TIME AND METHOD

Predetermined standard times

- The Predetermined Standard Time systems are based on the basic principle that every elementary movement / activity requires practically the same time, with the same working conditions and if performed by a sufficiently skilled executor
- Times are expressed in the particular unit TMU (Time Measurement Unit)
  - 1 TMU = 0.00001 hours = 0.0006 min = 0.036 sec
  - 1 hour = 100,000 TMU
- For the calculation of the Standard Times, a correction coefficient F is usually added

Predetermined standard times

- Steps of the method to Predetermined Standard Times:

1. Breakdown of the work to be performed in its basic microelements
2. Identification in the appropriate tables of the TMU values related to the micro-movements
3. Adjustment of values through corrective factors
4. Execution of the sum of the values of all the micro-elements to be performed to carry out the work
5. Determination of the total standard time

Predetermined standard times

- There are several families and subfamilies of methods / systems for the calculation of predetermined standard times
- The most common (from which derives most of the others) is the family known as MTM (Method Time Measurement)
- The different MTM systems allow the applicability of the method according to the diversity of user needs. The main families are:
  - Motion-based systems MTM 1
  - Element-based systems MTM II (es. MTM UAS, MTM MEK, MTM-HC)
  - Activity-based systems -MOST

Predetermined standard times

- The original MTM method defines the times of the main micromovements of upper limbs, eyes and lower limbs
- The 9 micromovements of the upper part of the body
  - (Reach)
  - (Move)
  - (Turn)
  - (Apply Pressure)
  - (Grasp)
  - (Release)
  - (Position)
  - (Disengage)
  - (Crank)

Each movement corresponds to a table that provides the TMU according to the boundary factors (distances to be covered, weights, shapes of objects ..)

Tempi standard predeterminati

TABLE 7.1 Predicted Move–Time Data in Which a *Move* is Defined as a Motion of the Hand Required to Transport an Object (from MTM Association for Standards and Research, Fairlawn, NJ 07410)

	Time, TMUs				Allowance			
Distance Moved (cm)	A	B	C	Hand in Motion B	Weight (kg) up to	Constant (TMUs)	Factor	Case and Description
0 to 2	2.9	2.0	2.0	1.7	1	0	1.00	A Move object to other hand or against stop
4	3.1	4.0	4.5	2.8	2	1.6	1.04	
6	4.1	5.0	5.8	3.1				
8	5.1	5.9	6.9	3.7				
10	6.0	6.8	7.9	4.3				
					4	2.8	1.07	
12	6.9	7.7	8.8	4.9				
14	7.7	8.5	9.8	5.4	6	4.3	1.12	
16	8.3	9.2	10.5	6.0				
18	9.0	9.8	11.1	6.5				
20	9.6	10.5	11.7	7.1	8	5.8	1.17	B Move object to approximate
22	10.2	11.2	12.4	7.6	10	7.3	1.22	

Tempi standard predeterminati

22	10.2	11.2	12.4	7.6
24	10.8	11.8	13.0	8.2
26	11.5	12.3	13.7	8.7
28	12.1	12.8	14.4	9.3
30	12.7	13.3	15.1	9.8
35	14.3	14.5	16.8	11.2
40	15.8	15.6	18.5	12.6
45	17.4	16.8	20.1	14.0
50	19.0	18.0	21.8	15.4
55	20.5	19.2	23.5	16.8
60	22.1	20.4	25.2	18.2
65	23.6	21.6	26.9	19.5
70	25.2	22.8	28.6	20.9
75	26.7	24.0	30.3	22.3
80	28.3	25.2	32.0	23.7

10	7.3	1.22	**B** Move object to approximate or indefinite location
12	8.8	1.27	
14	10.4	1.32	
16	11.9	1.36	C Move object to exact location
18	13.4	1.41	
20	14.9	1.46	
22	16.4	1.51	

Motion-based (MTM 1)

- MTM 1 is a very detailed and reliable system that focuses on the analysis of the movements of the two hands
- It is suitable for the study of processes:
  - to another degree of repetitiveness
  - very short cycles,
  - when errors of a few TMUs could cause great inconveniences in production and economic convenience

- For example for brake assembly lines

Motion-based (MTM-1)

