Chapter 10

Direct Time Study Dynamic Example

10 Introduction

Recording a video of a given repetitive task being performed is recommended to allow for a more thorough breakdown of the process into distinct, but separate, work elements. This also improves the accuracy of timed values for each work element versus direct observation without a video. Movements happen so quickly, and sometimes movements are combined, and there is a greater likelihood of observing these anomalies in a recorded video, where the video can be advanced or reversed, as necessary, to observe all the nuances of a given task or process. Additionally, a timeline is typically shown with a recorded video, albeit in whole minutes and seconds rather than in decimal seconds. If trying to conduct a time study without a video, it is likely that method variations or starting/stopping times for each work element will be missed or inconsistent and, therefore, diminishes the accuracy of the timed values and, ultimately, the standard time. Example 10.1 shows a complete Time Study Record.

Example A
Time Study Record
Ink, Inc.

1 to 10 = Each Individual Time	14 = Rating Factor (90% = 0.90, 100% = 1.00, 110% = 1.10)
11 = Total of all Times	15 = Base Time (13 multiplied by 14)
12 = Number of Time Values	16 = Frequency (1 = every cycle, 1/10 = once per 10 cycles)
13 = Average (11 divided by 12)	17 = Normal Time (15 multiplied by 16)

Element Description	1 Time	2 Time	3 Time	4 Time	5 Time	6 Time	7 Time	8 Time	9 Time	10 Time	11 Total	12 No.	13 Avg.	14 Rate	15 Base	16 Freq.	17 Norm.
Put Marker into a Retail Box.	6.90	9.85 T	6.75	7.04	7.32	6.04 D	6.81				34.82	5	6.964	.95	6.616	1	6.62
Put Retail Box of 4 Markers into a Master Box.	5.52	6.38									11.90	2	5.950	1.15	6.843	1/4	1.71
Push Master Box of 10 Retail Boxes onto Conveyor.	14.40										14.40	1	14.400	1.00	14.400	1/40	0.36
T = Tighten =	(9.85	-6.964)	=								2.886	1	2.886	.95	2.742	1/7	0.39
D = Discard =											6.04	1	6.040	.95	5.738	1/7	0.82

Operation: Box Markers Operator: Equipment: Manual Operation Date: Elapsed Time: 77.01 Seconds	Foreign Element Letter Codes and Explanations: 4 Markers per Retail Display Box. 10 Retail Boxes (or 40 Markers) per Shipping Carton. T = Tighten Cap and Put Marker in Box. D = Discard Defective Marker into Trash Can.	Total Normal Time = 9.90 12 % P, F, and D = 1.19 Total Standard Time = 11.09 Standard Time per: **Marker**

All time values are in seconds.

Figure 10.1. Example of a Time Study Record

10.1 Determining Standard Time and Standard Output

10.1.1 Standard Quantity

Standard Quantity is the predetermined quantity of materials, components, or products that should be used or produced in a specific period under normal operating conditions. It is established based on historical data, engineering studies, and production standards to ensure efficiency and cost control. Eq. 1 shows the formula for standard quantity.

$$Q_{std} = \frac{Clock\ time\ of\ the\ shift}{T_{std}} \tag{10.1}$$

Example 1. Standard Time and Standard Quantity

The normal time to perform the regular work cycle for a certain manual operation is 5.25 min. In addition, an irregular work element whose normal time is 1.50 min must be performed every 8 cycles. The PFD allowance factor is 15%. Determine (a) the standard time and (b) the quantity of work units produced if the worker's performance in an 8-hour shift is standard.

Solution:

(a) $T_n = 5.25\ min + \frac{1.50\ min}{8\ cycles} = 5.4375\ min/pc$

The standard time is:

$$T_{std} = T_n\left(1 + A_{pfd}\right) = 5.4375\ min(1 + 0.15) = 6.25\ min/pc$$

(b) The quantity of work units produced at standard performance in an 8-hour shift is the clock time of the shift divided by the standard time:

$$Q_{std} = \frac{8.0\ hr\left(\frac{60\ min}{1\ hr}\right)}{6.25\ min/pc} = 76.8, or\ 77\ pcs$$

10.1.2 Time Lost due to an Allowance Factor

The time lost due to an allowance factor can be calculated as the number of hours on the shift minus the actual time worked as in the following example.

Example 2. Time Lost due to an Allowance Factor

Determine the anticipated amount of time lost per 8-hour shift when an allowance factor of 12% is used, as in the previous example.

