Toyota Kaizen Patterns & Basic Stability:

Some observations and reflections on TPS

Art Smalley President

Art of Lean, Inc.

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Presentation Outline

- Introduction
- The Need for Basic Stability
- TPS Development Timeline
- Patterns of TPS / Kaizen
- Scientific Method
- Suggestions
- Final Q&A

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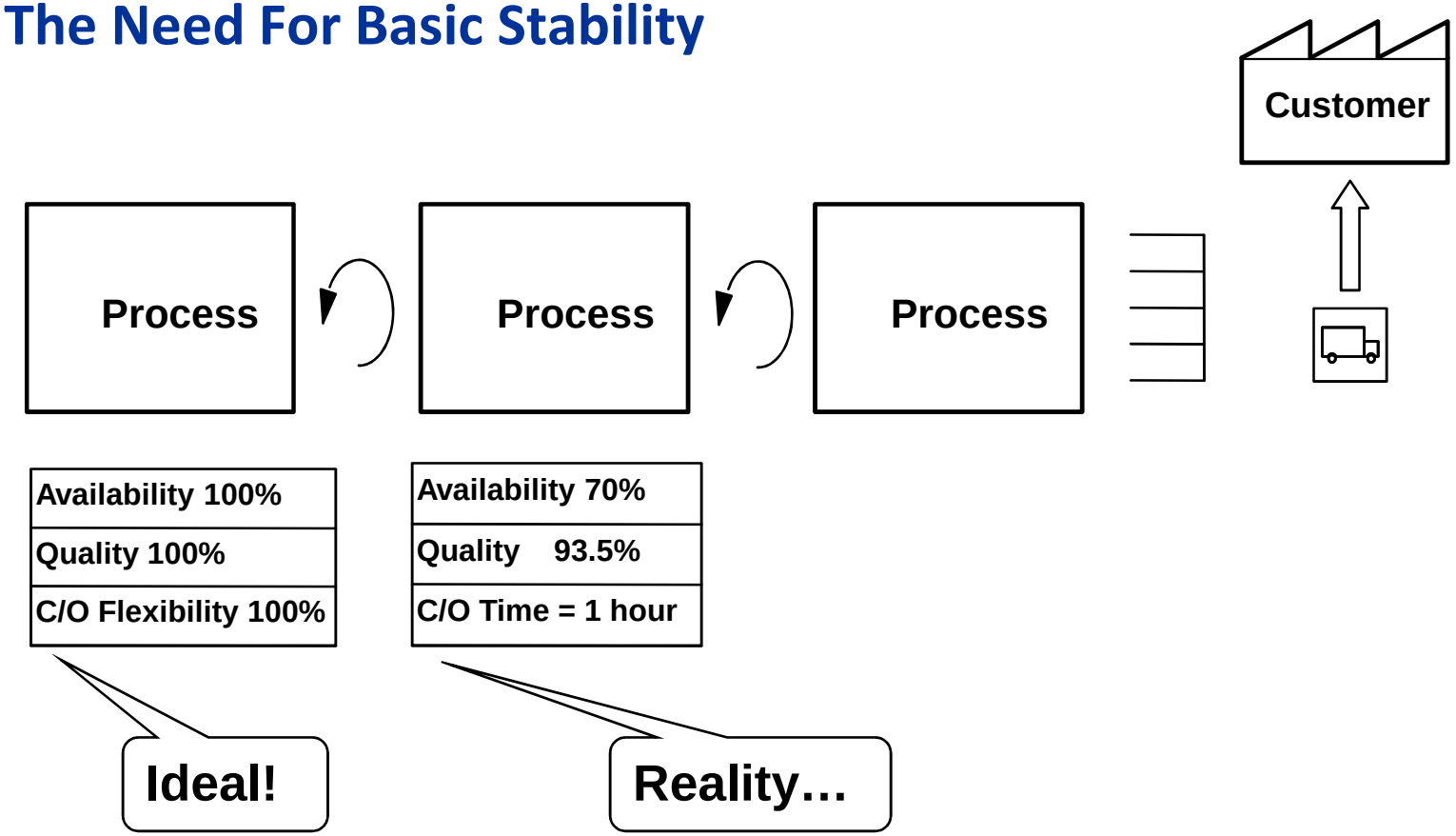
The Need For Basic Stability



Of course an ideal process would have no problems but who has that situation in their facility?

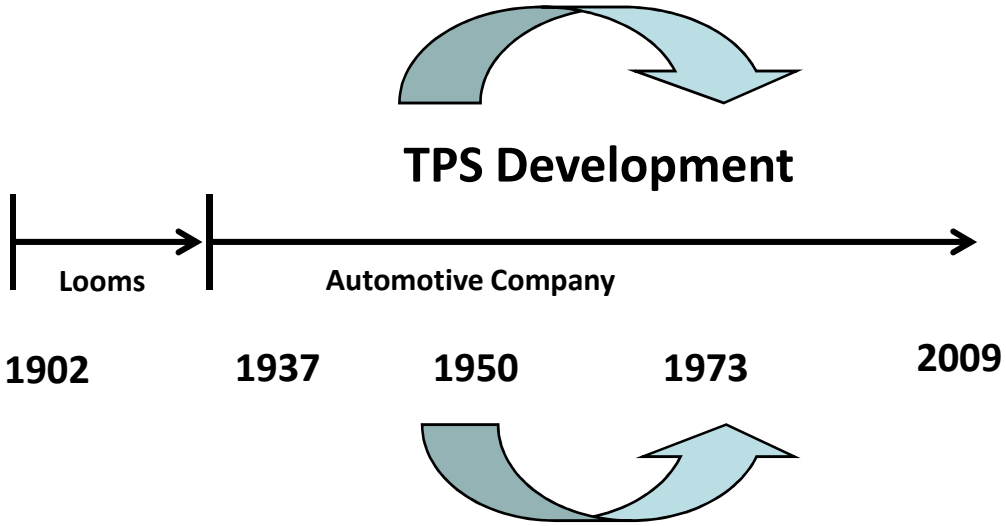
TPS development timeline

Influences

Mass Production moving conveyor lines

Scientific Principles Of Management

Standardization Of Parts



Sakichi Toyoda | Kiichiro Toyoda | Eiji Toyoda | Taiichi Ohno | Fujio Cho

Guess what – it did not just happen overnight!

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TPS Summary* 1945-1965

	Topic / Dates	1945-55	1955-65
JIT	1. Process flow	’50 Machining and Assembly Line Flow ’50 Machine Shop Flow	’55 Engine to Vehicle Plant Flow ’60 Intra Plant Flow
JIT	2. Conveyance	’53 1-4 Material Handling Call System	’60 Intra Plant Time Delivery ’55 Fixed quantity unfixed time based system
JIT	3. Set up Reduction	’50 1-4 Hour Set Up Time	’62 15 Minute Average C/O (New Technology – Danly Stamping Presses)
JIT	4. Kanban	’48 Replenishment pull pilot ’53 Machine shops implement pull & level scheduling	’62 Company wide pull established
JIT	5. Purchase Parts Management	’55 Fixed quantity delivery control system	’65 Adoption of supplier kanban
JIT	6. Ordering System	’55 Monthly Production Plans	
JIT	7. Production Instruction	’57 Adoption of Sequence List	’63 JIT Production Instruction Signals
Jidoka	8. Multi-Process Handling & Standardized Work	’47 1 Man 2 Machines ’53 Standardized Work ’49 1 Man 4 Machines	’55 1 Man 7 Machines (average in machine shop)
Jidoka	9. Visual Control & In Process Control	’50 Andon lights on engine assembly line	’62 Full work control system / Pokayoke

*Source: 創造限りなくトヨタ自動車50年史. Toyota 50 Year History Published 1987

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TPS Summary* 1965-1985

	Topic / Dates	1965-75	1975-85
JIT	1. Process flow	'75 Synchronization of Flow Between Plants	'75 Development of Equipment for Flow Production
	2. Conveyance	'70 All Plants on Call Conveyance Method	'77 Cross Docking Methods '83 Review from Sales to Manufacturing
	3. Set up Reduction	'71 3 Minute Average C/O Press Machines	'75 Single Minute C/O Machines at Suppliers
	4. Kanban		'77 Kanban Auto Sorting and Reading
	5. Purchase Parts Management		'77 Bar Code Reader for Supplier Kanban
	6. Ordering System	'65 10 Day Order Entry System '74 New Order System	'70 Daily Order Entry System '85 Lead Time Reduction Project
	7. Production Instruction	'71 Development Plant Production Instruction Signals	'80 Adoption of Automatic Signals '86 New Technology System
Jidoka	8. Multi-Process Handling & Standardized Work	'75 Company Wide Standardized Work	
	9. Visual Control & In Process Control	'66 Full Automated Machining Lines (JIT & Jidoka Fulfilled Kamigo Model Plant)	

*Source: 創造限りなくトヨタ自動車50年史. Toyota 50 Year History Published 1987

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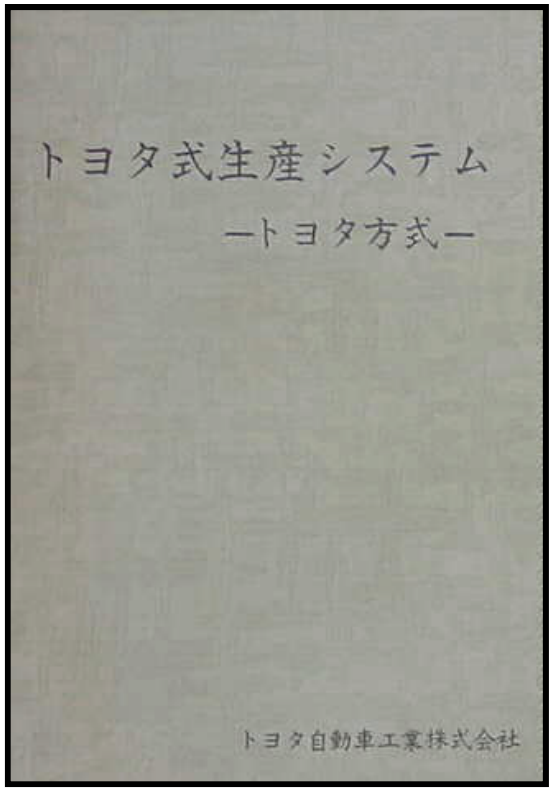
First TPS Manual 1973



First TPS Manual.
1973 Education & Training Department

論 よ り 実 践

“Practice over theory”

専務取締役 **Managing Director**

大野耐一

Ohno Taiichi

1. TPS is a series of related activities aimed at elimination of waste in order to **reduce cost, improve quality, and improve productivity**.

2. **Scientific Mindset**: On the shop floor it is important to start with **actual phenomenon** and search for the **root cause** in order to solve the problem. In other words we must emphasize **getting the facts.**.

