DIRECT TIME STUDY

Fall 2023

Direct Time Study Procedure

- ***Direct time study***, also known as ***stopwatch time study,*** involves the direct and continuous observation of a task using a stopwatch or other timekeeping device to record the time taken to accomplish a task. While observing and recording the time, an appraisal of the worker's performance level is made. These data are then used to compute a standard time for the task, adding an allowance for personal time, fatigue, and delays.
- The use of direct time study is most appropriate for tasks that involve a repetitive work cycle, at least a portion of which is manual. This kind of work is common in batch and mass manufacturing. Also, standards for routine office work can often be established using direct time study. Performing a direct time study is time-consuming and is therefore best justified when the job will have a relatively long production run, and/or there will be repeated orders in the future.
- A limitation of this work measurement technique is that it cannot be used to set a time standard prior to the start of production.

Direct Time Study Procedure

- The procedure for determining the standard time for a task using direct time study can be summarized in the following five steps:

1. **Define and document the standard method.**
2. **Divide the task into work elements.**
3. **Time the work elements to obtain the observed time for the task.**
4. **Evaluate the worker's pace relative to standard performance, a procedure called *performance rating*. This is used to determine the normal time. Steps 3 and 4 are accomplished simultaneously.**
5. **Apply an allowance to the normal time to compute the standard time.**

Direct Time Study Procedure

- Steps 1 and 2 are preliminary steps before actual timing begins, during which the analyst becomes familiar with the task and attempts to improve the work procedure before defining the standard method.
- In steps 3 and 4, several work cycles are timed, each one performance rated independently. Finally, the values collected in steps 3 and 4 are averaged to determine the normalized time.
- An appropriate allowance factor for the kind of work involved is then added to compute the standard time for the task. Let us examine each of the steps in more detail.

Define and Document the Standard Method

- Before defining and documenting the standard method, a methods engineering study should be undertaken to ensure that the standard method obeys the “one best method” principle—the best method that can be devised under the present economic and technological circumstances.
- All of the steps in the method should be defined. Any special tools, gauges, or equipment that can improve the task should be designed and included in the method.
- If there are irregular elements in the work cycle, the frequency with which these elements are to be performed should be stated explicitly.
- If the labor-management climate in the facility allows, the worker’s advice and opinion should be sought in developing the standard method. Once the standard method has been defined, it should be difficult or impossible for the operator to make further improvements.

Define and Document the Standard Method

- The standard method should be thoroughly documented. The company should have forms and/or checklists to make certain that all information about the method is included. An example of a methods description form is shown in Figure 1.
- The documentation should enumerate details about the procedure (hand and body motions), tools, equipment and the machine settings used for the equipment (e.g., feeds and speeds on machine tools), workplace layout, irregular work elements, working conditions, and setup.
- A videotape (or other video medium) of the standard method can also be made as part of the documentation. This is especially helpful for complex tasks in which details of the method are difficult to explain in writing.

Define and Document the Standard Method

Date	**Standard Method Description for Direct Time Study**	Page of

Operation	Dept.	Part No.
Machine	Analyst	

Methods Improvements (check if implemented)	Sketch of Workplace:

Work Element No. and Description with Machine Parameters for Machine Cycles	Freq.	Tools and Gauges

Additional Notes

Figure 1 Form for documenting the standard method.

Define and Document the Standard Method

- **There are several reasons why thorough documentation of the standard method is important:**
  - *Batch production. If the task is associated with batch production, then it is likely to be repeated at some time in the future. The time lapse may be significant between the previous batch and the next batch. A different worker may be assigned to perform the task on the next batch. The statement of the standard method provides the worker and the foreman with a complete description of the task and the procedure for doing it, as well as any tooling or equipment needed. This avoids "reinventing the wheel."*
  - *Methods improvement by the operator. At some future time, the operator may discover a way to improve the method. A question then arises: Should the methods improvement be incorporated into a new standard method (which would require a change in the standard time), or should the operator be allowed to benefit from the improvement without formally changing the standard method? The typical labor-management contract only allows for retiming the task if it can be demonstrated that a real change in the method has been made. If the operator has indeed made a methods improvement, this can be identified by comparing the method in use with the standard method description.*

