Chapter 11

Predetermined Motion Time System (PMTS)

11 Introduction

Predetermined Motion Time Systems (PMTS) are methods used to set labor standards in a consistent and accurate manner. Work tasks are analyzed by breaking them down into basic motions or work elements. The PMTS systems consist of a database of basic motion elements and their associated normal time values, which are then used to establish standard times. This allows for precise measurement and standardization of work without the need for time-consuming direct time studies. Basic motions include:

- Reach
- Grasp
- Move
- Release

11.1 PMTS Procedure

The PMTS procedure typically follows four steps, as follows:

Step 1: Synthesize the method, in terms of basic motion elements, that would be used to perform the task.

Step 2: Obtain individual normal time values from the PMTS tables for each motion element based on the work variables and conditions under which the element is performed, and then sum the work element normal times to determine the normal time for the task.

Step 3: Evaluate the method for possible improvements by eliminating motions, reducing distances, and so on.

Step 4: Apply allowance to the total normal time to determine the standard time for the task.

Although several PMTS families exist in the world today, two primary PMTS families are discussed in this chapter: (1) MTM and (2) MOST.

11.2 Methods-Time Measurement (MTM)

MTM is one of the most well-known PMTS, developed by the Methods Engineering Council in the United States. The MTM family consists of several systems, each suited for different types of work environments and complexities. The development and

introduction of MTM systems include:

1. MTM-1 (1948): The original and most detailed system, suitable for tasks that are
2. highly repetitive and involve short cycles. It breaks tasks down into basic motions such as reach, move, turn, grasp, position, and release.
3. MTM-2 (1965): A less detailed system compared to MTM-1, designed for less repetitive tasks with longer cycle times. It consolidates some of the basic motions into larger motion groups to simplify the process.
4. MTM-3 (1970): An even simpler and faster system than MTM-2, used for tasks with longer cycle times and less precision required in the standard times. It uses broader categories of motions and is easier to apply.
5. MTM-V (Variable) (1975): Developed for variable work environments where tasks change frequently. It is less precise but more flexible.
6. MTM-SAM (Standard Data) (1980): Used for standard repetitive tasks and provides standard data that can be quickly applied to similar tasks.

Examples of MTM:

- MTM-1: Detailed analysis of an assembly line worker placing parts on a conveyor belt.
- MTM-2: Time measurement for a worker performing machine operations with some manual handling.
- MTM-3: Estimating time for administrative tasks involving document handling and filing.

11.2.1 Differences Between First-Level PMTS and Higher-Level PMTS

First-level PMTS use basic motion elements, such as reach, grasp, release, while higher-level PMTS combine several basic motion elements into motion sequences. First-level PMTS are very detailed, with body motions and conditions specified in their databases. Higher-level PMTS used condensed databases, with fewer body motions specified in the tables and, consequently, longer normal time values for each motion sequence.

11.2.2 Motion Aggregates

A motion aggregate combines several basic motion elements that are performed together in a motion sequence. An example is “lay an object down,” which consists of the basic motions reach and release.

11.2.3 Time Units in Methods-Time Measurement

The normal time values in the MTM tables are in TMUs (or time measurement units). One TMU = 0.00001 hr = 0.036 sec, as follows.

$$1\ TMU = 0.00001\ hr = 0.0006\ min = 0.036\ sec \tag{11.1}$$

Conversely,

$$1\ sec = 27.8\ TMU \tag{11.2}$$

11.2.4 Advantages of Higher-Level PMTS

Advantages of higher-level PMTS over lower-level PMTS include:

1. Faster application speed (i.e., ratio of the time required to determine a time standard relative to the time standard itself). For example, an application speed ratio of 50 means it takes 50 minutes of a time analyst's time to determine a 1-minute time standard. There is an inverse relationship between application speed ratio and the accuracy of the time standard. The level of detail required to compute normal times in TMUs for MTM-1, for example, relates to a slow application speed ratio, but the normal times are more accurate than for higher-level MTMs with motion aggregates.
2. Can be used for longer feasible cycle times, and, as a result,
3. Are easier to apply.

11.2.5 MTM Procedure

MTM is a procedure that analyzes any manual operation or method into the basic motions required to perform it, represented by an MTM symbol, and assigns a predetermined TMU time standard from basic motion element tables to each task. Table values are determined by the nature of the motion and the conditions under which the motions are made. The total TMU time can then be converted to seconds by multiplying the total TMUs by 0.036 sec/TMU. Note that the MTM table values are "normalized" time values. Hence, there is no need to assign performance ratings to an MTM symbol. The MTM-1 tables (1a-1k)[1] follow.

Table 11.1(a). Normal Time Values for **MTM-1** Motion Element: **Reach** (R)

Distance		Time in TMU						Case and Description
						Hand in Motion		
cm	inches	A	B	C or D	E	A	B	
<2.0	< 0.75	2.0	2.0	2.0	2.0	1.6	1.6	**A** Reach to object in fixed location, or to object in other hand or on which other hand rests.
2.5	1	2.5	2.5	3.6	2.4	2.3	2.3	
5.1	2	4.0	4.0	5.9	3.8	3.5	2.7	
7.6	3	5.3	5.3	7.3	5.3	4.5	3.6	
10.1	4	6.1	6.4	8.4	6.8	4.9	4.3	**B** Reach to single object in location that may vary slightly from cycle to cycle.
12.5	5	6.5	7.8	9.4	7.4	5.3	5.0	
15.2	6	7.0	8.6	10.1	8.0	5.7	5.7	
17.8	7	7.4	9.3	10.8	8.7	6.1	6.5	
20.3	8	7.9	10.1	11.5	9.3	6.5	7.2	**C** Reach to object jumbled with other objects in a group so that search and select occur.
22.9	9	8.3	10.8	12.2	9.9	6.9	7.9	
25.4	10	8.7	11.5	12.9	10.5	7.3	8.6	
30.5	12	9.6	12.9	14.2	11.8	8.1	10.1	
35.6	14	10.5	14.4	15.6	13.0	8.9	11.5	
40.6	16	11.4	15.8	17.0	14.2	9.7	12.9	**D** Reach to a very small object or where accurate grasp is required.
45.7	18	12.3	17.2	18.4	15.5	10.5	14.4	
50.8	20	13.1	18.6	19.8	16.7	11.3	15.8	