Left hand description	F	Left hand movement	TMU	Right hand movement	F	Right hand description
SCREW 2 BOLTS						
Reach the bolt		R24C	12.5	R24C		Reach the bolt
Grasp		G4B	9.1	-		
		-	9.1	G4B		Grasp
Bolt to assembly		M24C	13.0	M24C		Bolt to assembly
Position 1st bolt		P2SE	16.2	-		
Search thread	2	M2B	4.0	-		
		-	16.2	P2SE		Position 1st bolt
		-	4.0	M2B	2	Search thread
Release		RL1	2.0	RL1		Release
fastening cycle	8	R2A	16.0	R2A	8	fastening cycle
	8	G1A	16.0	G1A	8	
	8	M2B	16.0	M2B	8	
	8	RL1	16.0	RL1	8	
		Total	**150.1**			
TIGHTEN 2 BOLTS WITH A WRENCH						
Reach the assembly		R-A	12.8	R30B		Reach the wrench
Grasp		G1A	3.5	G1B		Grasp
			15.1	M30C		Wrench to assembly
			14.7	P1SSD		Position
			1.6	SC2		Static component
			10.9	M20B2		Screw
			11.7	M20C		Recovery with wrench
			14.7	P1SSD		Reposition wrench
			1.6	SC2		Static component
			9.6	M16B2		Screw
			10.6	APA		Tighten
			13.3	M30B		Recovery with wrench
			2.0	RL1		Release
		Total	**122.1**			

Element-based (MTM 2)

- he Element-based family is a derivative of MTM-1, corresponding to a simplification of the detected movements and a specialization in different sectors
- There are a number of subfamilies of specialization in the sector, e.g. MTM-HC (for the healthcare industry), MTM-C (for office work), MTMM (for microscopic work ...)
- MTM UAS is a system derived from MTM-1 through statistical processing of the tabulated data, which does not distinguish the detail movement of the two hands
- It is the result of an aggregation of the basic movements of MTM 1 in main handling elements ,.
- Suitable for processes characterized by significant variations in the production cycle

Element-based (MTM 2)

Description	Code	TMU	F	TMU sum
SCREW 2 BOLTS				
Grasp and position bolts	AF2	65		65
	AF1	40		40
Screw with hand	ZB1	10	8	80
		Total		185
TIGHTEN 2 BOLTS WITH A WRENCH				
Grasp and reposition wrench	HB2	60		60
Screw	ZA1	5		5
Reposition wrench	ZC1	30		30
Tighten	ZD	20		20
		Total		115

Activity-based (MOST)

- MOST (Maynard Operation Sequence Tecnique) is a faster MTM system than previous families, because it identifies the main activities and not the single movements
- Naturally it loses in level of detail and therefore precision in the elaboration of the standard times MOST defines not a series of movements, but a sequence of events / activities that involve the movements
- The basic MOST events are:
  - The sequence of movement of an object
  - The control sequence of an object
  - The sequence of use of tools and an object
  - The sequence for the use of manual cranes

Activity-based (MOST)

- Alongside each sub-activity is the execution time, which derives (as in the other methods) from standardized tables according to different parameters (eg number of steps within the sub-activity)
  - The time indicated in the index is 1/10 of a standard TMU
  - The standard time is obtained as TMU + allowance factor, where allowance factor = increase of the standard time for personal rest (P), fatigue (F), different delays (D)
  - Usually the allowance factor is at least 15% of the standard time calculated with MOST

General move

- A B G A B P A

- A → action distance
- B → body motion
- G → gain control
- P → placement

BasicMOST® System — General Move — A B G A B P A

Index x 10	A Action Distance	B Body Motion	G Gain Control	P Placement	Index x 10
0	≤ 2 in. (5 cm)			Pickup Toss	0
1	Within Reach		GRASP: Light Object Light Objects Simo	PUT: Lay Aside Loose Fit	1
3	1 – 2 Steps	Sit or Stand Bend and Arise 50% occ.	GET: Light Objects Non-Simo Heavy or Bulky Blind or Obstructed Disengage Interlocked Collect	PLACE: Loose Fit Blind or Obstructed Adjustments Light Pressure Double Placement	3
6	3 – 4 Steps	Bend and Arise		POSITION: Care or Precision Heavy Pressure Blind or Obstructed Intermediate Moves	6
10	5 – 7 Steps	Sit or Stand with Adjustments			10
16	8 – 10 Steps	Stand and Bend Bend and Sit Climb On or Off Through Door			16

Figure 3.1 General Move data

Action Distance

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

General move

represents the activity "Walk for three steps and take a bolt from the floor, lift it up and put it in a box",

A6 B6 G1 A1 B0 P3 A0

TMU = (6 + 6 + 1 + 1 + 0 + 3 + 0) * 10 = 170 TMU = 0,102 min Tempo standard = 0,102 min * 1,15 = 0,1173 min

con allowance factor pari al 15%

Controlled move

- A B G M X I A

- A → action distance
- B → body motion
- G → gain control
- M→ Move controlled
- X →Process time
- I → alignment

BasicMOST® System **Controlled Move** **A B G M X I A**

Index x 10	M Move Controlled		X Process Time			I Alignment	Index x 10
	Push/Pull/Turn	Crank	Seconds	Minutes	Hours		
1	≤ 12 in. (30 cm) Button Switch Knob		.5 Sec.	.01 Min.	.0001 Hr.	1 Point	1
3	> 12 in. (30 cm) Resistance Seat or Unseat High Control 2 Stages ≤ 24 in. (60 cm) Total	1 Rev.	1.5 Sec.	.02 Min.	.0004 Hr.	2 Points ≤ 4 in. (10 cm)	3
6	2 Stages > 24 in. (60 cm) Total 1 – 2 Steps	2 – 3 Rev.	2.5 Sec.	.04 Min.	.0007 Hr.	2 Points > 4 in. (10 cm)	6
10	3 – 4 Stages 3 – 5 Steps	4 – 6 Rev.	4.5 Sec.	.07 Min.	.0012 Hr.		10
16	6 – 9 Steps	7 – 11 Rev.	7.0 Sec.	.11 Min.	.0019 Hr.	Precision	16

Figure 3.10 Controlled Move data card.

