APPLICATION of WORK SAMPLING and ECRS (Eliminate, Combine, Re-lay out and Simplify) PRINCIPLES of IMPROVEMENT at TO1 ASSEMBLY

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ABSTRACT

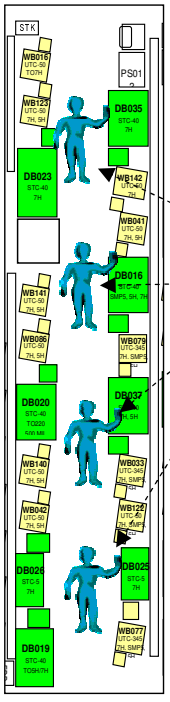
To continuously improve productivity, **Improvement Cycle** was developed, starting from the process and work content analysis down to the execution of process improvement using various IE methodologies.

The **WORK SAMPLING** Technique and **ECRS (Eliminate, Combine, Relay-out & Simplify)** principle of improvement was employed during the study in Transistor Outline Package (TO) assembly that resulted to a 25 % reduction of manpower allocation.

1.0 INTRODUCTION

Guided by the improvement cycle, each production line was studied. One of the areas identified with improvement opportunity is the Transistor Outline Package (TO1) assembly line. The Line comprised of Die bonding and Wire bonding machines. There are four (4) assigned manpower responsible for *Die bonding operation, Die bonding on-line inspection, Wire bonding operation and Wire bonding on-line inspection. See figure1.0.*

Fig.1.0 Transistor Package (TO) ASSEMBLY layout:



FUNCTION	NO. OF MAN PER SHIFT	TOTAL NO. OF MAN FOR 3 SHIFTS
Die bonding operator	1	3
Die bonding on-line	1	3
Wire bonding operator	1	3
Wire bonding on-line	1	3
TOTAL	**4**	**12**

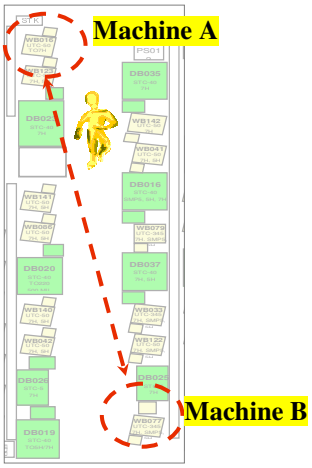
Legend:
-8 Die bonding machines
-12 Wire bonding machines

1.1 Problem objective

To come up with an improvement concerning manpower productivity and process efficiency

1.2 Problem statement

With the current set-up of machines, distance of end to end machines are far from each other which makes it difficult for both operators and inspectors during error assist, product and material handling. The issue concerning the distance travelled contributes to high man time.



**Walk time from machine A to B: 11 seconds*

1.3 Problem scope

The project is mainly focused at Transistor Outline Package (TO1) assembly line. Contributing factors such as man, machine, method and materials from the affected line will be subjected to analysis.

2.0 EXPERIMENTAL SECTION

2.1 Materials and Equipments

2.1.1 Production check sheets/lot b card
2.1.2 Stopwatch,
2.1.3 Time & motion worksheet.
2.1.4 Work instructions

2.1.5 Die bond and Wire bond Machines

2.2 PROCEDURE

2.2.1 TIME AND MOTION STUDY

TO1 Die bonding and Wire bonding assembly process was analyze into work elements to easily cater the application of **ECRS (Eliminate, Combine, Relay-out & Simplify)** principle. A time and motion study was conducted to determine the standard time to do each job. Shown below are the steps performed during the study:

A. Making the time study

The stop watch method was use in securing and recording the operation and operator being studied.

B. Determining the number of observation

A decision must be made as to the confidence level and the desired accuracy that are to be used in determining the number of observations to make. A 95% confidence level and ±5%precision are commonly used in the time study.

$$N' = \frac{40\sqrt{N\Sigma X^2) - (\Sigma X)^2}}{(\Sigma X)^2}$$

5% Precision

$$N' = \frac{20\sqrt{N\Sigma X^2) - (\Sigma X)^2}}{(\Sigma X)^2}$$

10% Precision

Where:
N= actual number of observations of the element
X= each stop- watch reading or individual observation
Σ *= sum of individual readings*

Codetermining Rating Factor and Normal Time

The WESTINGHOUSE system of rating was use to rate the operator's performance**.** (a) SKILL, (b) EFFORT,(c) CONDITIONS, (d) CONSISTENCY.