Solution: Given that $A_{pfd} = 0.12$, the anticipated amount of time lost per 8-hour shift is:

$$8.0\ hr = (actual\ time\ worked)(1 + 0.12)$$

$$Actual\ time\ worked = \frac{8.0\ hr}{1.12} = 7.143\ hr$$

$$Time\ lost = 8.0\ hr - 7.143\ hr = 0.857\ hr\left(\frac{60\ min}{hr}\right) = 51.42\ min$$

Example 3. Production Rate when Worker Performance Exceeds 100%

Now that the standard time (Tstd = 6.25 min/pc) has been determined from Example 1, and given the data from the previous examples, how many work units would be produced if the worker's average performance during an 8-hour shift were 120% and the hours actually worked were exactly 7.143 hours, which corresponds to the 12% allowance factor.

Solution: Based on the normal time Tn = 5.4375 min/pc, the actual cycle time with a worker performance of 120% is

$$T_c = \frac{T_n}{P_w} = \frac{5.4375\ min}{1.20} = 4.53\ min$$

Assuming one work unit is produced each cycle, the corresponding daily production rate, Rp, is

$$R_p = \frac{(Actual\ time\ worked)}{T_c} = \frac{7.143\ hr}{4.53\ min}\left(\frac{60\ min}{hr}\right) = 94.61, rounded\ to\ 95\ work\ units$$

10.1.3 Standard Hours

Standard Hours refer to the amount of work that is accomplished by the worker during a given period (i.e., 8-hr shift, week), expressed in terms of the number of standard hours of work that is performed in the given period. Standard hours is equivalent to the quantity of work produced during the period multiplied by the standard time per work unit, given by Eq. 2.

$$H_{std} = QT_{std} \tag{10.2}$$

Worker Efficiency refers to the amount of work produced during the shift expressed as a proportion of the number of hours on the shift, given by Eq. 3.

$$E_w = \frac{H_{std}}{H_{sh}} \tag{10.3}$$

Example 4. Standard Hours and Worker Efficiency

For the worker performance of 120% in the previous example, (Tstd = 6.25 min/pc), determine (a) number of standard hours produced and (b) worker efficiency.

Solution: Here, $Q = R_p$, the daily production rate.

(a) $H_{std} = QT_{std} = 95\ units \left(\frac{6.25\ min}{unit}\right)\left(\frac{hr}{60\ min}\right) = 9.9\ hr$

This means that the equivalent of 9.9 hours of work are performed in 8 hours.

(b) $E_w = \frac{H_{std}}{H_{sh}} = \frac{9.9\ hr}{8.0\ hr} = 1.2375 \times 100 = 123.75\%$

This means that this worker's pace is 23.75% faster than the normal pace.

10.2 Snapback Timing Method

The snapback timing method is a technique used in direct time studies where the stopwatch is reset to zero at the start of each work element. This method allows the observer to record the time taken for each individual element separately.

Example 5. Snapback Timing Method

Consider an assembly operation consisting of three elements:

1. Pick up part (Element 1)
2. Place part on assembly line (Element 2)
3. Return to start position (Element 3)

During a snapback timing study, the observer will:

- Start the stopwatch and record the time taken for Element 1, then reset the stopwatch.
- Start the stopwatch again for Element 2, record the time, and reset the stopwatch.
- Repeat the process for Element 3.

If the recorded times for each element are 2 seconds, 3 seconds, and 2 seconds respectively, the observer will have individual times for each element rather than cumulative times.

Example 6. Snapback Timing Method

The snapback timing method was used to obtain the average times and performance ratings for work elements in a manual repetitive task. See table below. All elements are worker-controlled. All elements were performance rated at 95%. Element e is an irregular element performed every three cycles. A 12% allowance for personal time, fatigue, and delays is applied to the cycle. Determine (a) the normal time and (b) the standard time for this cycle. If the worker's performance during actual production is 110% on all manual elements for seven actual hours worked on an eight-hour shift, (c) how many units will be produced and (d) what is the worker's efficiency?

Work element	a	b	c	d	e
Observed time (min)	0.30	0.82	0.45	0.51	1.25

Let T_n = normal time for work cycle, min
$T_e(i)$= observed time for ith work element, min
T_{std} = standard time per part, min
T_c = cycle time per part, min
H_w = actual hours worked, hr
H_{sh} = shift hours worked, hr

H_{std} = standard hours worked, hr
P_w = worker's pace, %
E_w = worker efficiency, %

Solution:

