PREDETERMINED TIME SYSTEMS

1.1 Introduction

There are a number of methods that can be used to calculate the time needed to carry out a job or a task. Time standards can be established by time study, by work sampling, or by the use of predetermined times.

What does a predetermined time system consist of?
A predetermined time system consists of a set of time data and a systematic procedure which analyses and subdivides any manual or human task into motions, body movements, or other elements of human performance, and assigns to each the appropriate time value.

Predetermined time systems can have different classifications.
They can be classified according to accuracy level, time required for application, and the extent of method description.
The systems that came in the beginning were designed for general use and they can be applied to most industrial operations. For the time being there are numerous specialised systems available.

The first predetermined time system was developed by A.B. Segur. Segur called it Methods-Time-Analysis (MTA) (Segur, 1956).

1.2 Methods-Time Measurement

1.2.1 Definition

Methods-Time Measurement can be defined as a procedure which analyses any manual operation or method into the basic motions required to perform it, and assigns to each motion a predetermined time standard which is determined by the nature of the motion and the conditions under which it is made.

The basic MTM system is MTM-1.

In 1963 a new member of the MTM system called General Purpose Data (MTM-GPD) was introduced. MTM systems include MTM-1, MTM-GPD, MTM-2, MTM-3, MTM-V, MTM-M, MTM-C, and 4M DATA.

1.2.2 MTM-1

MTM-1 is the most detailed system. Motions are broken down into 10 categories:

Reach
Move
Turn
Apply Pressure
Grasp
Position
Release
Disengage
Body (leg-foot, horizontal, and vertical) motions
Eye motions

The time for each basic element is given in units of TMU.
TMUs = Time Measurement Units
1 TMU = 0.000010 hr = 0.00060 min = 0.036 s
or conversely
1 s = 27.78 TMU
1 min = 1667 TMU
1 hr = 100,000 TMU
The following is a summarised description of the 10 MTM-1 categories:

Reach:

Reach is when the hand or finger is moved to a destination. Reach is usually a movement with an empty hand or finger. The time for performing a Reach depends on the following factors:

1- Condition (nature of destination)

2- Length of the motion

3- Type of Reach.

The time to perform a Reach is affected by the nature of the object toward which the Reach is made. There are five classes of Reach (A, B, C, D, and E). The following is a description of these five classes:

A: Reach to object in fixed location, or to object in other hand or on which other hand rests.

B: Reach to single object in location, which may vary slightly from cycle to cycle.

C: Reach to object jumbled with other objects in a group so that search and select occur.

D: Reach to a very small object or where accurate grasp is required.

E: Reach to indefinite location to get hand in position for body balance or next motion or out of way.

MTM-1 Reach is in table 1.

Move:

The difference between Move and Reach is that in Move the hand or finger is holding something. In Move the predominant purpose is to transport an object to a destination. The time of Move is affected by its length, nature of destination, type of move, and weight factor (static and dynamic).

There are three classes of Move:

Class A Move: object to other hand or against stop.

Class B Move: object to approximate or indefinite location.

Class C Move: object to exact location.

MTM-1 Move is in table 2.

Turn:

Turn is a movement that rotates the hand, either empty or loaded. The movement rotates the hand, wrist, and forearm about the long axis of the forearm.

The time for Turn depends on the following two factors:

1- The number of degrees turned.

2- The weight of the object or the resistance against which the turn is made (weight factor).

MTM-1 Turn is in table 3.

Apply Pressure:
Apply Pressure is the application of force without resultant movements.
MTM-1 Apply Pressure is in table 4.

Grasp:
Grasp is the motion used when the purpose is to gain control of one or more objects. Grasp is almost always followed by Move. There are five types of Grasp (Pick-up, Regrasp, Transfer, Select, Contact). MTM-1 Grasp is in table 5.