55.9 61.0 66.0 71.1 76.2	22 24 26 28 30	14.0 14.9 15.8 16.7 17.5	20.1 21.5 22.9 24.4 25.8	21.2 22.5 23.9 25.3 26.7	18.0 19.2 20.4 21.7 22.9	12.1 12.9 13.7 14.5 15.3	17.3 18.8 20.2 21.7 23.2	**E** Reach to indefinite location to get hand in position for body balance or next motion or out the way.
Additional		0.4	0.7	0.7	0.6	TMU per 2.54 cm> 76 cm (per 1.0 in> 30 in.)		

Table 11.1(b). Normal Time Values for **MTM-1** Motion Element: **Grasp** (G)

Type of Grasp	Case	Time, TMU	Description and Object Dimensions	
Pickup	lA	2.0	Any size object, by itself	
	IB	3.5	Object very small or lying close against a flat surface	
	lCl	7.3	Interference with grasp on bottom and one side of cylindrical object	Diameter> 1.3 cm (0.5 in.)
	1C2	8.7		Diameter 0.6 to 1.3 cm (0.25 to 0.5 in.)
	1C3	10.8		Diameter< 0.6 cm (0.25 in.)
Regrasp	2	5.6	Change grasp without relinquishing control	
Transfer	3	5.6	Control transferred from one hand to other	
Select	4A	7.3	Object jumbled with	Size larger than 2.5 x 2.5 x 2.5 cm

	4B 4C	9.1 12.9	other objects so that search and select occur	(1 x 1 x 1 in.) 0.6 x .6 x .3 cm (.25 x .25 x .12 in) to 2.5 x 2.5 x 2.5 cm (1 x 1 x 1 in.) Size smaller than .6 x .6 x .3 cm (.25 x .25 x .12 in.)
Contact	5	0	Contact, sliding, or hook grasp	

Table 11.1(c). Normal Time Values for **MTM-1** Motion Element: **Move** (M)

Distance		Time in TMU							
					Hand in motion	Weight up to	Formula Parameters		Case and Description
cm	inches	A	B	C	B	kg (lb)	Constant	Factor	
<2.0	< 0.75	2.0	2.0	2.0	1.7	1.1 (2.5)	0	1.00	A Move object to other hand or against stop.
2.5	1	2.5	2.9	3.4	2.3				
5.1	2	3.6	4.6	5.2	2.9				
7.6	3	4.9	5.7	6.7	3.6	3.4 (7.5)	2.2	1.06	
10.1	4	6.1	6.9	8.0	4.3				
12.5	5	7.3	8.0	9.2	5.0	5.7 (12.5)	3.9	1.11	**B** Move object to approximate or indefinite location.
17.8	7	8.9	9.7	11.1	6.5	7.9 (17.5)	5.6	1.17	
20.3	8	9.7	10.6	11.8	7.2				
22.9	9	10.5	11.5	12.7	7.9	10.2 (22.5)	7.4	1.22	C Move object to exact location.
25.4	10	11.3	12.2	13.5	8.6				
30.5	12	12.9	13.4	15.2	10.0	12.5 (27.5)	9.1	1.28	
35.6	14	14.4	14.6	16.9	11.4				
40.6	16	16.0	15.8	18.7	12.8	14.7 (32.5)	10.8	1.33	
50.8	20	19.2	18.2	22.1	15.6	17.0 (37.5)	12.5	1.39	
55.9	22	20.8	19.4	23.8	17.0	19.3 (42.5)	14.3	1.44	
61.0	24	22.4	20.6	25.5	18.4				
71.1	28	25.5	23.1	29.0	21.2	21.5 (47.5)	16.0	1.50	
76.2	30	27.1	24.3	30.7	22.7				

Additional	0.8	0.6	0.85	TMU per 2.54 cm> 76 cm (per 1.0 in.> 30 in.)

Table 11.1(d). Normal Time Values for MTM-1 Motion Element: **Position** (P)

			Time in TMU	
Class	Description of Fit	Symmetry	Easy to Handle	Difficult to Handle
1	Loose (no pressure required)	S	5.6	11.2
		SS	9.1	14.7
		NS	10.4	16.0
2	Close (light pressure required)	S	16.2	21.8
		SS	19.7	25.3

		NS	21.0	26.6
3	Exact (heavy pressure required)	S	43.0	48.6
		SS	46.5	52.1
		NS	47.8	53.4
Key: S = symmetrical, SS = semi-symmetrical, NS = nonsymmetrical.				