(a) Normal time: (all elements are worker-controlled)

$$T_n = T_e(a) + T_e(b) + T_e(c) + T_e(d) + \left(\frac{T_e(e)}{\#cycles}\right)(PR)$$

$$= \left(0.30 + 0.82 + 0.45 + 0.51 + \left(\frac{1.25}{3}\right)\right)(0.95)$$

$$= 2.50(0.95)$$

$$= 2.375\,min$$

(b) $T_{std} = T_n(1 + A_{pfd}) = 2.375\,min(\,1 + 0.12) = 2.66\,min$

(c) Given P_w = 110% for 7.0 hr on an 8-hour shift

$$T_c = \frac{T_n}{P_w} = \frac{2.375\,min}{1.10} = 2.159\,min/unit$$

$$Q = \frac{H_w}{T_c} = \frac{7\,hr}{2.159\,min} = \frac{7\,hr}{2.159\,min} \times \frac{60\,min}{hr} = 194.53, rounded\ up\ to\ 195\ units$$

(d) Standard hours and Worker efficiency:

$$H_{std} = QT_{std} = (195pc)\left(\frac{2.66\,min}{pc}\right)\left(\frac{1\,hr}{60\,min}\right) = 8.645\ std\ hr, or\ 8\ hr\ 38.7\ min$$

$$E_w = \frac{H_{std}}{H_{sh}} = \frac{8.645\,hr}{8hr} = 1.080 \times 100 = 108\%$$

Comment: The values of worker performance P_w and worker efficiency E_w are so close because the 7.0-hour actual work time is consistent with the PFD allowance factor of 12%.

Proof: 0.12 x 8 hrs = 0.96 hrs, which is close to 1 hr lost for the PFD allowance.

10.3 Continuous Timing Method

The continuous timing method involves running the stopwatch without resetting it. The observer records the cumulative time at the end of each work element. The time for each element is then calculated by subtracting the previous recorded time from the current recorded time.

Example 7. Continuous Timing Method

Using the same assembly operation:

1. Pick up part (Element 1)
2. Place part on assembly line (Element 2)
3. Return to start position (Element 3)

During a continuous timing study, the observer will:

- Start the stopwatch and record the cumulative time at the end of Element 1.
- Without resetting the stopwatch, record the cumulative time at the end of Element 2.
- Record the cumulative time again at the end of Element 3.

If the cumulative times are 2 seconds, 5 seconds, and 7 seconds respectively, the time for each element will be calculated as follows:

- Time for Element 1: 2 seconds
- Time for Element 2: 5 seconds - 2 seconds = 3 seconds
- Time for Element 3: 7 seconds - 5 seconds = 2 seconds

Example 8. Continuous Timing Method

A worker-machine cycle is direct time studied using the continuous timing method. One part is produced each cycle. The cycle consists of five elements: a, b, c, d, and e. Elements a, c, d, and e are manual elements, external to machine element b. Every 10 cycles the worker must replace the parts container, which was observed to take 2.5 min during the time study. All worker elements were performance rated at 90%. The PFD allowance is 15%, and the machine allowance = 10%. Determine (a) the normalized time for the cycle, (b) the standard time per part. (c) If the worker completes 200 parts in an 8-hour shift during which he works 7 hours and 30 min, what is the worker's efficiency?

Element	Description	Cumulative observed time (min)
a	Worker loads machine and starts automatic cycle.	0.20
b	Machine automatic cycle	1.35
c	Worker unloads machine.	1.85
d	Worker deburrs part to size.	2.20
e	Worker deposits part in container.	2.30

Let T_n = normal time for work cycle, min
T_{nw} = normal time for worker, min
T_{nm} = normal time for machine, min
$T_e(i)$= observed time for ith work element, min
T_{std} = standard time per part, min
T_c = cycle time per part, min
A_{pfd} = Allowance for P,F,D, %
A_m = Allowance for machine, %
H_w = actual hours worked, hr
H_{sh} = shift hours worked, hr
H_{std} = standard hours worked, hr
PR = performance rating, %
Q = quantity, pcs
P_w = worker performance, %
E_w = worker efficiency, %

Solution:

(a) Observed times must be determined for each element: T_e(a) = 0.20 min, T_e(b) = T_{nm} = 1.35 min – 0.20 min = 1.15 min, T_e(c) = 1.85 min – 1.35 min = 0.50 min, T_e(d) = 2.20 min – 1.85 min = 0.35 min, and T_e(e) = 2.30 min – 2.20 min = 0.10 min

