Chapter 8. Lean Operations and the Toyota Production System

The History of Toyota

- Sakichi Toyoda, the founder of the Toyota group of companies, started Toyota as a textile machine company.
- Kiichiro Toyoda, son of Sakichi, founded TMC in 1937.
- Taiichi Ohno, Toyota's chief of production in the post-WWII period. He was the main developer of Toyota Production System (TPS).

TPS (Toyota Production System) ⇒ outcome of a long evolution (overcoming the challenging environment of scarcity after World War II)

The History of Toyota

Two Crises

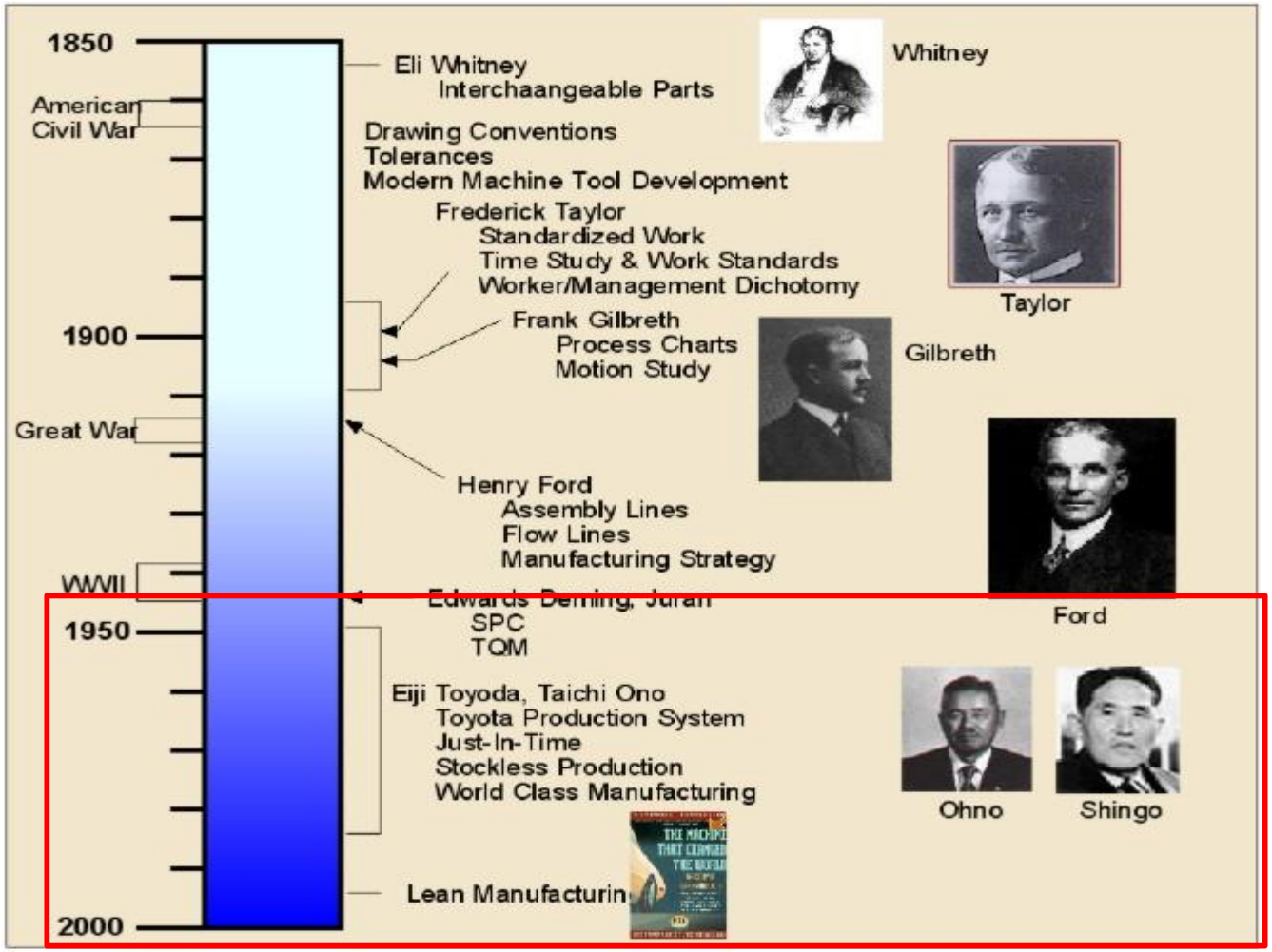
(1) Recall several million vehicles caused from unintended vehicle acceleration in 2009~2010