3. In problem solving the **purpose** must be made clear…in Kaizen the **needs** must be made clear.

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Sample early training courses in Toyota (1950's forward)

- **Training Within Industry (TWI) Courses - Started in 1951 & its influence continues today**
  1. **Job Instruction**
  2. **Job Relations**
  3. **Job Methods -- Replaced in 1955 by the P-course training**
  4. **Job Safety -- Internal version added by Toyota to the above courses**
- **Various "P-Courses" taught by Mr. Shingo – Started in 1955 and continued until 1980 taught on average 3 times per year mainly on:**
  1. **Motion analysis**
  2. **Time study analysis**
  3. **Operational analysis**
  4. **Process analysis**
- **TQC related courses (Starting around 1962 with the TQC program)**
  1. **QC Circle activity**
  2. **Basic problem solving**
  3. **Statistical quality control**
- **Standardized work – established in the early 1950's and refined up until1978**
- **Kaizen training course – formalized in 1978 and replaced the P-course**
- **Role of a Supervisor – formalized in 1970 and continues today**
  1. **Role of a Team Leader**
  2. **Role of a Group Leader**

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TPS Kaizen Patterns (e.g. “Method”)

- Three main types (and many derivatives…)

1. Man
2. Material
3. Machine

} Method

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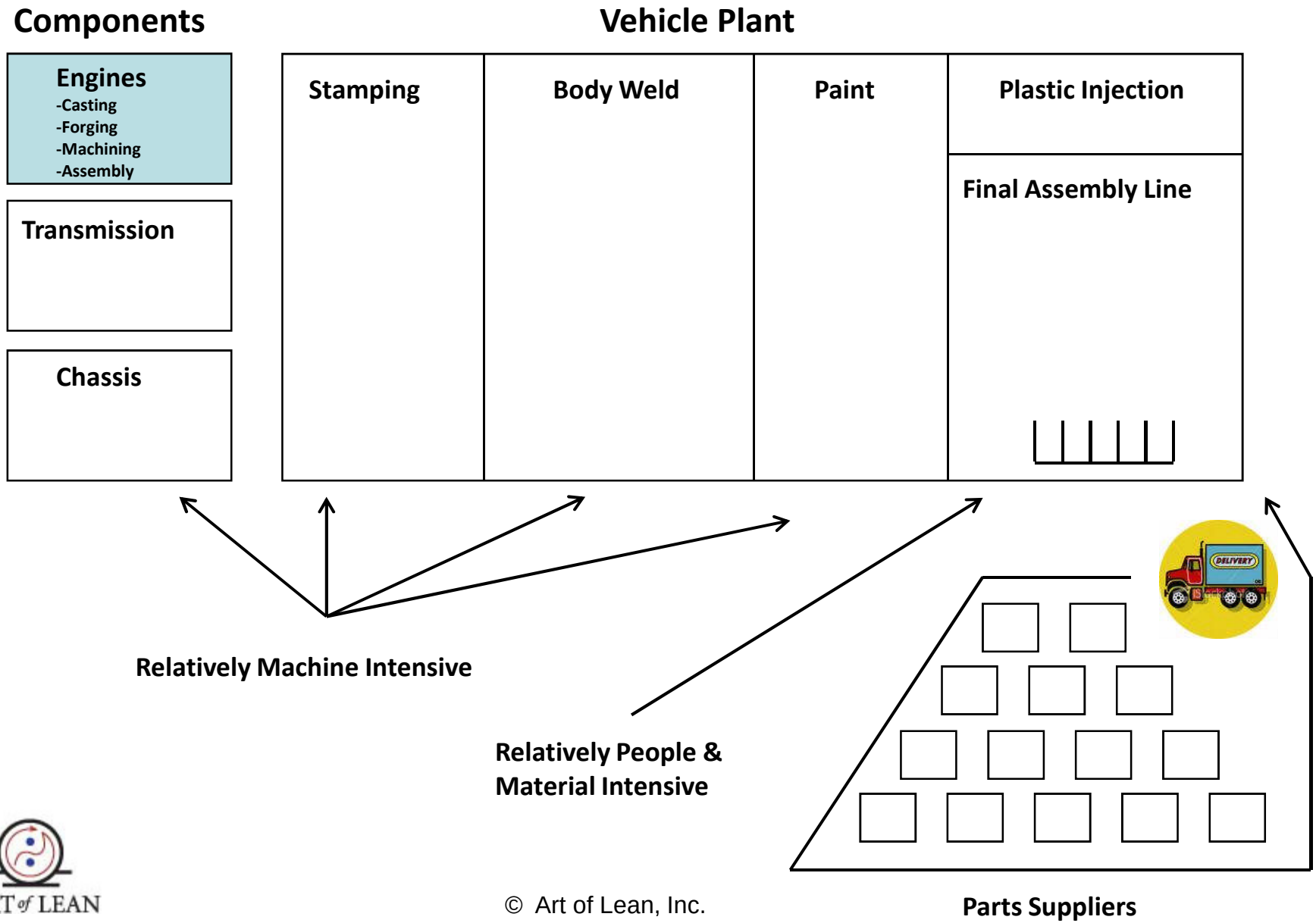
Generic Automotive Plant



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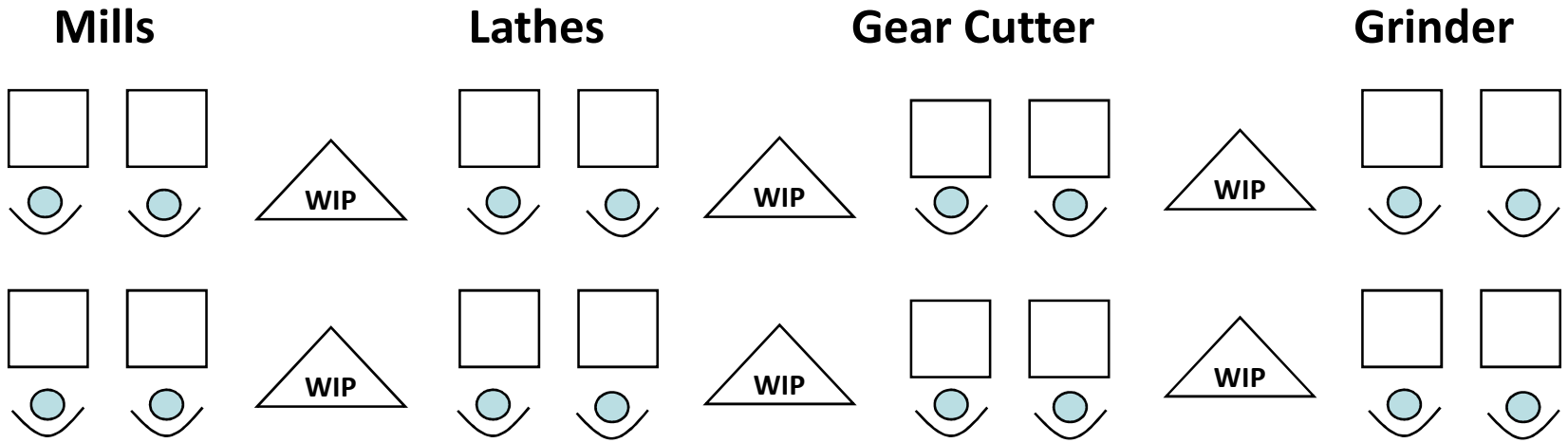
Process Based Layout In Ohno's Machine Shops



- Build up of WIP between stations and departments
- Over-production of wrong items / under-production of needed items
- Specialized operators only ran one type of machine
- Hard to realize productivity gains / work un-balanced
- Defects were hidden
- Down time problems were not obvious
- Lot's of "busy" work but too little value added work

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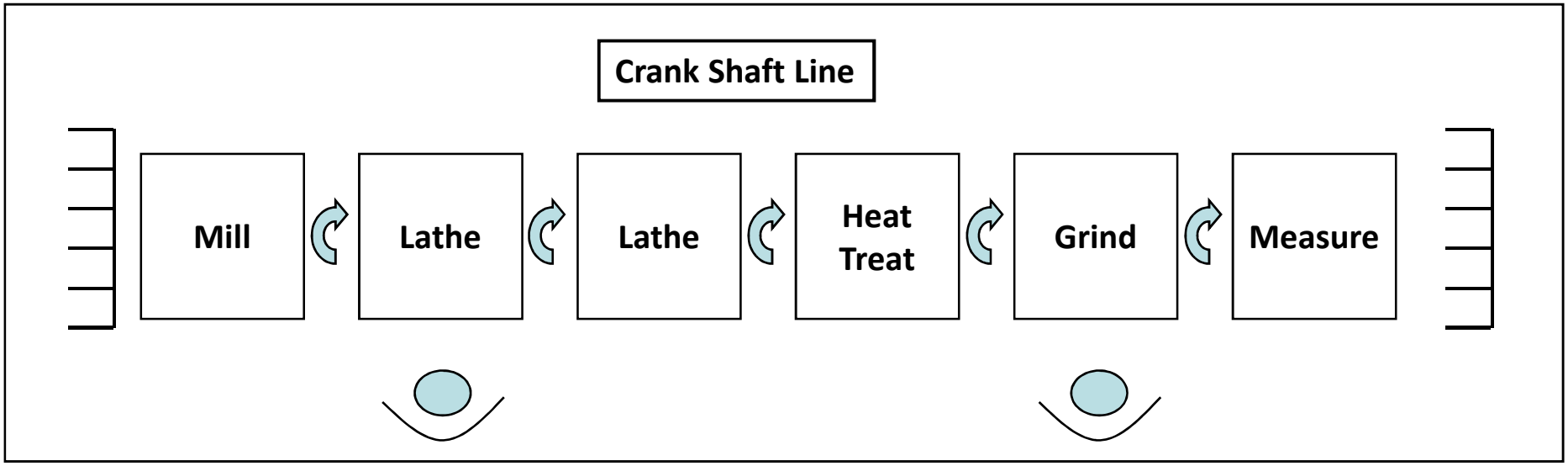
Conversion To Product Flow In Ohno's Machine Shops



- Stop overproduction. Avoid build up of WIP between stations
- Build in quality at the source
- Level the quantity produced on a daily basis (don't over-produce or under-produce)
- Pull production based upon downstream demand not a push
- Operators run more than one type of machine (multi-machine handing & multi-skilled)
- Work load balanced to takt time and adjusted monthly
- Defects are surfaced rapidly and dealt with as they happen (ideal case)
- Down time problems are surfaced and dealt with as they happen (ideal case)
- Reduction of waste in the overall sense and total system productivity gain

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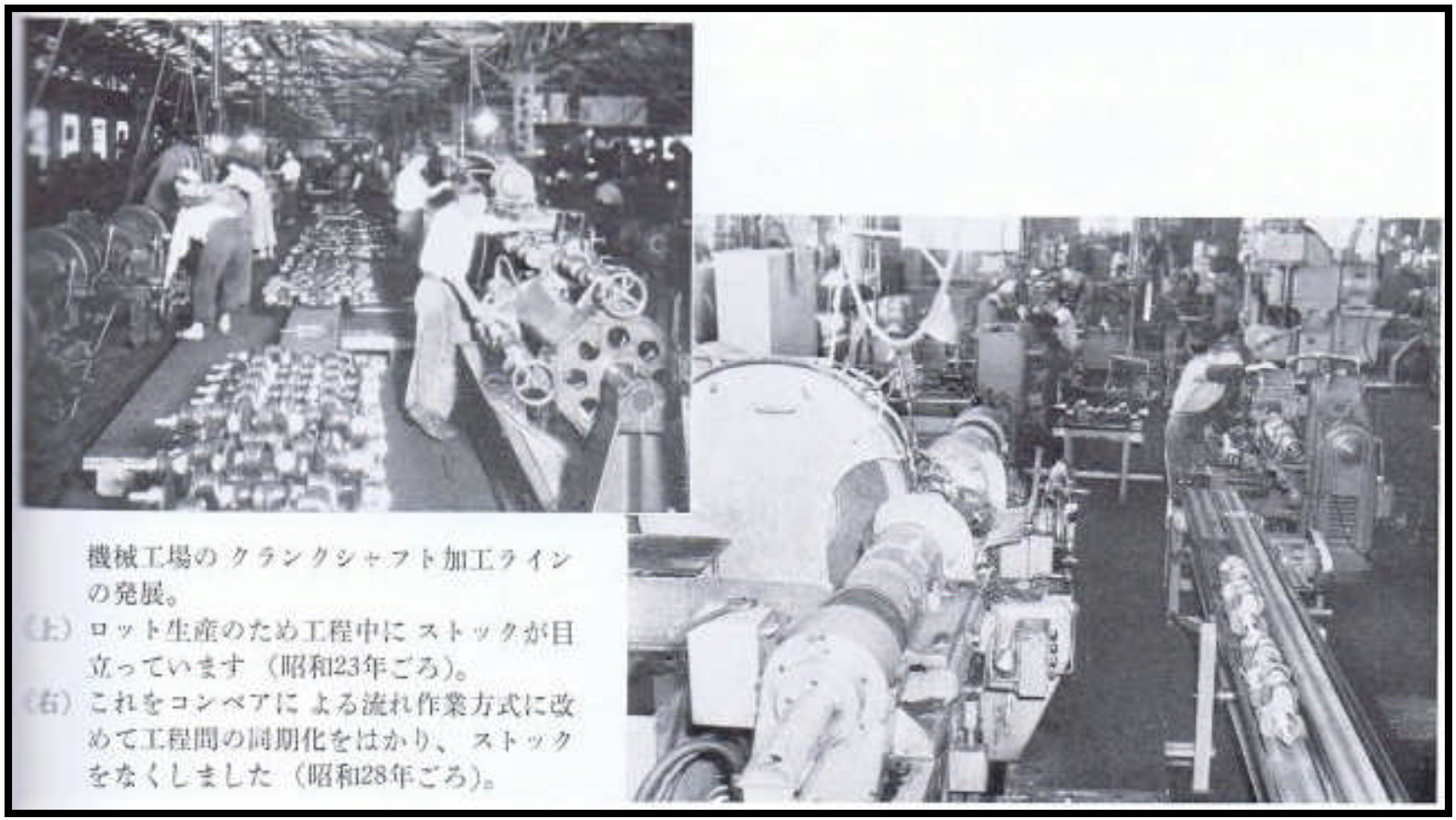
1950's Line Conversion Example



