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WHAT IS LEAN MANUFACTURING ?

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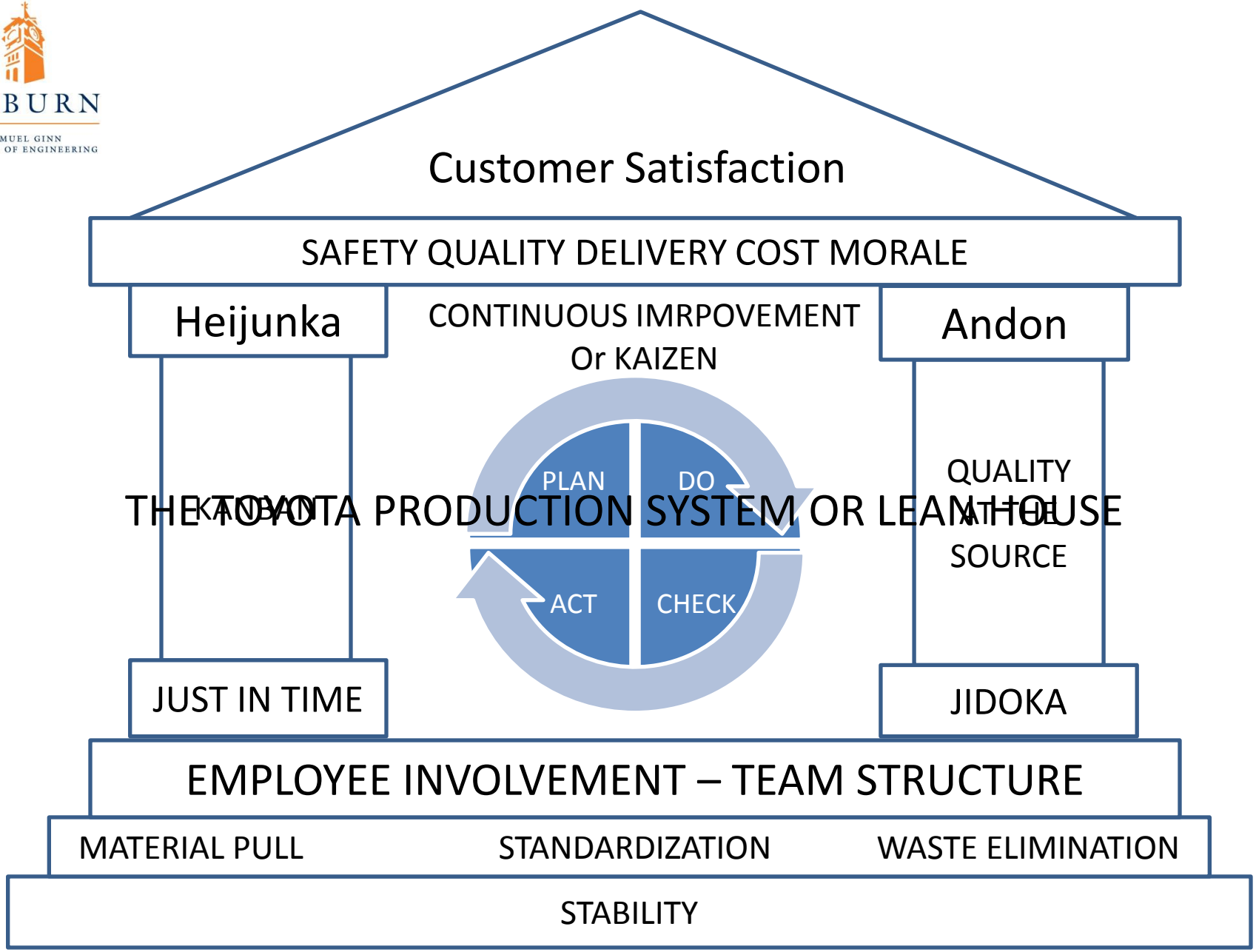
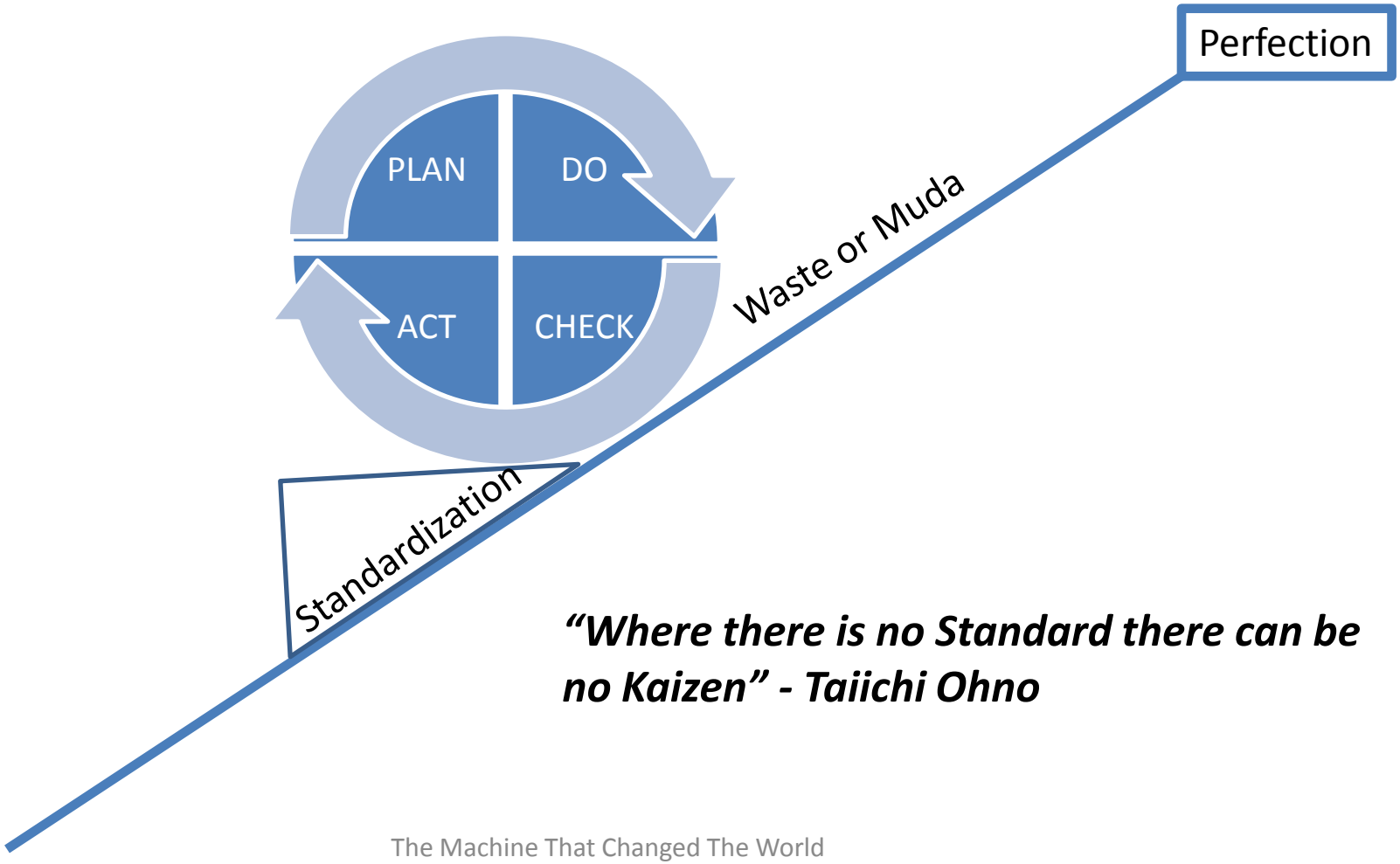


THE TOYOTA PRODUCTION SYSTEM OR LEAN HOUSE

The Machine That Changed The World

Continuous Improvement Cycle
The guiding principle



"Where there is no Standard there can be no Kaizen" - Taiichi Ohno

Service Industries can greatly benefit from Lean Methodology

- Transactional Lean is a discipline using Lean Manufacturing methods in within the Service Industry

- Standardized Work, People Involvement, Continuous Improvement with Key Process Indicators, Jidoka and Just In Time processing of the critical steps in completing services benefit from the Lean Operating System methodologies

- Lean Healthcare has exploded in the U.S. as a critical discipline to improve efficiency within the healthcare industry

The promise of Lean in Healthcare - *John S. Toussaint, MD, and Leonard L. Berry, PhD*
http://www.medline.com/media/mkt/pdf/research/or-safety-lean/The-Promise-of-Lean-in-Healthcare-Article.pdf

