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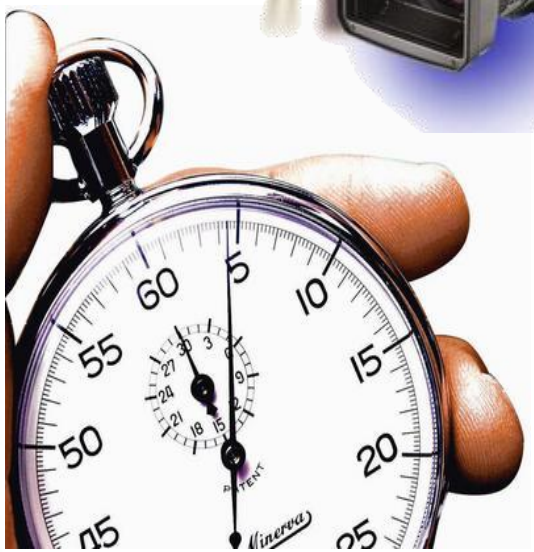
#11_*PREDETERMINED MOTION TIME SYSTEMS (PMTS)*

ANALISA DAN PENGUKURAN KERJA

METODE PENGUKURAN [WAKTU] KERJA

- PENGUKURAN [WAKTU] KERJA
  - DIRECT
    - STOP-WATCH
    - WORK SAMPLING
  - INDIRECT
    - STANDARD DATA
    - PMTS



An alternative time study that **does not require performance rating**.

A database of basic motion elements and their associated normal time values, together with procedures for applying the data to analyze manual tasks and establish **standard times** for the tasks.

PMTS defined

Basic motions include:

Reach | Grasp | Move | Release

A set of tables that listing **time values** that corresponds to **basic motion elements**, the lowest level in hierarchy of manual work activity.

Historical Notes

- Frank B. Gilberth- 17 therbligs
- Asa B. Segur – Motion Time Analysis (MTA) - the first commercial PMT system (1922) and base on Gilberth's 17 therbligs
- H. Quick – Work-factor system (1934-1938): cognitive work involved
- **Harold B. Maynard – Methods-Time Measurement (MTM) (1948): very successful and widely used**
- G.Chris Hyde- Modular Arrangement of Predetermined Time Standards (MODAPTS) –1966
- **Kjell B. Zandin- Maynard Operations Sequence Technique (MOST)-(1970s)**
- Computerization of systems as commercial products

PMTS Procedure

1. **Synthesize/Analyze method that would be used to perform the task**
   - The method is described in terms of basic motion elements
2. **Retrieve normal time values for each motion element**
   - Sum the element times to determine the task normal time
3. **Evaluate method to make improvements** by
   - eliminating motions
   - reducing distances
   - using both hands simultaneously etc.
4. **Apply allowances to determine standard time**

PMTS Levels and Generations

- **First-level PMTS** use the basic motion elements
  - Reach, grasp, and move used separately to define the task
- **Higher-level PMTS** combine several motion elements into motion aggregates
  - Reach and grasp combined into one element called “get”
- First-level systems were chronologically the first to be developed and are called first generation PMTS

Comparisons

First-level PMTS

- Most accurate
- High application speed ratio
- Most suited to highly repetitive short cycles
- Basic motion elements
- Very detailed
- Highest flexibility

Detailed

MTM

Higher-level PMTS

- Less accurate
- Less time to set standards
- Longer cycle times feasible
- Motion aggregates
- Less detailed
- Less flexible

Simplified and condensed

MOST

METHODS TIME MEASUREMENT (MTM)