機械工場のクランクシャフト加工ラインの発展。
(上) ロット生産のため工程中にストックが目立っています（昭和23年ごろ）。
(右) これをコンベアによる流れ作業方式に改めて工程間の同期化をはかり、ストックをなくしました（昭和28年ごろ）。

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Manpower Related Kaizen

Basic Items

- Time Study
- Motion Analysis
- Work Element Analysis

Advanced Items

- Standardized Work & Kaizen

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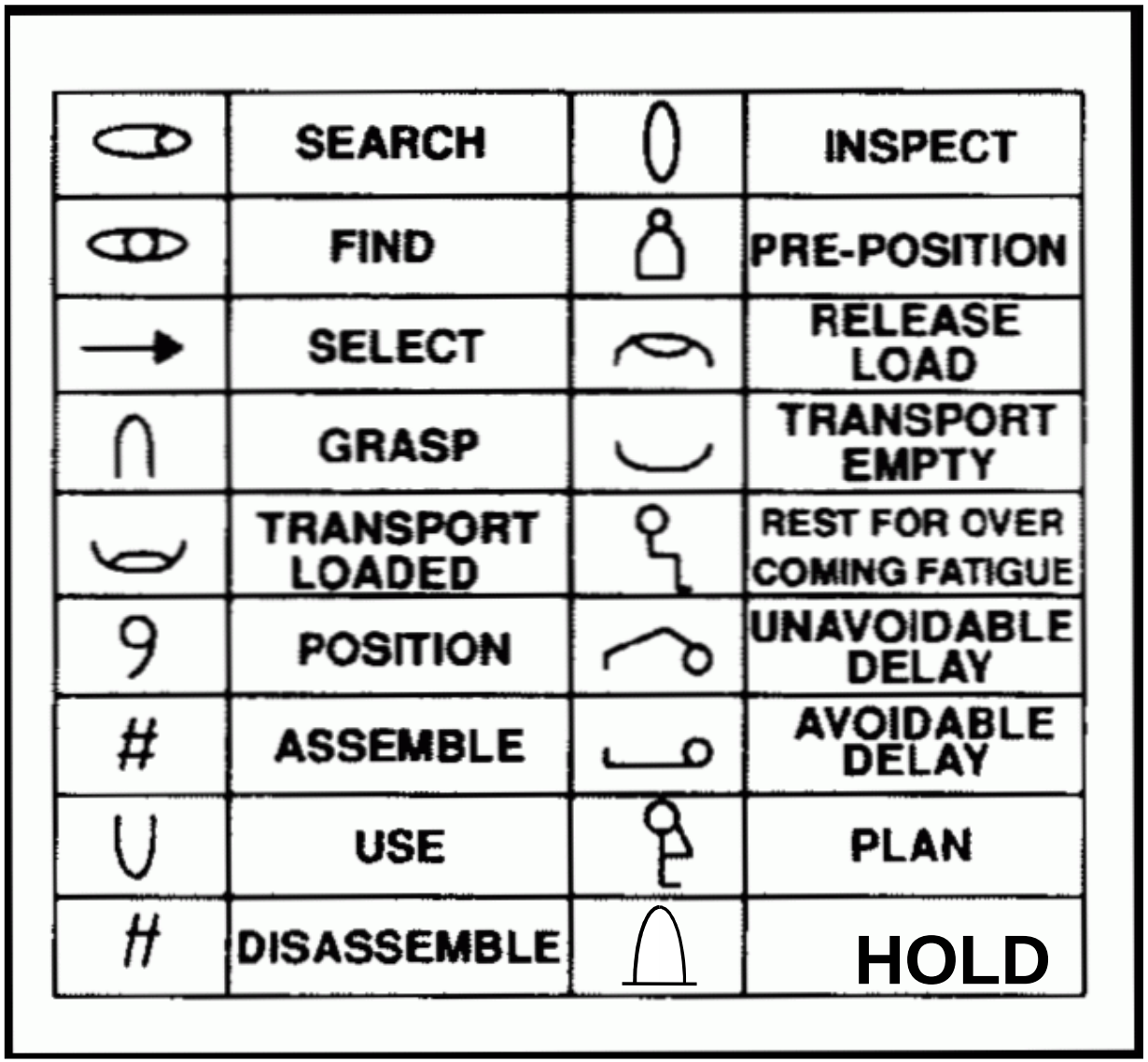
Time Study

Time Observation

Process:								Observer:							Date:
Step #	**Work Element**	1	2	3	4	5	6	7	8	9	10	11	12	**Task Time**	**Remarks**
	Time for 1 Cycle														lowest repeatable Cycle time

Motion Study Frank & Lillian Gilbreth (Therbligs)



	SEARCH		INSPECT
	FIND		PRE-POSITION
	SELECT		RELEASE LOAD
	GRASP		TRANSPORT EMPTY
	TRANSPORT LOADED		REST FOR OVER COMING FATIGUE
9	POSITION		UNAVOIDABLE DELAY
#	ASSEMBLE		AVOIDABLE DELAY
U	USE		PLAN
#	DISASSEMBLE		HOLD

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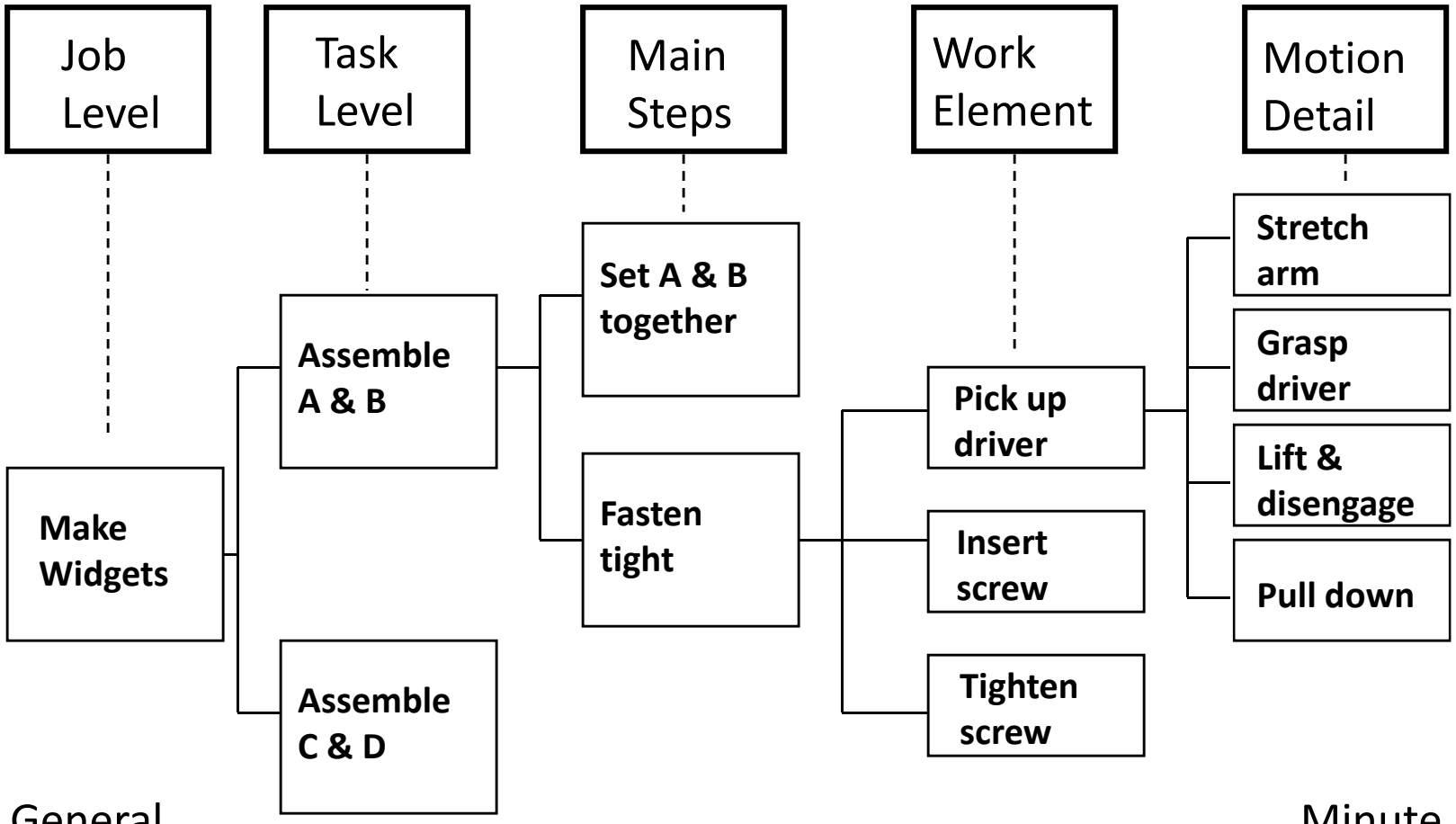
Work Elements & Analysis Unit



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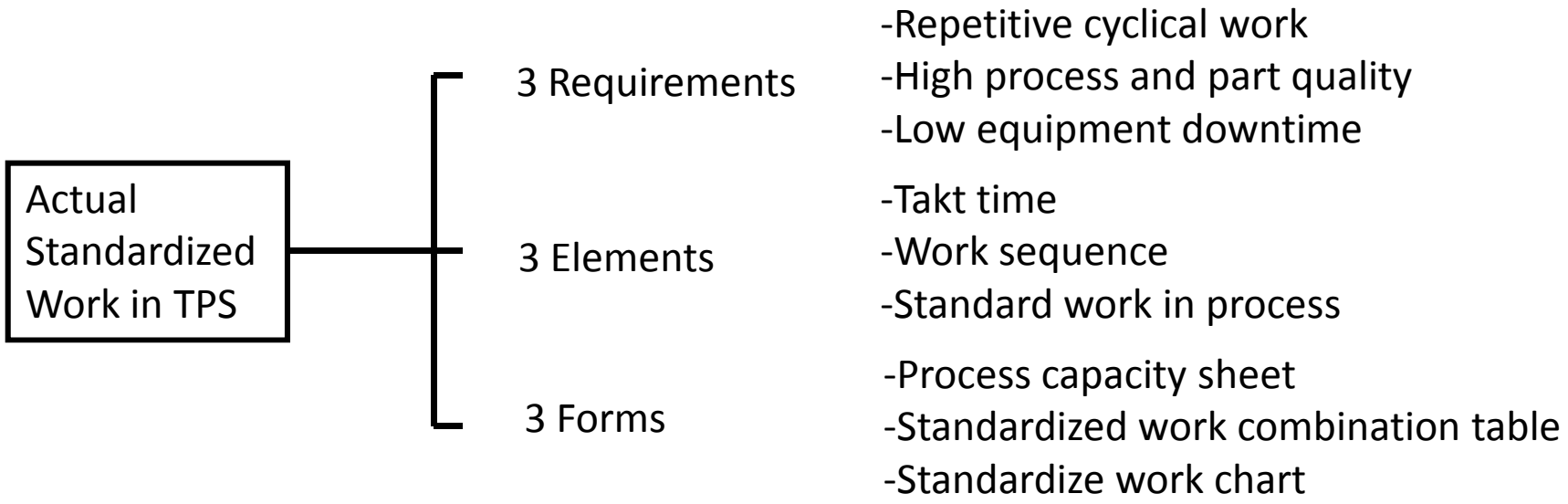
Work Elements Worksheet

No.	Work Elements	Safety Distance Dimension Quality Ease	Why	What	Where	When	Who	How	Improvement Ideas	E	C	R	S

Standardized Work (More Advanced)

Definition: a document centered around *human motion* that combines the elements of a job into the most effective sequence with minimal waste to achieve the most efficient level of production possible under current conditions.