Table 11.1(e). Normal Time Values for MTM-1 Motion Element: **Release** (RL)

Case	TimeinTMU	Description
1	2.0	Normal release performed by opening fingers as an independent motion
2	0	Contact release with no finger motion

Table 11.1(f). Normal Time Values for MTM-1 Motion Element: **Disengage** (D)

			Time in TMU	
Class	Description of Fit	Height of Recoil	Easy to Handle	Difficult to Handle
1	Loose (very slight effort, blends with subsequent move)	Up to 2.5 cm (1 in)	4.0	5.7
2	Close (normal effort, slight recoil) (1 to 5 in)	2.5 to 12.7 cm	7.5	11.8
3	Tight (considerable effort, hand recoils markedly)	12.7 to 30 cm (5 to 12 in)	22.9	34.7

Table 11.1(g). Normal Time Values for **MTM-1** Motion Element: **Turn** (T)

	Time in TMU for Degrees Turned										
Weight, kg (lb)	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
Small, up to 0.9 (2)	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium,1 to 4.5 (2 to 10)	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large, 4.5 to 16 (10 to 35)	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

Table 11.1(h). Normal Time Values for **MTM-1** Motion Element: **Apply Pressure** (AP)

Symbol	TimeinTMU	Description
APA	10.6	Apply pressure alone
APB	16.2	Apply pressure preceded by regrasp

Table 11.1(i). Normal Time Values for **MTM-1** Motion Element: **Eye Travel (ET)** and **Eye Focus (EF)**

Eye motion	Symbol	TimeinTMU	Key to Symbols
Eye travel	ET	15.2L *D*	*L* = distance between points from and to which eye travels, *D* = perpendicular distance from the eye to the line of travel. Maximum time allowed = 20TMU
Eye focus	EF	7.3	
Reading	(none)	*5.05N*	*N* = number of words read (330 words/min)

Table 11.1(j). Normal Time Values for MTM-1 Motion Element: **Body, leg,** and **foot motions** (various symbols given in table)

Motion	Symbol	TimeinTMU	Description and Conditions
Sit	SIT	34.7	From standing position
Stand	STD	43.4	From seated position
Turn body	TBCl	18.6	Turn body 45° to 90°, Case 1 - Lagging foot not aligned with leading foot
Turn body	TBC2	37.2	Turn body 45° to 90°, Case 2 - Lagging foot aligned with leading foot
Bend	B	29.0	Bend body forward so hands can reach knees
Stoop	S	29.0	Stoop body forward so hands can reach floor
Arise	AB	31.9	Arise from bent position
Arise	AS	31.9	Arise from stooped position
Kneel	KOK	29.0	Kneel on one knee
Kneel	KBK	69.4	Kneel on both knees
Arise	AKOK	31.9	Arise from kneeling position on one knee
Arise	AKBK	76.7	Arise from kneeling position on both knees

Walk	*WXFT*	5.3 per ft	Walking in ft of distance, *X* = distance in ft
Walk	*WNP*	15.0/pace	Walking in number of paces, *N* = number of paces
Walk	WNPO	17.0/pace	Walking in number of paces with weight or obstruction, *N* = number of paces
Leg motion	LM6	7.1	Move leg up to 6 in. any direction
Leg motion	LMX	7.1 + l.2(X-6)	Move leg more than 6 in. any direction, where *X* = distance of movement
Foot motion	FM	8.5	Foot moves up to 4 in. hinged at ankle
Foot motion	FMP	19.1	Foot moves up to 4 in. hinged at ankle, apply heavy pressure with leg muscles

Table 11.1(k). MTM-1 Simultaneous Hand and Arm Motion Elements

Motion of One Hand		Reach	Grasp	Move	Position	Disengage
Motion of other hand	Case or Class	A B C E D	lA lB 4 2 lC 5	A B C Bm[a]	1S lSS lNS 2S 2SS 2NS	lE 2 1D
Reach	A,E B C,D	1 1 1 1 1 1 1 1 1	1 1 1 1 1 2 2 3	1 1 2 1 2 2 2 3	1 1 2 2 3 2 3 3	1 1 1 1 2 3
Grasp	lA, 2,5 lB,lC 4	1 1 1 1 1 2 1 2 3	1 1 1 1 3 2 1 2 3	1 1 1 1 1 2 1 2 3	1 1 3 3 3 3 3 3 3	1 3 3 3 3 3

Move	**A**	1	1	2	1	1	1	1	1	1	1	2	1	1	
	B	1	1	2	1	1	2	1	1	1	2	3	1	1	
	C	2		3	1		3	1	1	2	3	3		3	
			2			2							2		
Position	1S	1	2	3	1	3	3	1	2	3	2	3	3	3	3
	ISS,2S	1	2	3	1	3	3	1	2	3	3	3	3	3	3
	INS,2SS,2NS	2	3	3	3	3	3	2	3	3	3	3	3	3	3
Disengage	1E,1D	1	1	2	1	3	3	1	1	2	3	3	3	1	1
	2	1	1	3	3	3	3	1	1	3	3	3	3	1	1

[3]Bm is Case B with hand in motion.

(continued)

Table 11.1(k). *(continued)*

Key: The cell numbers indicate the degree of difficulty when motions are performed simultaneously. 1 = Easy to perform simultaneously. Use the longest motion element time. 2 = Can be performed simultaneously with practice. Use the longest motion element time. 3 = Difficult to perform simultaneously. Add the times of the two simultaneous motion elements.
Assumptions: All Reach, Grasp, and Move motions are performed within the area of normal vision. In the Position and Disengage motion elements, objects are assumed easy to handle. In general, the degree of difficulty increases if these assumptions are violated.
Motions not included in the table: Turn: normally degree of difficulty = 1 except when Turn is controlled or with Disengage. Position Class 3: degree of difficulty = 3. Disengage Class 3: normally, degree of difficulty = 3. Release: degree of difficulty = 1.