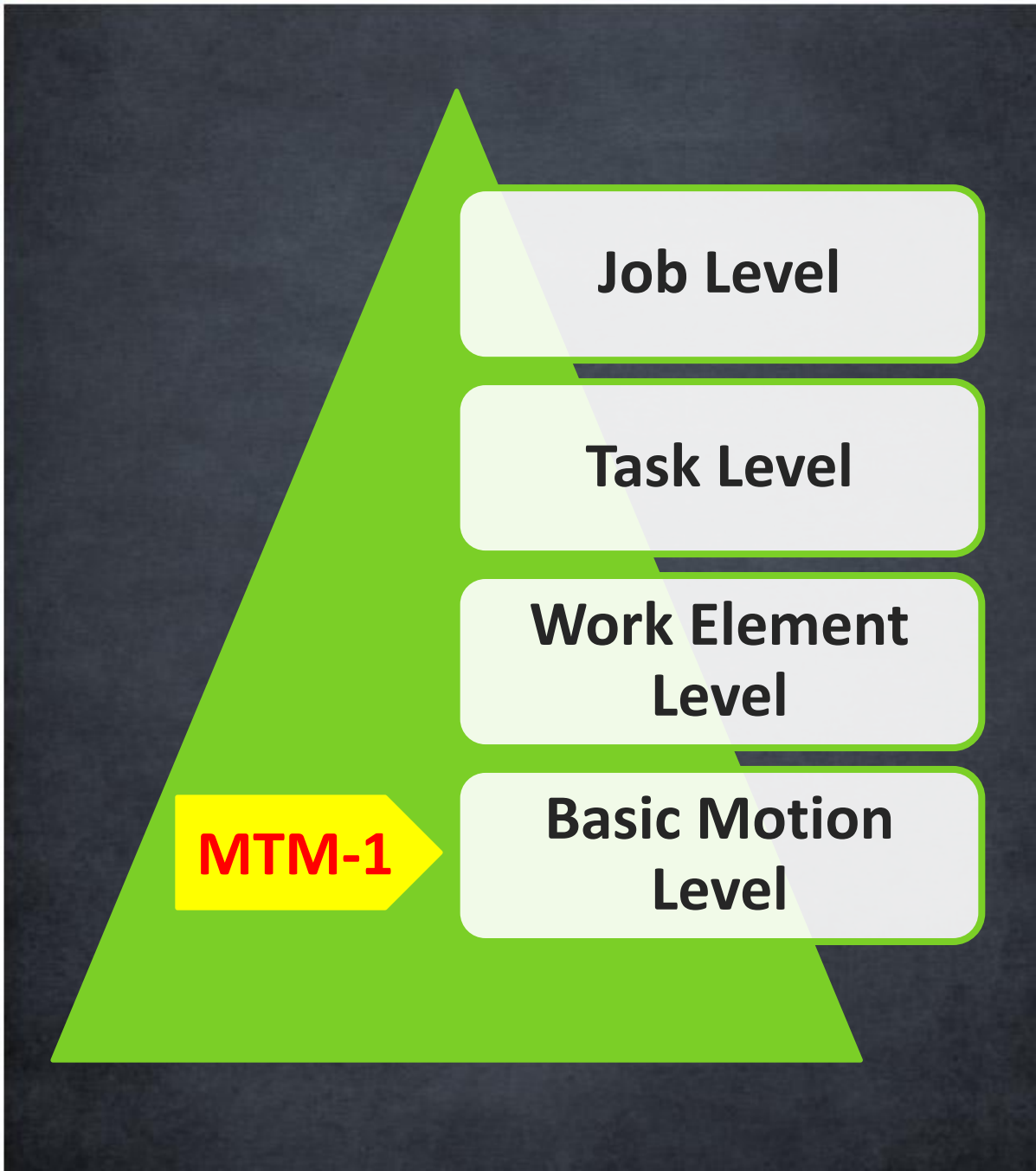
Methods-Time Measurement (MTM)

- ✓ Procedure which analyzes 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.
- ✓ Time units are TMUs

  1 TMU = 10^{-6} hr = 0.0006 min = 0.036 sec

  1 sec = 27.8 TMU
- ✓ MTM is a family of products available through the MTM Association (www.mtm.org)

HIERARCHY OF WORK ACTIVITY



M T M - 1

- Operates at **the basic motion element level** in our pyramidal structure of work
  - Most MTM-1 basic motions involve hand and arm movements
  - Also includes elements for eye, leg, foot, and body actions
- Many of the basic motion elements correspond to the original Therbligs developed by Frank Gilbreth
- More appropriate for tasks that are **highly repetitive** and **cycle times are less than 1 min**