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Standardized Work Forms

Sample Process Capacity Sheet

Definition:

A basic tool used to measure process output capability considering the time available and time required for change over work. It represents the maximum output possible from the process under current operating conditions.

Process Capacity Sheet					Dept: Product:			Line: Created by:	
Step #	Process Name	Machine Number	Manual Time	Auto Time	Total CT	# Pcs. / Change	Time to Change	Time Per Pc.	Shift Capacity
1	Mill Face	MI1764	3”	25”	28”	100	60”	0.6”	965
2	Drill Holes	DR2424	3”	21”	24”	1000	30”	0.03”	1148
3	Tap Holes	TP1101	3”	11”	14”	1000	30”	0.03”	1967

Standardized Work Combination Table

Acme Corp.
Standardized Work Combination Table

Plant: Acme | Product: 8" Pinion Gear
Area: Machining | Op. _1_ of _1_
Process: Gear Cutting Exercise | Pg. _1_ of _1_
Date: 5/23/2006 | By: Art of Lean | Line Takt: 46 secs.
Shifts: 2
Volume: 600 / Shift
Manual Work / Automatic | Walking / Wait

No.	Major Steps	MAN	AUTO	WAIT	WALK	Time Graph (Seconds) 5 10 15 20 25 30 35 40 45
1	Pick up raw material	1	--	--	2	
2	Unload / load and start M/C GC-614	5	38	--	2	
3	Unload / Load and start M/C CH-228	6	7	--	2	
4	Unload / Load and start M/C GC-1444	6	38	--	2	
5	Unload / load and start M/C GC-1445	6	30	--	2	
6	Unload / load and start M/C TS-110	7	3	--	2	
7	Pack Part	1	--	--		
	Totals	32		---	14	

TT 46 Secs.

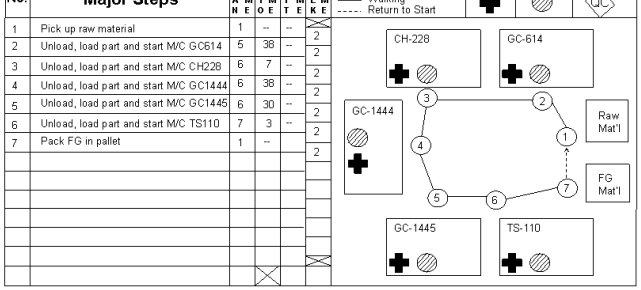
Standardized Work Chart

Acme Corp.
Standardized Work Combination Table

Plant: Acme | Product: 8" Pinion Gear
Area: Gear Machining | Op. _1_ of _1_
Process: Gear cutting exercise | Pg. _1_ of _1_
Date: | By: | Approved By:
Shifts: 2
Volume: 600
Takt Time: 46 secs. | Cycle Time: 46 secs.

No.	Major Steps	MAN	AUTO	WAIT	WALK
1	Pick up raw material	1	--	--	2
2	Unload, load part and start M/C GC614	5	38	--	2
3	Unload, load part and start M/C CH228	6	7	--	2
4	Unload, load part and start M/C GC1444	6	38	--	2
5	Unload, load part and start M/C GC1445	6	30	--	2
6	Unload, load part and start M/C TS110	7	3	--	2
7	Pack FG in pallet	1	--		2

Working Sequence / Walking / Return to Start
Safety | SWIP | Quality



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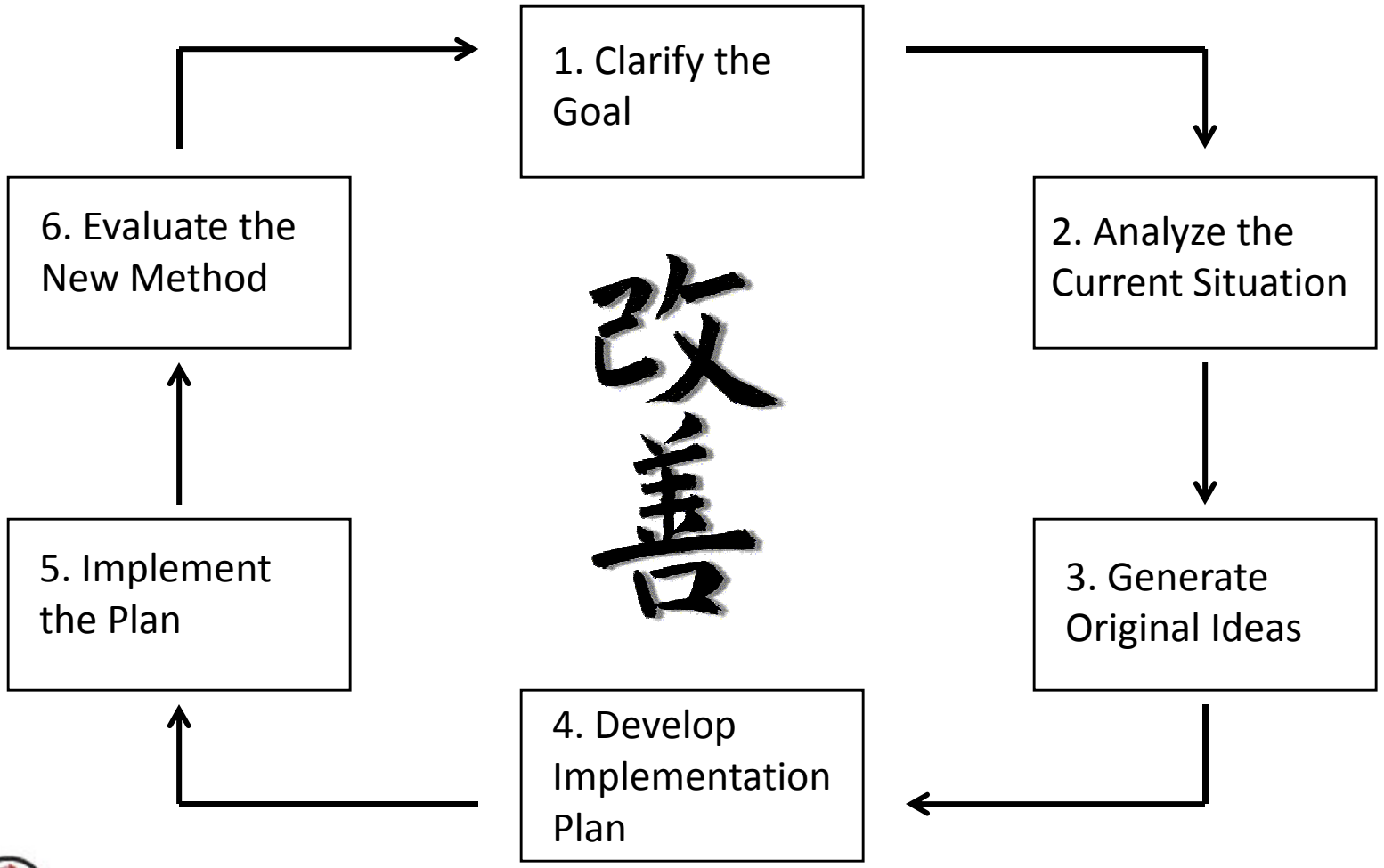
Standardized Work & Kaizen (Monthly Cycle)



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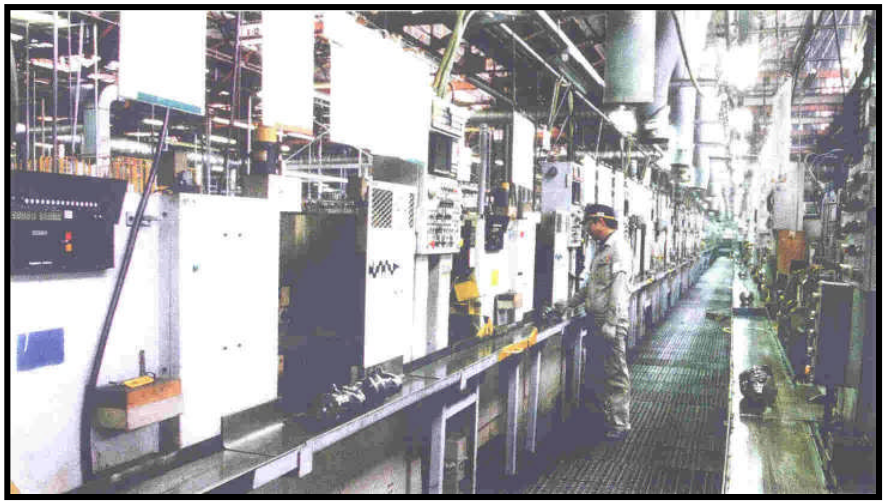
Toyota Machining Line 1950 versus 1990

- 1945 Machine Tool in Toyota
- 1 Person operates 1 machine
- Low Productivity / Low Quality



- 1990 Machining Line in Toyota
- 1 Person operates 20+ machines
- High Productivity / High Quality

Toyota Supplier

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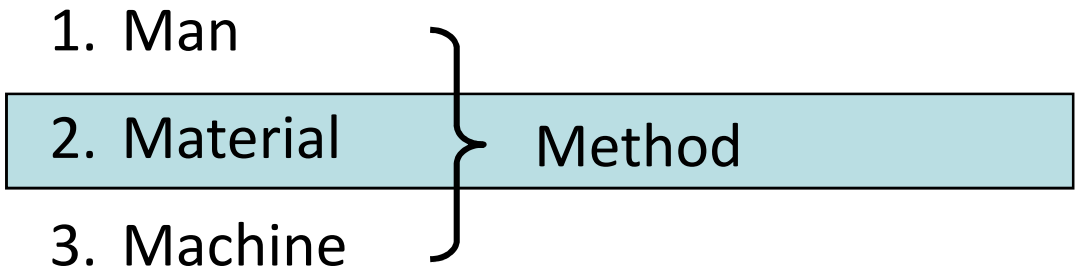
Kaizen Patterns

- Three main types (and many derivatives…)