Define and Document the Standard Method

- *Disputes about the method. If the operator complains that the standard for the task is too tight, or there is some other reason for a dispute about the standard method, documentation of the standard method can be used to settle the dispute. Perhaps the operator is using a less efficient method than the standard method, or a certain hand tool that should be used in the operation has been neglected. These problems can be addressed by reference to the standard method documentation.*
- *Data for standard data system. Time standards developed by direct time study are sometimes used in standard data systems. Good documentation of the standard method, especially regarding the work elements and associated normal times, is essential in developing the database for a standard data system.*

Divide the Task into Work Elements

- Any task can be divided into work elements. A ***work element*** is a series of motion activities that are logically grouped together because they have a unified purpose in the task. The description of the standard method can be organized into work elements suitable for use in direct time study.
- Indeed, the most natural way to describe the standard method is often as a list of work elements. Some practical guidelines for defining work elements in direct time study are presented in Table 1.
- An important reason for defining the work elements is that the worker may exhibit different performance levels on different elements.
- Accordingly, these performance levels are rated and recorded separately by the time study analyst.

Divide the Task into Work Elements

TABLE 1 Guidelines for Defining the Work Elements in Direct Time Study

Guideline	Explanation and Examples
Each work element should consist of a logical group of motion elements.	The work element should have a unified purpose, such as reaching for an object and moving it to a new location (e.g., reach, grasp, move, and place). There would be no purpose in separating the reach from the move motions since they both involve the same object.
Beginning point of one element should be end point of preceding element.	There should be no gap between one element and the next in the task sequence. Otherwise, the time of the gap is omitted from the recorded total time.
Each element should have a readily identifiable end point.	A readily identifiable end point can be easily detected during the study. It can often be anticipated to allow reading of the watch more conveniently. An audible sound, such as the actuation of a pneumatic device, provides a readily identifiable end point.
Work elements should not be too long.	If a work element is very long (i.e., several minutes), it should probably be divided into multiple elements that are timed separately. Machine semiautomatic cycle time is an exception. Some machine cycles can take several minutes and should be identified as one element.
Work elements should not be too short.	A practical lower limit in direct time study is around 3 sec. Below this, reading accuracy may suffer. If a video camera is used for timing purposes, shorter elements may be possible.
Irregular work elements should be identified and distinguished from regular elements.	Irregular elements are work elements that do not occur every cycle. The frequency with which they should be performed must be noted. The time(s) for the irregular element(s) are prorated across the regular work cycle when the standard time is computed.
Manual elements should be separated from machine elements.	Manual elements depend on the operator's performance (pace) and therefore vary over time. Machine elements are generally constant values that depend on machine settings. Once the settings are established, the actuation time shows no perceptible variation.
Internal elements should be separated from external elements.	Internal elements are performed by the operator during the machine cycle. In most cases, they do not affect the overall work cycle time. External elements are performed outside of the machine cycle. They contribute to the overall work cycle time.

Time the Work Elements

- Once the work elements have been defined, the analyst is ready to collect data. The time data are usually recorded on a time study form, similar to the one shown in Figure 2. Space is provided for a listing of the work elements, which can be referenced to the more complete standard method documentation.

- Each element should be timed over several cycles to obtain a reliable average, and the form is designed for recording multiple cycles of the task.

- For the convenience of the analyst, the time study form is usually held in a special clipboard that also holds the stopwatch used in the study.

Time the Work Elements

Date	**Direct Time Study Observation Form**		Page of
Operation	Dept.	Part No.	
Machine		Tooling	
Worker		Worker No.	
Analyst	Start Time	Finish Time	Elapsed Time

Work Elements, Machine Settings, and Observations				Cycle No. (regular elements)										
Element Number and Description	Feed	Speed		1	2	3	4	5	6	7	8	9	10	Avg T_n
1			T_{obs}											
			PR											
			T_n											
2			T_{obs}											
			PR											
			T_n											
3			T_{obs}											
			PR											
			T_n											
4			T_{obs}											
			PR											
			T_n											
5			T_{obs}											
			PR											
			T_n											
6			T_{obs}											
			PR											
			T_n											
7			T_{obs}											
			PR											
			T_n											
8			T_{obs}											
			PR											
			T_n											
Normal time = Sum of T_n (regular work elements)														

Irregular Element and Description	Freq	T_0	T_f	PR	T_n		**Calculation of Standard Time T_{std}**	
A							Sum of T_n (regular work elements)	
B							Sum of freq x T_n (irregular elements)	
C							Total T_n per cycle	
D							PFD allowance A_{pfd}	
E							Standard time $T_{std} = T_n(1 + A_{pfd})$	
Additional Notes								

Figure 2 Direct time study form.