Notasi Gerakan

- Notasi umum untuk setiap gerakan pada MTM adalah:

a b c

dimana :

a : gerakan dasar yang bekerja

b: jarak yang ditempuh

c : kelas dari gerak dasar yang bersangkutan

Example : R10C = 12.9 TMUs

LE 14.4 (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	**B** Reach to single object in location that may vary slightly from cycle to cycle.
10.1	4	6.1	6.4	8.4	6.8	4.9	4.3	
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	**C** Reach to object jumbled with other objects in a group so that search and select occur.
20.3	8	7.9	10.1	11.5	9.3	6.5	7.2	
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	**D** Reach to a very small object or where accurate grasp is required.
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	
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	**E** Reach to indefinite location to get hand in position for body balance or next motion or out the way.
55.9	22	14.0	20.1	21.2	18.0	12.1	17.3	
61.0	24	14.9	21.5	22.5	19.2	12.9	18.8	
66.0	26	15.8	22.9	23.9	20.4	13.7	20.2	
71.1	28	16.7	24.4	25.3	21.7	14.5	21.7	
76.2	30	17.5	25.8	26.7	22.9	15.3	23.2	
Additional		0.4	0.7	0.7	0.6	TMU per 2.54 cm > 76 cm (per 1.0 in > 30 in.)		

E 14.4 (b) Normal Time Values for MTM-1 Motion Element: **Grasp** (G)

Example : G1C3 = 10.8 TMUs

e of Grasp	Case	Time, TMU	Description and Object Dimensions	
Pickup	1A	2.0	Any size object, by itself	
	1B	3.5	Object very small or lying close against a flat surface	
	1C1	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 other objects so that search and select occur	Size larger than 2.5 × 2.5 × 2.5 cm (1 × 1 × 1 in.)
	4B	9.1		0.6 × .6 × .3 cm (.25 × .25 × .12 in) to 2.5 × 2.5 × 2.5 cm (1 × 1 × 1 in.)
	4C	12.9		Size smaller than .6 × .6 × .3 cm (.25 × .25 × .12 in.)
Contact	5	0	Contact, sliding, or hook grasp	

TABLE 14.4 (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				**A** Move object to other hand or against stop.
2.5	1	2.5	2.9	3.4	2.3	1.1 (2.5)	0	1.00	
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				**B** Move object to approximate or indefinite location.
12.5	5	7.3	8.0	9.2	5.0	5.7 (12.5)	3.9	1.11	
15.2	6	8.1	8.9	10.3	5.7				
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				**C** Move object *to* exact location.
22.9	9	10.5	11.5	12.7	7.9	10.2 (22.5)	7.4	1.22	
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	
45.7	18	17.6	17.0	20.4	14.2				
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				
61.0	24	22.4	20.6	25.5	18.4	19.3 (42.5)	14.3	1.44	
66.0	26	24.0	21.8	27.3	19.8				
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.)				

Motion Element : Move (M)

Normal Time = constant + (factor * time in TMU)

- Example : M6B12
- Normal Time = 3.9 + (1.11 * 8.9)

  = 13.8 TMUs

Example : P3NSD = 53.4 TMUs

TABLE 14.4 (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.

- Round peg in a round hole: S(ymmetrical)
- Key inserted in a lock: N(on)S(ymmetrical)

Example : RL1 = 2 TMUs

TABLE 14.4 (e) Normal Time Values for MTM-1 Motion Element: **Release** (RL)

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

TABLE 14.4 (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

Example : D2D = 11.8 TMUs

Example : T30L = 8.4 TMUs

LE 14.4 (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°
mall, 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
edium, 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
rge, 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

Example : APB = 16.2 TMUs

TABLE 14.4 (h) Normal Time Values for MTM-1 Motion Element: **Apply Pressure** (AP)

Symbol	Time in TMU	Description
APA	10.6	Apply pressure alone
APB	16.2	Apply pressure preceded by regrasp

E 14.4 (i) Normal Time Values for MTM-1 Motion Element: **Eye Travel** (ET) and **Eye Focus** (EF)

Eye motion	Symbol	Time in TMU	Key to Symbols
Eye travel	ET	$\frac{15.2L}{D}$	L = distance between points from and to which eye travels, D = perpendicular distance from the eye to the line of travel. Maximum time allowed = 20 TMU
ye focus	EF	7.3	
eading	(none)	$5.05N$	N = number of words read (330 words/min)

TABLE 14.4 (j) Normal Time Values for MTM-1 Motion Element: **Body, leg**, and **foot motions** (various symbols given in table)