(2) Japanese earthquake of March 2011

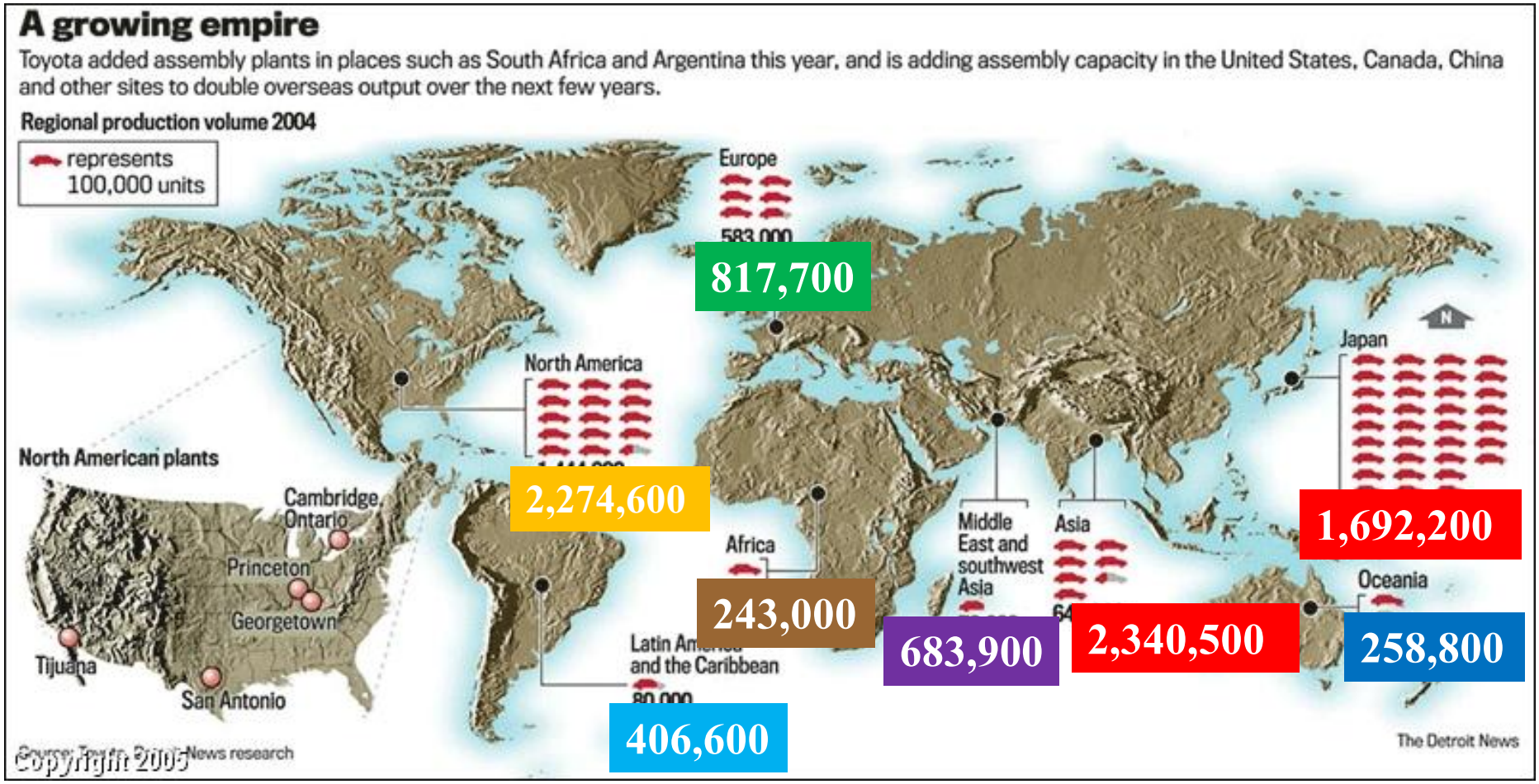
⇒ Shut down several assembly plants