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

Controlled move

- indicates the activity of setting a control parameter on a machine (eg milling machine)

A1 B0 G1 M1 X10 I0 A0

Tool use

- A B G A B P … A B P A

- A → action distance
- B → body motion
- G → gain control
- P → placement
- … → F fasten, L loosen, C cut, S surface treat, M measure, R record, T think

BasicMOST® System Tool Use A B G A B P A B P A

Index x 10	Finger Action	Wrist Action				Arm Action					Power Tool	Index x 10
	F Fasten or **L** Loosen											
	Spins	Turns	Strokes	Cranks	Taps	Turns		Strokes	Cranks	Strikes	Screw Diam.	
	Fingers, Screwdriver	Hand, Screwdriver, Ratchet, T-Wrench	Wrench	Wrench, Ratchet	Hand, Hammer	Ratchet	T-Wrench, 2-Hands	Wrench	Wrench, Ratchet	Hammer	Power Wrench	
1	1	-	-	-	1	-	-	-	-	-	-	**1**
3	2	1	1	1	3	1	-	1	-	1	1/4 in. (6 mm)	**3**
6	3	3	2	3	6	2	1	-	1	3	1 in. (25 mm)	**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	15	30	12	8	6	6	16		**32**
42	47	23	13	20	39	15	11	8	8	21		**42**
54	61	29	17	25	50	20	15	10	11	27		**54**

BasicMOST® System Tool Use A B G A B P [illegible] A B P A

Index x 10	C Cut				S Surface Treat			M Measure	R Record			T Think			Index x 10
	Cutoff	Secure	Cut	Slice	Air-Clean	Brush-Clean	Wipe	Measure	Write		Mark	Inspect	Read		
	Pliers		Scissors	Knife	Nozzle	Brush	Cloth	Measuring Tool	Pencil/Pen		Marker	Eyes/ Fingers	Eyes		
	Wire		Cuts	Slices	sq. ft. (0.1 m^2)	sq. ft. (0.1 m^2)	sq. ft. (0.1 m^2)		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	Medium	Twist Form Loop	4	-	1 Spot Cavity	1	-		4	1	2	5 Feel 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		Secure Cotter Pin	11	4	3	2	2	Fixed Scale Caliper $\le$ 12 in. (30 cm)	9 Signature or Date	2	5	14	Table Value	38	**16**
24			15	6	4	3	-	Feeler Gauge	13	3	7	19		54	**24**
32			20	9	7	5	5	Steel Tape $\le$ 6 ft. (2 m) Depth Micrometer	18	4	10	26		72	**32**
42			27	11	10	7	7	OD-Micrometer $\le$ 4 in. (10 cm)	23	5	13	34		94	**42**
54			33					ID-Micrometer $\le$ 4 in. (10 cm)	29	7	16	42		119	**54**

Manual crane model

- A T K F V L V P T A

- A → distanza percorsa
- T → trasport unloaded
- K → Hook-Unhook
- F → Free
- V → Vertical move
- L → Loaded move
- P → Placement