Motion	Symbol	Time in TMU	Description and Conditions
Sit	SIT	34.7	From standing position
Stand	STD	43.4	From seated position
Turn body	TBC1	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	W*X*FT	5.3 per ft	Walking in ft of distance, X = distance in ft
Walk	W*N*P	15.0/pace	Walking in number of paces, N = number of paces
Walk	W*N*PO	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	LM*X*	7.1 + 1.2(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

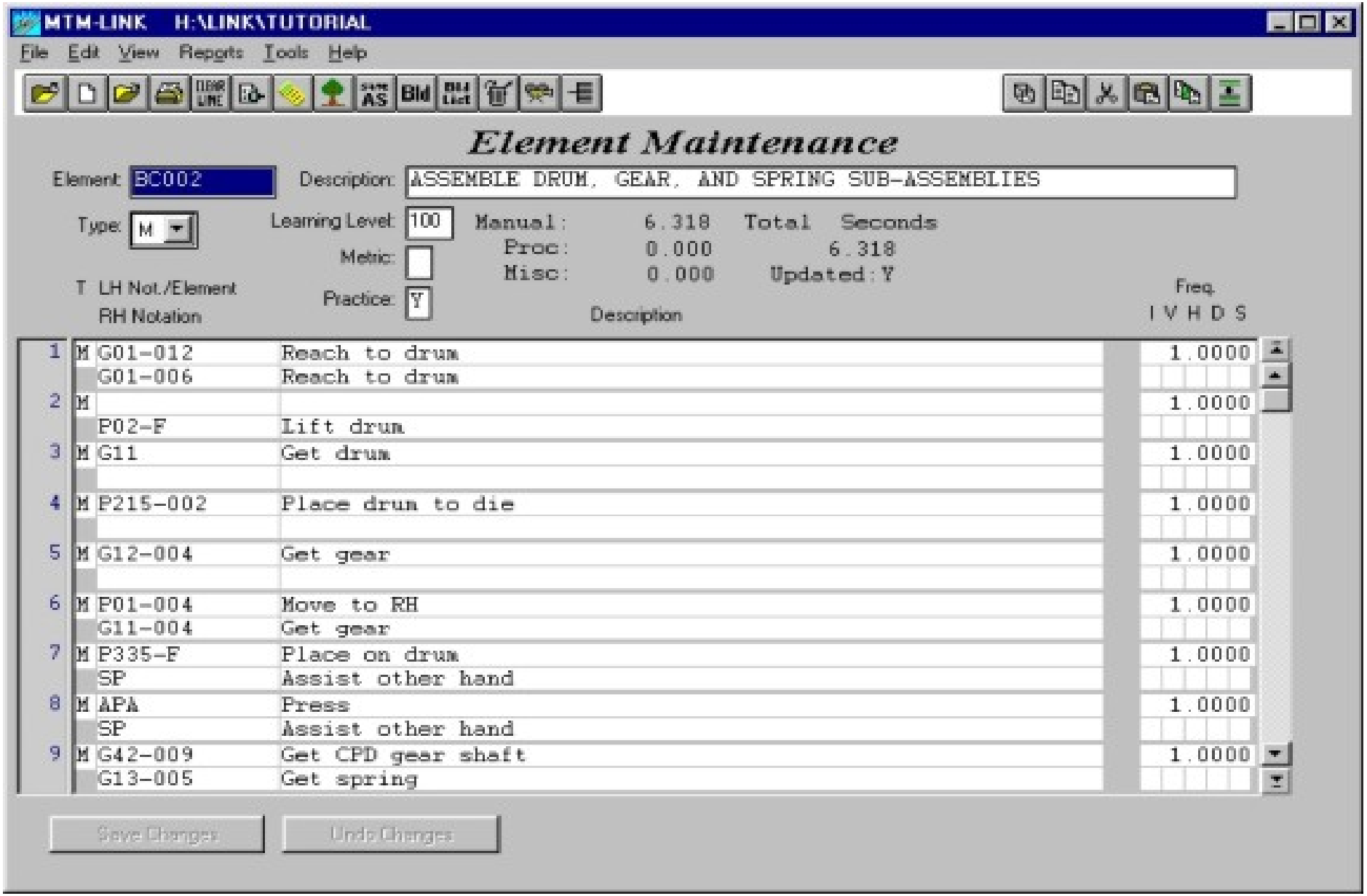
Other MTM Systems

- **MTM-2** – Second-level PMTS in which basic motion elements are combined into motion aggregates (11 motions)
  - GET – combines Reach and Grasp
  - PUT – combines Move and Position
  - For tasks that are not highly repetitive and cycle times are greater than 1 min