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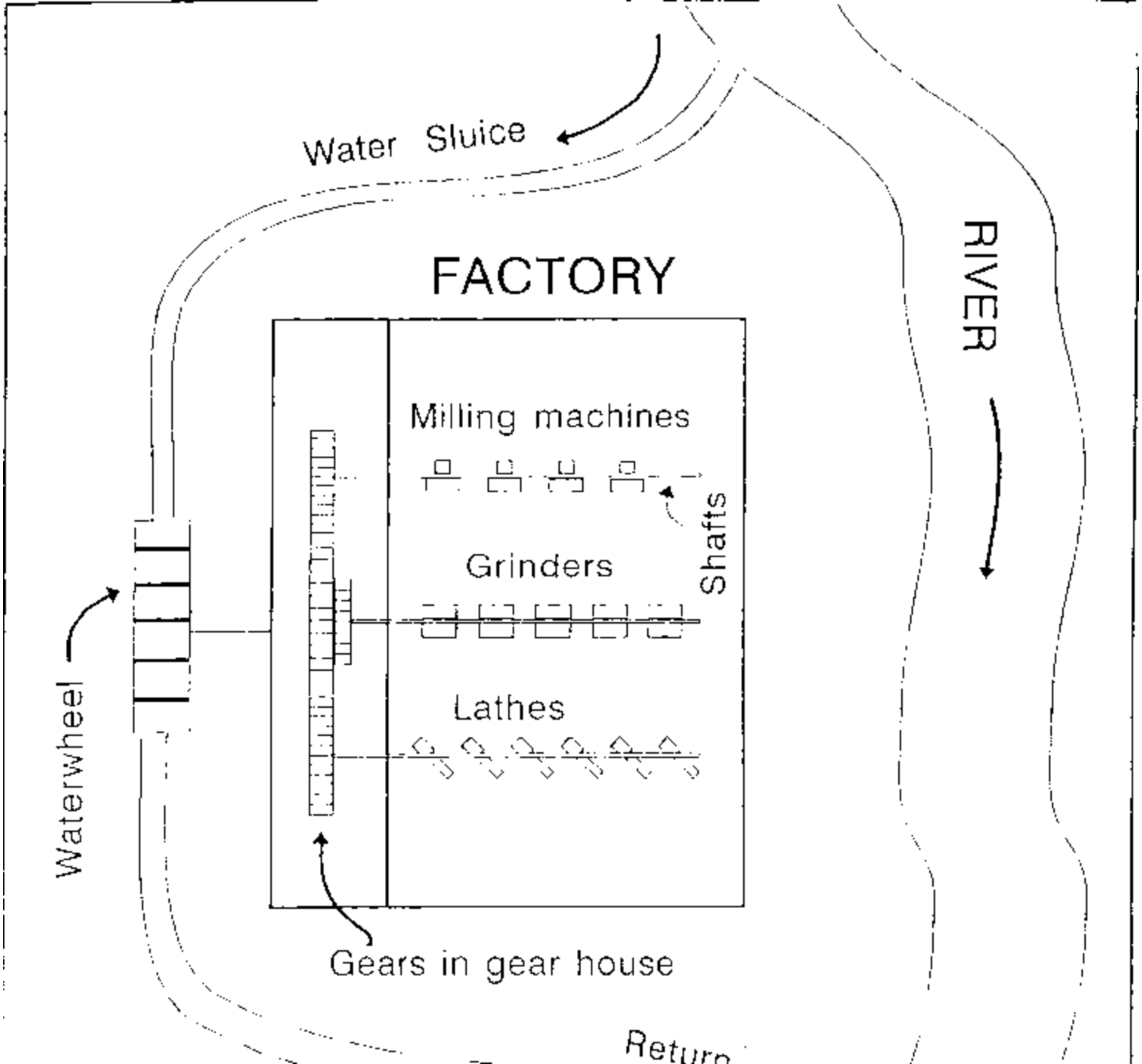
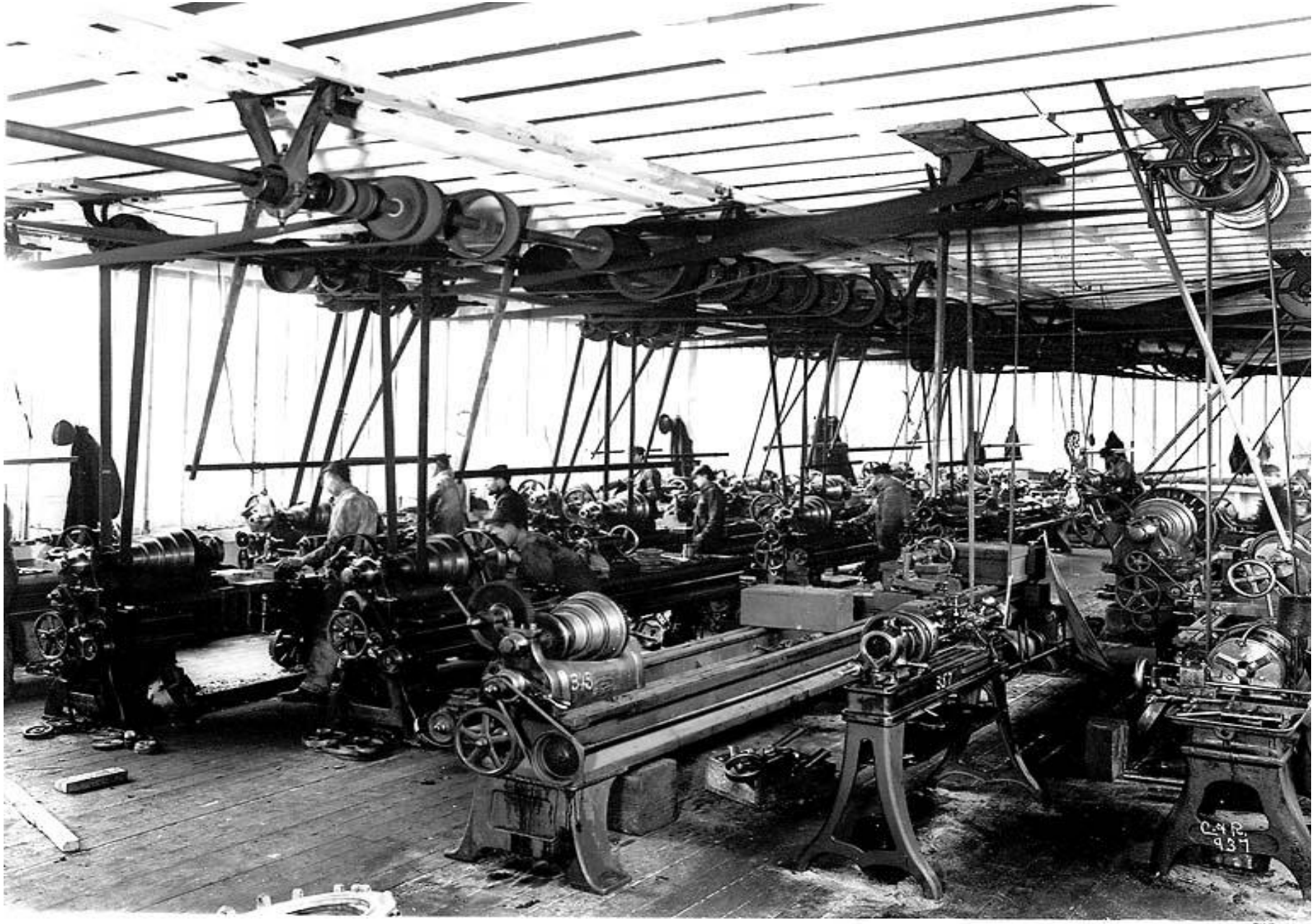
Evolution of Manufacturing

Craft Production 1700

1st Factory Design - 1840
Job Shop


Water Sluice
FACTORY
RIVER
Milling machines
Shafts
Grinders
Lathes
Waterwheel
Gears in gear house
Return



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Evolution of Manufacturing

2nd Factory Design - 1910

Mass Production – Ford

The Machine That Changed The World

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Evolution of Manufacturing

3rd Factory Design - 1970
Toyota Production System

The Machine That Changed The World

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FORD MOTOR COMPANY
Mass Production Results

- By 1914, the Model T had been so streamlined it took only 93 minutes to assembly a car (through all processes)
- In 1915 Highland Park workers spoke more than fifty languages. Many could not speak English. ***How with lack of common language could they produce the model T at such volume?***
- The model T was a great commercial success. By the 10 millionth unit, 9 of 10 cars in the world were Fords
- Employment at the Rouge facility employed 100,000 at it's height
- Early price for the model T was $850. By the 1920's the price had fallen to $300 or $3,300 in 2005 dollars

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FORD MOTOR COMPANY

Weakness of Mass Production

- **Limited goals:** acceptable defect rate, maximum inventory levels, narrow range of standardized product.
- **End of Line repair:** Large number of off line repairmen to address issues which occur in process. Employees had no authority to stop the line to rework / repair or more importantly, solve problems
- **Low Employee Morale:** Employees were as interchangeable as the parts they installed. They had no value beyond the specialized work

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GENERAL MOTORS
Alfred Sloan – Perfects Mass Production

- **Product Variety:** Five models from cheap to expensive that fully accommodate buyers of every income throughout their lives

- **Decentralization:** divisions financially managed – a response to Fords complete centralized control

- **Division of professional labor** – (Finance, Engineering, Manufacturing) this facilitated the spread of mass production beyond Ford's highly centralized organization. Single direction could not absorb the ability to grow

- **Standardization of component parts:** Across all divisions allowing variety while maintaining efficiency. Added "hang on" features such as automatic transmission, radios and air conditioning.

American Auto Industry
"The Arsenal of Democracy" – President Franklin Roosevelt

Germany takes Paris
June 23, 1940

Chrysler Tank Production
How Detroit Won The War
– Life Magazine

B41 Liberator Bombers roll down Ford Willow Run Assembly line
One Per Hour
February of 1943

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GENERAL MOTORS
Key Weakness Remains

- No improvement of the labor issue
- Mass Production is now fully matured yet full of hidden waste
- Toyota had produced only 2685 autos in the thirteen years after the war compared to Ford's Rouge plant at 7000 per day
- Opportunity for Toyota: From a small island country, a company dwarfed in size relative to the Ford, is positioned to exploit the inherent weakness of the mass production and nearly put the "Arsenal of Democracy" out of business. **HOW WAS THIS POSSIBLE?**

Toyota Production System

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Key Leaders in Toyota's Development

SAKICHI TOYODA 1867 – 1930

- Inventor / Industrialist
- Father of Japanese industrial revolution
- Founder of Toyoda Loom Works, Toyota Industries Co.
- Inventor of the automatic power loom – **Jidoka**
- Developed **5 Why** technique "Basis of Toyota's scientific approach" - Taiichi Ohno

Jidoka Origin for Toyota

Toyoda Automatic Loom - 1926

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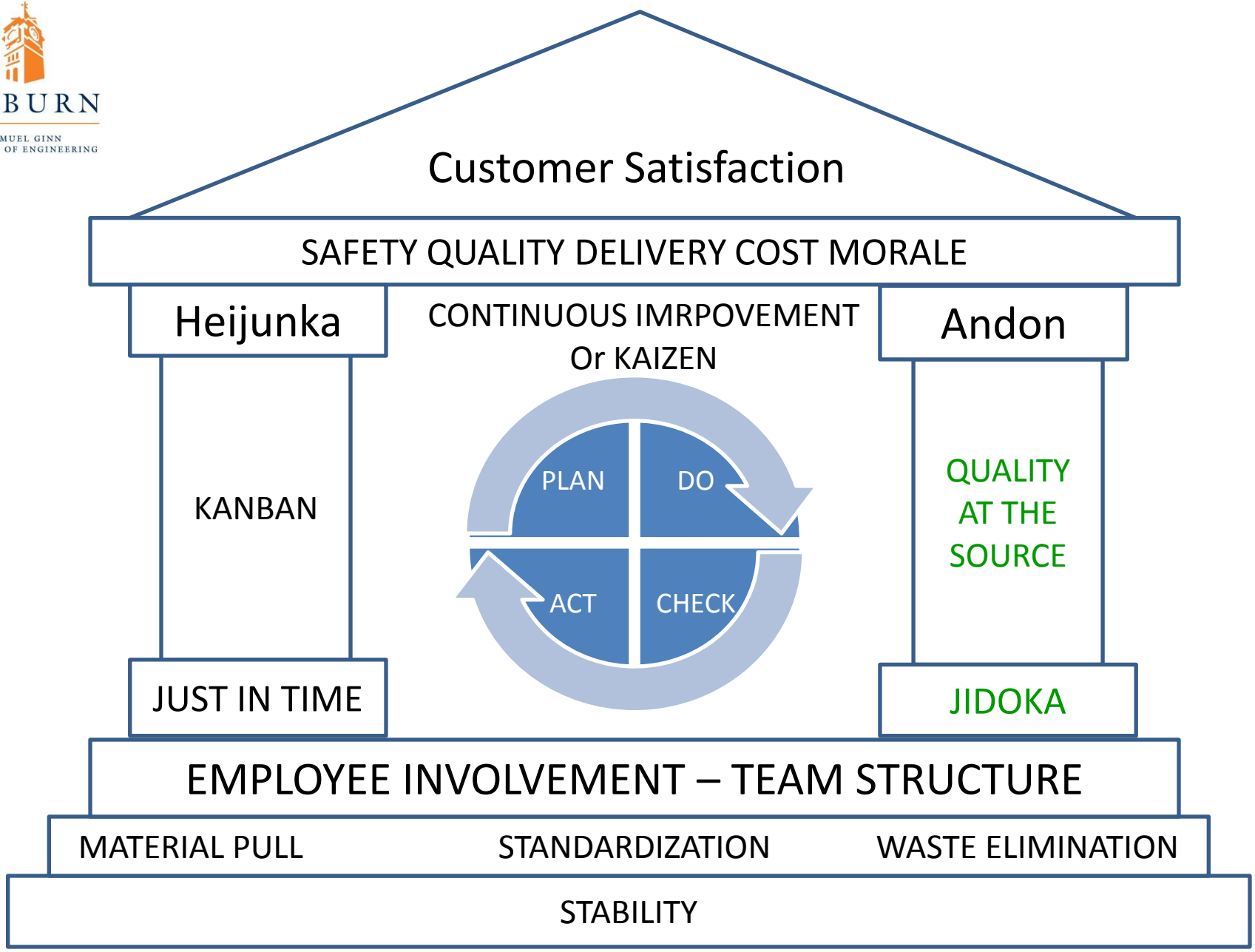

Key Leaders in Toyota's Development

Kiichiro Toyoda
(1894-1952)
President 1941 – 1950

- Founder Toyota Group 1937
- Implemented Chain Driven Assembly Line
- Initial efforts for **Just In Time** flow of material