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Time the Work Elements

- There are several pieces of equipment that can be used to record the times for the work cycles. The traditional instrument in direct time study is the stopwatch, which is usually calibrated in decimal minutes.
- There are two principal methods for using a stopwatch in direct time study: (1) snapback timing method and (2) continuous timing method. In the ***snapback timing method***, the watch is started at the beginning of every work element by snapping it back to zero at the end of the previous element. The reader must therefore note and record the final time for that element just as the watch is being zeroed.
- In the ***continuous timing method***, the watch is zeroed at the beginning of the first cycle and allowed to run continuously throughout the duration of the study. The analyst records the running time on the stopwatch at the end of each respective element. Some analysts prefer to adapt the continuous method by zeroing at the beginning of each work cycle, so that the starting time of any given work cycle is always zero. This facilitates cycle-to-cycle comparisons during the study.

Time the Work Elements

- There are two advantages to the snapback method: (1) the analyst can readily see how the element times vary from one cycle to the next, and (2) no subtraction is necessary, as in the continuous timing method, to obtain individual element times.
- The advantages of the continuous method include the following: (1) when the clock is continuously running, elements are not as easily omitted by mistake, (2) regular and irregular elements can be more readily distinguished, and (3) not as much manipulation of the stopwatch is required as in the snapback method.

Rate the Worker’s Performance

- While observing and recording the time data, the analyst must simultaneously observe the performance of the worker and rate this performance relative to the definition of standard performance used by the organization.
- Other terms for performance include pace, speed, effort, and tempo.
- Standard performance is given a rating of 100%. A performance rating greater than 100% means that the worker’s performance is better than standard (which results in a shorter observed work cycle time), and less than 100% means poorer performance than standard (and a longer observed time).

Rate the Worker’s Performance

- The observed time is subsequently multiplied by the performance rating to obtain the ***normal time*** (other names include ***normalized time*** and ***base time***) for the element or cycle. The calculation is summarized in the following equation:
  - $T_n = T_{obs}(PR)$
- Performance rating is the most difficult and controversial step in direct time study. The reason is that it requires the judgment of the analyst to assess the value of *PR*. The analyst’s judgment of standard performance may differ from that of the worker who is being observed.
- It is in the worker’s interest and advantage to be rated at a high performance level during the study, because that will mean that the normal time and ultimately the standard time for the task will be longer (resulting in a looser standard). Thus, it will be easier for the worker to achieve a higher efficiency level as the job continues. This is especially important to the worker if he or she is paid on a wage incentive plan.

Apply Allowance to Compute Standard Time

- To obtain the standard time for the task, a PFD allowance is added to the normal time, as calculated in the following equation:
  - $T_{std} = T_n(1 + A_{pfd})$

- This is often expressed as a percentage but used as a decimal fraction in our equation. The function of the allowance factor is to inflate the value of the standard time relative to the normal time in order to account for the various reasons why the operator loses time during the work shift.
- The allowance factor represents an average for the type of work, equipment, and conditions under which the operator works. Some days the worker may lose more time, other days less time, than what is provided by the allowance factor. In the long run it is intended to average out to a realistic value.

Apply Allowance to Compute Standard Time

- Example 1:

A direct time study was taken on a manual work cycle using the snapback timing method. The regular work cycle consisted of three elements, identified as *a*, *b*, and *c* in the following table. Element *d* is an irregular element performed every 5 cycles. Observed times and performance ratings of the elements are also given. Determine (a) the normal time and (b) the standard time for the work cycle, using an allowance factor of 15%.

Work Element	*a*	*b*	*c*	*d*
Observed time	0.56 min	0.25 min	0.50 min	1.10 min
Performance rating	100%	80%	110%	100%

Apply Allowance to Compute Standard Time

- Example 1: cont..

(a) The normal time for the cycle is obtained by multiplying the observed element times by their respective performance ratings and summing. In the case of element *d*, this normal time is prorated over 5 cycles.