History of Manufacturing Management

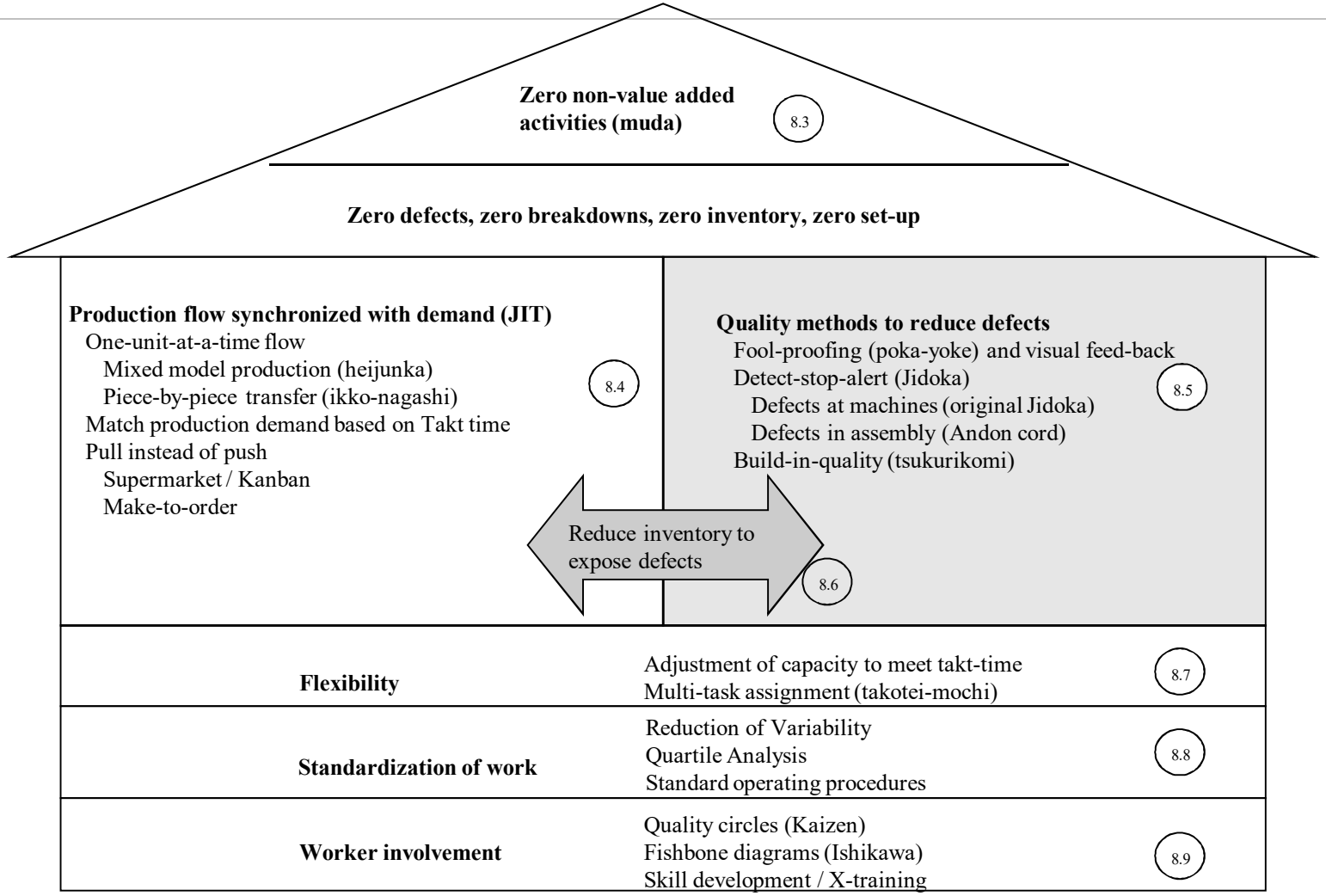
- Toyota's role in the history of manufacturing management