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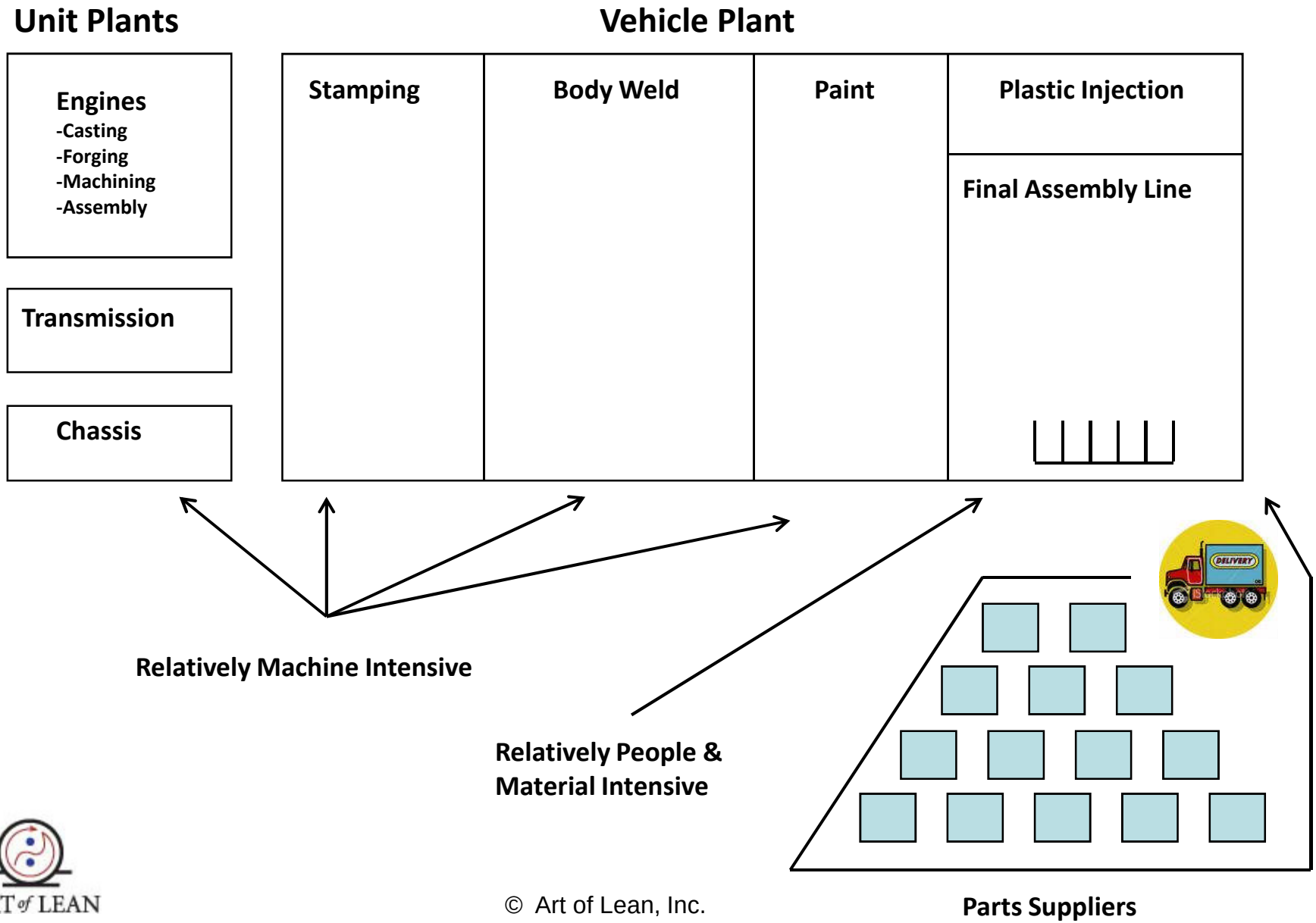
Generic Automotive Plant



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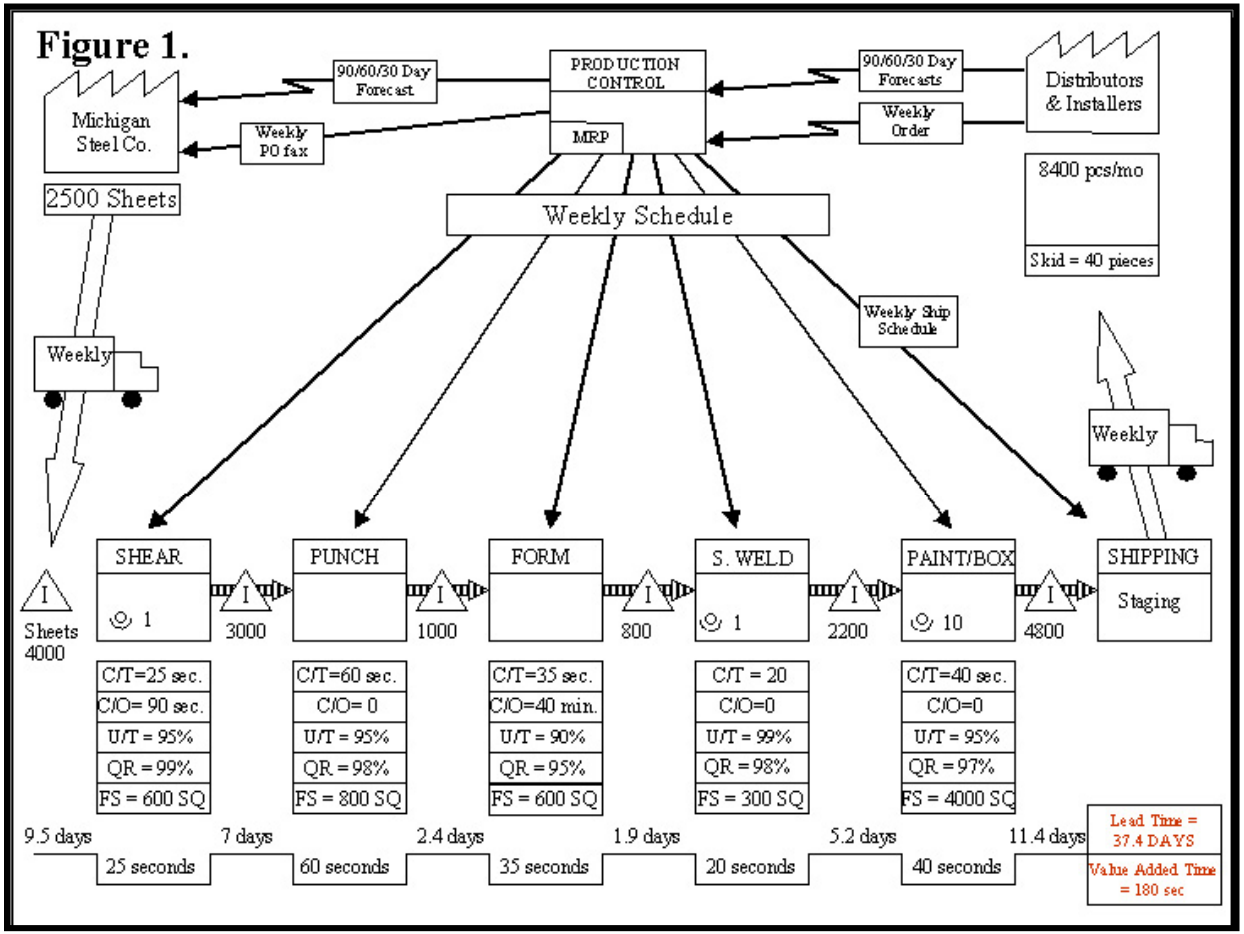
Material & Information Flow Analysis (MIFA/VSM)



Takt Time

Flow
-Material
-Information

Inventory

Process Info

Lead-time

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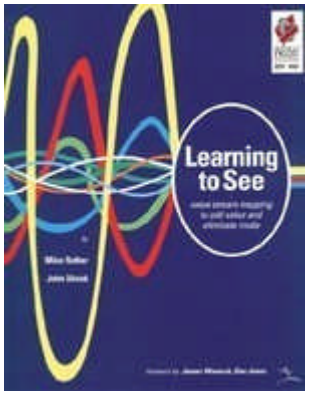
Learning To See

1. What is takt time?
2. How to create flow?
3. Where is the pacemaker?
4. How to implement pull?
5. Make to order to make to stock?
6. How to level production?
7. What pitch increment?
8. How to improve process flow?



1. Which products should you hold in a finished-goods inventory, and which to stock?
2. How much of each product should you hold in finished goods?
3. How will you organize and control the finished-goods store?
4. At what single point will you schedule the value stream?
5. How will you level production at the pacemaker?
6. How will you convey demand to the pacemaker
7. How will you manage information and material flow upstream?
8. How will you size your markets and trigger withdrawal pull?
9. How will you control batch processes upstream from the market?
10. How will you expand the level pull system across the facility?
11. How will you sustain your level pull system?
12. How will you improve your level pull system?

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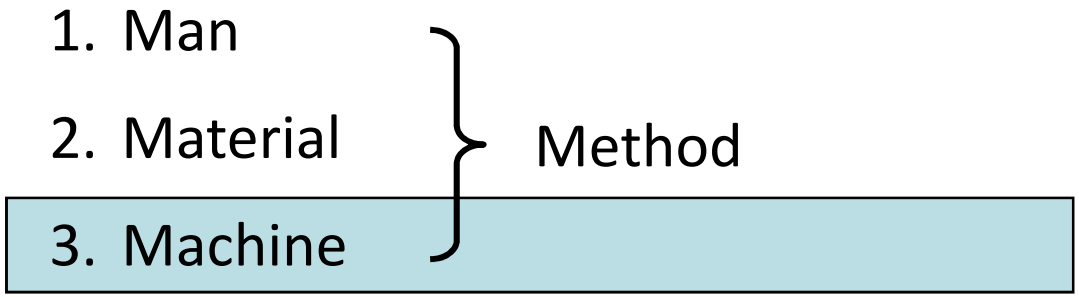
Kaizen Patterns

- Three main types (and many derivatives…)



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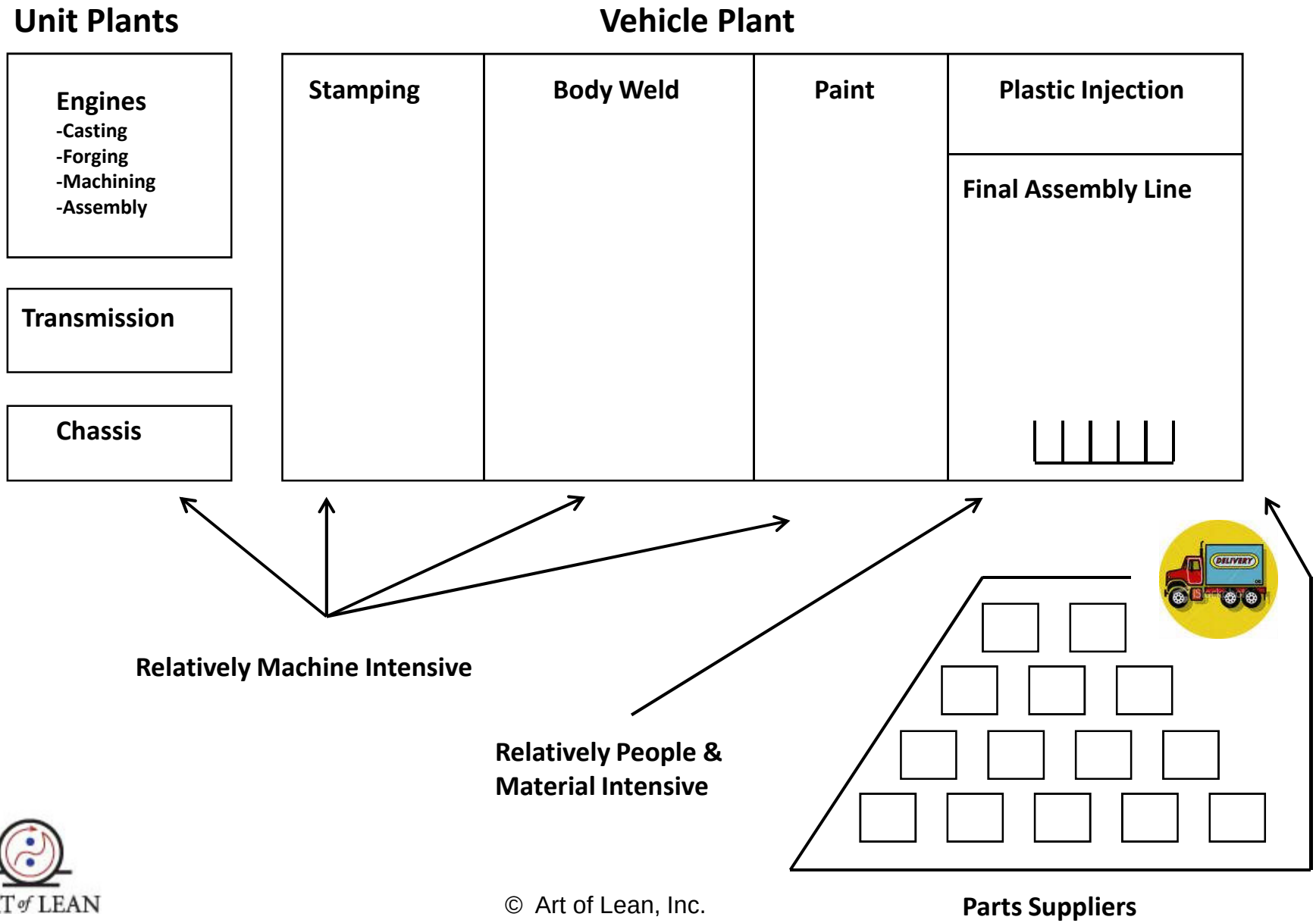
Generic Automotive Plant