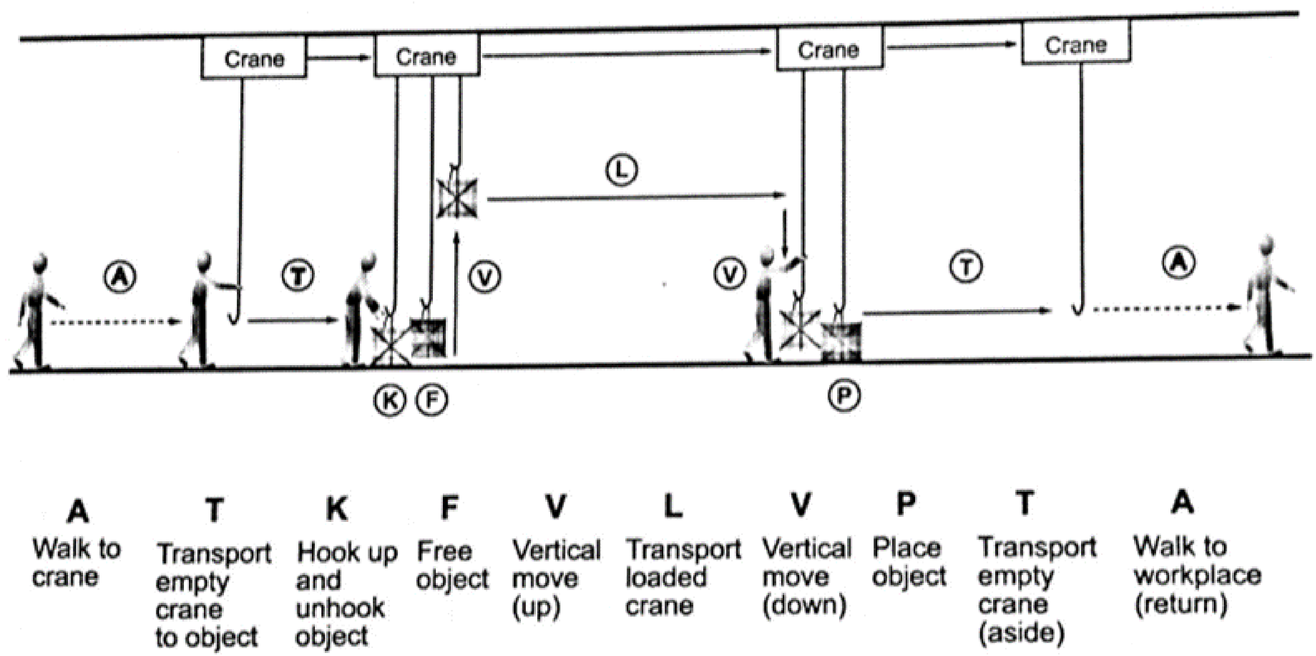


Figure 3.55 Illustration of Manual Crane Sequence Model.

BasicMOST® System **Manual Crane**

Index x 10	T	L	K Hook-up and Unhook	F Free Object	V Vertical Move	P Placement	Index x 10
	Transportation up to 2 Tons						
	Unloaded	Loaded			Inches (cm)		
	Feet (m)						
3				Without Direction Change	8 (20)	Without Direction Change	3
6				With Single Direction Change	16 (40)	Align with One Hand	6
10	5 (1.5)	5 (1.5)		With Double Direction Change	30 (75)	Align with Two Hands	10
16	13 (4)	12 (3.5)		With One or More Direction Changes, Care in Handling or Apply Pressure	45 (115)	Align and Place with One Adjustment	16
24	20 (6)	18 (5.5)	Single or Double Hook		60 (150)	Align and Place with Several Adjustments	24
32	30 (9)	26 (8)	Sling			Align and Place with Several Adjustments and Apply Pressure	32
42	40 (12)	35 (10)					42
54	50 (15)	45 (13)					54

Figure 3.56 Manual Crane data card. Values are read up to and including. Transportation times for the **T** and **L** parameters must be validated before application of the Manual Crane Sequence Model.

Activity-based (MOST)

TEMPI STANDARD LAVORAZIONI ELETTRICHE

INSERZIONE TAPPO CON ROJONIC WW015

DESCRIZIONE ATTIVITA'	NOTA	CODICE SEQUENZA	TEMPO CICLO SEC.	% MEDIA FATTORE RIPOSO	TOTALE TEMPO TP	TOTALE TEMPO TL
Attivare il sistema informatico e leggere a terminale le istruzioni	*	A1B0G1M3X32I0A0	13.32		14.52	
Cliccare sul mouse per visualizzare posizione di inserzione.		A1B0G1M3X3I0A0	2.88			3.11
Identificare il foro illuminato sul connettore		A0B0G0A0B0P0T3A0B0P0A0	1.08			1.17
Spostare i cavi già inseriti per liberare il foro illuminato		A1B0G1A1B0P3A0 (F2)	4.32			4.66
Prendere il piolo e inserirlo nel foro del connettore illuminato da Rojonic		A1B0G1A1B0P3A0	2.16			2.27
Prendere l'insertore posizionarlo sul piolo e inserirlo, togliere e posare l'insertore sul banco		A1B0G1A1B0P6F3A1B0P1A0	5.04	8		5.44
Prendere il tappo e inserirlo nel foro del connettore illuminato da Rojonic		A1B0G1A1B0P3A0	2.16			2.27
Prendere l'insertore posizionarlo sul tappo e inserirlo, togliere e posare l'insertore sul banco		A1B0G1A1B0P6F3A1B0P1A0	5.04			5.44
Segnalare al sistema mediante mouse dell'operazione eseguita	*	A1B0G1M3X32I0A0	13.32		14.52	
TOTALE TEMPO ASSEGNATO (SEC.) PER ATTIVITA' DI SETUP (TP) COMPRESA % PER FATTORE DI RIPOSO + 5% PER IMPREVISTI					30	
TOTALE TEMPO ASSEGNATO (SEC.) PER ATTIVITA' DI RUN (TL) COMPRESA % PER FATTORE DI RIPOSO + 5% PER IMPREVISTI						26