Toyota's Worldwide Sales (units) in 2012

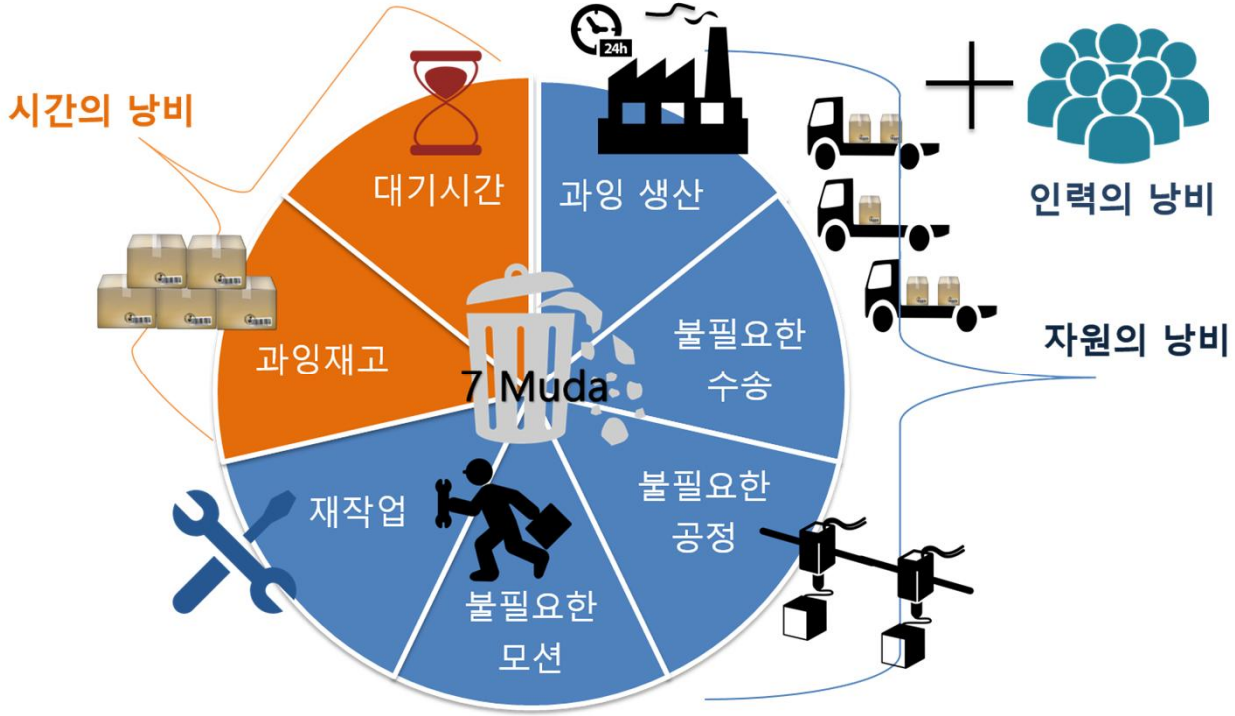


Toyota Production System: Framework

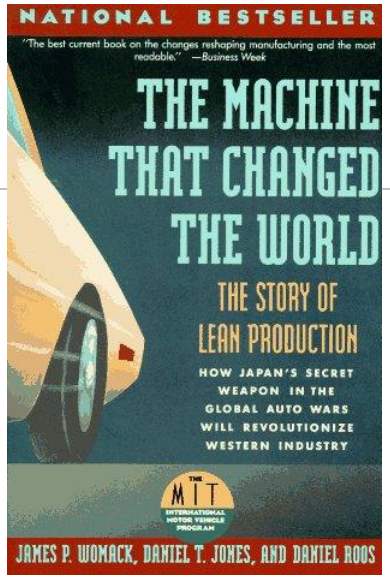


The Seven Sources of Waste

- 도요타 생산 시스템의 기본은 다음 7가지 낭비(Muda, 無駄) 들을 제거하는 것



The IMVP Studies



The data are already more than 30 years old
⇒ still of high relevance today!