Example 1. MTM-1 (REACH)

A worker at a workbench performs a REACH. The sought-after wrench is lying on top of the workbench, and the distance of the reach is 12 in. Determine the MTM-1 symbol and normal time in both TMUs and seconds for this motion element.

Solution:

$$MTM-1\ Symbol = R12A$$

$$T_n = 9.6\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 0.3456\ sec$$

Example 2. MTM-1 (MOVE)

An office worker sitting at her desk performs a MOVE. The file folder being moved weighs less than one lb. It is moved to an exact location in her file cabinet a distance of 30 in. Determine the MTM-1 symbol and normal time in both TMUs and seconds for this motion element.

Solution:

$$MTM-1\ Symbol = M20C1$$

$$T_n = 0 + 1(30.7) = 30.7\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 1.1052\ sec$$

Example 3. MTM-1 (MOVE)

A production worker standing at her machine performs a MOVE. The part being moved weighs less than 1 lb. It is moved to an approximate location in her work area a distance of 4 ft. Determine the MTM-1 symbol and normal time in both TMUs and seconds for this motion element.

Solution:

$$MTM-1\ Symbol = M48B1$$

$$Given\ a\ distance\ of\ 4\ ft = 48\ in, we\ have\ 24.3 + 0.6(18) = 35.1\ TMU$$

$$Hence, T_n = 0 + 1(35.1) = 35.1\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 1.2636\ sec$$

Example 4. MTM-1 (Walking)

A worker must walk a distance of 20 ft (both ways) to perform a certain manual task. What is the MTM-1 normal time in both TMUs and seconds for this motion element?

Solution:

$$MTM-1\ Symbol = W40FT$$

$$T_n = 40(5.3) = 212\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 7.632\ sec$$

Example 5. MTM-1 (Sequence of motions)

A work element in a setup task consists of the following MTM-1 elements: (1) Reach for a long T-handle Allen wrench located 20 in away hanging on a hook on a machine; (2) Grab the T-handle. It weighs less than 1 lb.; (3) Move the T-handle to tighten a loose nut on a head a distance of 20 in.; (4) Position the T-handle into the nut head with close fit, non-symmetrical, easy-to-handle; (5) Tighten nut on the head turning the T-handle four turns of 180 degrees; (6) Move the T-handle back to the hook on the machine; (7) Position the T-handle on the hook, loose fit, non-symmetrical, easy to handle; (8) Release T-handle normally. What is the MTM-1 normal time in both TMUs and seconds for this motion element?

Solution:

$(1)\ MTM-1\ Symbol = R20A, T_n = 13.1\ TMU$
$(2)\ MTM-1\ Symbol = G1A, T_n = 2.0\ TMU$
$(3)\ MTM-1\ Symbol = M20C, T_n = 0 + 1.0(22.1) = 22.1\ TMU$
$(4)\ MTM-1\ Symbol = P2NSE, T_n = 21.0\ TMU$
$(5)\ MTM-1\ Symbol = TS180, T_n = 4(9.4) = 37.6\ TMU$
$(6)\ MTM-1\ Symbol = M20C, T_n = 0 + 1.0(22.1) = 22.1\ TMU$
$(7)\ MTM-1\ Symbol = P1NSE, T_n = 5.6\ TMU$
$(8)\ MTM-1\ Symbol = RL1, T_n = 2.0\ TMU$

$$Total\ T_n = 125.5\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 4.518\ sec$$

Example 6. MTM-1 (Sequence of Motions)

A worker picks up a small bolt from a bin of similar bolts on top of a machine and places it into a bolt hole on a cutting die to secure it to a cylinder on the machine. The bin is within 12 in from her starting position. She grasps the bolt in the bin and moves the bolt from the bin to the bolt hole on the cutting die a distance of 20 in. She positions the bolt accurately in the bolt hole with a close fit and light pressure, easy to handle, non-symmetrical. She turns the bolt by hand 180º six times. She then performs a normal release of the bolt. What is the MTM-1 normal time in both TMUs and seconds for this motion element?

Solution:

$(1)\ MTM-1\ Symbol = R12C, T_n = 14.2\ TMU$
$(2)\ MTM-1\ Symbol = G1A, T_n = 2.0\ TMU$
$(3)\ MTM-1\ Symbol = M20B2, T_n = 0 + 1.0(15.6) = 15.6\ TMU$
$(4)\ MTM-1\ Symbol = P2NSE, T_n = 21.0\ TMU$
$(5)\ MTM-1\ Symbol = TS180, T_n = 6(9.4) = 56.4\ TMU$
$(6)\ MTM-1\ Symbol = RL1, T_n = 2.0\ TMU$

$Total\ T_n = 111.2\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 4.00\ sec$

11.3 Maynard Operation Sequence Technique (MOST)

MOST is another widely used predetermined motion time system developed by Zjell Zandin in the early 1980s to analyze and measure work activities. MOST is designed to be more efficient and faster to apply than traditional MTM systems. It is less detailed than MTM-1 but provides a balance between accuracy and efficiency in time study analysis. MOST breaks down tasks into sequence models, each comprising standard sequences of movements and corresponding time values. It simplifies the process by focusing on the sequence of movements rather than individual motions, which significantly reduces the time required to establish a standard.

MOST analyzes work in terms of activity sequences, with each sequence consisting of standard phases or activities. The three main types of MOST are:

1. BasicMOST: The most commonly used version, suitable for general tasks. It uses four activity sequence models: General Move, Controlled Move, Tool Use, and Manual Crane. In this chapter, we will focus on General Move, Controlled Move, and Tool Use.