$T_n = 0.56(1.00) + 0.25(0.80) + 0.50(1.10) + 1.10(1.00)/5 = 0.56 + 0.20 + 0.55 + 0.22 = 1.53$ min

(b) The standard time is computed by adding the allowance. $T_{std} = 1.53\ (1 + 0.15) = 1.76$ min.

Apply Allowance to Compute Standard Time

- If the task includes a machine cycle, then company policy may provide for a machine allowance factor to be included in the standard time computation. The standard time equation becomes
  - $T_{std} = T_{nw}(1+A_{pfd})+T_m(1+A_m)$

- If the work cycle includes internal elements, then it must be determined whether the sum of the worker internal elements or the machine cycle time is larger in order to determine the normal time and the standard time.
- Internal elements are performed by the operator during the machine cycle. Usually, it does not affect total cycle time

Apply Allowance to Compute Standard Time

- Example 2:

The snapback timing method was used in a direct time study of a task that includes a machine cycle. Elements *a*, *b*, *c*, and *d* are performed by the operator, and element *m* is a machine semi- automatic cycle. Element *b* is an internal element performed simultaneously with element *m*, and element *d* is an irregular element performed once every 15 cycles. Observed times and performance ratings are given in the table below. The PFD allowance factor is 15%, and the machine allowance is 20%. Determine (a) the normal time and (b) the standard time for the work cycle.

Worker element	*a*	*b*	*c*	*d*
Observed time, manual	0.22 min	0.65 min	0.47 min	0.75 min
Performance rating	100%	80%	100%	100%
Machine element		*m*		
Observed time, machine	(idle)	1.56 min	(idle)	(idle)

Apply Allowance to Compute Standard Time

- Example 2: cont..

(a) The normal time must take account of which element, *b* or *m*, has the larger value. Also, element *d* must be prorated across 15 cycles.

T_n = 0.22(1.00) + Max{0.65(0.80), 1.56} + 0.47(1.00) + 0.75(1.00)/15 = 0.22 + 1.56 + 0.47 + 0.05 = 2.30 min

(b) The same comparison between elements *b* and *m* must be made in computing the standard time.

T_{std} = (0.22 + 0.47 + 0.05)(1 + 0.15) + Max{0.52 (1 + 0.15), 1.56 (1 + 0.20)} = 0.85 + 1.87 = 2.72 min

NUMBER OF WORK CYCLES TO BE TIMED

- One of the practical issues in taking a time study is determining how many work cycles should be timed. The reason this issue arises is that there is statistical variation in the times of respective elements from one work cycle to the next.
- Direct time study involves a sampling procedure, and the objective is to determine a value for the population work element time as accurately as is possible and practical. As we increase the sample size, we expect the accuracy of the estimate to improve.
- On the other hand, increasing the sample size also increases the cost of taking the time study. It seems reasonable to try to find a balance between these competing factors.

NUMBER OF WORK CYCLES TO BE TIMED

- There is inherent variability in any human activity, and performing manual work is a human activity. Work element times vary from cycle to cycle because of the following reasons:
  - *Variations in hand and body motions*
  - *Variations in the placement and location of parts and tools used in the cycle*
  - *Variations in the quality of the starting work units(e.g., a plastic molded part with flash that must be trimmed)*
  - *Mistakes by operator (e.g., operator accidentally drops the work part)*
  - *Errors in timing the work elements by the analyst*
  - *Variations in worker pace*

NUMBER OF WORK CYCLES TO BE TIMED

- All of these variations are manifested in the work element times recorded for the cycle. Performance rating is supposed to compensate for the last item, variations in worker pace. However, because performance rating requires judgment by the analyst, that also introduces error and variation.
- For analysis purposes, we assume that the observed work element times are normally distributed about the true value of the work element time. For practical purposes, we identify the longest work element in the cycle, or the most critical element (the one in whose accuracy we are most interested), as the element to focus on.
- Let us call this element time T_e. Our objective is to be able to identify the true value of T_e within a certain confidence interval. For example, we might state that we want to be 95% confident that the true value of T_e lies within +/- 10% of the observed average value of the element time.

NUMBER OF WORK CYCLES TO BE TIMED

- Let us identify the average value simply as *x*. This is illustrated in Figure 3, which shows the distribution of observed time values taken during the time study.