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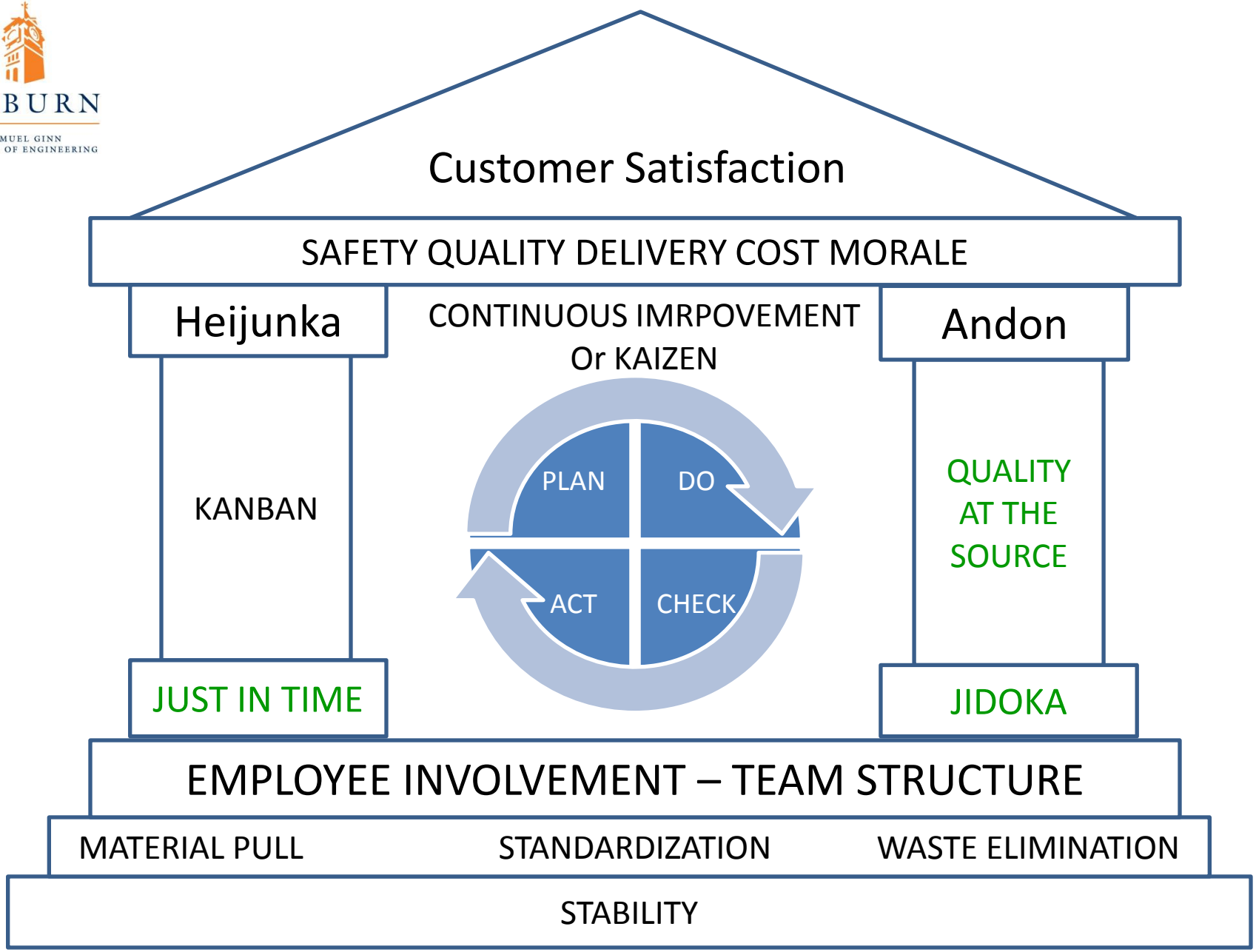

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Key Leaders in Toyota's Development

Eiji Toyoda (9.12.1913 - 9.17.2013)

- President for 67 – 82
- Credited with **JIT** and **Jidoka** implementation

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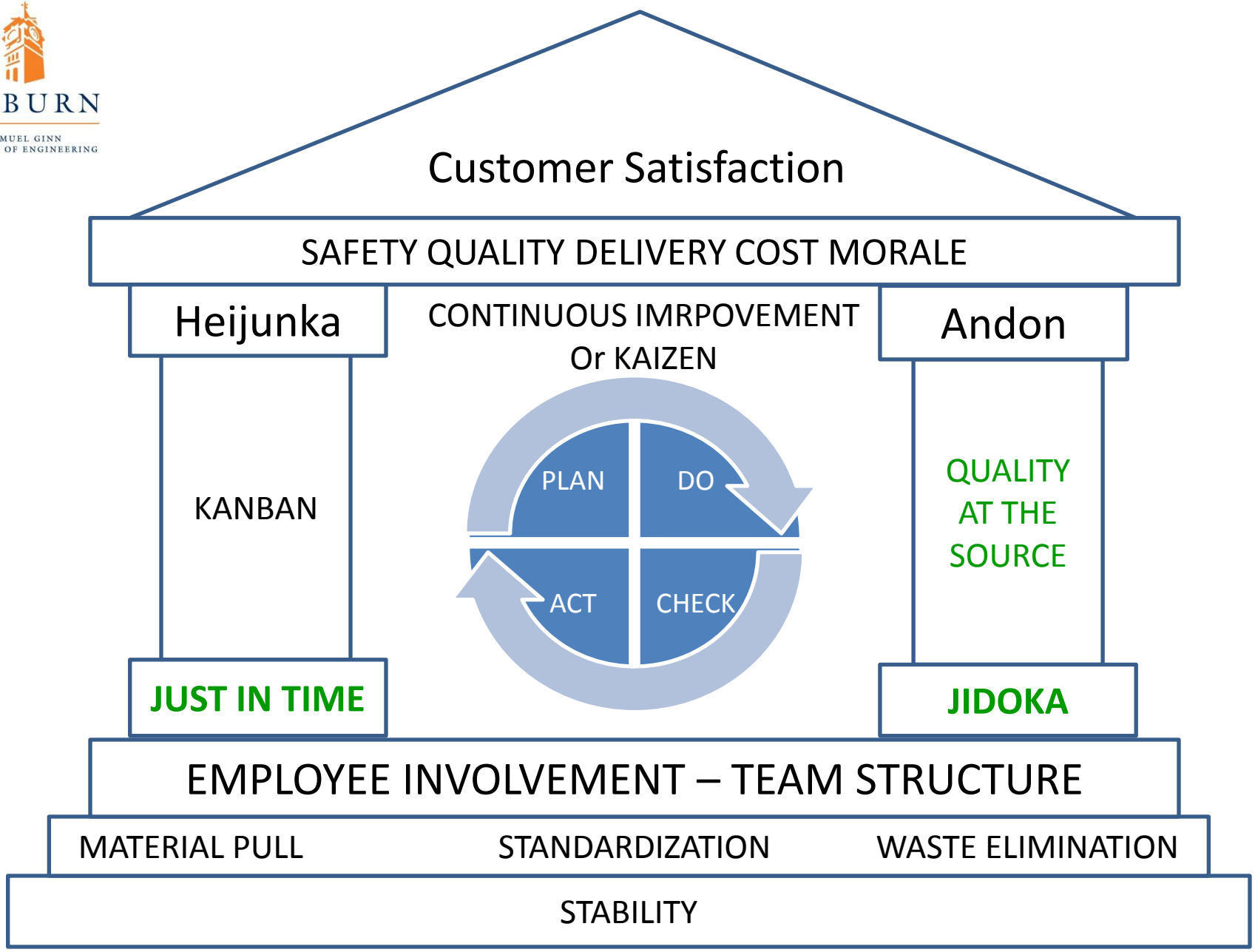

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Key Leaders in Toyota's Development

TAIICHI OHNO 1912 - 1990
Executive Vice President
Father of the Toyota Production System

- Defined the 7 Wastes – **MUDA**
- Refined Just In Time **(JIT)** Material flow with Kanban. Inspired by methods used within American supermarkets
- Refined **Jidoka** methods adding Andon
- Standardization

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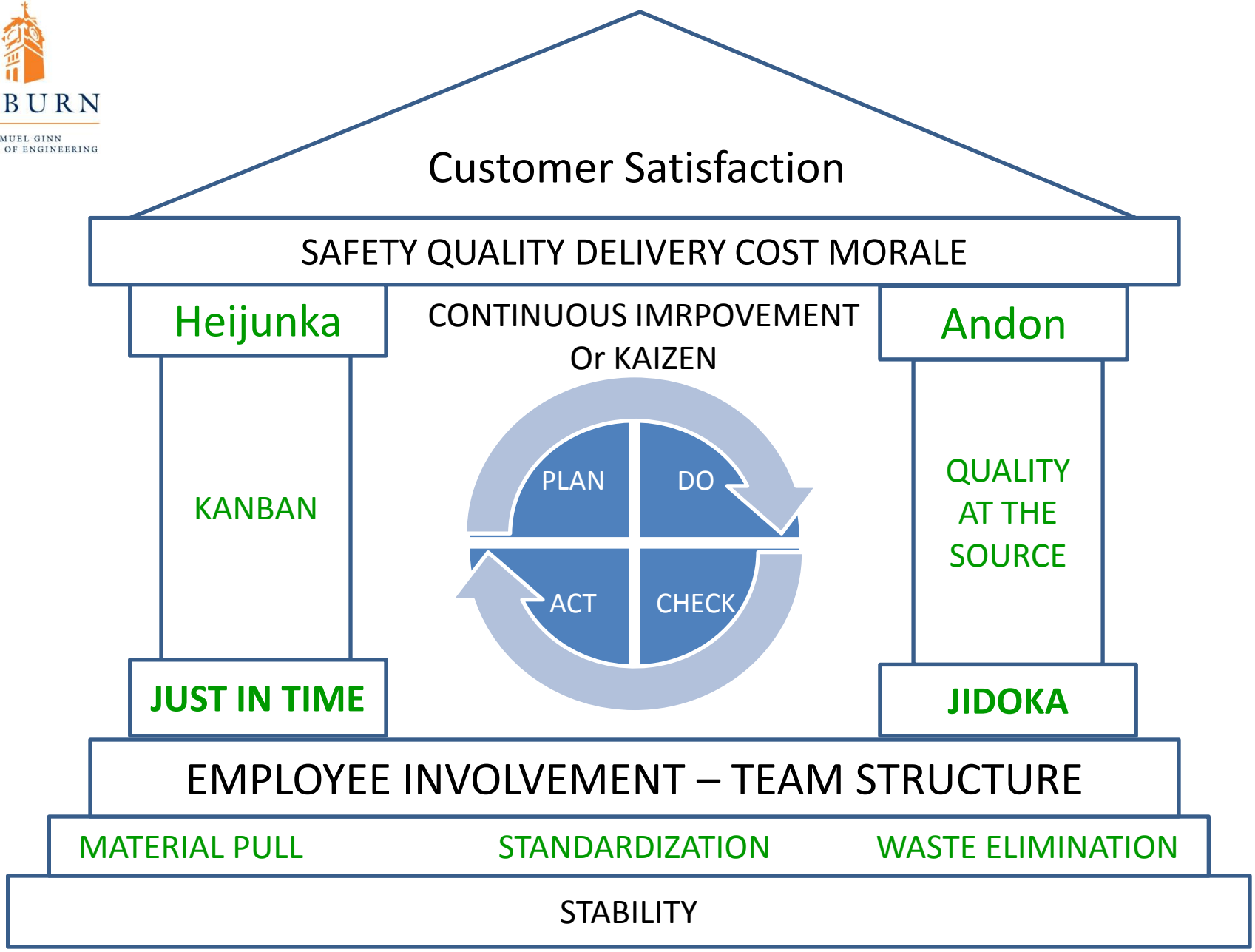

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Key Leaders in Toyota's Development

SHIGEO SHINGO 1909 - 1990

- Developed Single Minute Exchange of Dies **- SMED**
- Refined error proofing strategies **- Poke Yoke**
- Taiich Ohno's Industrial Engineering Consultant