2. MiniMOST: A more detailed version for short-cycle, highly repetitive tasks, primarily used in manufacturing environments.
3. MaxiMOST: Designed for long-cycle, non-repetitive tasks, typically used in construction, maintenance, and similar industries.

Examples of MOST:

- BasicMOST: Evaluating the time required for a worker to move a tool from one location to another and use it in an assembly operation.
- MiniMOST: Analyzing repetitive tasks on an assembly line where workers perform the same set of movements repeatedly.
- MaxiMOST: Determining the time for a construction worker to complete various stages of a building project, such as laying bricks or installing electrical wiring.

11.3.1 Basic MOST

Basic MOST is focused on work that involves the movement of objects (i.e., parts, tools, inventory) from one location to another in the workplace. Basic MOST uses motion aggregates, or activity sequence models, which combine several basic motion elements that are performed together in an activity sequence.

11.3.1.1 MOST Procedure

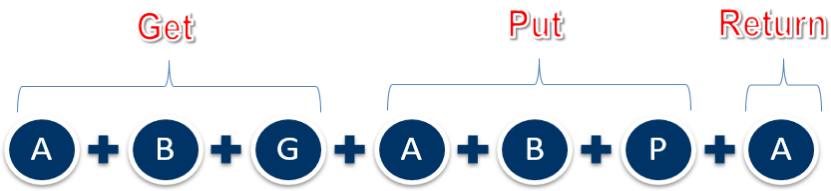
MOST is a procedure that analyzes any manual operation or method into the basic motions required to perform it in an activity sequence model and assigns a predetermined time standard from activity sequence model tables to each task. Table values are determined by the nature of the motion and the conditions under which the motions are made. Index values from the tables are shown as subscripts for each letter in the activity sequence model. The index values are summed, and this total is multiplied by 10 to yield the total task time, in TMUs, which can then be converted to seconds or minutes. Note that the MOST table values are “normalized” time values. Hence, there is no need to assign performance ratings to an activity sequence model. Figure 11.1 displays symbols and descriptions used to describe General Move, Controlled Move, and Tool Use.

SYMBOL	DESCRPITION	GENERAL MOVE	CONTROLLED MOVE	TOOL USE
A	Action Distance	✓	✓	✓
B	Body Motion	✓	✓	✓
G	Gain Control	✓	✓	✓
P	Place/Attach	✓		✓
M	Move Controlled		✓	
X	Process Time		✓	
I	Alignment		✓	
F	Fasten			✓
L	Loosen			✓
C	Cut			✓
S	Surface Treat			✓
M	Measure			✓
R	Record			✓
T	Think/Read			✓
W	Keyboard/Electric Typewriter			✓
K	Keypad			✓
H	Letter/Paper handling			✓

Figure 11.1. Symbols and descriptions used for activity sequence models.

11.3.1.2 Activity Sequence Models

The activity sequence model for a General Move is illustrated below.



The MOST table for a General Move is shown in Figure 11.2. Here, A = action distance, B = type of body motion, C = type of gained control, and P = placement of object.

As with all activity sequence models, the index value used to describe each aspect of the activity sequence model becomes a subscript for that letter. The index values are summed and then multiplied by 10 to yield the normal time, in TMUs. The total TMUs, when multiplied by 0.036 sec/TMU will yield the total normal time for the task.

ABG Get **ABP** Put **A** Return — **General Move**

Index x 10	A Action Distance	B Body Motion	G Gain Control	P Placement	Index x 10
0	≤ 2 in. (5 cm.)	No Body Motion	No Gain Control Hold	No Placement Hold Toss	0
1	Within Reach		Grasp Light Object Grasp Light Objects Simo	Lay Aside Loose Fit	1
3	1 - 2 Steps	Sit without adjustments Stand without adjustments Bend and Arise 50% occ.	Get Non-simo Get Heavy/Bulky Get Blind Get Obstructed Free Interlocked Disengage Collect	Loose Fit Blind Place with Adjustments Place with Light Pressure Place with Double Placement	3
6	3 - 4 Steps	Bend and Arise		Position with Care Position with Precision Position Blind Position Obstructed Position with Heavy Pressure Position with Intermediate Moves	6
10	5 - 7 Steps	Sit Stand			10
16	8 - 10 Steps	Bend and Sit Climb on Climb off Stand and Bend Through Door			16

A Action Distance Extended Values

Index	Steps	Distance (ft.)	Distance (m.)
24	11-15	38	12
32	16-20	50	15
42	21-26	65	20
54	27-33	83	25
67	34-40	100	30
81	41-49	123	38
96	50-57	143	44
113	58-67	168	51
131	68-78	195	59
152	79-90	225	69
173	91-102	255	78
196	103-115	288	88
220	116-128	320	98
245	129-142	355	108
270	143-158	395	120
300	159-174	435	133
330	175-191	478	146

Figure 11.2. MOST table for General Move.

Example 7. General Move

An office worker walks eight steps, bending down to pick up a file folder that fell to the floor, arising, returning the eight steps, and placing the file folder loosely on her desk. What is the MOST normal time in both TMUs and seconds for this activity sequence model?

Solution:

$$A\ B\ G\ A\ B\ P\ A$$

$$A_{16}B_6G_1A_{16}B_0P_1A_0 =$$

$$(16 + 6 + 1 + 16 + 0 + 1 + 0) = 40 * 10 = 400\ TMU$$

$$T_n = 400\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 14.4\ sec$$

Example 8. General Move

A shipping worker slightly bends over and reaches for a box that weighs less than 1 lb that is within reach on a table to put it on a shelf 3 steps away and returns to her original position. What is the MOST normal time in both TMUs and seconds for this activity sequence model?

