study.

a. Advantages

i. Results in complete record
ii. If done properly, all activities that occur over the duration of the study are documented and timed.

b. Disadvantages

i. Analyst must learn how to read a running watch. (Note: With an electronic watch user has the option to “freeze” a split.)
ii. More clerical time is required to compute elemental times from elapsed times. (Note: With spreadsheet software, repetitive calculations are done automatically.)
iii. Requires organization and concentration due to the need to read a running watch, observe the worker, and write observed times. This can be confusing and can result in a lot of "missed" elements, particularly for novice analysts.

3. Recording

a. Only two digits are written, the decimal point and elapsed minutes are generally not recorded

b. Special notations

i. Missed reading: Fault of time study analyst. Record an "M" in Running Time (R) cell of the time study form.

ii. Omitted element: Fault of operator. Record a dash "–" in R cell of the form.

iii. Out-of-order: Fault of process or operator. Divide "R" cell into two areas, one above the other. Record start time in lower half; end time in upper half. Repeat for each out-of-order element and then the first element in the correct sequence. <u>Note: This requires practice and is particularly difficult for novice analysts.</u>

iv. Foreign elements: Assign a letter code in "R" column, and record beginning and ending time in foreign element box. Write description of foreign element.

v. Short foreign element or "wild" element: Circle the reading and write a brief comment to the side.

vi See pages 386-394 in text for additional discussion of recording issues.

E. Sample size considerations

1. Time study statistics are based on the assumption that the population of elemental times over many work cycles is normally distributed: N (μ, σ^2).

2. If we sample a subset of work cycles and compute the average time $\bar{x}$, we can compute a confidence interval around $\bar{x}$:

   C.I. ($\bar{X}$) = $\bar{X} \pm t_{p,n-1}$ x S/sqrt(n)

   where:

   $\bar{\mathbf{X}}$ is the sample mean for observations 1, 2, 3, ... n,
   S is the sample standard deviation,
   $\mathbf{t_{p,n-1}}$ is the t statistic for (1-p) confidence with (n-1) degrees of freedom (for two-sided values of the t-distribution refer to Table A3-3 on page 696 of your text, and
   n is the number of observations in your sample.

3. Usually, the time study analyst needs to compute the required sample size N that assures the desired level of precision for a pre-determined level of statistical confidence:

   a. **Precision** is usually expressed as a percentage of the mean time

      Precision = k x $\bar{X} = t_{p,n-1}$ x S/sqrt(n)

      where k is a constant determined by the desired level of precision, e.g.

Precision	k
± 1 %	.01
± 5 %	.05
± 10 %	.10

   b. To determine N, use the equation:

      N = $[(t_{p,n-1} \times S)/(k \times \bar{X})]^2$

4. Example - Computation of 95 percent confidence interval about a mean elemental time:

$n = 15$
$t_{95,14} = 2.145$
$\bar{x} = 0.55$
$S = 0.12$

What is the 95% confidence interval?

$0.55 \pm (2.145)(.55/\sqrt{15}) = .55 \pm .07$

Range of confidence interval is between 0.48 and 0.62

5. Example: It is desired to compute the mean time of a element with ± 10 percent precision and 99% confidence. Initially, 5 observations were taken with the following results:

<u>Times</u>

.31
.34
.32
.36
.33

=>

$\bar{x} = 0.332$
$S = 0.019$
$t_{.99,\,4} = 4.604$

We use this information to make a preliminary estimate of the required sample size:

$$N = \left(\frac{4.604 \text{ X } .019}{.10 \text{ X } .332}\right)^2 = 6.9 \simeq 7$$

This result tells us that two more observations are needed. After these observations are taken we can re-compute N:

<u>Times</u>

.30
.31

=>

$\bar{x} = 0.324$
$s = 0.021$
$t_{.99,\,6} = 3.707$

$$N = \left(\frac{3.707 \text{ X } .021}{.10 \text{ x } .324}\right)^2 = 5.7 \simeq 6$$

Because we have already taken seven observations, we can terminate the study.

6. The above computation applies to each element. When many elements are involved the standard practice is to use the element with the highest COV ($S/\bar{x}$) for computing N.

F. Rating the Operator (For details, see notes on Performance Rating)

1. Short cycle work — Rate the entire study as a percentage of normal performance.

2. Long cycle/long element — Rate each element.

3. Normal time = Observed time (average) X Performance Rating.

G. Determine Allowances (For details, see notes on Allowances)

1. Operator cannot maintain observed normal performance for a full day. Delays and interruptions always occur and must be accounted for:

a. Personal: Bathroom, drink of water, etc.
b. Fatigue
c. Unavoidable: Machine down, bad stock, shortages in stock, etc.
d. Referred to as PF&D.

H. Calculate study

1. Required checks

a. Final watch reading should be close to elapsed clock reading (assuming continuous measurement method)
b. Sum of all elemental times, foreign elements, missed elements, abnormal elements, wild elements should equal final stopwatch reading (continuous measurement)

2. Deduct "included" foreign elements from elemental times.

3. Check for any abnormal or “wild” element times. Decide whether to eliminate or include.

4. Adjust element or cycle times with performance rating.

5. Apply allowances.

V. SOURCES OF ERROR

A. Representativeness: Are the conditions present at the time of the study typical of conditions that will be present when the standard is in effect (i.e. quality of parts, machine condition, workstation layout, raw material availability, etc.)?

B. Statistical: Most analysts won't compute N, precision and confidence can be compromised.

C. Equipment: Not usually a concern. But errors can happen with watches.

D. Performance Rating: Can be major source of error. Will be discussed later.