Table 1. MTM-1 Reach

Distance Moved in Inches	Time TMU				Hand in Motion	
	A	B	C or D	E	A	B
3/4 or less	2.0	2.0	2.0	2.0	1.6	1.6
1	2.5	2.5	3.6	2.4	2.3	2.3
2	4.0	4.0	5.9	3.8	3.5	2.7
3	5.3	5.3	7.3	5.3	4.5	3.6
4	6.1	6.4	8.4	6.8	4.9	4.3
5	6.5	7.8	9.4	7.4	5.3	5.0
6	7.0	8.6	10.1	8.0	5.7	5.7
7	7.4	9.3	10.8	8.7	6.1	6.5
8	7.9	10.1	11.5	9.3	6.5	7.2
9	8.3	10.8	12.2	9.9	6.9	7.9
10	8.7	11.5	12.9	10.5	7.3	8.6
12	9.6	12.9	14.2	11.8	8.1	10.1
14	10.5	14.4	15.6	13.0	8.9	11.5
16	11.4	15.8	17.0	14.2	9.7	12.9
18	12.3	17.2	18.4	15.5	10.5	14.4
20	13.1	18.6	19.8	16.7	11.3	15.8
22	14.0	20.1	21.2	18.0	12.1	17.3
24	14.9	21.5	22.5	19.2	12.9	18.8
26	15.8	22.9	23.9	20.4	13.7	20.2
28	16.7	24.4	25.3	21.7	14.5	21.7
30	17.5	25.8	26.7	22.9	15.3	23.2
Additional per inch over 30 inches	0.4	0.7	0.7	0.6		

Position:
Position is the basic element employed to align, orient, and engage one object with another object, where the motions are so minor that they do not justify classification as other basic elements.
The time of Position depends on the following:
1- Class of fit (loose, close, and exact)
2- Symmetry (symmetrical, non-symmetrical, semi symmetrical)
3- Ease of handling.
MTM-1 Position is in table 6.

Release:
Release is the relinquishing of control of an object by the hand or fingers.
There are two classes of Release:
1- Normal release performed by opening of fingers.
2- Contact release, the release begins and is completed at the instant the following Reach begins (no time allowed).
MTM-1 Release is in table 7.

Table 2. MTM-1 Move

Distance moved in Inches	Time TMU				Wt. Allowance		
	A	B	C	Hand In Motion B	Wt. (lb). Up to	Dynamic Factor	Static Constant TMU
¾ OR LESS	2.0	2.0	2.0	1.7	2.5	1.00	0
1	2.5	2.9	3.4	2.3			
2	3.6	4.6	5.2	2.9	7.5	1.06	2.2
3	4.9	5.7	6.7	3.6			
4	6.1	6.9	8.0	4.3	12.5	1.11	3.9
5	7.3	8.0	9.2	5.0			
6	8.1	8.9	10.3	5.7	17.5	1.17	5.6
7	8.9	9.7	11.1	6.5			
8	9.7	10.6	11.8	7.2	22.5	1.22	7.4
9	10.5	11.5	12.7	7.9			
10	11.3	12.2	13.5	8.6	27.5	1.28	9.1
12	12.9	13.4	15.2	10.0			
14	14.4	14.6	16.9	11.4	32.5	1.33	10.8
16	16.0	15.8	18.7	12.8			
18	17.6	17.0	20.4	14.2	37.5	1.39	12.5
20	19.2	18.2	22.1	15.6			
22	20.8	19.4	23.8	17.0	42.5	1.44	14.3
24	22.4	20.6	25.5	18.4			
26	24.0	21.8	27.3	19.8	47.5	1.50	16.0
28	25.5	23.1	29.0	21.2			
30	27.1	24.3	30.7	22.7			
Additional	0.8	0.6	0.85		TMU per inch over 30 inches		

Table 3. MTM-1 Turn

Weight	Time TMU for Degrees Turned										
	30	45	60	75	90	105	120	135	150	165	180
Small 0 to 2 Pounds	2.8	3.5	4.1	4.8	5.4	6.1	6.8	7.4	8.1	8.7	9.4
Medium 2.1 to 10 Pounds	4.4	5.5	6.5	7.5	8.5	9.6	10.6	11.6	12.7	13.7	14.8
Large 10 to 35 Pounds	8.4	10.5	12.3	14.4	16.2	18.3	20.4	22.2	24.3	26.1	28.2

Table 4. MTM-1 Apply Pressure (Barnes, 1980), (Konz, 1995)

Full Cycle			Components		
Symbol	TMU	Description	Symbol	TMU	Description
APA	10.6	AF+DM+RLF	AF	3.4	Apply Force
			DM	4.2	Dwell_Minimum
APB	16.2	APA+G2	RLF	3.0	Release Force

Table 5. MTM-1 Grasp

Type of Grasp	Case	Time TMU	Description	
Pick-UP	1A	2.0	Any size object by itself, easily grasped.	
	1B	3.5	Object very small or lying close against a flat surface.	
	1C1	7.3	Diameter Larger than ½"	Interference with Grasp on bottom and one side of nearly cylindrical object.
	1C2	8.7	Diameter 1/4" to 1/2"	
	1C3	10.8	Diameter Less than 1/4"	
Regrasp	2	5.6	Change grasp without relinquishing control.	
Transfer	3	5.6	Control transferred from one hand to the other.	
Select	4A	7.3	Larger than 1 x1 x1	Object jumbled with other objects so that search and select occur.
	4B	9.1	1/4 x1/4 x1/8 to 1 x1 x1	
	4C	12.9	Smaller than 1/4 x1/4 x1/8	
Contact	5	0	Contact, Sliding, or Hook Grasp.	