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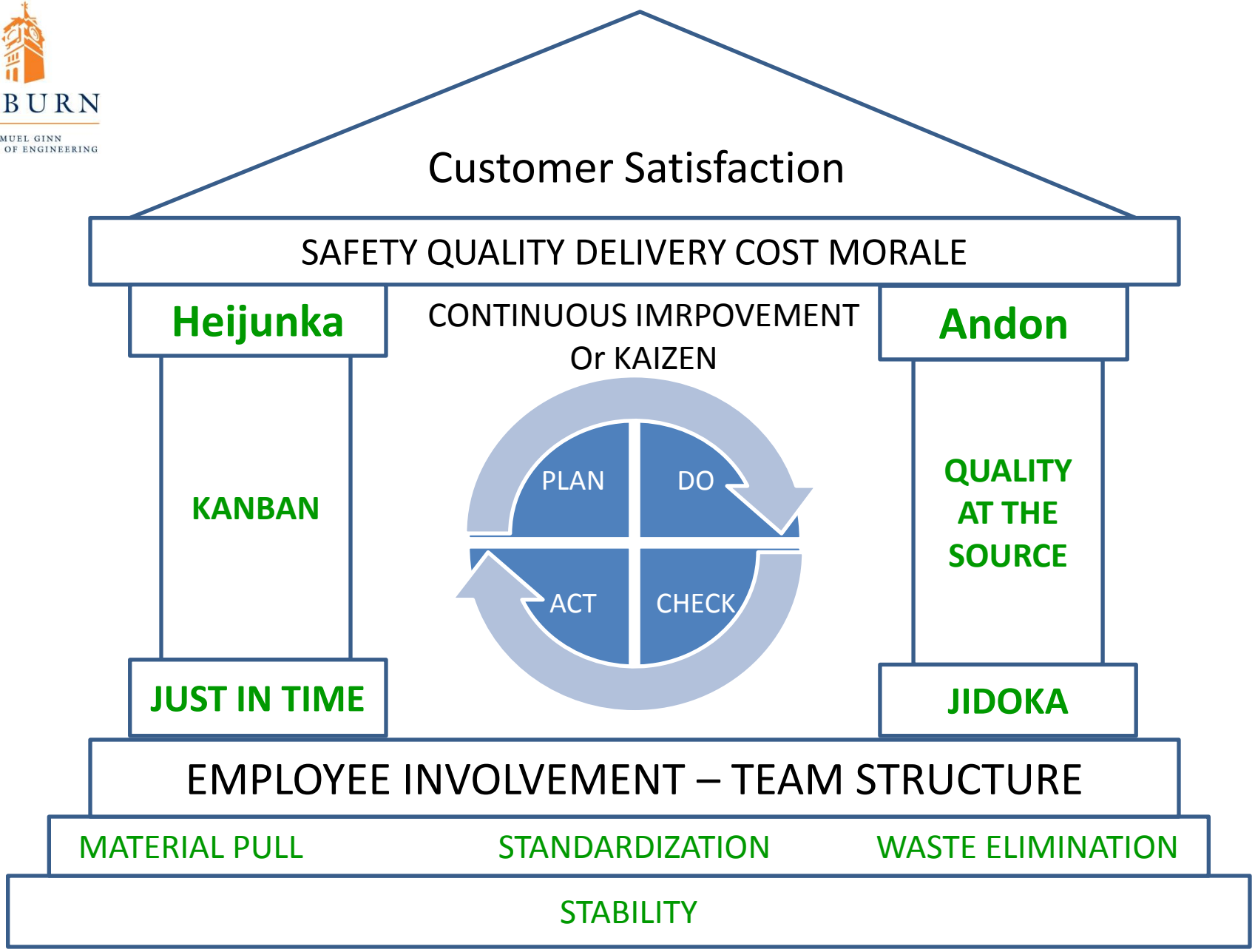

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Development of the Toyota Production System

"Necessity is the Mother of Invention"

- The unions supported by the American occupation in Japan made it very difficult to layoff employees

- At the end of '49 a collapse in sales forced Toyota to terminate a large part of the work force. After a long strike, Kiichiro Toyoda resigned, taking responsibility for failure

- The company agreed to the following:
  - Lifetime employment
  - Wages steeply tied to seniority rather than job function
  - Wages tied to company profitability through bonus payments

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Development of the Toyota Production System
"Necessity is the Mother of Invention"

- The company position: " if we are going to take you on for life, you have to do your part by doing the jobs that need doing". Employees are now viewed by Ohno as FIXED ASSETS

- Employees agreed to flexibility in work assignments. The employees also agree to initiate improvements rather than merely responding to problems

- Contrast this role to mass production employees (compensation, flexibility of work assignments, problem solving skills, value the company places on them

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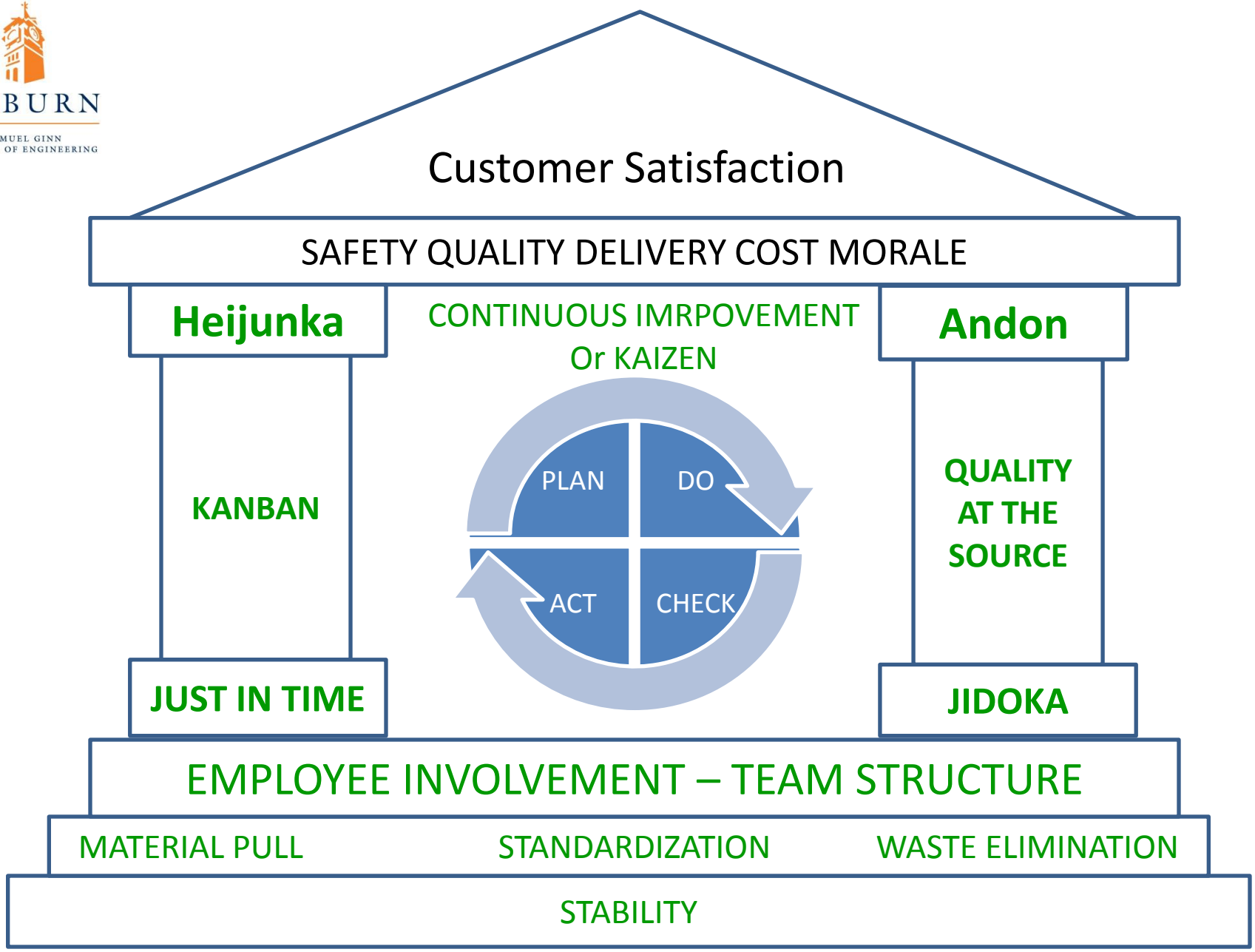

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Development of the Toyota Production System
"Necessity is the Mother of Invention"

- The Japanese domestic market required a wide variety of vehicles. If Toyota were to grow & expand, they would be required to satisfy their own market first.

- Eiji Toyoda and Taiichi Ohno visited Ford's Rouge plant in the spring of 1950. Eiji's uncle, Kiichiro, had visited Ford in 1929

- Toyota had produced only 2685 autos in the thirteen years after the war compared to Rouge at 7000 per day. Eiji along with Taiichi Ohno determined Ford's Mass Production model could not work for Toyota

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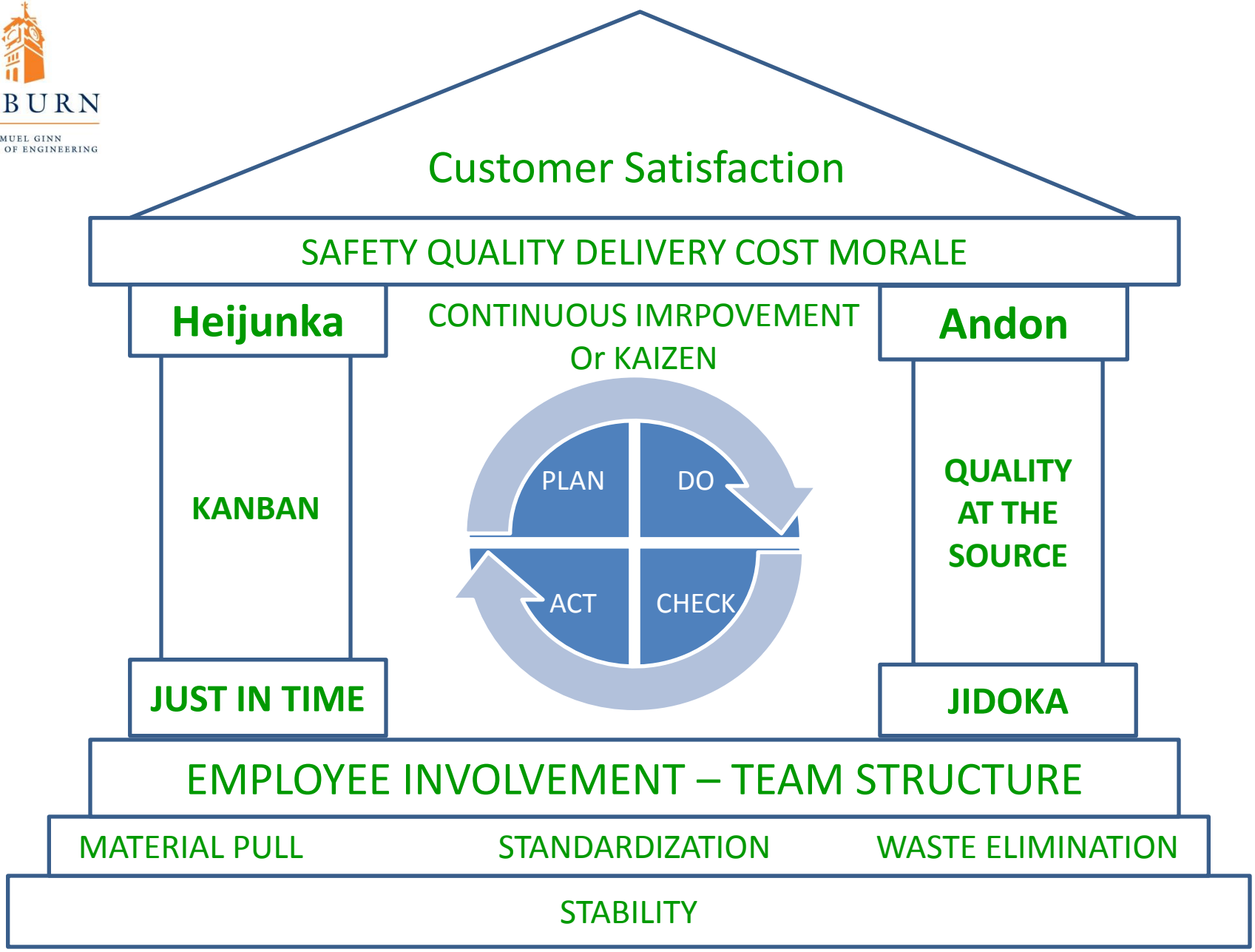