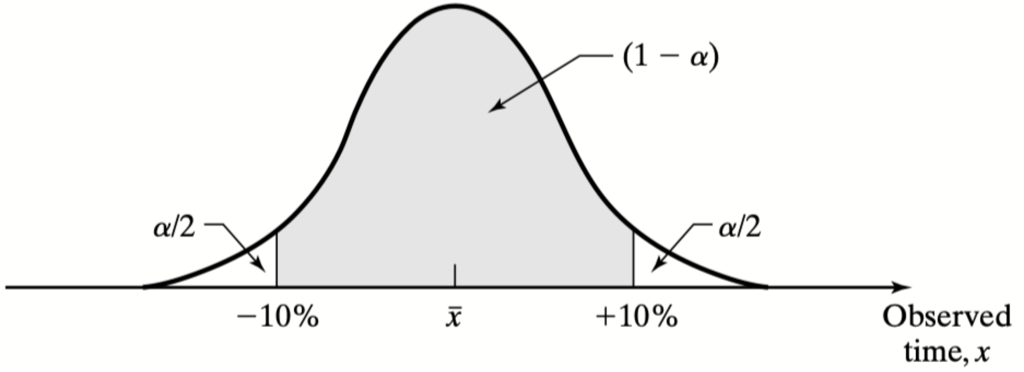

Figure 3 Distribution of observed element times in a direct time study.

TIME STUDY EQUIPMENT

- In direct time study, the analyst directly observes the task as a worker performs it. The equipment used by the analyst ranges from simple to sophisticated.

- We divide the range into three categories:

  (1) traditional time study using a stopwatch

  (2) video camera to record the observation on tape

  (3) computerized time study techniques

TIME STUDY EQUIPMENT

- **Stopwatch Time Study:** The traditional equipment used in direct time study consists of a stopwatch and a time study form on which to record the times during observation.
- There are alternatives to the stopwatch, such as a wristwatch or wall clock, but the proper professional instrument is a stopwatch.
- The time study form is usually held on a clipboard, which is designed to hold the stopwatch as well. Following the observation, the collected time data are analyzed, and a time standard is calculated for the task.

TIME STUDY EQUIPMENT

- ***Mechanical stopwatches*** have the familiar round face with one or more rotating hands, as shown in Figure 4. They are designed to be held in the time study clipboard or the palm of one's hand so the fingers can actuate the pin and slide at the top.
- Mechanical stopwatches are not a recent development. They have been used for time study since the late 1800s. Modern stopwatches for time study are typically graduated in one of three time measurement scales:
  - (1) decimal minutes, shown in Figure 4
  - (2) decimal hours
  - (3) TMUs (Time Measurement Units); 1 TMU ☐ 0.00001 hr or 0.036 sec)

TIME STUDY EQUIPMENT

- The reason for having different scales is that different organizations have adopted different units to express their time standards. Decimal minute watches seem to be the most common, decimal hours less common, and TMUs are sometimes used because they are usually the time units in certain predetermined motion time systems.