Table 6. MTM-1 Position

Class of Fit	Symmetry	Easy to Handle	Difficult to Handle
1 Loose	S	5.6	11.2
	SS	9.1	14.7
	NS	10.4	16.0
2 Close	S	16.2	21.8
	SS	19.7	25.3
	NS	21.0	26.6
3 Exact	S	43.0	48.6
	SS	46.5	52.1
	NS	47.8	53.4
Supplementary Rule for Surface Alignment			
P1SE per alignment: >1/16 1/4		P2SE per alignment: 1/16	

Table 7. MTM-1 Release

Case	Time TMU	Description
1	2.0	Normal release performed by opening fingers as independent motion
2	0	Contact Release

Disengage:

Disengage is the basic element used to break contact between one object and another. The time required for Disengage is affected by the following:

1- Class of fit (loose, close, tight)

2- Ease of handling (easy and difficult)

3- care of handling. MTM-1 Disengage is in table 8.

Table 8. MTM-1 Disengage

Class of Fit	Height Of Recoil	Easy to Handle	Difficult to Handle
1 Loose Very slight effort, blends with subsequent move.	UP TO 1	4.0	5.7
2 Close Normal effort, slight recoil.	Over 1 to 5	7.5	11.8
3 Tight Considerable effort, hand recoils markedly.	Over 5 to 12	22.9	34.7

Body, Leg, and Foot Motions:

The previous motions were motions of the hand and arm. Body motions are motions of the leg-foot, horizontal torso motions, and vertical torso motions. A look through the tables of Body, Leg and Foot Motions published by the MTM Association gives a reasonable explanation of these motions. MTM-1 Body, Leg, and Foot Motions are in table 9.

Eye motions:

Eye time must be considered when the eyes do direct the hands or body movements. There are two types of Eye time:

1- Eye focus time (time required to focus the eyes on an object and look at it long enough to determine certain distinguishable characteristics within the area which may be seen without shifting the eyes).

2- Eye travel time (affected by the distance between points from and to which the eye travels, and the perpendicular distance from the eye to the line of travel). MTM-1 Eye Travel (ET) and Eye Focus are in table 10.

1.2.3 MTM-2

The most accurate predetermined time system of the family of MTM is MTM-1. MTM-1 provides the most detailed description of methods. But in the other hand it requires longer time for analysis. In MTM-1 it takes about 250 times the cycle time to analyse the task while in MTM-2 it takes about 100 times, and in MTM-3 about 35 times. For the previous reasons MTM-2 and MTM-3 were developed. MTM-2 was developed by constructing motion combinations from basic motions of MTM-1. The number of distance range is smaller and the cases of control are fewer than MTM-1. MTM-2 is best used for work that is not highly repetitive and for elements that are not less than one minute long. MTM-2 consists of nine manual motion categories. These nine motion categories and their symbols are as follows:

MOTION	SYMBOL
1- Get	G
2- Put	P
3- Apply Pressure	A
4- Regrasp	R
5-Eye Action	E

6- Crank   C

7- Step   S

8- Foot Motion   F

9- Bend and Arise   B

The two key motion categories are Get and Put. Get and Put are the only two variable categories and only 37 time standards appear on the MTM-2 table. The following is a brief explanation of the nine categories of MTM-2:

Get:

Get is reaching with hand or fingers to an object, grasping object, and subsequently releasing it. Get is combining Reach, Grasp, and Release.

The variables of Get are:

1- Action employed: GA-no grasping motion; GB-closing fingers to gain control; GC-complex grasping.

2- The distance reached: 0-2, over 2-6, over 6-12, over 12-18, and over 18 inches.

3- Object weight, or its resistance to motion: GW-1 add 1 TMU per 2 pounds moved.

Put:
Put is moving an object to a destination with the hand or fingers. Put is combining Move and Position. The variables of Put are:
1- The number of correcting motions or no correction required: PA-continuous smooth motion; PB-one correction; and PC-more than one correction.
2- The distance moved (same as for Get).
3- Object weight, or its resistance to motion (same as for Get): PW-1 add 1 TMU per 10 pounds moved.