- **MTM-3** – Third-level PMTS which has four motion categories

  Handle | Transport | Step and foot motions | Bend and arise

MTM Software (www.mtm.org)



MAYNARD OPERATION SEQUENCE TECHNIQUE (MOST)

M O S T

- MOST is a high-level PMTS based on MTM
  - Same time units as MTM: TMU
  - Developed around 1967 under the direction of Kjell Zandin
  - MOST is a product of H.B. Maynard and Company (an educational and consulting firm), Pittsburgh, Pennsylvania

    (www.hbmaynard.com)

HIERARCHY OF WORK ACTIVITY

Basic MOST

- Focused on work **involving the movement of objects** (e.g., parts, tools) from one location to another in the workplace
  - Uses motion aggregates
  - Called activity sequence models

- **Three activity sequence models**:
  1. **General move** – object moved freely in space
  2. **Controlled move** – object remains in contact with a surface
  3. **Tool use** – use of hand tools (e.g., hammer, screwdriver)

Basic MOST

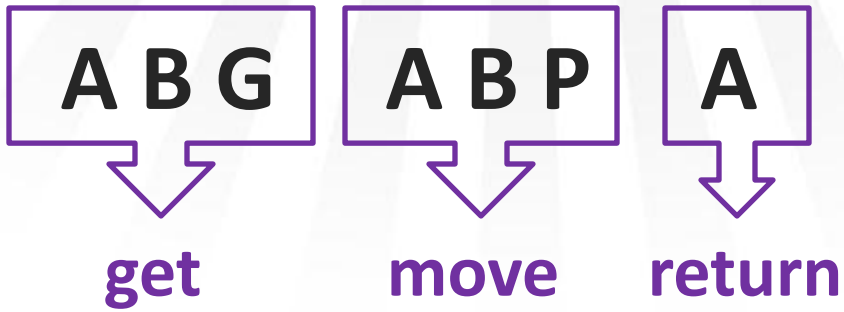
Activity	Sequence Model	Subactivities
General Move	ABG ABP A	A - Action Distances
		B - Body Motion
		G - Gain Control
		P - Place
Controlled Move	ABG MXI A	M - Move controlled
		X - Process time
		I - Align
Tool Use	ABG ABP * ABPA	*F – Fasten
		*L – Loosen
		*C – Cut
		*S – Surface treat
		*R – Record
		*M - Measure

1. General Move

- Consists of sequence model parameters, which correspond roughly to basic motion elements
- Sequence model parameters for General Move:
  - **A : Action distance** (move hands or feet) – horizontal body motions
  - **B : Body motion** (sit, stand up) – vertical body motions
  - **G : Gain control** (closely related to grasp)
  - **P : Placement** (e.g., position, lay aside, orient)

1. General Move

- Standard sequence in General Move:



ABG : to get an object;

ABP : to move the object to a new location;

A : return to original position

TABLE 14.6 MOST Parameters and Index Values for the General Move Activity Sequence Model

General Move activity sequence model = **A B G A B P A**				
Index	**A** = Action distance	**B** = Body motion	**G** = Gain control	**P** = Placement
0	Close ≤ 5 cm (2 in.)			Hold, Toss
1	Within reach (but > 2 in.)		Grasp light object using one or two hands	Lay aside Loose fit
3	1 or 2 steps	Bend and arise with 50% occurrence	Grasp object that is heavy, or obstructed, or hidden, or interlocked	Adjustments, light pressure, double placement
6	3 or 4 steps	Bend and arise with 100% occurrence		Position with care, or precision, of blind, or obstructed, or heavy pressure
10	5, 6, or 7 steps	Sit or stand		
16	8, 9, or 10 steps	Through door, or Climb on or off, or Stand and bend, or Bend and sit		

1 Index = 10 TMU

1. General Move

Develop the activity sequence model and determine the normal time for the following work activity:

A worker walks 5 steps, picks up a small part from the floor, returns to his original position, and places the part on his worktable.