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Development of the Toyota Production System
“Necessity is the Mother of Invention”

- No guest workers allowed in Japan (Ford utilized a large population of immigrant labor for the Rouge facility)
- Foreign investment was prohibited in Japan to protect the development of their industry
- Japan was starved for foreign capital. Purchase of technology was not possible
- Toyota’s capital budget could not fund the stamping press methods used by Mass producers. The mass production method required 100’s of presses while Toyota budget could only support a few press lines

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Development of the Toyota Production System
“Necessity is the Mother of Invention”

- Western presses were designed to operate at 12 strokes per minute. Toyotas projected annual volume at the time was a few thousand per year

- Dies could be changed to utilize the press but the dies weighed tons and required very precise alignment. A slight alignment issue would create defects and even damage the dies

- Detroit employed die change specialists. Changeover could take a day. Some presses were dedicated for the life of the product

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Development of the Toyota Production System
"Necessity is the Mother of Invention"

- The only solution was to develop die changes every two or three hours vs. two or three months
- Due to production workers being idled by changeover, Taiichi Ohno decided to deploy the idled workers to perform die changes (not possible with mass production - why)
- Toyota purchased a few used American presses and experimented with a process for rapid die change. Ohno perfected quick change of dies by the late 50's
- Time reduced from a day to three minutes –
  (Single Minute Exchange of Dies SMED) Shigeo Shingo

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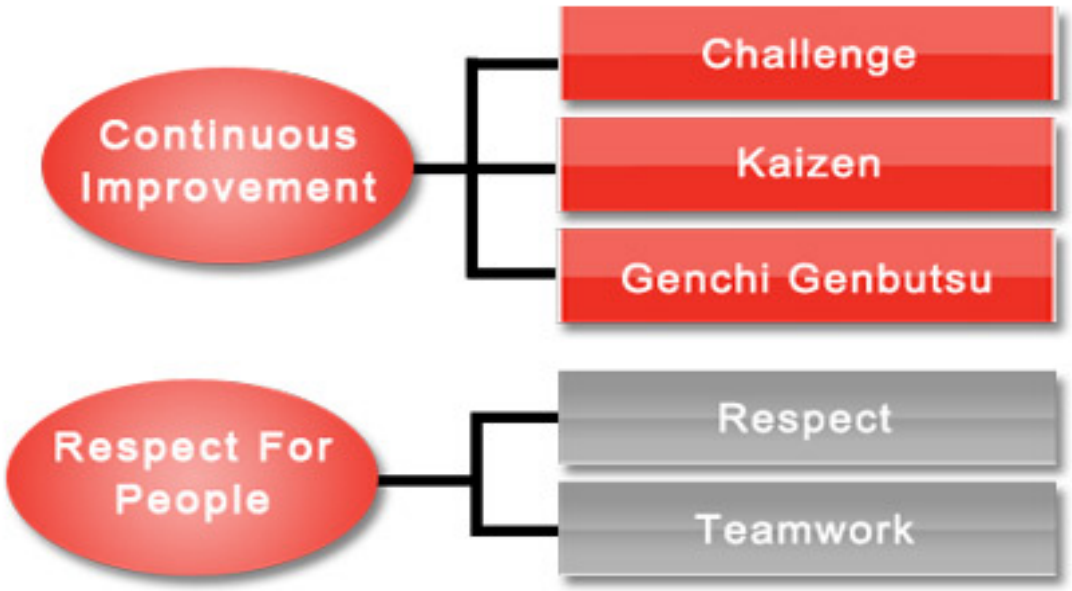
Development of the Toyota Production System
"Necessity is the Mother of Invention"

- At the time of the study, Toyota used very little off line repair. Traditional mass production used 20 to 25% of labor for off line repair. Why?

- Ohno – Andon Cords stop the line and solve problems as they occur. Team Leader vs. Supervisor

- Utilize Five Why method of resolution - Compare to Six Sigma

- Line stops were excessive in the beginning. Toyota could not survive unless the problems were permanently resolved – (Irreversible corrective action). Proper use of the Five Why methodology was critical to success. Workforce skill and motivation absolutely required



Continuous Improvement means that we never perceive current success as our final achievement. We are never satisfied with where we are and always improve our business by putting forth our best ideas and efforts: we are keen to create better alternatives, question our accomplishments and investigate future definitions of success.

There are three building blocks shaping our commitment to **Continuous Improvement**:

1. **Challenge** – we form a long term vision, meeting challenges with courage and creativity to realize our dreams;
2. **Kaizen** – we improve our business operations continuously, always driving for innovation and evolution
3. **Genchi Genbutsu** – we go to the source to find the facts to make correct decisions, build consensus and achieve goals.

Respect For People refers to our own staff as well as the communities and stakeholder groups that surround us and we are part of. We respect our people and believe the success of our business is created by individual efforts and good teamwork.

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The Machine That Changed The World
Essential Lean Tools

Jidoka
- •Andon
- •Poke Yoke – Mistake Proofing
- •Standardized Work
- • PFMEA - **Process Failure Modes Effects Analysis**

JIT
- •Value Stream Mapping
- •SMED
- •Kanban
- •Supermarkets
- •Heijunka – Product Mix Leveling

Kaizen
- •Work Cell Design
- •Muda – **Seven Waste: Transportation, Inventory, Motion, Wait Over Production, Over Production, Defects**
- •5S Sort, Set In Order, Shine Standardize and Sustain
- • Visual Factory
- •Seven Basic Quality Tools:

  As much as 95% of *quality* related problems in the factory can be solved with *seven* fundamental quantitative *tools*." –Kaoru Ishikawa
- • Hoshin Kanri – Policy Deployment

Respect for People

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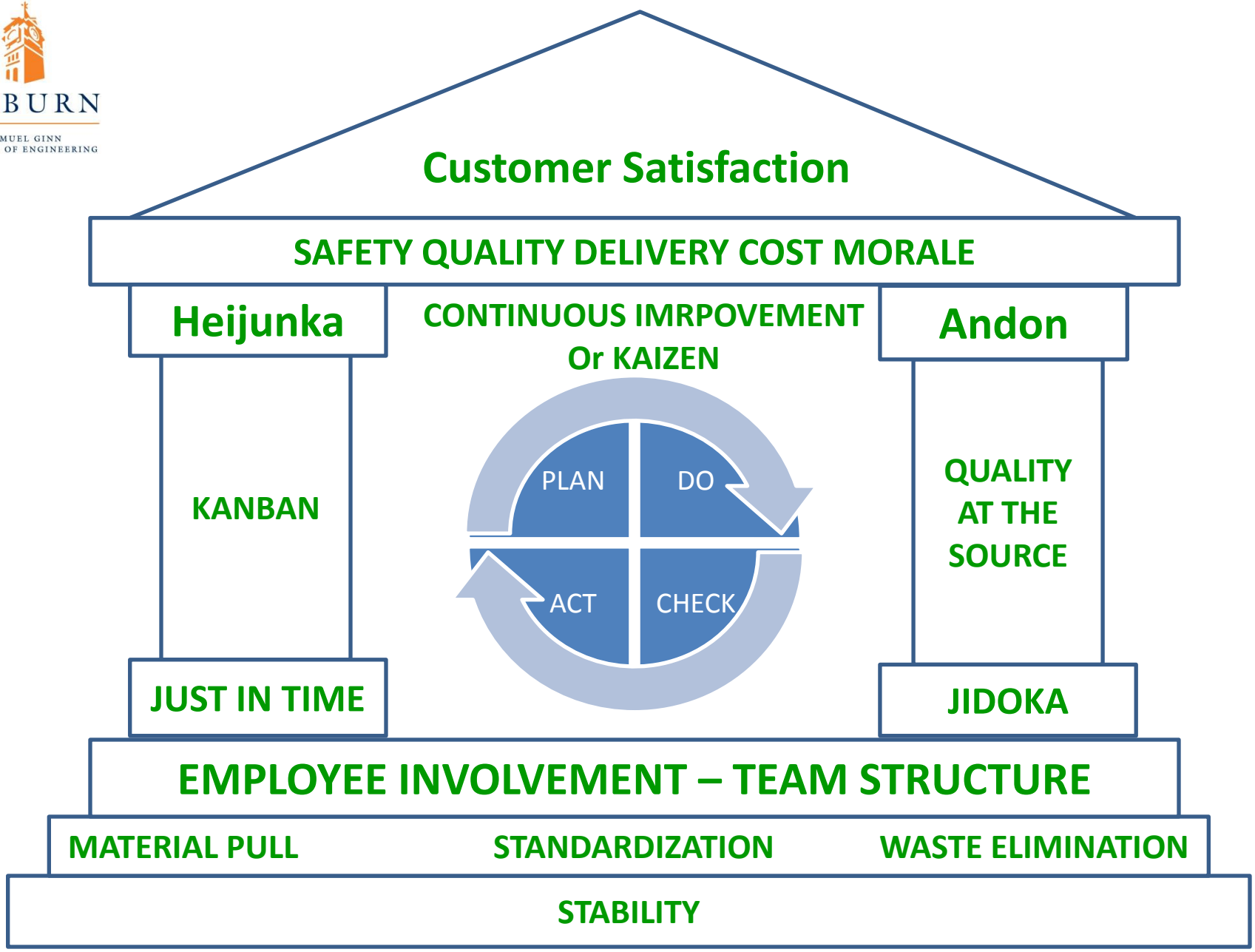


Future State Value Stream Mapping

VALUE STREAM MAPPING:

"The most important tool they will need to make sustainable progress in the war against Muda" – Jim Womack, Dan Jones

"All we are doing is looking at the time line **(defined as Lead Time)** , from the moment the customer gives us an order to the point when we collect the cash. And we are reducing the time line by reducing the non-value adding wastes." – **Taiichi Ohno**