For elements a, c, d, and e, (worker-controlled)
Normal time for the worker:

$$T_{nw} = (T_e(a) + T_e(c) + T_e(d) + T_e(e) + T_{irr})(PR)$$

$$= \left(0.20 + 0.50 + 0.35 + \frac{2.5}{10}\right)(0.90)$$

$$= (1.30)(0.90)$$

$$= 1.17\ min/pc$$

Normal time for the cycle: (element b is machine-controlled)

$$T_{nc} = T_{nw} + T_{nm} = 1.17\,min + 1.15\,min = 2.32\,min$$

(b) Standard time:

$$T_{std} = T_{n_w}(1 + A_{pfd}) + T_{nm}(1 + A_m) = 1.02\,min(\,1 + 0.16) + 1.25\,min(\,1 + 0.20)$$

$$= 1.17\,\mathrm{min}(1 + 0.15) + 1.15\,\mathrm{min}(1 + 0.10)$$

$$= 1.3455\,min + 1.265\,min$$

$$= 2.61\,min$$

(c) Standard hours and Worker efficiency:

$$H_{std} = QT_{std} = (200\,pc) \times \left(\frac{2.61\,min}{pc}\right) = 522\,min \times \left(\frac{1\,hr}{60\,min}\right) = 8.7\,hr$$

$$E_w = \frac{H_{std}}{H_w} = \frac{8.7\ hr}{7\ hr\ 30\ min} = \frac{8.7\ hr \times \frac{60\ min}{1\ hr}}{(420+30)min} = \frac{522\ min}{450\ min} = 1.16\ \times 100 = 116\%$$

10.4 Dynamic Example of a Time Study

A class exercise may consist of a recorded video of an industrial process or an innovative activity that can be recorded and time-studied during class. An alternative is to ask an AI Large Language Model (LLM) (i.e., ChatGPT) to create a time study example that can be conducted in class. Watch the video once to get a feel for what the task involves and try to mentally envision the various distinct work elements with the same starting and stopping points for each cycle. You may want to have a class discussion and write down your observations. Then watch the video again. It is very likely that you will observe things the second time that you did not readily observe the first time. You may want to write down your new observations. Advance and reverse the video, as necessary. Then watch the video a third or fourth time, and so on, until you feel you have grasped all the nuances of the task, including defining distinct work elements (with no overlap), the same starting and stopping points for each work element, and any abnormalities, such as irregular or foreign elements, work elements performed in different sequences (i.e., methods variation) from one cycle to another, separate steps vs. combined steps, changes in worker pace, etc. Examples of class examples include folding paper airplanes, origami, or any assembly process (i.e., ballpoint pens).

10.5 Complete the Time Study

Completion of the Time Study Record requires the following steps:

1. Define each distinct work element in sequential order. Identify any irregular or foreign elements either by circling or highlighting the observed time and assigning a code letter. Define specific starting and stopping points for each work element. Watch the video as often as necessary, advancing or reversing the video as necessary, and record the observed time for each work element for each cycle.
2. Irregular and foreign elements should be shown at the bottom of the Element Description column. Their respective times are used in calculations here, not in the work element from which it was observed (i.e., do not double-count irregular or foreign element time values).
3. Assign performance ratings. Typically, a performance rating is assigned for each work element, but other options include assigning one performance rating for the entire task or assigning performance ratings for each observed time for each cycle.

4. Perform calculations for all columns for each work element, irregular element, and foreign element.
5. Complete the bottom middle box. Be sure to show all code letters accompanied by brief descriptions. Also, include a statement regarding the unit of measurement of time values.
6. Complete the bottom right box. Sum the normal times for all work elements, irregular elements, and foreign elements. Declare an allowance factor for P, F, and D and compute the allowed time for P, F, and D. Then find the standard time by summing the total normal time plus the allowed time for P, F, and D. Be sure to include the unit of measurement for this time study in this box (i.e., Standard Time per Marker).
7. Complete the information required in the bottom left box. Be sure to include the Elapsed Time along with its unit of measurement (i.e., 370.10 seconds).
8. Double-check your work. Assure that the time study worksheet is aesthetically appealing. That is, all numbers should be in alignment and to the same number of decimal places in each column. Check for and correct any spelling, calculation, alignment, etc. errors. Your completed time study worksheet should be clear for anyone else (i.e., supervisor, co-worker, auditor) to read and interpret. In other words, it should be a professional-looking document that is suitable for a Standard Operating Procedure (SOP) manual.

10.6 Summary

Dynamic direct time studies and their associated metrics play a crucial role in establishing accurate and fair time standards. Metrics such as cycle time, normal time, standard time, PFD allowances, standard quantity, standard hours, production rate, and worker efficiency provide a comprehensive framework for measuring and managing productivity. The choice between snapback and continuous timing methods depends on the nature of the task and the specific requirements of the time study. Each method has its advantages and appropriate applications, ensuring that time studies can be tailored to various production environments and task complexities.

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References

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