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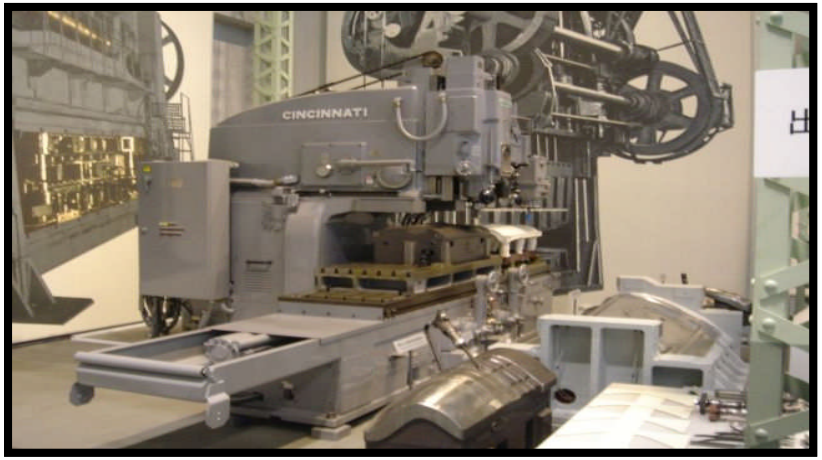
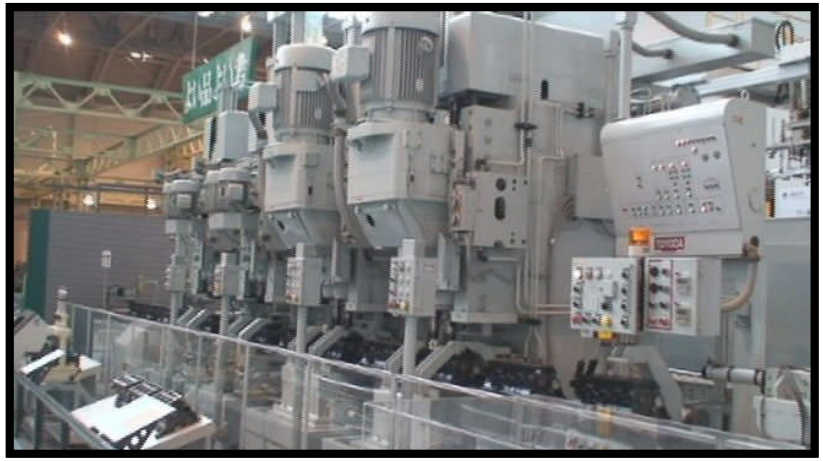
Old Toyota Machines 1950's – 1960's

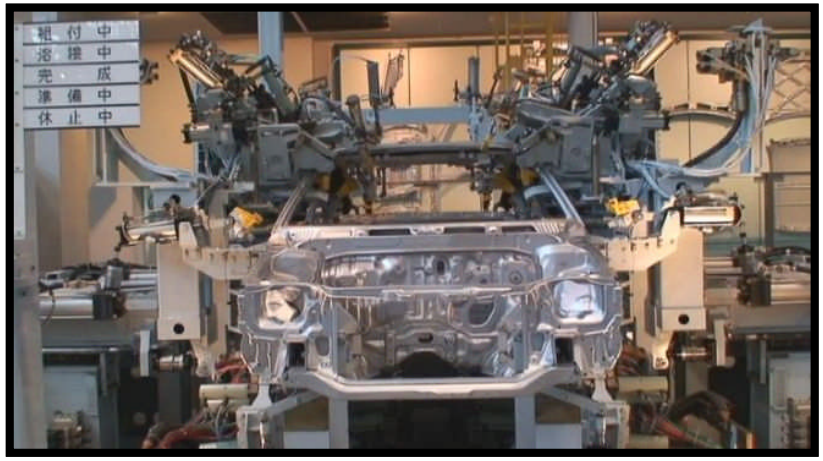


Cincinnati Milling Machine



Toyoda Transfer Machine

Danly Stamping Press



Automated Body Welding Machine

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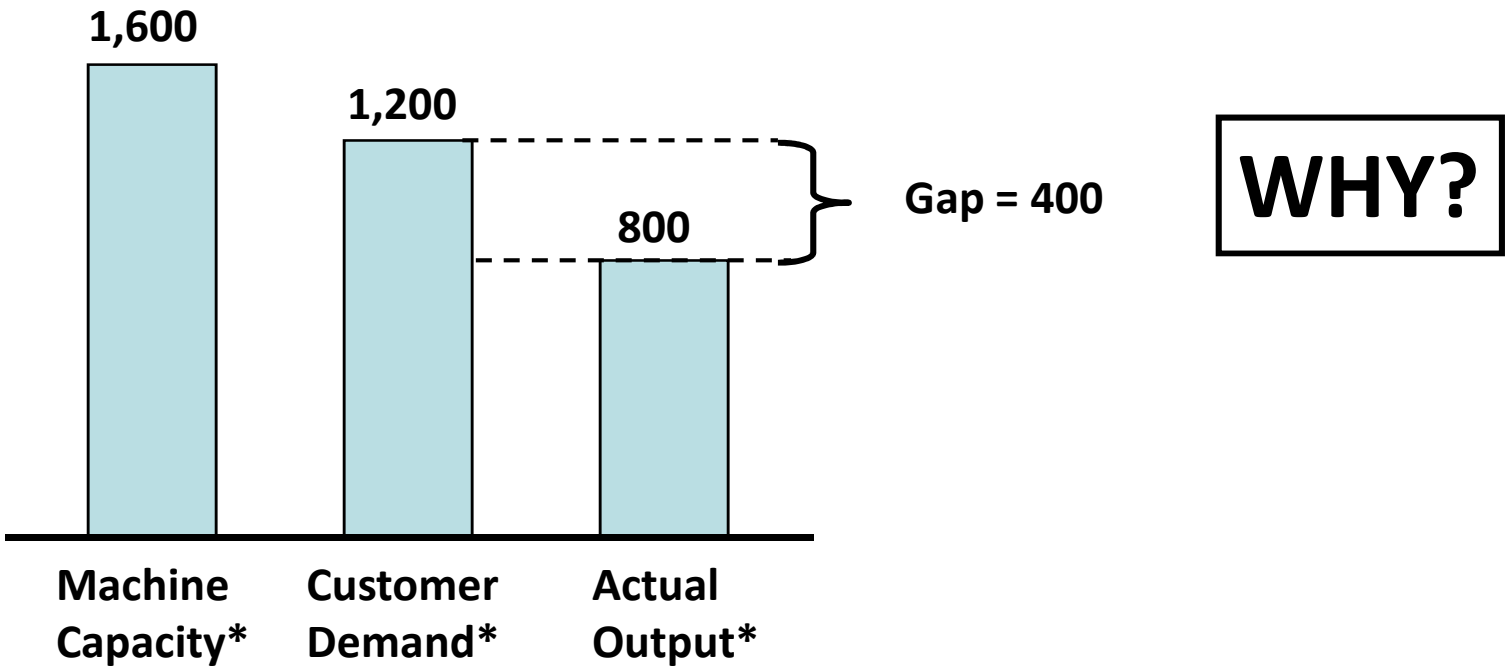
Machine Related Workshop

Problem Solving 101



WHY?

*Per Shift in this example

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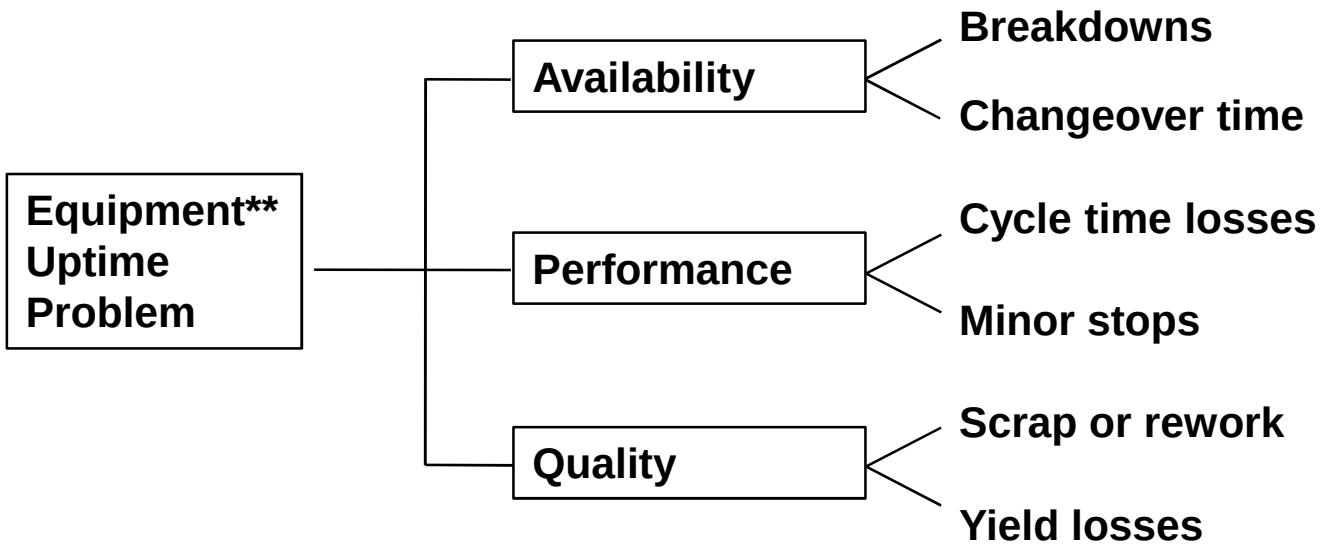
Analytic Thinking (1/3)

1. Classify and organize (MECE*)
2. Quantify the observations
3. Specific details



*Logic principle of Mutually Exclusive and Collectively Exhaustive
**Machine focus example (not Man, Material or Method focused)