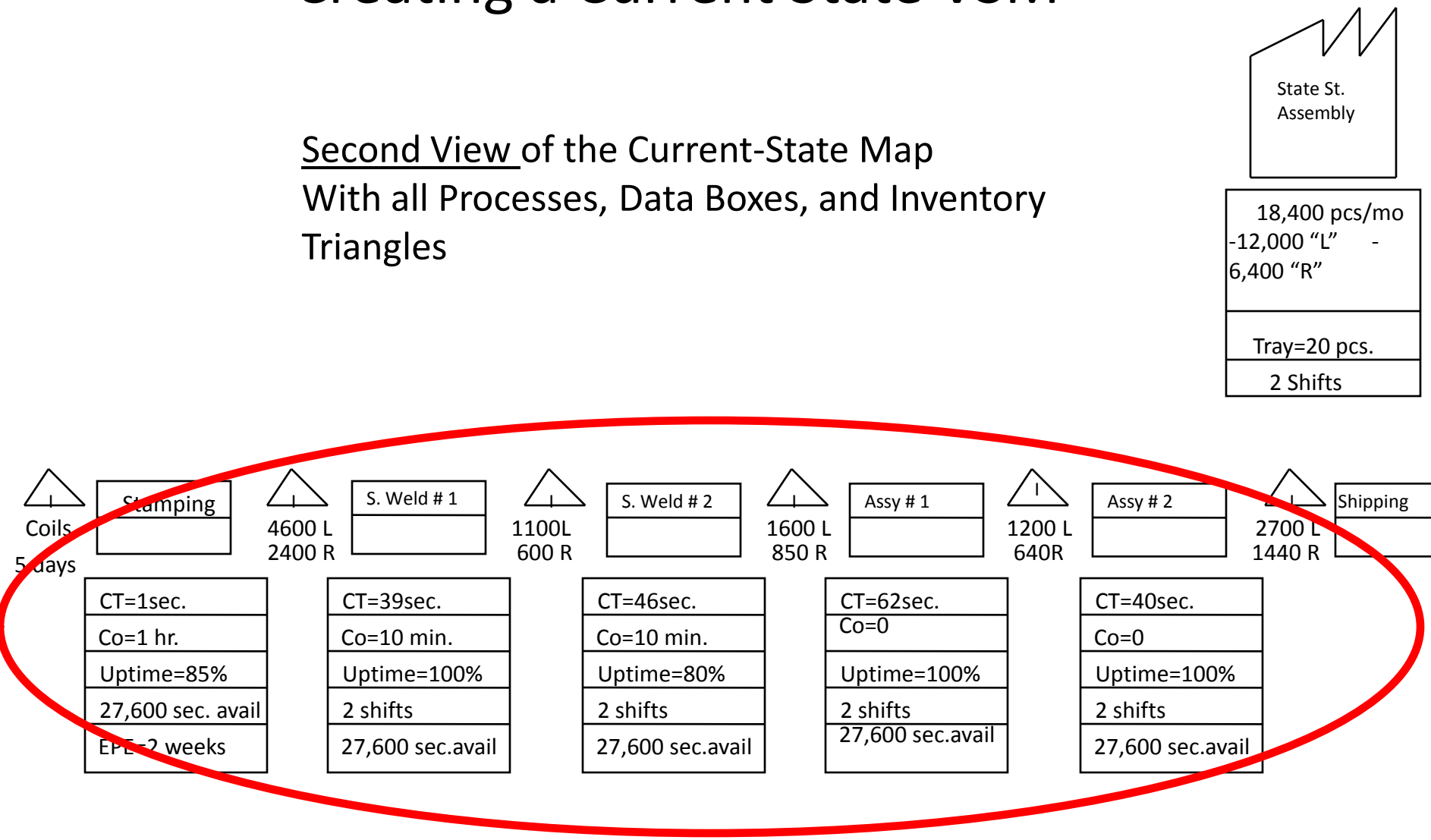
Creating a Current State VSM

CYCLE TIME (C/T)
How often a part or product actually is completed by a process,
As timed by observation. Also, the time it takes an operator to
Go through all of their work elements before repeating them. Both
Value and Non Value added time

LEAD TIME (L/T)
The time it takes one piece to move all the way through a
value stream, from start to finish. Envision timing
A marked part as it moves from beginning to end through the WIP First
In First Out.

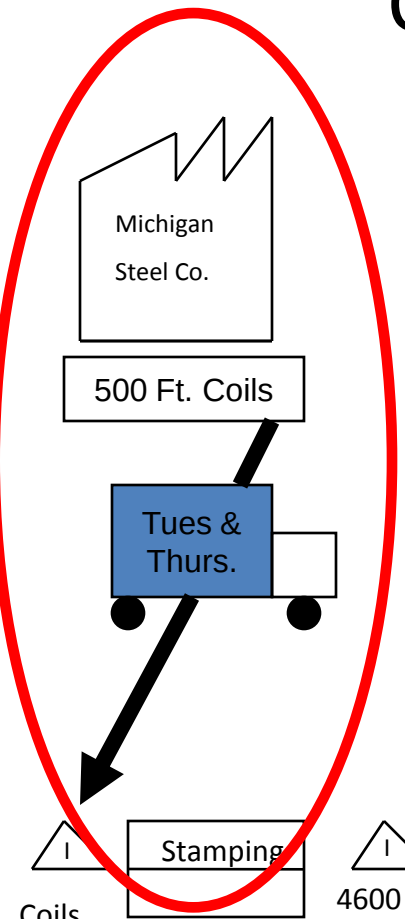
Creating a Current State VSM

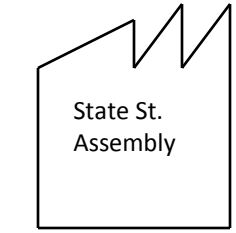
<u>Second View</u> of the Current-State Map
With all Processes, Data Boxes, and Inventory Triangles



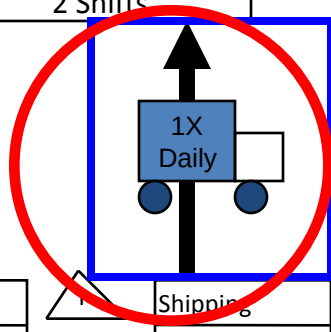
Creating a Current State VSM

Third View of the Current – State Map Showing the Materials Flow from the supplier and to the customer





18,400 cs/mo
-12,000 "L"
-6,400 "R"
Tray=20 pcs.
2 Shifts



Coils
5 days

Stamping	S. Weld # 1	S. Weld # 2	Assy # 1	Assy # 2	Shipping
CT=1sec.	CT=39sec.	CT=46sec.	CT=62sec.	CT=40sec.	
Co=1 hr.	Co=10 min.	Co=10 min.	Co=0	Co=0	
Uptime=85%	Uptime=100%	Uptime=80%	Uptime=100%	Uptime=100%	
27,600 sec. avail	2 shifts	2 shifts	2 shifts	2 shifts	
EPE=2 weeks	27,600 sec.avail	27,600 sec.avail	27,600 sec.avail	27,600 sec.avail	