Normal Time was measured to determine the time that a qualified operator would need to perform the job if he worked at a normal pace.

NORMAL TIME=Observed Average Time X rating Factor

C. Determining Allowances and Standard Time

Allowances were considered during the study depending on the work content; such interruptions were classified as follows: (1) Personal Allowance, (2) Fatigue Allowance, or (3) Delay Allowance. STANDARD TIME computation includes all elements in the operation and all necessary allowances. Standard time is equal to normal time plus the allowances.

STANDARD TIME = Normal Time x {100/(100-Allowance in Percent)}

2.2.2 WORK SAMPLING AND STRUCTURED ESTIMATING

After the standard time was determined, Work sampling technique was used to easily discern how much time is spend waiting for work, or performing paperwork tasks, or even performing activities that are not included in their job descriptions.

A. WORK SAMPLING PROCEDURE
The following steps used for WORK SAMPLING were carried out:

A.1 Establish the Purpose of the study-
the objective of the study should be established.

A.2 Identify the Subjects-
the people performing the task must be identified

A.3 Identify the Measure of Output –
the identification of the measure of the output produced or the types of activities performed on the jobs being studied.

A.4 Establish a Time Period-
Starting and stopping points for the study must be defined as well.

A.5 Define the Activities-
activities that are performed by the people under study must be define.

-Direct Productive Work- work that is focused on the product and machine operations.

-Indirect Productive Work-work that is complementary to the product or machine operations.

-Non-Productive Work- actions that are not needed in the product or lot.

-Out of Work: operator is not within the area or line. They are furthered classified as ASSIGNED (deployed at an area) or UNKNOWN.
-Break time: Scheduled (Company Mandated Break time) Personal

-Working Time = Direct and Indirect ProductiveWork and Out of Work (Assigned).

-Idle Time = Out of Work (Unknown) and Breaktime.

A.6 Determine the Number of Observations Needed

$$\sigma p = \sqrt{\frac{pq}{n}}$$

where

σp = standard error of proportion

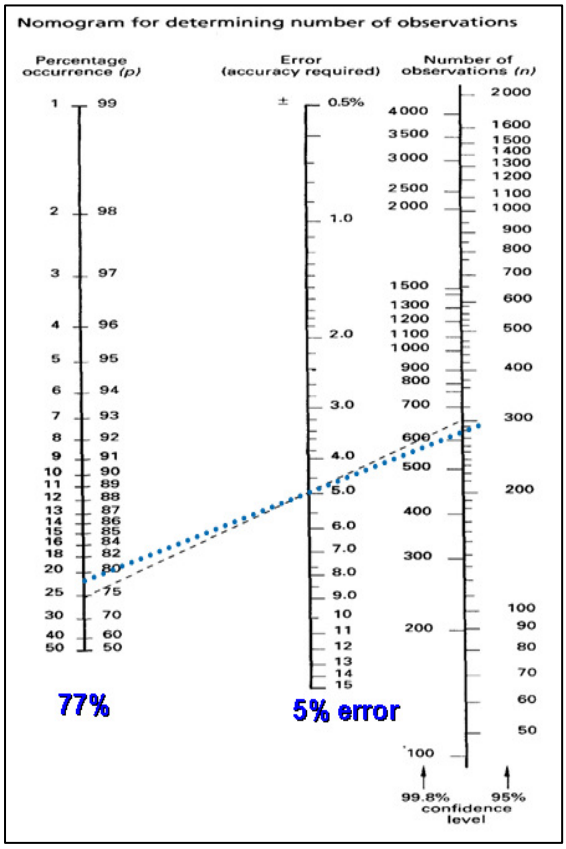
p = percentage of idle time

q = percentage of working time

n = number of observations or sample size we wish to determine.