NOTA : (*) attivita' di setup da dividere per il n° di cavi componenti l'operazione

Advantages

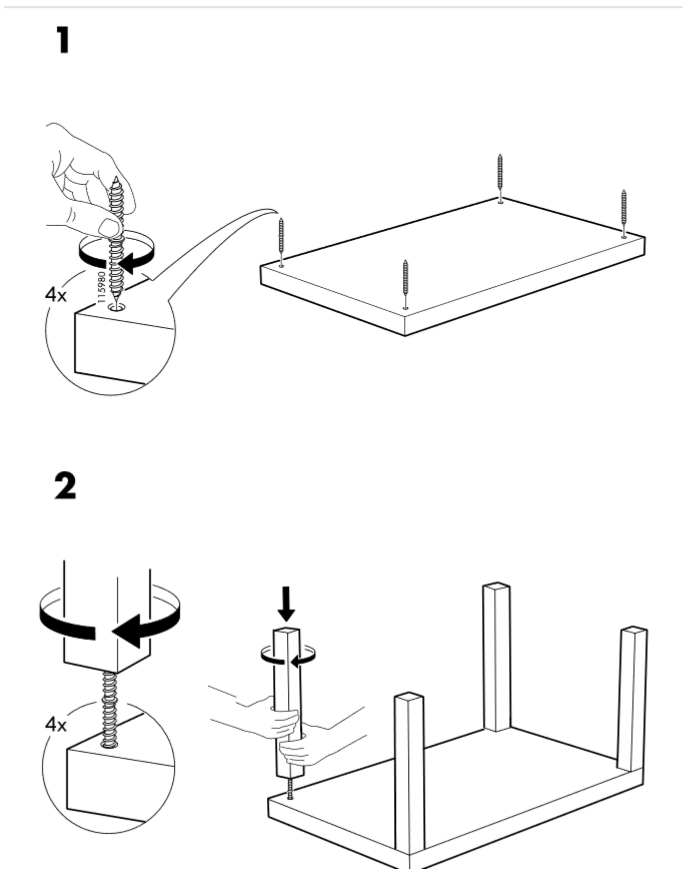
- The standard times can be accurately evaluated (differently depending on the MTM family) before production starts
- You can compare without making more alternatives on the work cycles
- The possibilities of error in the recording of times and performances are theoretically reduced
- It is easier to apply and cheaper than Time Study systems. They are usually more easily accepted by trade union

Disadvantages

- It is practically inapplicable if the activities are not very repetitive
- In the application of more detailed families (eg MTM 1) the division of labor into micro-operations can be very difficult
- The parameters chosen for the timing determination may not be suitable for any work situation
- Factors that could introduce variability in execution times are potentially unlimited, therefore not all are included in the tables (eg MTM 1 does not consider the shape of the pieces to be moved)

Example

- A B G A B P A
- A B G M X I A
- A B G A B P … A B P A



Learning curve

Definizione

The learning curve (or progress curve or learning curve) is a tool used to design (or reorganize) production systems in consideration of variations that occur over time as a result of the learning phenomenon.

‘The productive efficiency of each activity increases continuously by repeating this activity’

A concept that, translated into appropriate mathematical models, makes it possible to forecast with reasonable accuracy the variation in time of learning-related quantities (and progress) such as the unit cost of the product, the time needed to build it, the maintenance hours necessary, etc.

Learning

Learning is the sum of:

Discrete factors: they cause a practically instantaneous and easily perceived variation of the observed quantity

- Inventions
- Discoveries
- applications., widespread and in short time, of innovative technologies

Continuous improvements: non-perceptible events, if the observation is superficial, due to the areas

- design
- technological / technical
- organization / management

Continuous improvements

Project area
- documentation on the state of the art
- product design
- better definition of operating methods

Technological / technical area
- automation
- Application of alternative technologies
- Procedures optimization

More appropriate choices of tools
- Management organizational area
- Organization of departments
- level of training

Production control
- Employment of labor
- Use of materials
- Use of energy

Continuous improvements

In order to continuously improve it is still necessary to create ideal conditions in the company. In fact, learning depends on:

Attitude / ability to learn
- Physical adaptability
- Cultural degree
- Grounds

Characteristics of the work to be done
- complexity
- Length of cycle times

Boundary conditions
- External motivations
- Changes in situations
- Conditions related to work