4600 L
2400 R

1100L
600 R

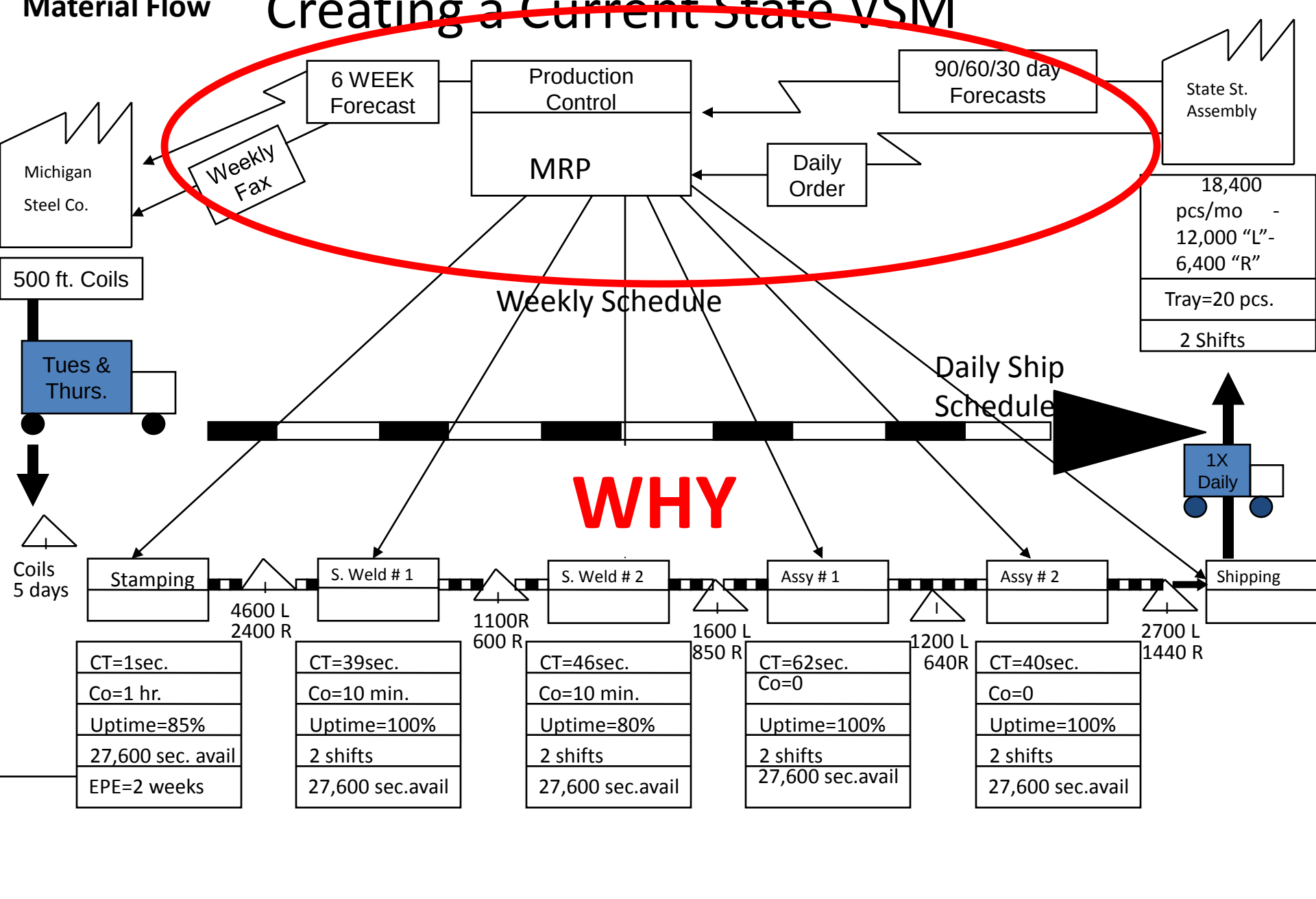
1600 L
850 R

1200 L
640R

2700 L
1440 R

Fourth View
Material Flow

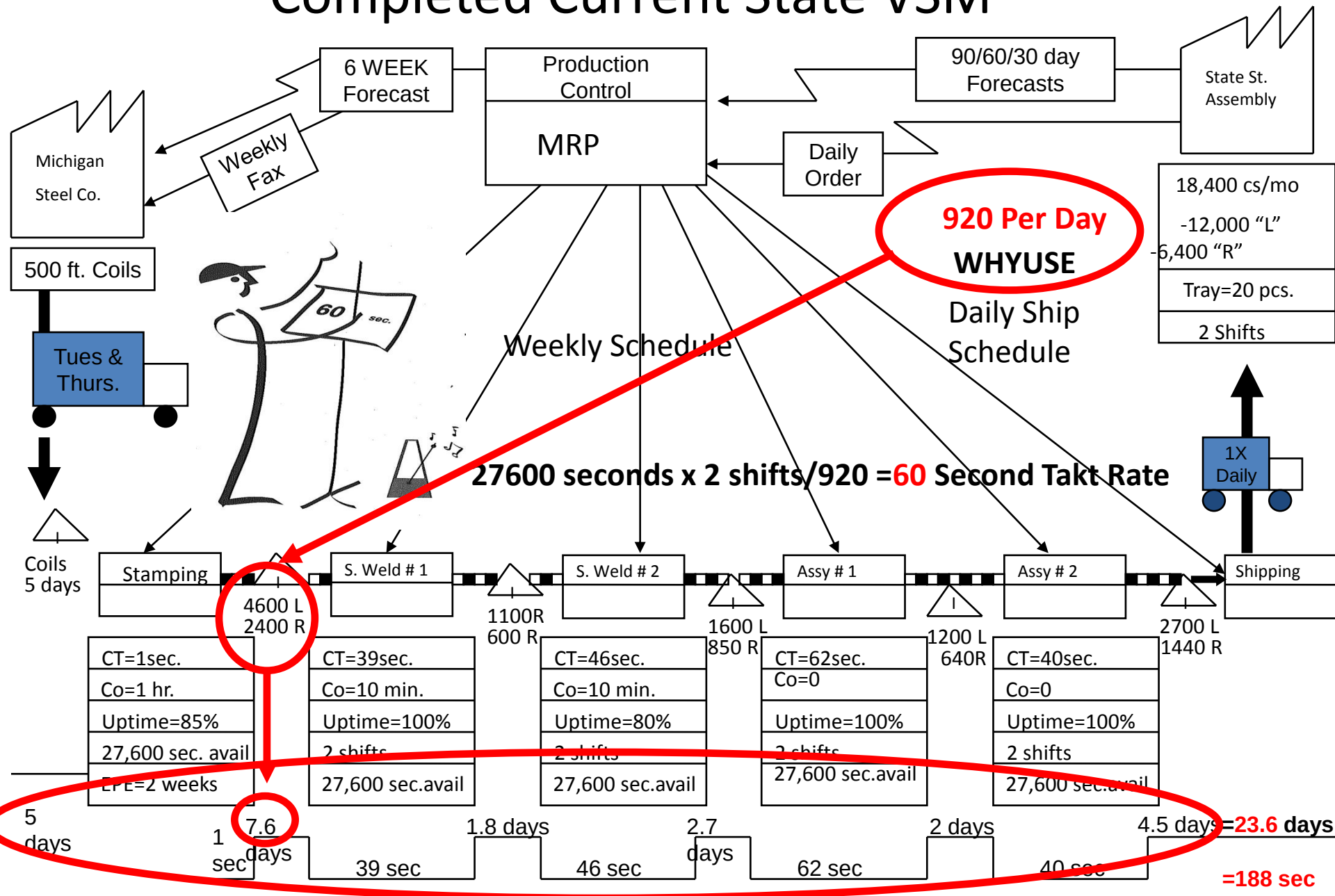
Creating a Current State VSM

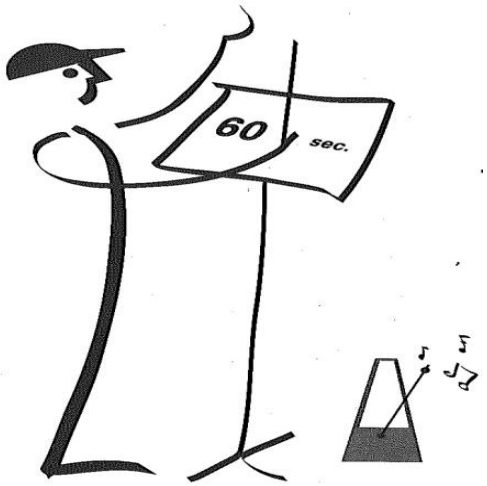


Fifth View

Lead Time Defined

Completed Current State VSM





60 Seconds Takt Rate

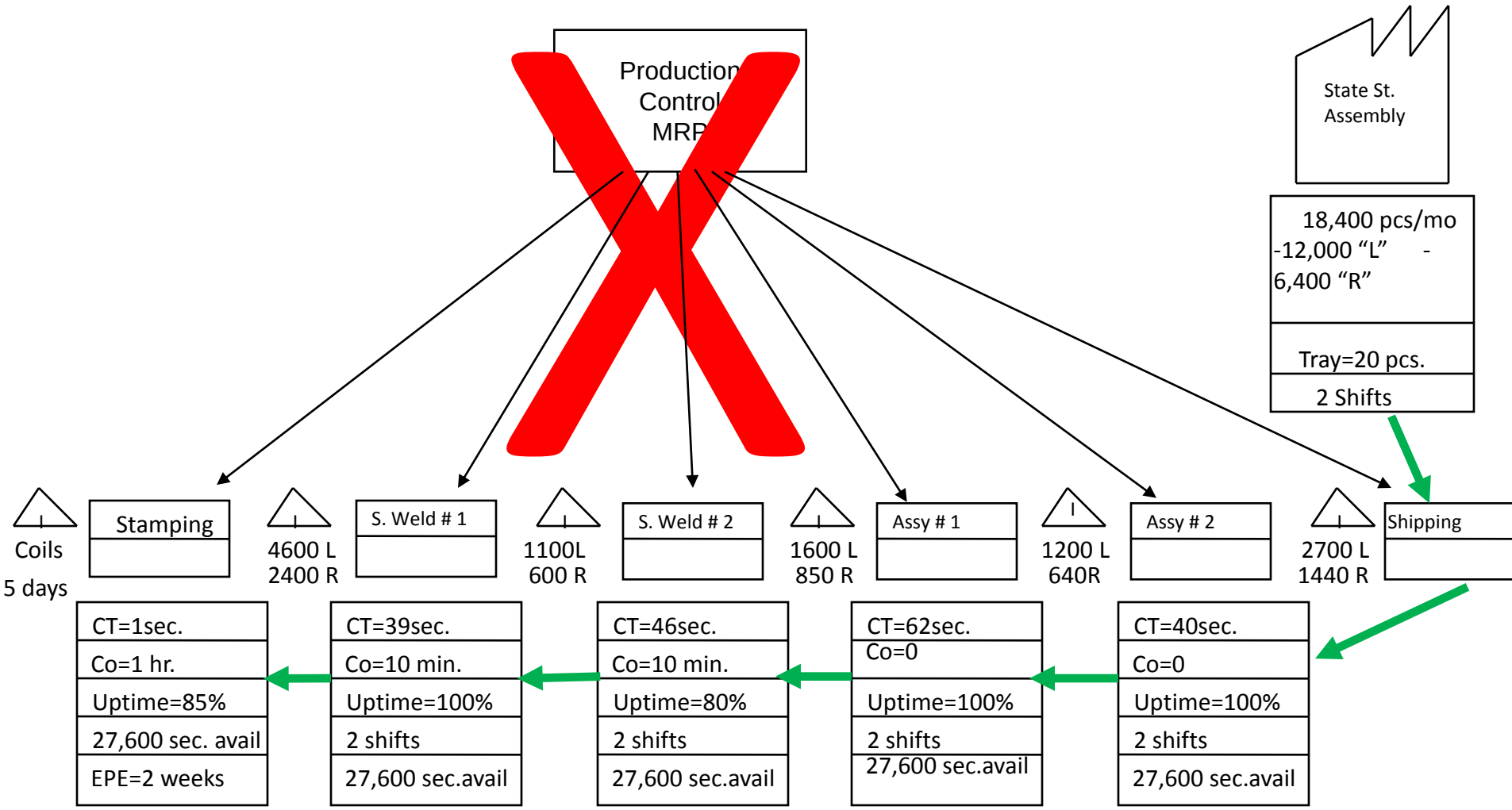
Stamping	Weld 1	Weld 2	Assembly 1	Assembly 2
1 second	39 seconds	46 seconds	62 seconds	40 seconds
59 second	21 seconds	14 seconds	-2 seconds	20 seconds
Overproduction			**Overtime Required**	**Overproduction**

The number 1 waste
Of Taiichi Ohno's Seven Wastes

23.6 days **Lead Time**

188 seconds **Cycle Time**

Material Pull vs. Push



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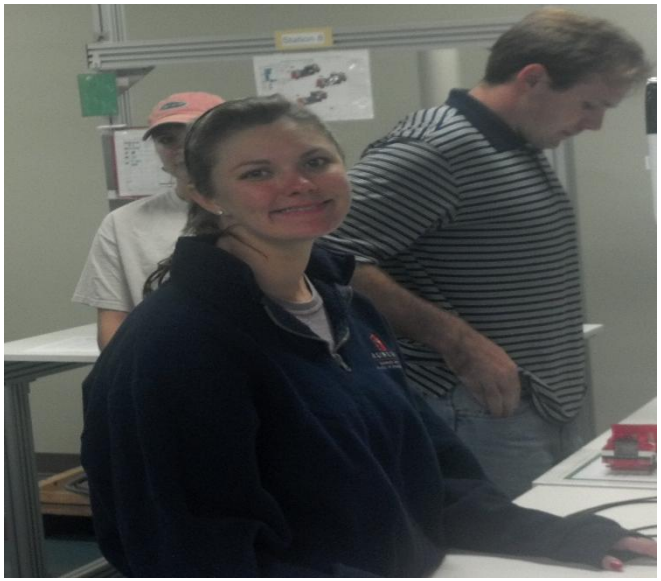
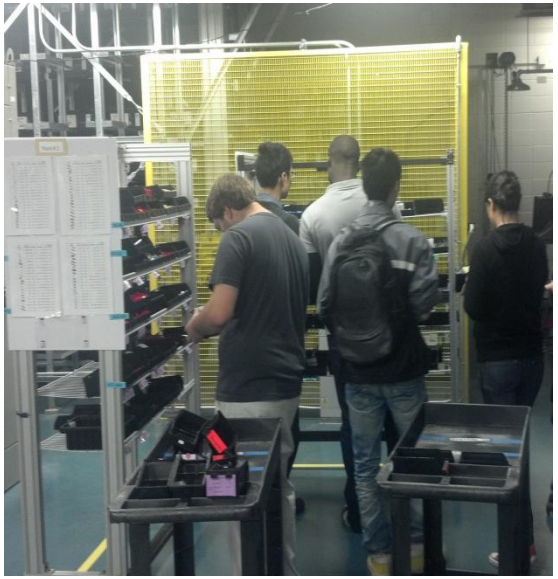
Tiger Motors – Lego Manufacturing Lab



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Tiger Motors - Lego Manufacturing Lab

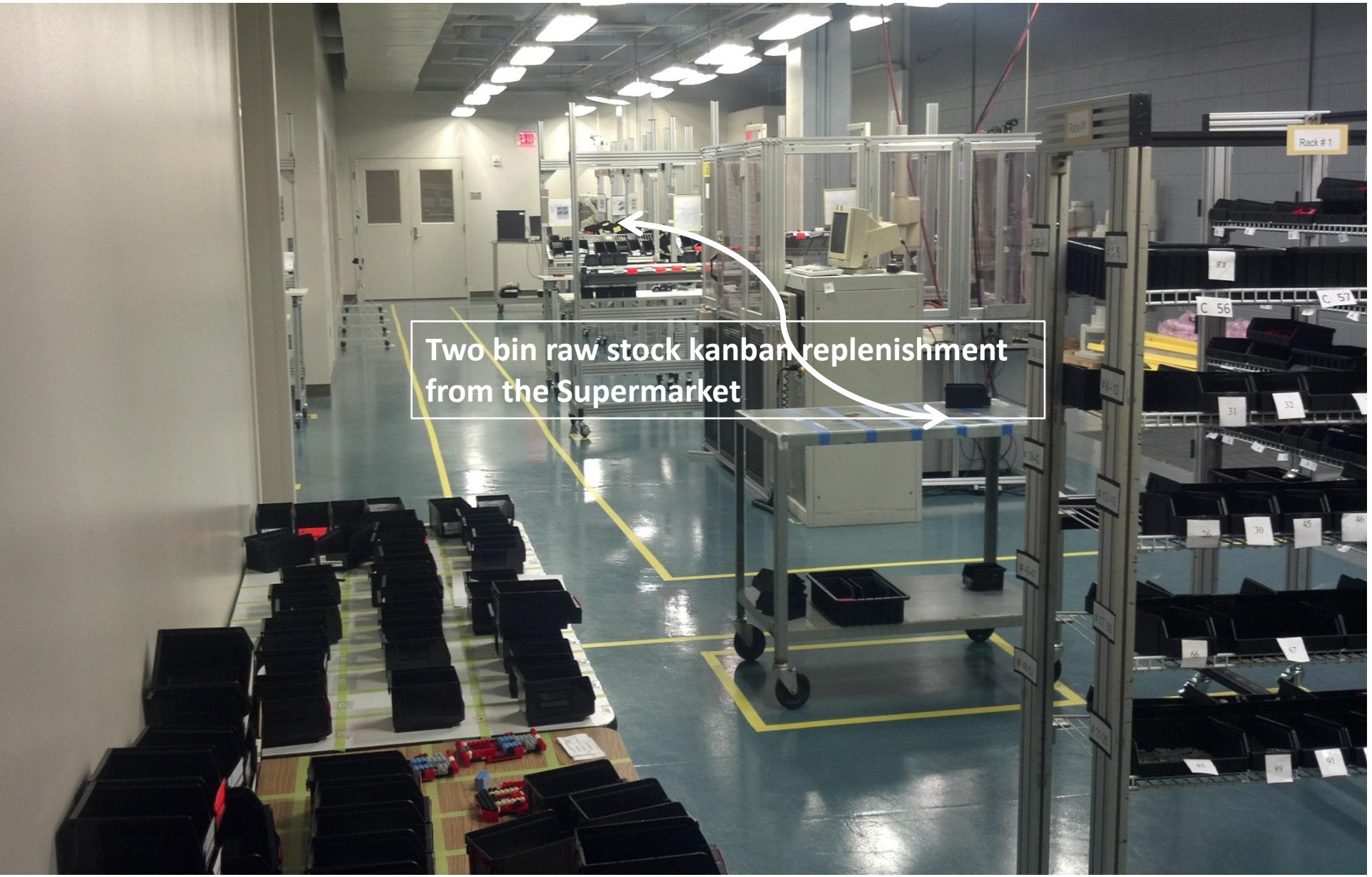
PRODUCT

- Products : SUV (244 pieces) Speedster (277 pieces)
- Takt Rate: 65 Seconds / 830 per day / 200,000 Per Year Demand
- 3 Cells – 5 workstation per cell – 2 U-Shaped / 1 Straight Line
- Three production runs per semester: Mass / Lean System / Kaizen