A.6.A Using the statistical method

A.6.2 Using the nomogram method-
*a*n easier way to determine sample size is to read off the number of observations needed directly from a nomogram



A.7 Schedule the Observations –
Once the number of required observations has been determined, the actual observations must be scheduled using random number table .Refer to table shown:

Table 1:Table of Random Numbers

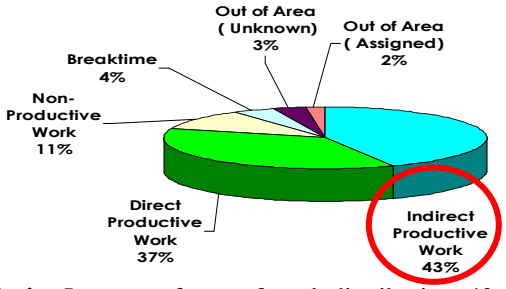
49 54 43 54 82	17 37 93 23 78	87 35 20 96 43	84 26 34 91 64
57 24 55 06 88	77 04 74 47 67	21 76 33 50 25	83 92 12 06 76
16 95 55 67 19	98 10 50 71 75	12 86 73 58 07	44 39 52 38 79
78 64 56 07 82	52 42 07 44 38	15 51 00 13 42	99 66 02 79 54
09 47 27 96 54	49 17 46 09 62	90 52 84 77 27	08 02 73 43 28
44 17 16 58 09	79 83 86 19 62	06 76 50 03 10	55 23 64 05 05
82 97 77 77 99	83 11 46 32 24	20 14 85 88 45	10 93 72 88 71
82 97 77 77 81	07 45 32 14 08	32 98 94 07 72	93 85 79 10 75
50 92 26 11 97	00 56 76 31 38	80 22 02 53 53	86 60 42 04 53
83 39 50 08 30	42 34 07 96 88	54 42 06 87 98	35 85 29 48 39
40 33 20 38 26	13 89 51 03 74	17 76 37 13 04	07 74 21 19 30
96 83 50 87 75	97 12 25 93 47	70 33 24 03 54	97 77 46 44 80
88 42 95 45 72	16 64 36 16 00	04 43 18 66 79	94 77 24 21 90
33 27 14 34 09	45 59 34 68 49	12 72 07 34 45	99 27 72 95 14
50 27 89 87 19	20 15 37 00 49	52 85 66 60 44	38 68 88 11 80
55 74 30 77 40	44 22 78 84 26	04 33 46 09 52	68 07 97 06 57
59 29 97 68 60	71 91 38 67 54	13 58 18 24 76	15 54 55 95 52
48 55 90 65 72	96 57 69 36 10	96 46 92 42 45	97 60 49 04 91
66 37 32 20 30	77 84 57 03 29	10 45 65 04 26	11 04 96 67 24
68 49 69 10 82	53 75 91 93 30	34 25 20 57 27	40 48 73 51 92
83 62 64 11 12	67 19 00 71 74	60 47 21 29 68	02 02 37 03 31
06 09 19 74 66	02 94 37 34 02	76 70 90 30 86	38 45 94 30 38
33 32 51 26 38	79 78 45 04 91	16 92 53 56 16	02 75 50 95 98
42 38 97 01 50	87 75 66 81 41	40 01 74 91 62	48 51 84 08 32
96 44 33 49 13	34 86 82 53 91	00 52 43 48 85	27 55 26 89 62
64 05 71 95 86	11 05 65 09 68	76 83 20 37 90	57 16 00 11 66
75 73 88 05 90	52 27 41 14 86	22 98 12 22 08	07 52 74 95 80
33 96 02 75 19	07 60 62 93 55	59 33 82 43 90	49 37 38 44 59
97 51 40 14 02	04 02 33 31 08	39 54 16 49 36	47 95 93 13 30
15 06 15 93 20	01 90 10 75 06	40 78 78 89 62	02 67 74 17 33
22 35 85 15 33	92 03 51 59 77	59 56 78 06 83	52 91 05 70 74
09 98 42 99 64	61 71 62 99 15	06 51 29 16 93	58 05 77 09 51
54 87 66 47 54	73 32 08 11 12	44 95 92 63 16	29 56 24 29 48
58 37 78 80 70	42 10 50 67 42	32 17 55 85 74	94 44 67 16 94
87 55 36 22 41	26 78 63 06 55	13 08 27 01 50	15 29 39 39 43
71 41 61 50 72	12 41 94 96 26	44 95 27 36 99	02 96 74 30 83
23 52 23 33 12	96 93 02 18 39	07 02 18 36 07	25 99 32 70 23
31 04 49 69 96	10 47 48 45 88	13 41 43 89 20	97 17 14 49 17
31 99 73 68 68	35 81 33 03 76	24 30 12 48 60	18 99 10 72 34
94 58 28 41 36	45 37 59 03 09	90 35 57 29 12	82 62 54 65 60