Apply Pressure:
An action with the purpose of exerting muscular force on an object.

Regrasp:
An action performed by the hand with the purpose of changing the grasp on an object.

Eye Action:

An action with the purpose of recognising a readily distinguishable characteristic of an object or shifting the aim of the axis of vision to a new viewing area.

Crank:

A motion with the purpose of moving an object in a circular path of more than half a revolution with the hand or fingers.

Step:

Either a leg motion with the purpose of moving the body or a leg to motion more than 12 inches.

Foot Motion:

A short foot or leg motion when the purpose is not to move the body.

Bend and Arise:

A bend, stoop, or kneel on one knee, and the subsequent rise.

MTM in -2 is table 11.

Table 9. MTM-1 Body, Leg, and Foot Motions

Type		Symbol	TMU	Distance	Description
Leg-Foot Motion		FM	8.5	To 4	Hinged at ankle.
		FMP	19.1	To 4	With heavy pressure.
		LM_	7.1	To 6	Hinged at knee or hip in any direction
			1.2	Each additional inch	
Horizontal Motion	Side Step	SS_C1	*	<12	* Use Reach or Move time when less than 12 . Complete when leading leg contacts floor.
			17.0	12	
			0.6	Each additional inch	
		SS_C2	34.1	12	Lagging leg must contact floor before next motion can be made.
			1.1	Each additional inch	
	Turn Body	TBC1	18.6		Complete when leading leg contacts floor
		TBC2	37.2		Lagging leg must contact floor before next motion can be made
	Walk	W_FT	5.3	Per Foot	Unobstructed.
		W_P	15.0	Per Foot	Unobstructed.
		W_PO	17.0	Per Foot	When obstructed or with weight.
Vertical Motion		SIT	34.7		From standing position.
		STD	43.4		From sitting position.
		B,S,KOK	29.0		Bend, Stoop, Kneel on one knee.
		AB,AS,AKOK	31.9		Arise from Bend, Stoop, Kneel on one knee.
		KBK	69.4		Kneel on Both Knees.
		AKBK	76.7		Arise from Kneel on Both Knees.

Table 10. MTM-1 Eye Travel and Eye Focus

Eye Travel Time = 15.2 X T/D TMU, with a maximum value of 20 TMU Where T = the distance between points from and to which the eye travels. D = the perpendicular distance from the eye to the line of travel T. Eye Focus Time = 7.3 TMU.
Supplementary Information Area of Normal Vision = Circle 4 in Diameter 16 from eyes Reading Formula = 5.05 N Where N = The number of words

Table 11. MTM-2

Range	Code	GA	GB	GC	PA	PB	PC
Up to 2	-2	3	7	14	3	10	21
Over 2 -6	-6	6	10	19	6	15	26
Over 6 -12	-12	9	14	23	11	19	30
Over 12 -18	-18	13	18	27	15	24	36
Over 18	-32	17	23	32	20	30	41
GW 1 per 2 lb.				**PW** 1 per 10 lb.			
	A	R	E	C	S	F	B
	14	6	7	15	18	9	61

1.2.4 MTM-3

The simplest MTM system is MTM-3. This system is used with long-cycle short-run operations. MTM-3 consists of four motion categories. Speed of the analysis with MTM-3 is seven times as fast as with MTM-1 and three times as fast as with MTM-2. The following is the four motion categories of MTM-3 and their symbols:

MOTION   SYMBOL
1- Handle   H
2- Transport   T
3- Step and Foot Motion   SF
4- Bend and Arise   B

The two key motion categories are Handle and Transport. These two categories are the only categories of the MTM-3 four categories, which have variable values. Only ten time standards appear on the MTM-3 table.

The following is a brief explanation of the four motion categories of MTM-3:

Handle:

It is getting control over an object with the hand or fingers and placing the object in a new location. Handle is defined as gaining control of an object and placing it in a new location.

Transport:

It is placing an object in a new location with the hand or fingers. Transport is defined as placing an object in a new location when the hand already has control of the object.

Step and Foot Motion:

Step and Foot combines the S and F categories of MTM-2.

Bend and Arise:

A bend, stoop, or kneel on one knee, and the subsequent rise. It is the same as MTM-2.

MTM-3 is in table 12.

Table 12. MTM-3

Range	Code	HA	HB	TA	TB
Up to 6	-6	18	34	7	21
Over 6	-32	34	48	16	29
		SF	18	B	61