General Motors Framingham Assembly Plant Versus Toyota Takaoka Assembly Plant, 1986

	GM Framingham	Toyota Takaoka
Gross Assembly Hours per Car	40.7	18
Assembly Defects per 100 Cars	130	45
Assembly Space per Car	8.1	4.8
Inventories of Parts (average)	2 weeks	2 hours

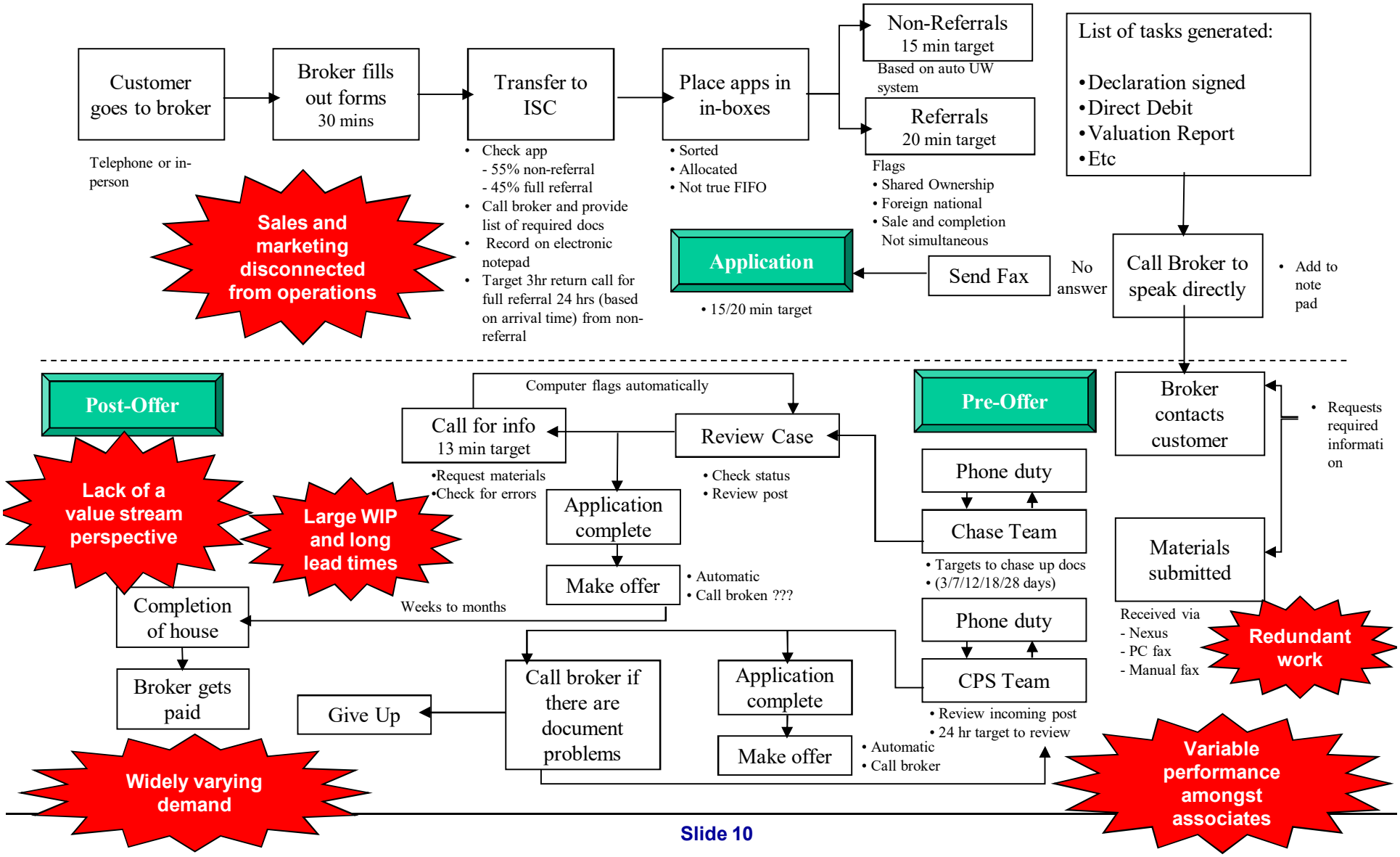
Gross assembly hours per car are calculated by dividing total hours of effort in the plant by the total number of cars produced
Defects per car were estimated from the JD Power Initial Quality Survey for 1987
Assembly Space per Car is square feet per vehicle per year, corrected for vehicle size
Inventories of Parts are a rough average for major parts