Wright Model (1936)

$$y = a * x^{-b}$$

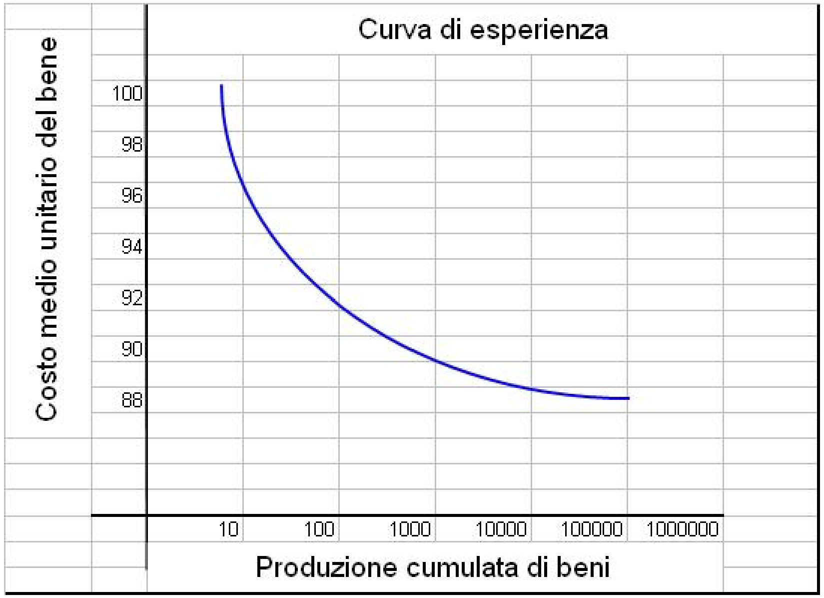
y = measure of productivity (eg: unit cycle time, unit cost, unit weight)

a = parameter linked to the measure of productivity or productivity at the initial time (e.g.: first piece)

x = cumulated volume of production

b = learning rate or margin of productivity margin

Wright model



Wright model

- The variation in productivity is normally expressed in percentage terms which obviously corresponds to a precise numerical value of the parameter b

Productivity variation %	Learning curve(**b**)
55	0,8292
60	0,7372
70	0,514
80	0,322
90	0,152
95	0,074

Wright model

- How to define the parameters a and b

- Cochran
- Williams
- Baloff
- Westinghouse

Wright model

- Determination of the values of parameters a and b
- Cochran method:

a) Determine the value of steady-state productivity (eg: standard productivity after n productions)
b) Estimate the percentages of improvement of each of the activities in which the production is divided
c) Assign a weight to each activity to arrive at a weighting average improvement rate
d) Starting from the regime productivity and thus having estimated the rate of improvement, determine the initial productivity a

Wright model

- Determination of the values of parameters a and b
- Williams method:

a) Examination of curves for similar productions and confirmed in practice
b) The curve considered most suitable among the examined is taken into consideration, assuming its rate of improvement b
c) The productivity of the second production is measured by calculating the initial productivity a

Wright model

- Baloff method:
- A correlation between the rate of improvement b and productivity y is considered
- Westinghouse method:

a) Like Williams, it takes a characteristic curve to determine the rate of improvement b and productivity y

b) Like Cochran, he estimates steady-state productivity and the amount of production to achieve it to determine initial productivity a

Determination of the values of parameters a and b

- By increasing the cumulative production, as a result of learning rates related to the various operations, it could generate imbalances between the stations of the line. To avoid this problem and rebalance the lines, one can take a cue from what Dar-El and Rubinovitz suggested

Determination of the values of parameters a and b

- Dar-El and Rubinovitz method
- Using fairly simple criteria, the operations are divided into two categories
  - Phases characterized mainly by intellectual learning. These phases are further distinguished between phases of high and low intellectual learning, respectively with improvement rates b between 70% and 75% and rates between 75% and 80%
  - Stages characterized mainly by acquisition of manual skills. These phases are further distinguished between phases of high and low acquisition of manual skill, respectively with b improvement rates between 80% and 85% and rates between 85% and 90%
- The weighted curve to be used is determined
- By means of an algorithm that takes into account the different regressions, the redefinition of the production lines is achieved as a function of the increase in the cumulative production

Determination of the values of parameters a and b

- To take into account the fact that production can be suspended for a certain period of time and then resumed, typical of batch production, it is necessary to consider the possibility of forgetting, the forgetting factor. In general terms the forgetting factor depends mainly on the time interval between the production of a batch and the next and the complexity of the operations.