A.8 Inform the Personnel Involved-the personnel involved should be informed about the objective of the study and the methodology that will be employed

A.9 Record the Raw Data

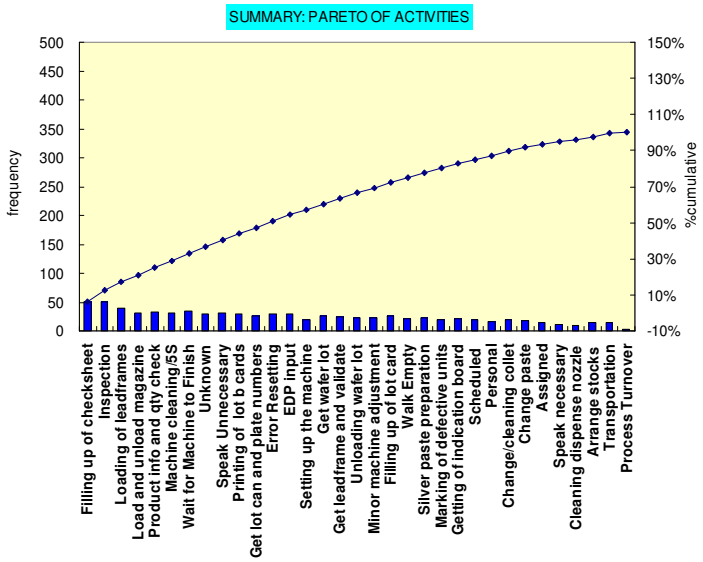
A.10 Summarize the Data-after the data collection, result of the study must be summarized. Shown below is the summary of the actual study conducted.

✓ **Work sampling result –In terms of work category**



Analysis: In terms of type of work distribution, 43 % of the proportion of time spent on indirect productive work activities that are complementary only to the product or machine operations.

✓ **Work sampling result –Pareto of activities**



Analysis: Filling up of check sheets and inspection were the top activities observed.

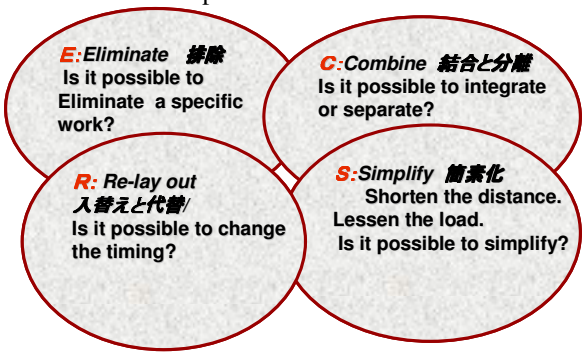
✓ **Computed Utilization rate of operators**

	AVERAGE UTILIZATION RATE OF OPERATORS
WORKING	82%
IDLE	18%

Analysis: It was found out that the average utilization rate of operators is 82% only.
Source: Work sampling and structured estimating -Internet

2.2.3 APPLICATION OF ECRS

Utilizing the result of work sampling, the ECRS approach was use for the improvements.



Each work elements were analyzed for the possibility of ECRS application. However the top activities from the work sampling result were prioritized. Shown below are samples of the improvements done per improvement type:

A.ELIMINATE: Redundant inspection was applied for removal. One task found to be with unnecessary inspection is the after Change gold wire.

BEFORE	
Symbol	Work elements
○	Bond 1 pellet
◇	Machine monitor /microscope inspection
○	Bond 1 leadframe
◇	Microscope inspection using machine
○	Bond 5 leadframes
◇	Microscope inspection using machine
◇	Normal sampling inspection using machine

AFTER	
Symbol	Work elements
○	Bond 1 pellet
◇	Machine monitor /microscope inspection
○	Bond 1 leadframe
◇	Microscope inspection using machine
◇	Normal sampling inspection using machine

Summary:

	BEFORE	AFTER	DIFFERENCE
○-Operation	3	2	1
◇-Inspection	4	3	1

B.COMBINE:
The operation and inspection function were merged. Operators assigned at Transistor Package (TO) assembly were cross trained to on-line inspection. Also same inspection items were combined.