Lean Tool-box

This set of slides summarizes a set of lean operations tools (there is much more):

1. Mapping the Process Flow
2. Identifying sources of wasted capacity
3. Understanding barriers to flow
4. Standardization of work / standard operating procedures
5. Balance resources and have demand drive the process
6. Overall Equipment Effectiveness / Effective Capacity Utilization

Tool 1: Mapping Out the Process



Tool 2: Understand Sources of Wasted Capacity

Poor use of capacity – Waste of the Resource's time

Overproduction **Transportation** **Rework** **Over-processing** **Motion**

The seven sources of waste (Muda:無駄)

waste

Potential eighth source of waste:
The waste of intellect

Inventory **Waiting**

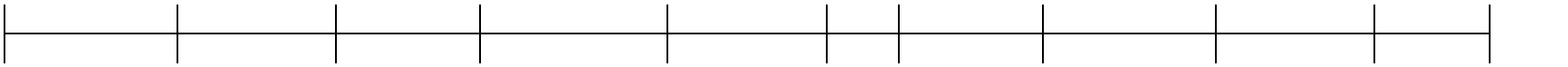
Not "orthogonal to each other"

Poor flow – Waste of Customer's time

- The first five sources are RESOURCE centric.
- You find them by observing / attaching yourself to a resource.
- Observation and data collection on the front line is key.

Tool 3: Understand the Barriers to Flow: Customer's Perspective

How much time does a patient spend on a primary care encounter?



Driving Parking Check-in Vitals Waiting PCP Appt. Check out Labs Drive home

Two types of wasted time:

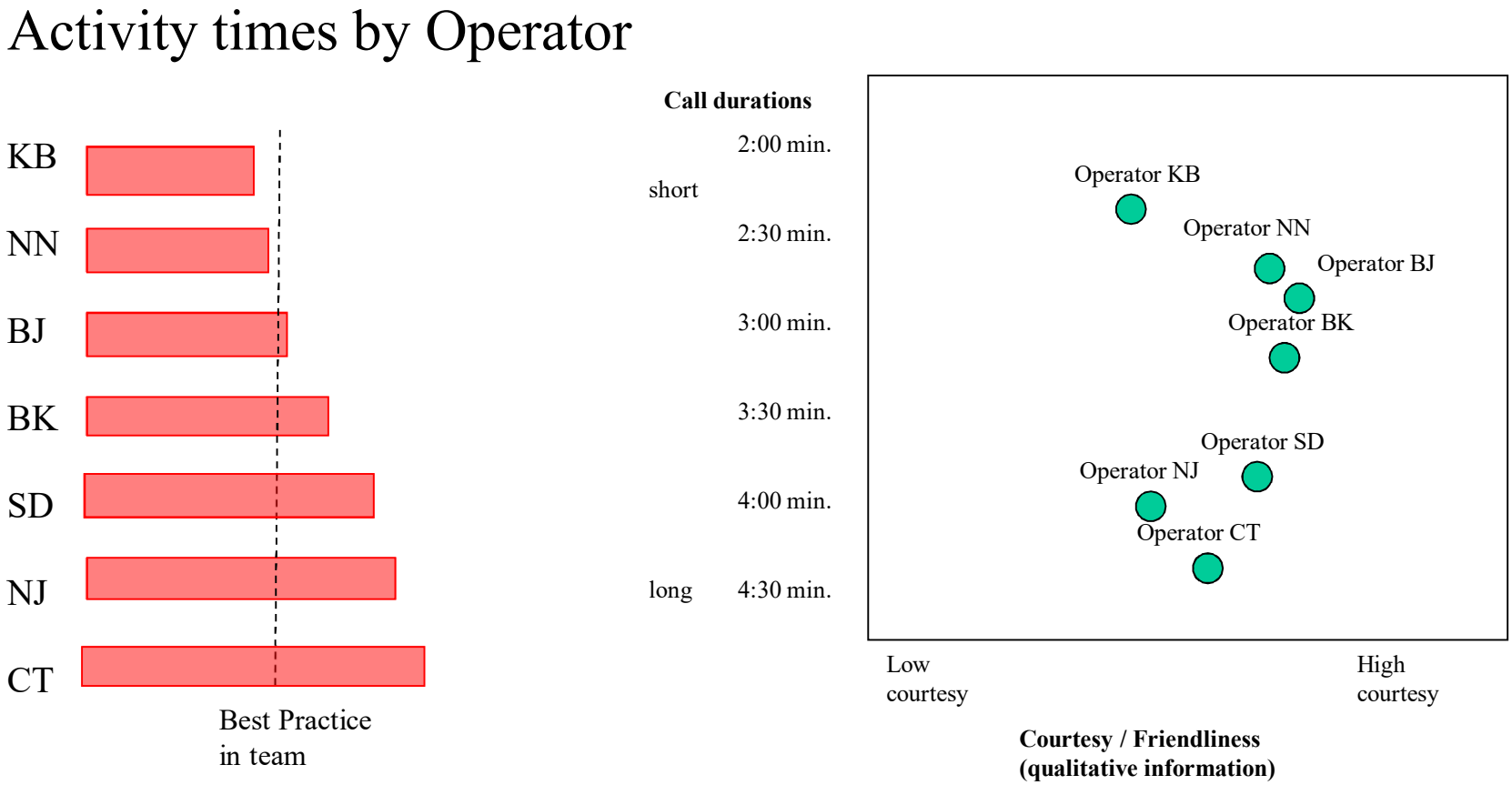
Auxiliary activities required to get to value added activities (result of process location / lay-out)