Yamekalani Moyo - PHD
Helped develop Lego Lab

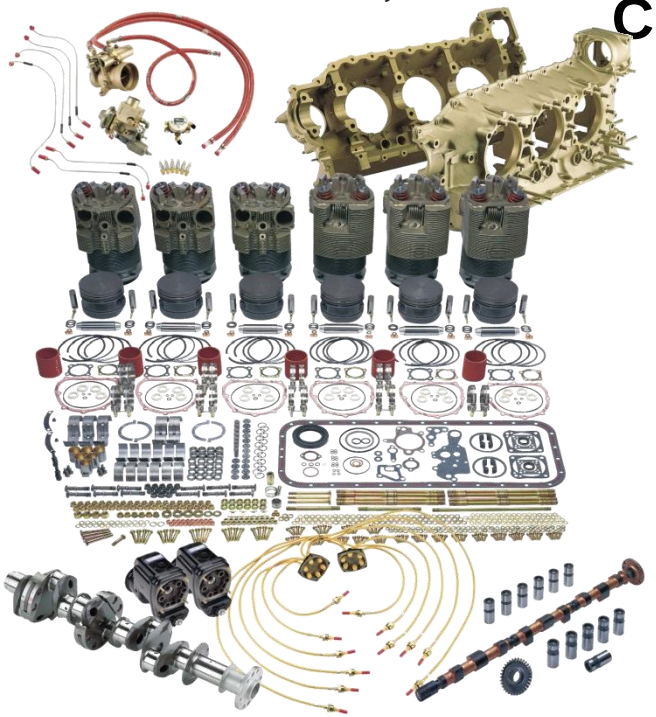

Kanban Loop 1
Kanban Loop 2
Kanban Loop 3
Heijunka to Station 11
Heijunka from Station 15
Tiger Motors
SQDCM Metrics
Safety
Quality
Delivery
Cost
Morale
AUBURN
6
12
18
24
30
36
42
SPEEDER
SUV

PULL SYSTEM FOR MATERIAL COMPLETE



Continental Motors, Inc.

Michael D. Skolnik
V.P. Operations
Continental Motors, Inc.
Mobile, AL



Continental Motors, Inc.

Material Pull System Implementation
Crankcase Machining - Continental Motors

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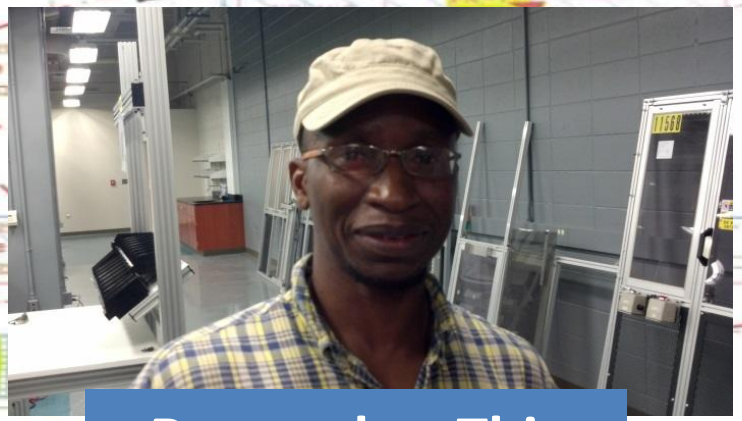
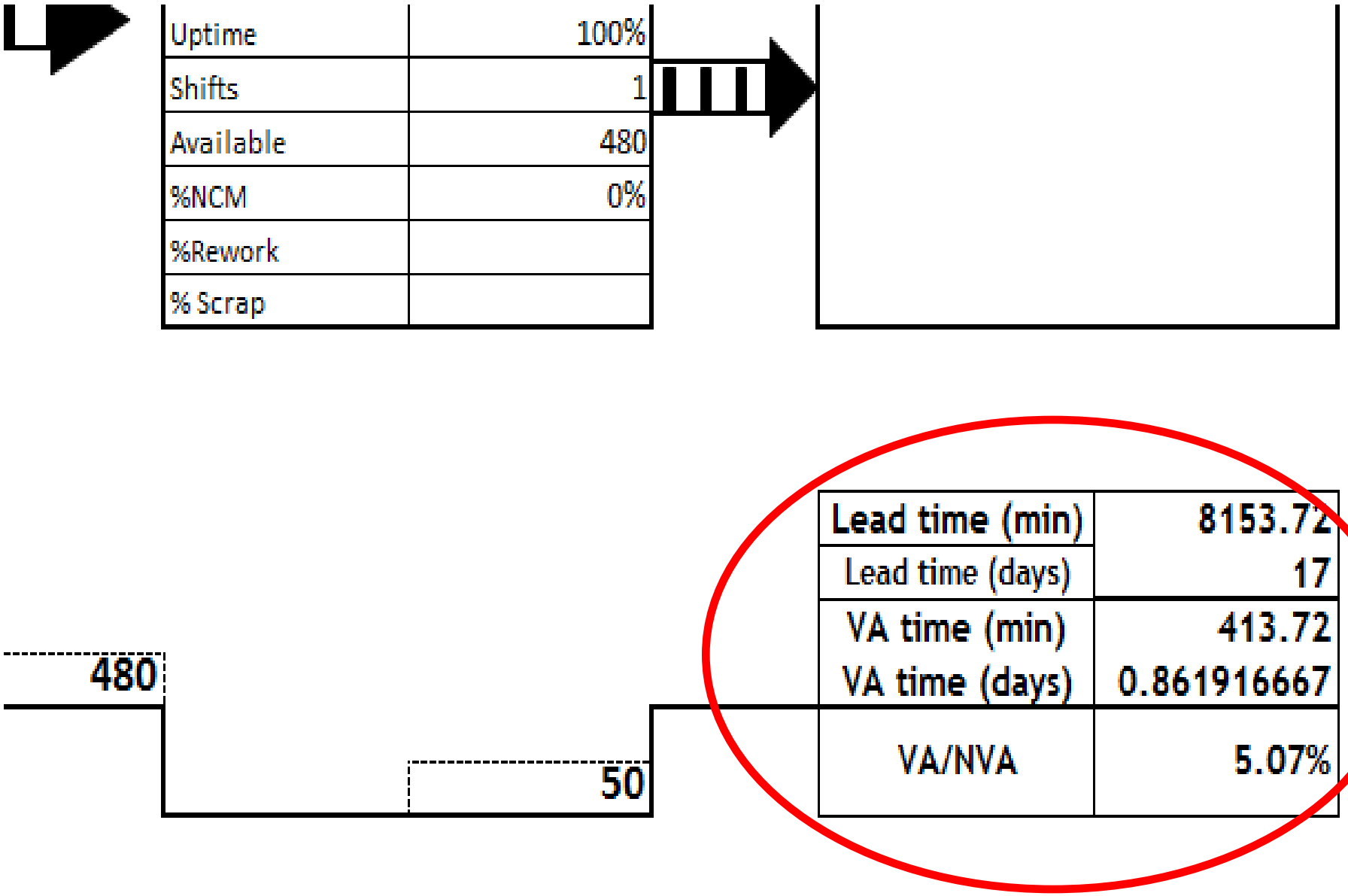
Kanban Loop 1

Kanban Loop 2

Kanban Loop 3



Remember This Guy?

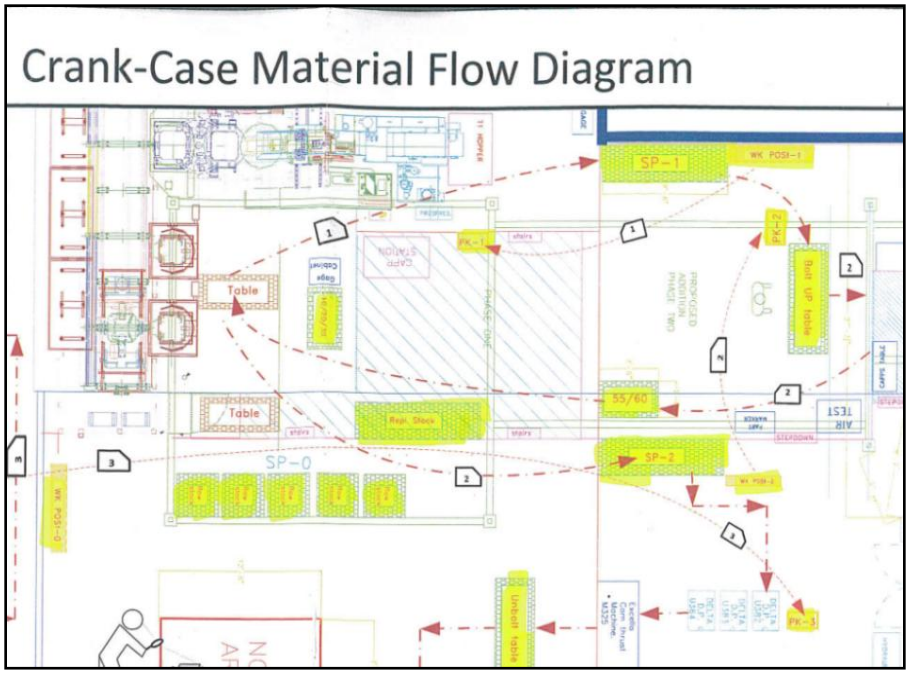

Uptime
100%
Shifts
1
Available
480
%NCM
0%
%Rework
% Scrap
480
50
Lead time (min)
8153.72
Lead time (days)
17
VA time (min)
413.72
VA time (days)
0.861916667
VA/NVA
5.07%

“Don’t say anything to him yet but we will be extending a permanent offer to the Yamekalani today!”

M. Skolnik – VP of Operations, Continental Motors

Auburn Project - Kanban

- **Transition from <u>Planned</u> to <u>Material Pull</u> for Crankcase Operations**



<u>Continuing Needs:</u>

Expansion of **<u>Material Pull</u>** to all departments feeding engine assembly & aftermarket

*** Cylinders** *** Crankshaft** *** Camshaft** *** Rocker Arms**
*** Con Rods** *** Fuel/Ignition Systems** *** Sub-Assembly** *** Misc. Machining**

Impact

- Kaoru Ishikawa, one of the fathers of quality in japan, creator of fishbone diagram and the seven basic quality tools stated:
  - *"It takes three years to see significant impact of kaizen"*
- The impact relates to the sheer weight of many small improvements over time. Think of small deposits in a 401K that at a point in time the growth curve becomes exponential
- Anecdotal Evidence:
  - *DaimlerChrysler's Sterling Heights Assembly Plant :*
    - *After three years of implementation, the plant experienced the first perfect build; 8hours of production, a vehicle every 51 seconds without a lost unit*