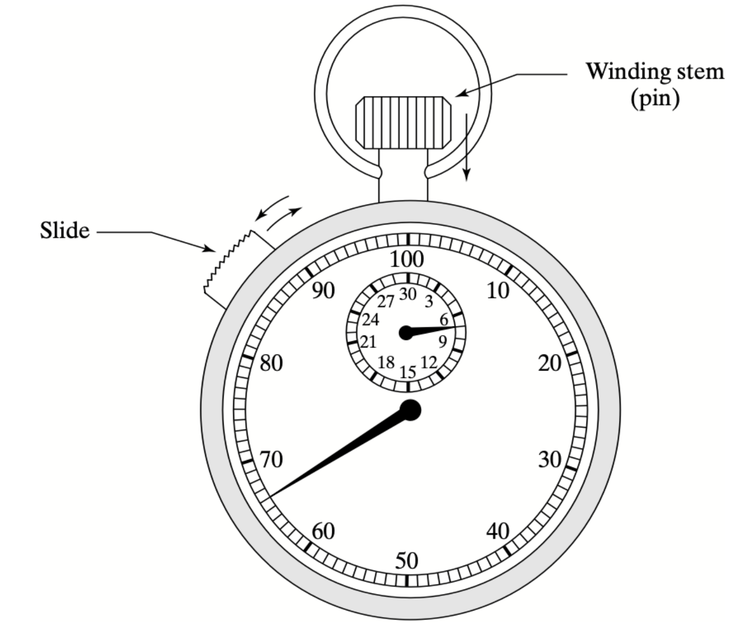

Figure 4 Mechanical stopwatch calibrated in decimal minutes (0.01 min) on the large dial. The small dial reads up to 30 minutes. Depressing the pin (also used as the winding stem) zeros the watch. The slide is used to start and stop the timing of individual work elements.

TIME STUDY EQUIPMENT

- ***Electronic stopwatches*** (Figure 5) provide a digital display of the time. They have largely replaced mechanical stopwatches in time study for several compelling reasons:

    1. They display a digital readout, they are easier to read than the graduated mechanical dial, especially if the mechanical hand is moving.

    2. They are easier to read, reading errors occur less frequently.

    3. They are lighter in weight and generally less susceptible to damage when dropped or otherwise abused.

    4. Electronic watches are also more accurate and precise, which allows them to be used to read shorter work elements more conveniently.

TIME STUDY EQUIPMENT

- 5. Some electronic watches can be switched back and forth between different time scales.
- 6. They can be used for either the continuous timing mode or the snapback mode.
- 7. Electronic stopwatches are less expensive than mechanical stopwatches.

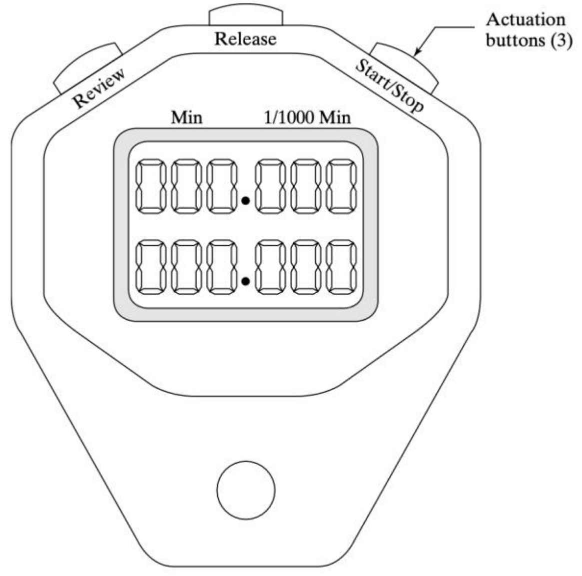

Figure 5 Electronic stopwatch with LED read-out, that can be used for continuous or snapback timing methods.

TIME STUDY EQUIPMENT

- Video cameras have become a familiar piece of electronic equipment not only to consumers but to time study analysts as well. They are useful in direct time study because they provide a complete visual and audio record of the method used by the worker.
- The method is captured in much greater detail than the analyst can observe with the naked eye or is willing to include in any written documentation of the method.
- *The tape also provides an accurate record of the times taken by each work element (accurate to 1/30 sec based on a frame-to-frame frequency of 30 Hz in the United States, or 1/25 sec based on 25 Hz in Europe).*

TIME STUDY EQUIPMENT

- The tape can be subsequently played and replayed (in slow motion if desired) to analyze the method, perhaps uncovering possible improvements in the task.
- Work element times can be analyzed for cycle-to-cycle variations.
- Operator performance can be rated in a much more relaxed and objective setting than what is possible in the shop floor environment. And finally, a standard time can be determined for the task from the tape.

TIME STUDY EQUIPMENT

- Later, if a dispute arises about the standard time, the method, or the performance rating, the tape can be viewed to help settle the dispute, perhaps avoiding a formal grievance.
- If the operator wants to watch his own work performance, perhaps to decide whether he agrees with the rating, this can be accommodated.
- The tape can be used for training purposes for new time study analysts.
- The videotape provides an objective and accurate record of the worker performing the task using the method for which the time standard was determined.

TIME STUDY EQUIPMENT

- Video cameras can be used for a variety of work situations in motion and time study: short repetitive work cycles, long cycles with variable elements, worker-machine systems, crews of workers, and several workers working independently but captured in the field of vision of the camera.