Solution :

$$A_{10}B_6G_1A_{10}B_0P_1A_0$$

where

A_{10}=walk 5 steps;

B_6=bend and arise;

G_1=gain control of small part;

A_{10}=return back;

B_0=no body motion;

$P_{1=}$lay aside part on table;

A_0=no motion

The sum of index values: 28.

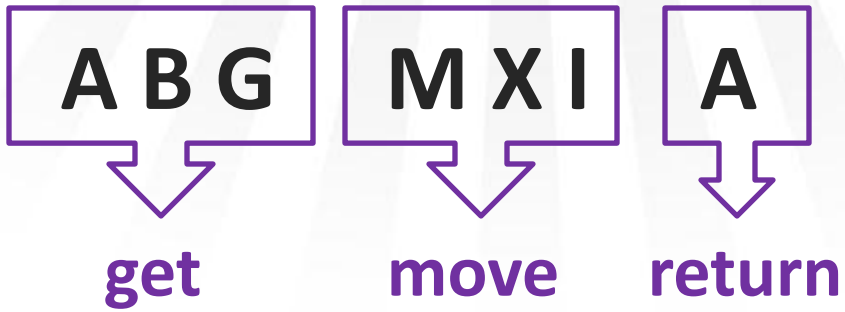
Normal time: 10*28=280 TMUs

2. Controlled Move

- Used when an object is moved through a path that is somehow constrained.
  - M : Move, controlled
  - X : Process time
  - I : Align

2. Controlled Move

- Standard sequence in Controlled Move:



ABG : to get an object;

MXI : to move the object followed by a process time and alignment,

A : to return

TABLE 14.7 MOST Parameters and Index Values for the Controlled Move Activity Sequence Model

Controlled Move activity sequence model = **A B G M X I A**				
Index	**M** = Move, controlled	**X** = Process time[a]		**I** = Alignment
		Seconds	Minutes	
1	Push, pull, pivot: button, switch, knob (≤ 12 in.)	0.5	0.01	Align to one point
3	Push and pull, turn, open, seat, shift, press: resistance encountered, or high control required, or 2 stages of control (≤ 12 in.); 1 crank of lever.	1.5	0.02	Align to 2 points, Close align (≤ 4 in.)
6	Open and shut, operate, push or pull: with 1 or 2 steps (> 12 in.); 3 cranks of lever.	2.5	0.04	Align to 2 points, Close align (> 4 in.)
10	Manipulate, maneuver, push, or pull with 3, 4, or 5 steps; 6 cranks of lever.	4.5	0.07	Precision align
16	Push or pull with 6, 7, 8, or 9 steps included; 11 cranks of lever.	7.0	0.11	High precision align

[a]For process times longer than those listed in the table, the actual process time in seconds can be multiplied by 2.78 and rounded to the next higher value to obtain the index for the X parameter.

2. Controlled move

Develop the activity sequence model and determine the normal time for the following work activity:

A worker takes 2 steps, grasp the waist-level feed lever on the lathe, pulls up the lever approximately 15 cm to engage the feed. Process time to turn the part is 25 sec.

- Solution:
  25 sec.s = 69.5 indices

$$A_3B_0G_1M_1X_{70}I_0A_0$$

where
A_3=walk 2 steps;
B_0=no body motion;
G_1=gain control of lever;
M_1=pull the lever up 15 cm:
X_{70}=process time of ;
I_0=no alignment;
A_0=no motion

The sum of index values: 75.
Normal time: 10*75=750 TMUs = 27 seconds

3. Tool use

- Applies a variety of work situations
  - F : fasten
  - L : loosen
  - C : cut
  - S : surface treat
  - M :measure
  - R : record
  - T : think

3. Tool use

- Only one is used in a sequence:

ABG ABP * ABP A

ABG: to get the tool

ABP: put the tool in the position

*: tool use code

ABP: put the tool aside

A: return

Other Versions of MOST

- **Maxi MOST** – for work cycles performed fewer than 150 times per week and there are variations in the cycle
  - Can be applied to tasks of several hours
- **Mini MOST** – for highly repetitive work cycles performed more than 1500 times per week
- **Clerical MOST** – similar to Basic MOST but designed for clerical tasks
- **MOST for Windows** – Computerized technique that allows user to apply Basic MOST, Maxi MOST, or Mini MOST to the task

“Knowing exactly what you want to do, and then seeing that they do it the best and cheapest way.”

- Frederick W. Taylor-