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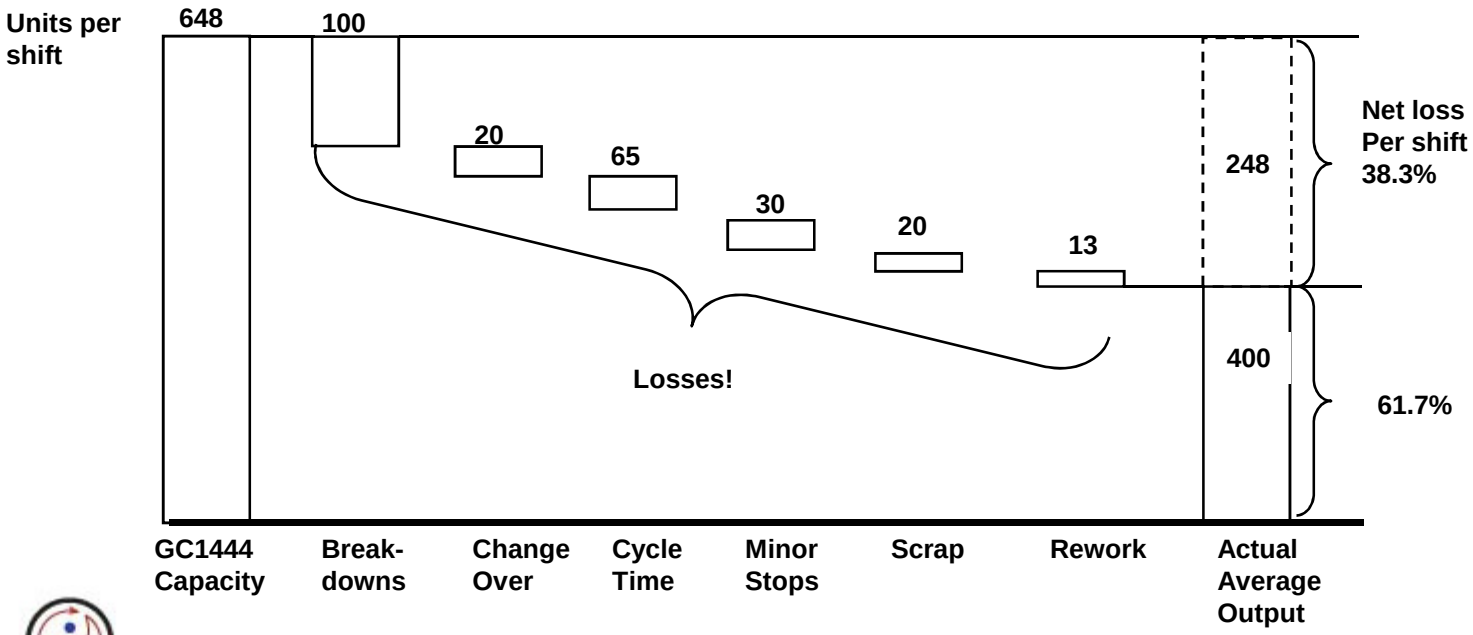
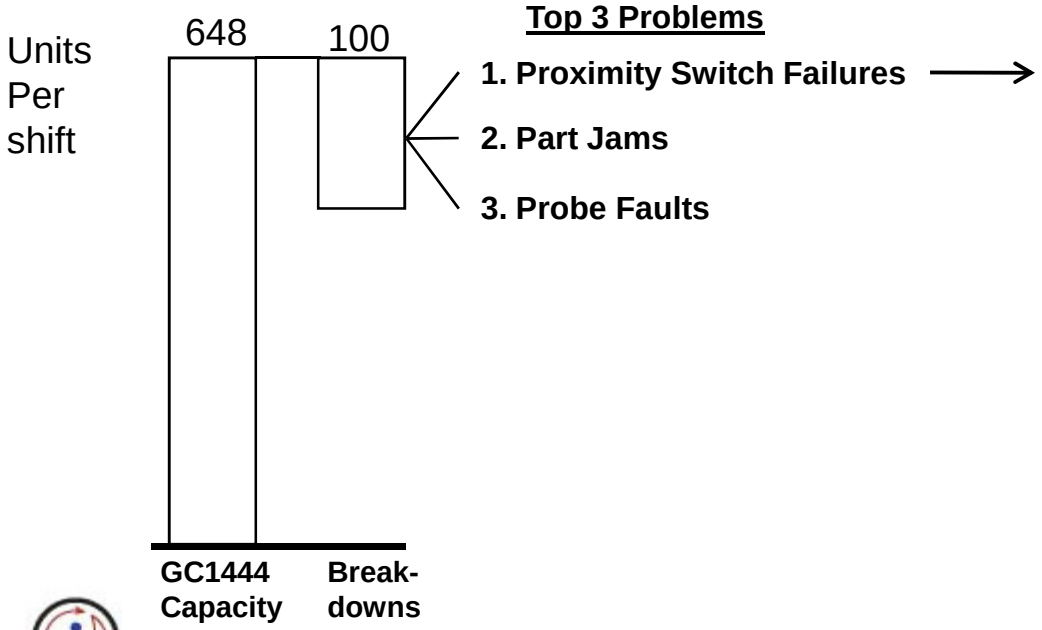
Analytic Thinking (2/3)

1. Classify and organize (MECE)
2. Quantify the observations
3. Specific details



Analytic Thinking (3/3)

1. Classify and organize (MECE*)
2. Quantify the observations
3. Specific details



- Correct switch?
- Alter bracket?
- Strengthen?
- Move location?
- Eliminate switch?
- Other?

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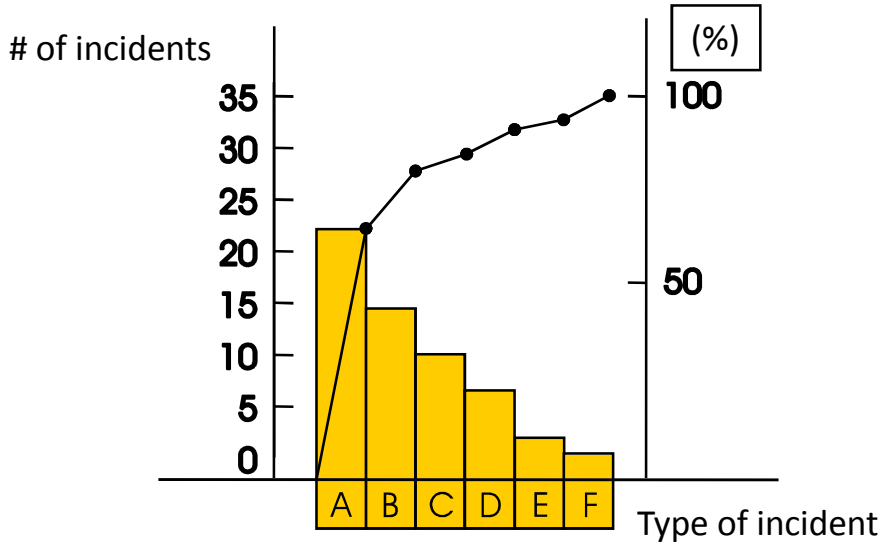
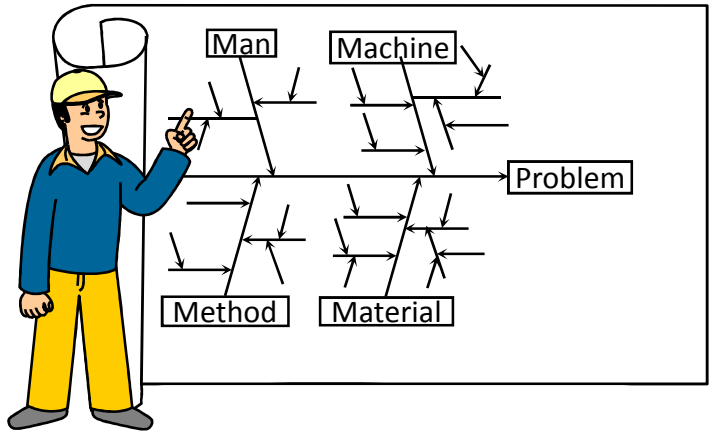
1. Breakdowns and Problem Solving

Pareto's Curve Graph



Cause and Effect Diagram



The same type of rigor that is used in "quality" problem solving should be applied to "machine breakdown" problem solving…

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2. Set Up Reduction For Changeover

Line Name		Set Up Reduction Worksheet						
Part Name		(Work element analysis, time study, problem identification sheet)						
Process Name	Machine Name				Part Number			
No.	Main Set Up Work Elements	Time Study			Category		Problem Point	Countermeasure
		Start	End	Total	Int.	Ext.		
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

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3. Machine Cycle Time Study

Illustrative Example

1.	Automatic doors open	2”
2.	Remove part from machine (or auto eject, etc.)	2”
3.	Load next part	2”
4.	Clamp part / Coolant on	3”
5.	Table index	3”
6.	Grinding wheel on (or tool rotates, etc)	4”
7.	Rapid feed advance	4”
8.	Air cut	2”
9.	Rough cut	18”
10.	Dwell	2”
11.	Finish cut	20”
12.	Air cut	2”
13.	Rapid feed retract	4”
14.	Table return / Coolant off / Air blow	4”
15.	Unclamp part	2”
16.	Automatic door open – Repeat cycle	76”

Usually not all of the machine cycle time is value added…

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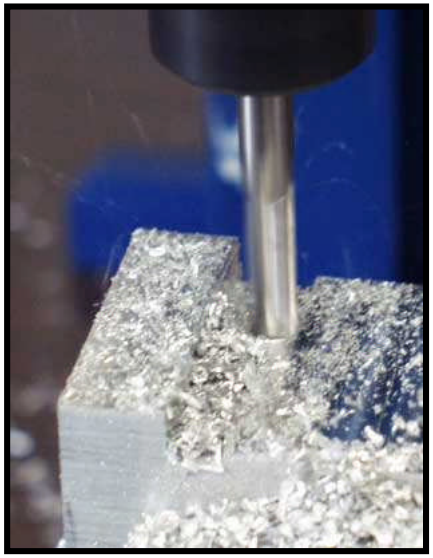
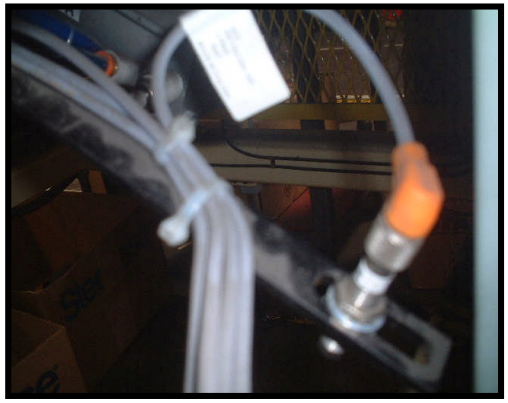
4. Minor Stops (Machining example)

1. Cutting chips on fixtures
2. Limit or proximity switch problems
3. Part jamming
4. Operator adjusting “something”
5. Confusion of on-line and off-line work for operator
6. Etc.





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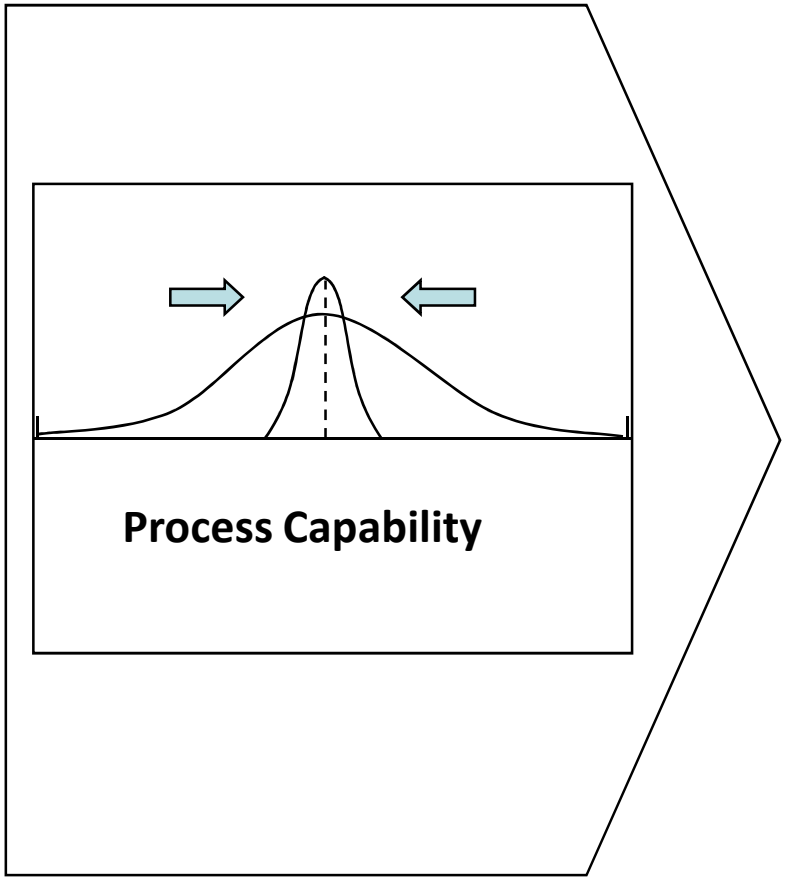
5 & 6. Scrap and Yield Losses (Machining Example)



1. What is the actual capability of the process?
2. Which dimension is in trouble? By exactly how much? Since when?
3. How is the condition of the tool?
4. Where is the datum? What is its condition?
5. How is the part located and clamped?
6. How is the part measured and gauged?
7. What is the condition of the various fluids (coolant, oil, grease, etc.)
8. What is the actual machining cycle?
9. What mechanical interference might be occurring?
10. What is misaligned in the machine – how much?
11. What is the condition of the spindle head / bearing unit (e.g. run out)
12. How is the tool holder condition?
13. How good is the incoming material?
14. What else is worn that can cause variation?