Solution:

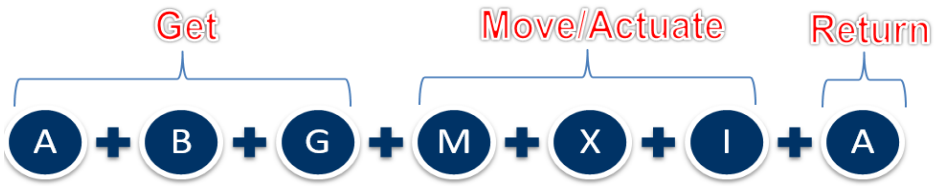
$$A\ B\ G\ A\ B\ P\ A$$

$$A_1B_3G_1A_6B_0P_1A_1 =$$

$$(1 + 3 + 1 + 6 + 0 + 1 + 1) = 13 * 10 = 130\ TMU$$

$$T_n = 130\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 4.68\ sec$$

The activity sequence model for a Controlled Move is illustrated below



The MOST table for a Controlled Move is shown in Figure 11.3. The activity sequence ABG is described in the General Move table. Here, M = type of controlled move, X = process time (in sec, min, or hr), and I = type of alignment.

ABG Get **MXI** Move/Actuate **A** Return — **Controlled Move**

Index x 10	M Move Controlled: Push/Pull/Pivot	M Move Controlled: Crank	X Process Time: Seconds	X Process Time: Minutes	X Process Time: Hours	I Alignment	Index x 10
0	No Action	No Action	No Process Time			No Alignment	0
1	Push/Pull/Pivot ≤ 12 in. (30 cm.) Push Button Push or Pull Switch Rotate Knob		.5 sec.	.01 min.	.0001hr.	Align to 1 Point	1
3	Push/Pull/Pivot > 12 in. (30 cm.) Push/Pull with Resistance Seat Unseat Push/Pull with High Control Push/Pull 2 Stages ≤ 12 in.(30 cm.) Push/Pull 2 Stages ≤ 24 in. Total	1 Rev.	1.5 sec.	.02 min.	.0004 hr.	Align to 2 Points ≤ 4 in. (10 cm.)	3
6	Push/Pull 2 Stages > 12 in. (30 cm.) Push/Pull 2 Stages > 24 in. Total Push with 1 - 2 Steps	2 - 3 Revs.	2.5 sec.	.04 min.	.0007 hr.	Align to 2 Points > 4 in. (10 cm.)	6
10	Push/Pull 3 - 4 Stages Push with 3 - 5 Steps	4 - 6 Revs.	4.5 sec.	.07 min.	.0012 hr.		10
16	Push with 6 - 9 Steps	7 - 11 Revs.	7.0 sec.	.11 min.	.0019 hr.	Align with Precision	16

M Push or Pull Extended Values

Index	Steps
24	10-13
32	14-17
42	18-22
54	23-28
67	29-34

Crank Extended Values

Index	Revs.
24	12-16
32	17-21
42	22-28
54	29-36

X Process Time Extended Values

Index	Seconds	Minutes	Hours
24	9.5	.16	.0027
32	13.0	.21	.0036
42	17.0	.28	.0047
54	21.5	.36	.0060
67	26.0	.44	.0073
81	31.5	.52	.0088
96	37.0	.62	.0104
113	43.5	.72	.0121
131	50.5	.84	.0141
152	58.0	.97	.0162
173	66.0	1.10	.0184
196	74.5	1.24	.0207
220	83.5	1.39	.0232
245	92.5	1.54	.0257
270	102.0	1.70	.0284
300	113.0	1.88	.0314
330	124.0	2.06	.0344

Figure 11.3. MOST table for Controlled Move.

Example 9. Controlled Move

A bandsaw operator takes one step back to gain control of a small handful of 4 x 8 ft sheet stock to move it 16 in. The sheet is aligned to a long, affixed guide on one side of the sheet stock. It is not necessary to reposition the operator's hands during alignment. What is the MOST normal time in both TMUs and seconds for this motion sequence?

Solution:

$$A\ B\ G\ M\ X\ I\ A$$

$$A_3 B_0 G_3 M_6 X_0 I_1 A_0 =$$

$$(3 + 0 + 0 + 6 + 0 + 1 + 0) = 10 * 10 = 100\ TMU$$

$$T_n = 100\ TMU \left(\frac{0.036\ sec}{TMU}\right) = 3.6\ sec$$

Example 10. Controlled Move

A worker picks up a small bolt from a bin of similar bolts on top of a machine and places it into a bolt hole on a cutting die to secure it to a cylinder on the machine. The bin is within 12 in from her starting position. She grasps the bolt in the bin and moves the bolt from the bin to the bolt hole on the cutting die a distance of 20 in. She positions the bolt accurately in the bolt hole with a close fit and light pressure, easy to handle, non-symmetrical. She turns the bolt by hand 180º six times, which takes 3 sec. She then performs a normal release of the bolt. What is the MOST normal time in both TMUs and seconds for this activity sequence model?