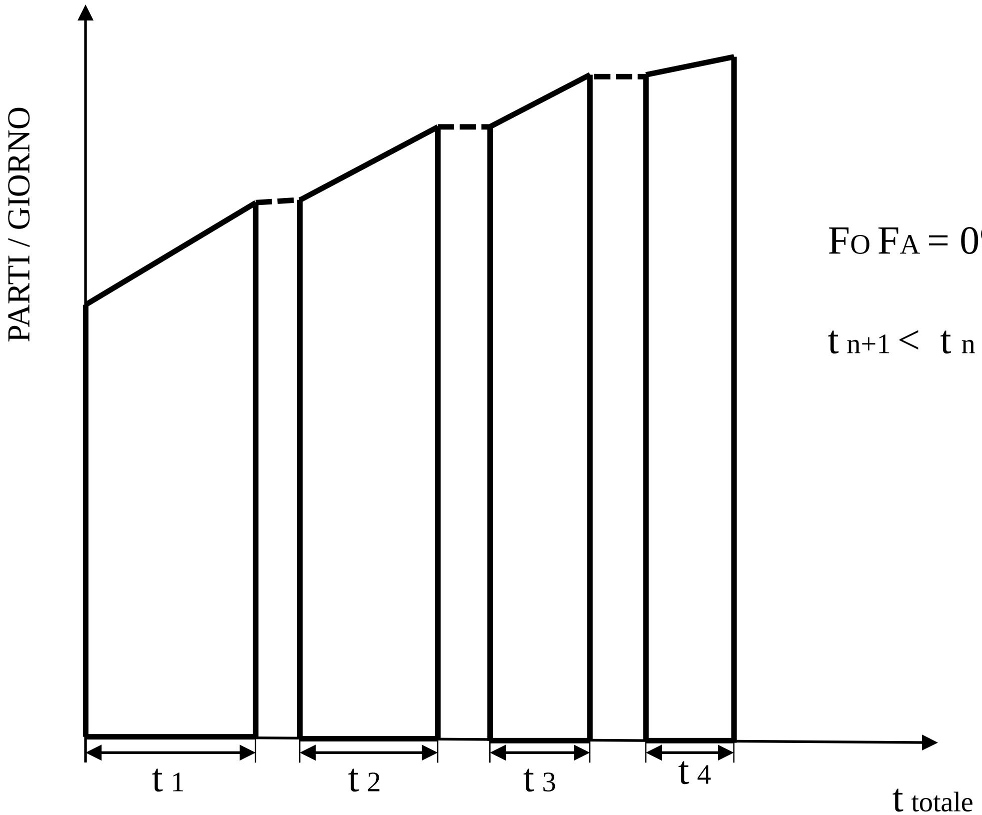
- Towill exemplified what can happen when the forgetting factor changes.

Determinazione dei valori dei parametri **a** e **b**

- Towill analysis

a) A certain quantity of identical parts is considered to be produced in n lots of equal sizes interspersed with equal times
b) The size of the lots is varied
c) The value of the forgetting factor expressed in percentage terms is changed
d) The result is analyzed according to the total time necessary for the production of the whole quantity assumed.