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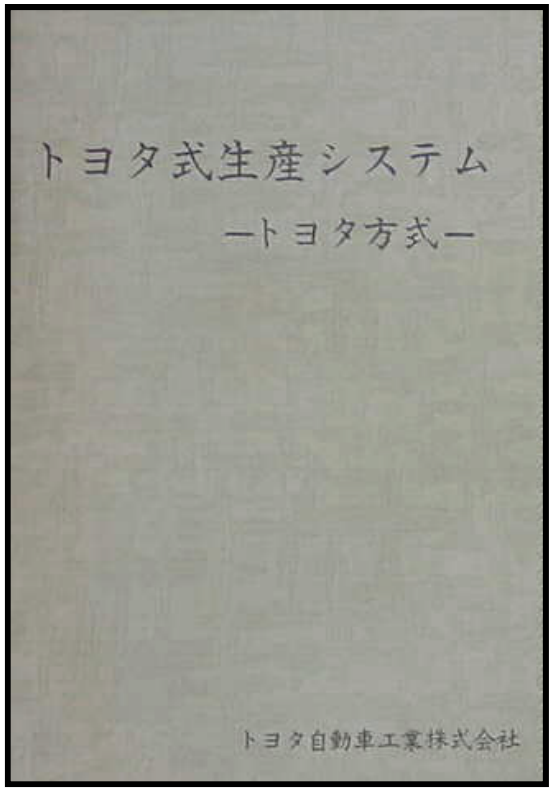
TPS Summary 1973



First TPS Manual.
1973 Education & Training Department

論　よ　り　実　践

“Practice over theory”

専務取締役 **Managing Director**

大野耐一

Ohno Taiichi

1. TPS is a series of related activities aimed at elimination of waste in order to **reduce cost, improve quality, and improve productivity**.

2. **Scientific Mindset**: On the shop floor it is important to start with **actual phenomenon** and search for the **root cause** in order to solve the problem. In other words we must emphasize **getting the facts.**.

3. In problem solving the **purpose** must be made clear…in Kaizen the **needs** must be made clear.

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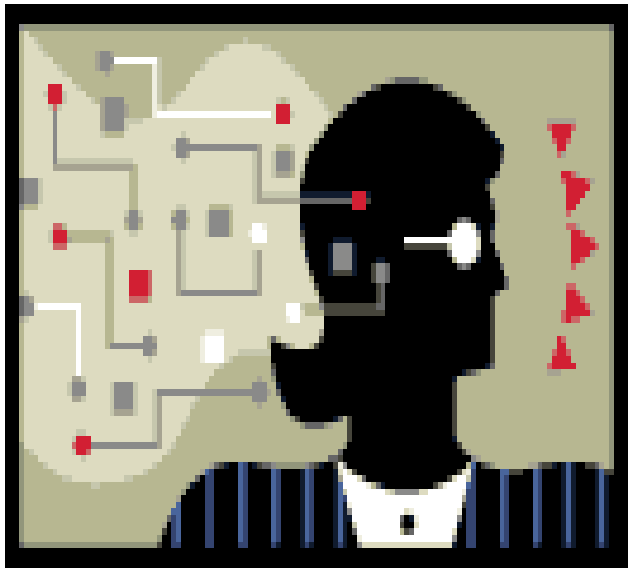
TPS is built on the scientific way of thinking*…



*Quote by Taiichi Ohno. Graphic and comment by Hajime Ohba Toyota Supplier Support Center

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General Scientific Method

1. Define the question / make observations
2. Gather information and facts
3. Form hypothesis
4. Perform experiment and collect data
5. Analyze data
6. Interpret data and draw conclusions
7. Summarize results

TPS Basic Problem Solving / Kaizen

1. Define the problem / opportunity
2. Analyze the causes
3. Set a goal
4. Implement the action items
5. Check the results
6. Follow up / Standardize

Comparison

Scientific Method*	Problem Solving*	Kaizen Steps*
•Make Observations	•Define Problem	•Clarify the Goal
•Gather Information	•Analyze Causes	•Analyze Situation
•Form Hypothesis	•Set a Goal	•Generate Original Ideas
•Perform Experiment to Test Hypothesis	•Implement Corrective Action Items	•Develop an Implementation Plan
•Analyze Data	•Check Results	•Implement Action Items
•Draw Conclusions & Summarize	•Follow Up / Standardize	•Evaluate Results / Standardize

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***Generic patterns. Other versions exist.**

Fujio Cho & Russ Scaffede Example

•Teach your managers the importance of “standards”.

•Standards are a *basis for comparison*.

•Without a standard I can’t objectively tell what has changed let alone improved.

•With no “standard” there can be no “kaizen”

-Time
-Quantity
-Quality
-Cost
-Etc.

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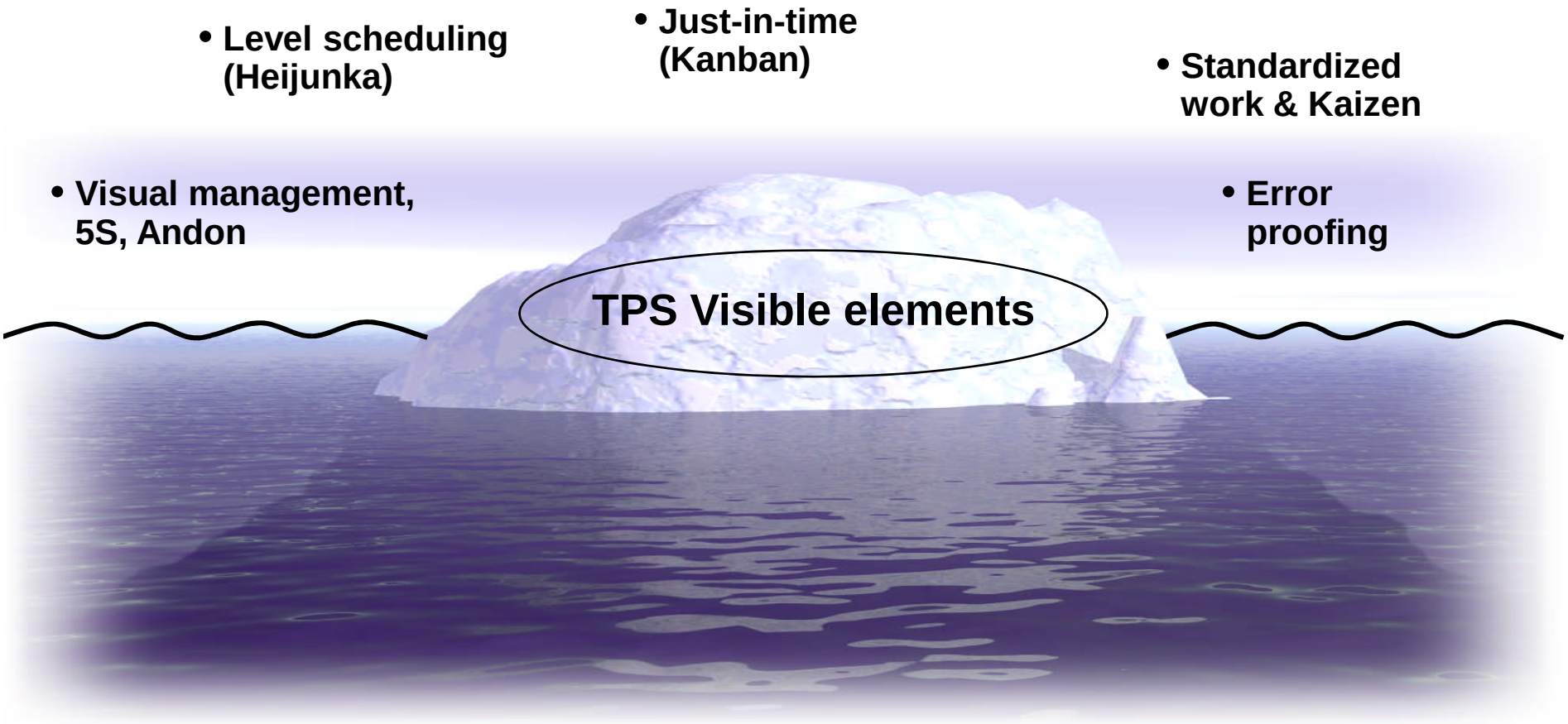
Basis Stability & Toyota Production System



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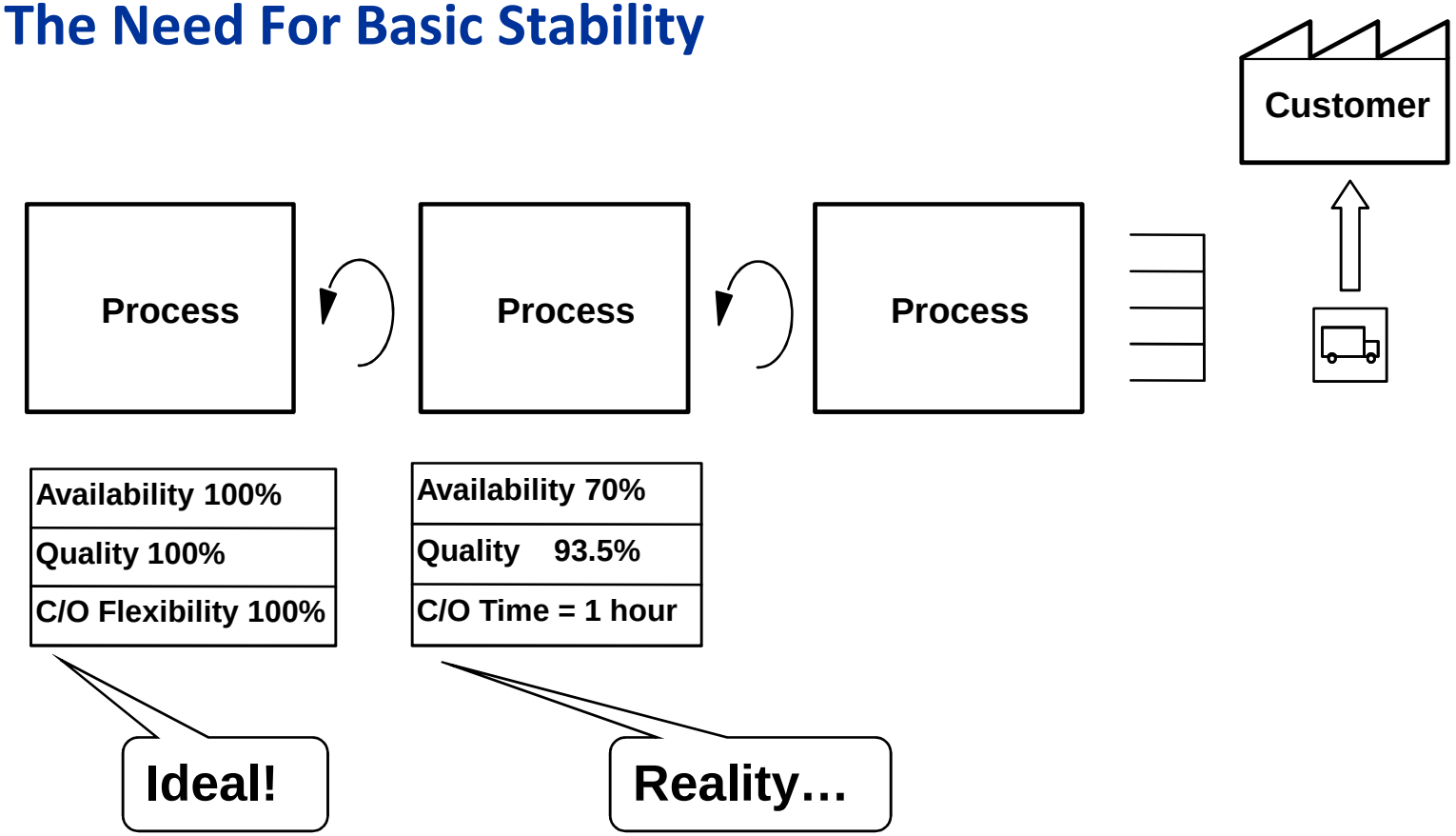
The Need For Basic Stability



Note: Implementation starts with reality and keeps an eye on the ideal…

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Suggestions and Final Comments

- **Leaders and managers really matter…**
  - -Eiji Toyoda
  - -Taiichi Ohno
- **Problem solving and analytic ability is critical…**
  - -Classify
  - -Quantify
  - -Specify
  - -Etc.
- **Kaizen Patterns & Problem Solving > "Tools" Approach…**
  - -Manpower intensive?
  - -Material intensive?
  - -Machine intensive?

  } What Method?
- **Focus on the basics…it helped Toyota**
- **Got to get results…if no results question your method!**
  - -Quality
  - -Cost
  - -Productivity
  - -Delivery
  - -Etc.

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Final Q&A

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