Solution:

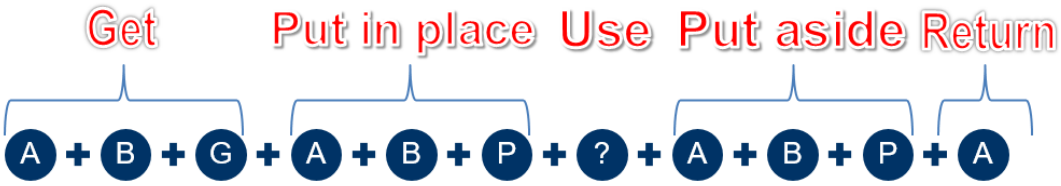
$$A\ \ B\ \ G\ \ M\ \ X\ \ I\ \ A$$

$$A_1 B_0 G_1 M_6 X_{10} I_{10} A_0 =$$

$$(1 + 0 + 1 + 6 + 10 + 10 + 0) = 28 * 10 = 280\ TMU$$

$$T_n = 280\ TMU \left(\frac{0.036\ sec}{TMU}\right) = 10.08\ sec$$

The activity sequence model for a Tool Use is illustrated below



The various types of tools are denoted by letter designation in Figure 11.4 and described in Table 11.2.

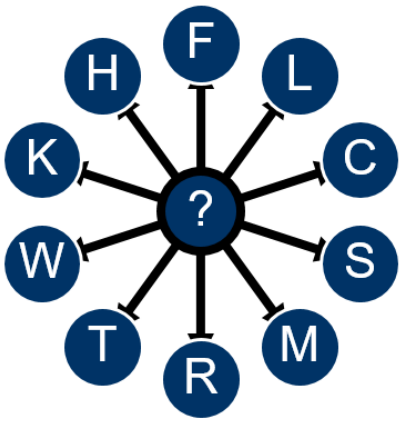


Figure 11.4. MOST Tool Use Code Letters

where

Table 11.2. Symbols and Descriptions for Tool Use.

Symbol	Description	Symbol	Description
F	Fasten	R	Record
L	Loosen	T	Think
C	Cut	W	Computer Keyboard
S	Surface Treat	K	Keypad
M	Measure	H	Letter/Paper Handling

The MOST table for Tool Use is shown in Figure 11.5(a) and (b). The activity sequence ABG is described in the General Move table and the activity sequence model for ABP is described in the Controlled Move table. Here, * is designated for the type of tool used.

ABG Get Tool **ABP** Put Tool ***** Use Tool **ABP** Aside Tool **A** Return

Tool Use

F L Fasten or Loosen

Index x 10	Finger Action	Wrist Action				Arm Action					Tool Action	Index x 10
	Spins	Turns	Strokes	Cranks	Taps	Turns		Strokes	Cranks	Strikes	Screw Dia.	
	Fingers, Screwdriver	Hand, Screwdriver, Ratchet, T-Wrench	Wrench, Allen key	Wrench, Allen key, Ratchet	Hand, Hammer	Ratchet	T-Wrench 2-Hands	Wrench, Allen key	Wrench, Allen key, Ratchet	Hand, Hammer	Power Wrench	
1	1	-	-	-	1	-	-	-	-	-	-	1
3	2	1	1	1	3	1	-	1	-	1	1/4" (6mm)	3
6	3	3	2	3	6	2	1	-	1	3	1" (25mm)	6
10	8	5	3	5	10	4	-	2	2	5		10
16	16	9	5	8	16	6	3	3	3	8		16
24	25	13	8	11	23	9	6	4	5	12		24
32	35	17	10		30	12	8	6		16		32
42	47	23	13		39	15	11	8		21		42
54	61	29	17		50	20	15	10		27		54

P Tool Placement

Tool	Index
Hammer	0 (1)
Fingers or Hand	1 (3 or 6)
Knife	1 (3)
Scissors	1 (3)
Pliers	1 (3)
Writing Instrument	1
Measuring Device	1
Surface Treating Device	1
Screwdriver	3
Ratchet	3
T-Wrench	3
Fixed End Wrench	3
Allen Wrench	3
Power Wrench	3
Adjustable Wrench	6

I Alignment of Machining Tools

Index	Align to
3	Workpiece
6	Scale Mark
10	Indicator Dial

Alignment of Nontypical Objects

Index	Positioning Method
0	Against stop(s)
3	1 adjustment to stop
6	2 adjustments to stop(s) 1 adjustment to 2 stops
10	3 adjustments to stop(s) 2-3 adjustments to linemark

Nontypical Object Characteristics
Flat, Large, Flimsy, Sharp, Difficult to Handle

Figure 11.5(a). MOST table for Tool Use.

ABG Get Tool **ABP** Put Tool ***** Use Tool **ABP** Aside Tool **A** Return

Tool Use

Index x 10	C Cut				S Surface Treat			M Measure	R Record			T Think			Index x 10
	Twist/ Bend	Cutoff	Cut	Slice	Air-Clean	Brush-Clean	Wipe	Measure	Write		Mark	Inspect	Read		
	Pliers		Scissors	Knife	Nozzle	Brush	Cloth	Measuring Device	Pencil		Marker	Eyes, Fingers	Eyes		
		Wire	Cut(s)	Slice(s)	sq. ft. (0, 1 m.²)	sq. ft. (0, 1 m.²)	sq. ft. (0, 1 m.²)	in.(cm.) ft.(m.)	Digits	Words	Digits	Points	Digits, Single Words	Text of Words	
1	Grip		1	-	-	-	-		1	-	Check Mark	1	1	3	1
3		Soft	2	1	-	-	1/2		2	-	1 Scribe Line	3	3 Gauge	8	3
6	Twist Bend-Loop	Medium	4	-	1 Spot Point Cavity	1 Small Object	-		4	1	2	5 Touch for Heat	6 Scale Value Date or Time	15	6
10		Hard	7	3	-	-	1	Profile-Gauge	6	-	3	9 Feel for Defect	12 Vernier-Scale	24	10
16	Bend Cotter Pin		11	4	3	2	2	Fixed Scale Caliper 12 in. (30 cm.)	9 Signature or Date	2	5		Table	38 Value	16
24			15	6	4	3	-	Feeler-Gauge	13	3	7			54	24
32			20	9	7	5	5	Steel-Tape 6 ft. (2 m.) Depth Micrometer	18	4	10			72	32
42			27	11	10	7	7	OD-Micrometer 4 in. (10 cm.)	23	5	13			94	42
54			33					ID-Micrometer 4 in. (10 cm.)	29	7	16			119	54

Figure 11.5(b). MOST table for Tool Use (cont'd).