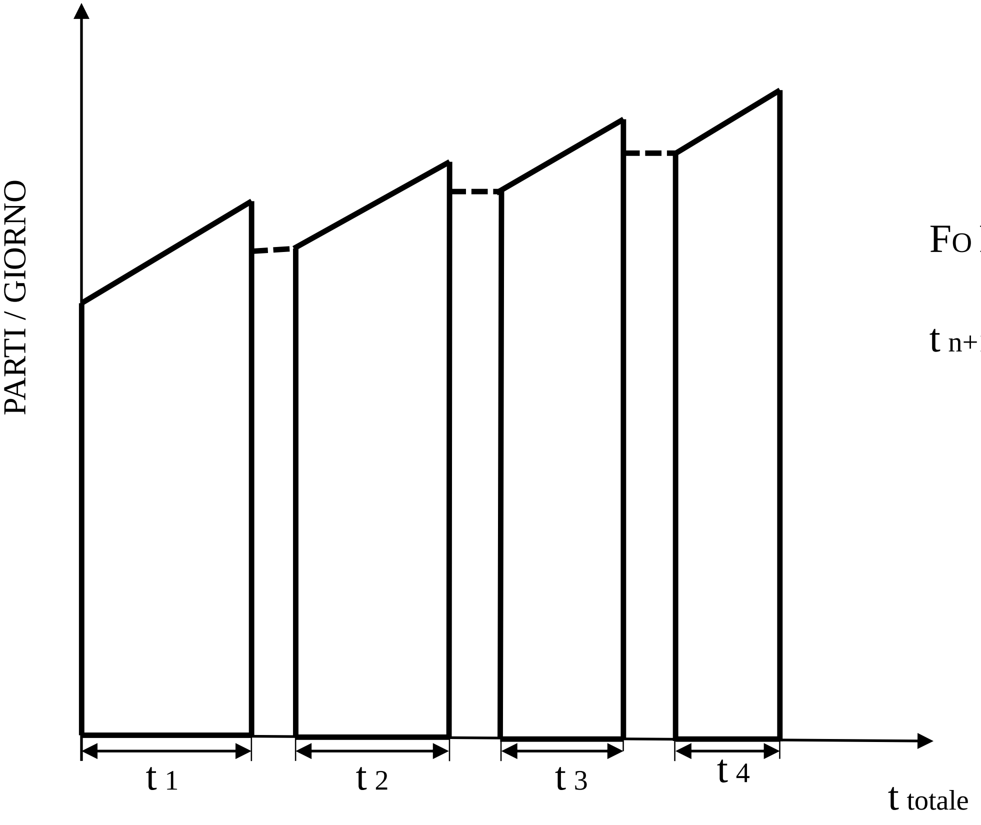
Towill



$F_O F_A = 0\%$

$t_{n+1} < t_n$

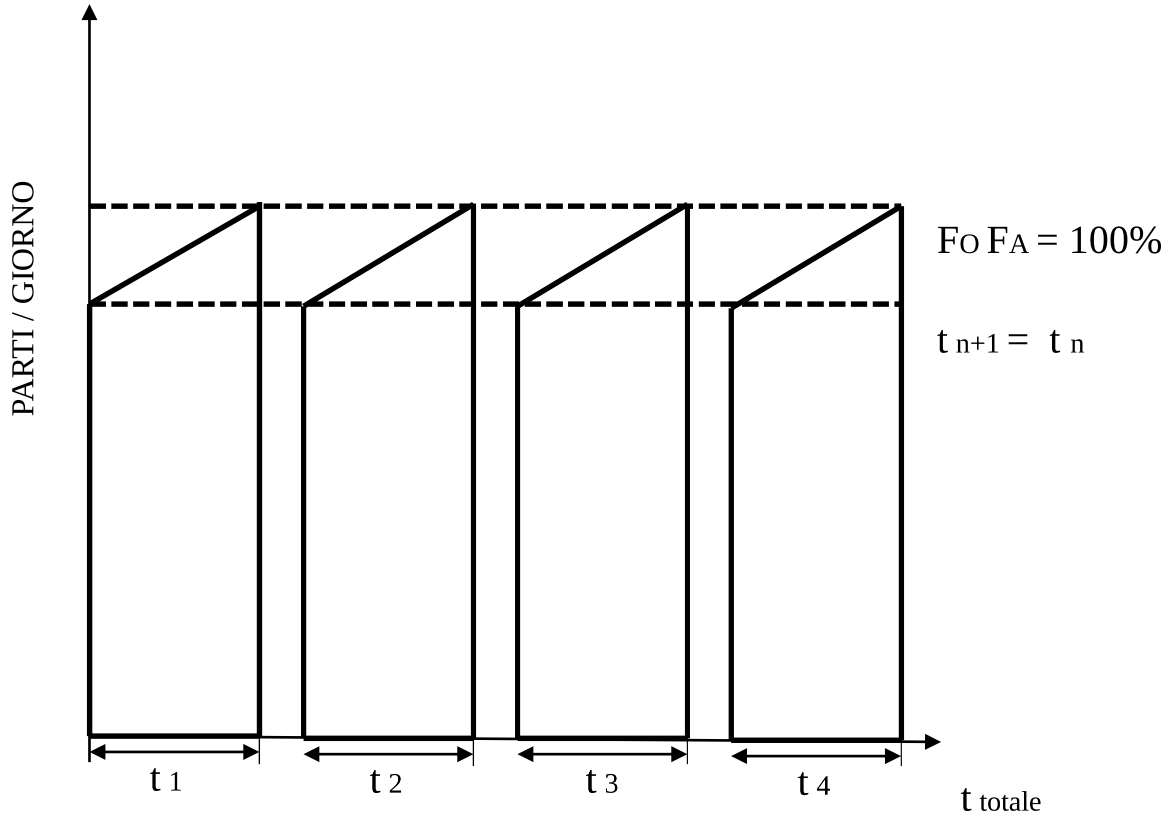
Towill



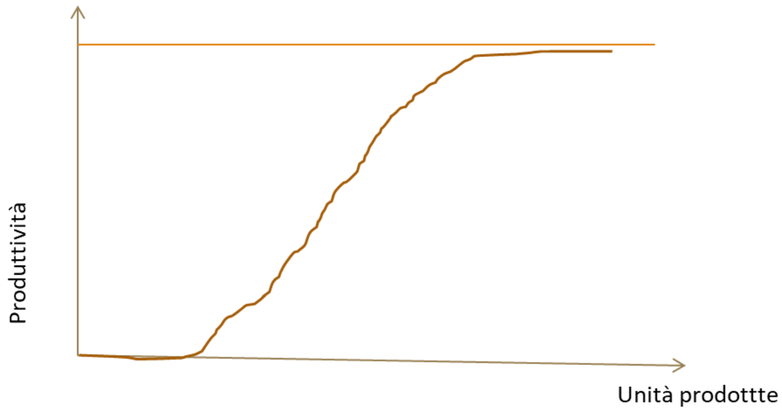
$F_O F_A = 50\%$

$t_{n+1} < t_n$

Towill



Other model



- Curves to S
- The canonical S curve provides:
  - a first slow learning phase
  - a second fast learning phase
  - a third slow-learning phase tending to an asymptote

- The variants to the canonical model are the:
  - multi-stage S-curves
  - asymmetrical S curves