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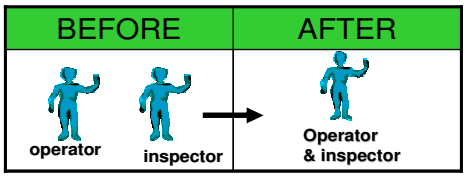
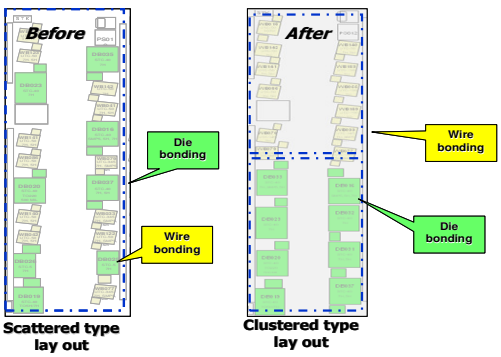


C.RELAY OUT:
An efficient lay out is vital to achieved a smooth production flow. Transistor package assembly was subjected to major lay out from a scattered type (mixed machines) to Clustered type (machines grouped per process).The main objective of machine re-lay out is to be able to reduced walk time of operators and to reduce the man machine assignment.



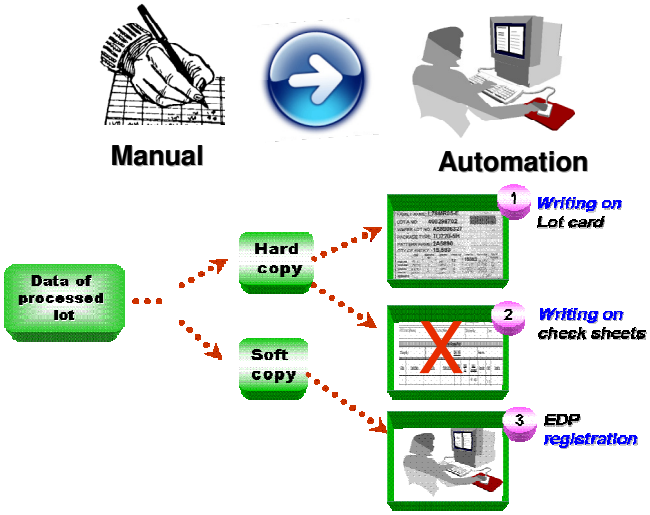
D.SIMPLIFY

To lessen the load of operators the following items were done:

D.1 Machines with manual loading of frames and wafers were replaced to automatic machines.

MANUAL LOADING --→ AUTOMATIC

D.2 Since it was found out that most of the time the operator spends on check sheets filling up, automation of daily production record was implemented.



2.2.3 MAN AND MACHINE COMPUTATION

From the determined standard time and after the implementation of improvements, man machine requirement was computed. See figure below:

Table 2: Man requirement:

Function	Actual Man deployed	Man need (computed)	Difference
Die bonding operator	1	0.95	0.05
Die bonding on-line	1	0.63	0.37
Wire bonding operator	1	0.58	0.43
Wire bonding on-line	1	0.85	0.15
TOTAL	4	3.01	1

** The man requirement is computed using standard time, total time to operate and the time available per day.*

Analysis:

Computation shows that there is a difference of 1 man from the actual manpower deployed.

Table.3 Number of machine to assign:

Function	Number of
Operator 1	8
Operator 2	6
Operator 3	6

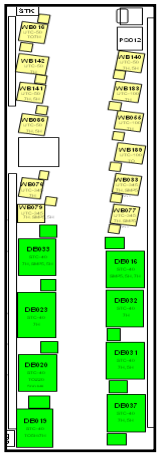
** The number of machine is computed using the prescriptive symbolic model of multiple activity chart.*

3.0 RESULTS AND DISCUSSIONS

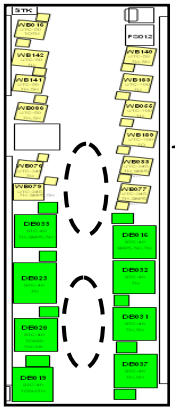
The application of Work sampling and ECRS principle yielded the following results aligned with our company policy of:

3.1 *HIGH QUALITY*

3.1.1Cases of swapped lots will be avoided since machines are clustered according to process. *No case of swapped lots (Oct'09-to present.)*

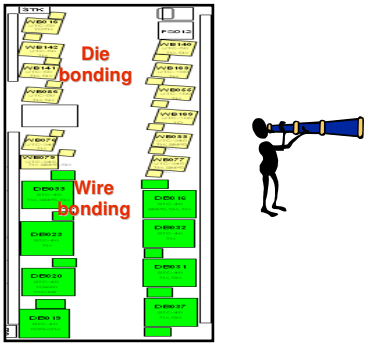


3.1.2 Due to merged machines, immediate assist on errors is expected. Defect produced by errors will be minimized.



	Before	After
Time per error assist	12.3 secs	5.7 secs

3.1.3 Early detection of on-line inspector is expected since machines are group together per process.



3.2 HIGH SPEED

3.2.1Applying the clustered type of lay out, walk time of operators from one machine to another during error assist will be reduced. Also the distance traveled by On-line inspectors will be lessen. Table A shows the time saved per job function.

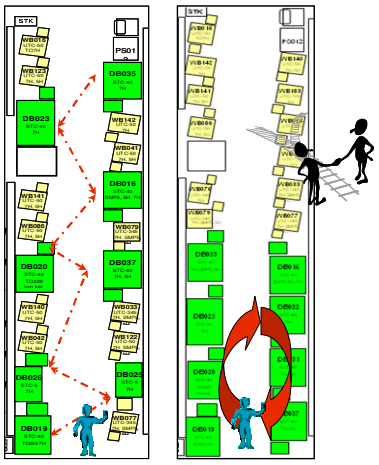


Table 3.

Function	BEFORE	AFTER	SAVINGS (mins)
Die bonding	100%	57%	43%
Die bonding on-	100%	69%	31%
Wire bonding operator	100%	61%	39%
Wire bonding on-	100%	61%	39%
Average	**100%**	**62%**	**38%**

62% Decreased in walk time/lot

3.2.2 Machines with manual loading of frames and wafer were line out from the line as shown in Table 4.

Table 4

:	BEFORE (Manual)	AFTER (Automatic)	SAVINGS (mins)
Loading of leadframes	100%	80%	20%
Loading of wafer	100%	79%	21%
Average	100%	80%	21%

80% Decreased in assist **time/lot**

3.3 LOW COST

3.3.1 Clustered type of lay out with improvements on work elements resulted to reduction of man assignment.

	BEFORE	AFTER	SAVINGS /year
Manpower assignmen	12	9	3

3.3.2 Increase in multi skilled rate by 27%.

	BEFORE	AFTER	SAVINGS /year
Multi skilled rate	63%	100%	27%

3.3 .3 Thru the implementation of automated daily production record cost of paper and printing was eliminated. Thus the company saves money.

3.4 OTHERS

After proving the effectiveness of Work Sampling and ECRS principle of improvement, this methodology was implemented to other company's production process. The implementation contributes a good result on the attainment of company's goal.

4.0 CONCLUSION

The application of ECRS Principle is therefore effective to increase man efficiency thereby reducing manpower cost.

5.0 RECOMMENDATIONS

The use of IE methodology such as Work sampling and ECRS fundamentals are best recommended to any manufacturing work stations to improve productivity and cost.

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6.0 ACKNOWLEDGMENT

This project shall not be realized without the help of the following who shared their expertise, time and ideas unreservedly. Thus, my sincere thanks to all of them!

- Manufacturing shift in-charge– for ensuring proper implementation of the new system
- Die bonding and Wire bonding operators, inspectors and Technicians – for complying the set standard
- Edwin Buscas and Jinky Andres –for providing the training needs
- Arnel Hulipas and Dennis Ayson – for the support on relay out activities
- Louie Dizon & Jason Capati – for the unending support in time, resources and management intervention for the realization of the project

7.0 REFERENCES

1. Time and Motion study-Author: Ralph Barnes
2. Work sampling and structured estimating-internet

8.0 ABOUT THE AUTHOR

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