Example 11. Tool Use

A mechanic picks up a feeler gauge from her rolling toolbox five steps away and checks the gap width of a sparkplug on a gas-powered mobile cart and then puts the feeler gauge back in her toolbox. What is the MOST normal time in both TMUs and seconds for this activity sequence model?

Solution:

$$A\ B\ G\ A\ B\ P\ *\ A\ B\ P\ A$$

$$A_{10}B_0G_1A_{10}B_0P_6M_{24}A_{10}B_0P_1A_{10} =$$

$$(10 + 0 + 1 + 10 + 0 + 6 + 24 + 10 + 0 + 1 + 10) = 72 * 10 = 720\ TMU$$

$$T_n = 720\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 25.92\ sec$$

Example 12. Tool Use

A worker picks up a screw from her workbench, positions it into a drilled hole, and turns it four spins with her fingers. She then picks up a screwdriver from the workbench, positions it on the head of the screw, fastens the screw with four turns, and then lays the screwdriver aside. What is the MOST normal time in both TMUs and seconds for this activity sequence model?

Solution:

This requires two activity sequence models, corresponding to the two sentences of the work description.

$$A\ B\ G\ A\ B\ P * A\ B\ P\ A$$

The first activity sequence model:

$$A_1B_0G_1A_0B_0P_3F_{10}A_0B_0P_0A_0 = 15 * 10 = 150\ TMU$$

The second activity sequence model:

$$A_1B_0G_1A_1B_0P_3F_{10}A_1B_0P_1A_0 = 18 * 10 = 180\ TMU$$

$$T_n = 150\ TMU + 180\ TMU = 330\ TMU\left(\frac{0.036\ sec}{TMU}\right) = 11.88\ sec$$

11.3.2 MOST Software

MOST is available in software packages to expedite the computation of activity sequence models. An example of input values using MOST software[3] is shown in Figure 11.6.

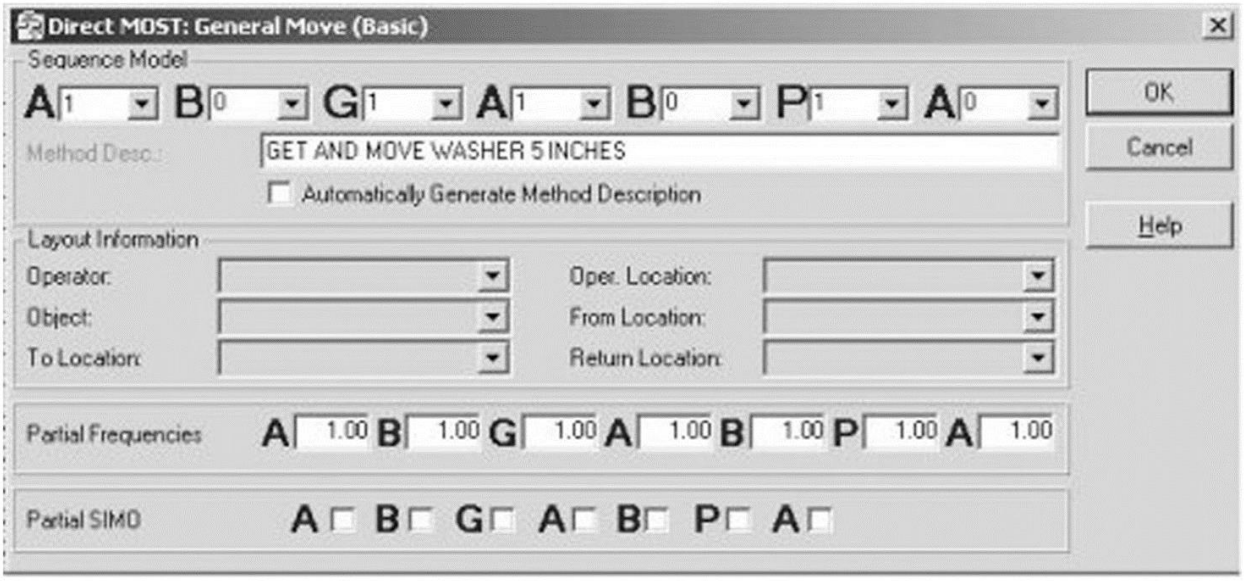


Figure 11.6. An example of MOST software.

11.4 Summary

Predetermined Motion Time Systems (PMTS), such as the MTM family and MOST, provide standardized ways to measure and improve worker productivity by breaking down tasks into basic motion elements or activity sequences, assigning standard times in TMUs which can be converted into seconds, and thus allowing for better planning and optimization of work processes.

==========

References

[1] Groover, M.P. *Work Systems and the Methods, Measurement, and Management of Work*, Upper Saddle River, NJ: Pearson Prentice Hall, 2007.

[2] Atkins, R.W. *Work Measurement and Ergonomics*, Grandpappy, Inc., 2019.

[3] Freivalds, A. *Niebel's Methods, Standards, and Work Design*, 13th ed., McGraw-Hill, 2014.