Wait time (result of bottlenecks / insufficient capacity) =>"Product has to flow like water"?

Inventory: the symptom of poor flow - associated with (a) financing cost (b) customer wait (c) quality problems

$$Flow\ Time\ Efficiency\ (or\ \%\ VAT) = \frac{Total\ value\ added\ time\ of\ a\ unit}{Total\ time\ a\ unit\ is\ in\ the\ process}$$

Tool 4: Standard Operating procedures / Quartile Analysis

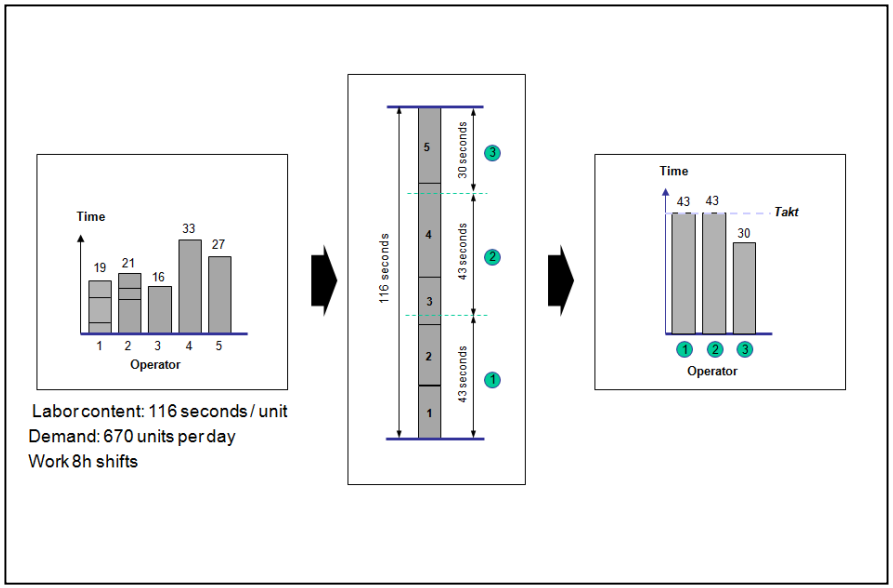


Quartile analysis is an easy tool to identify performance variation

Variation in performance often reflects a poor process standardization

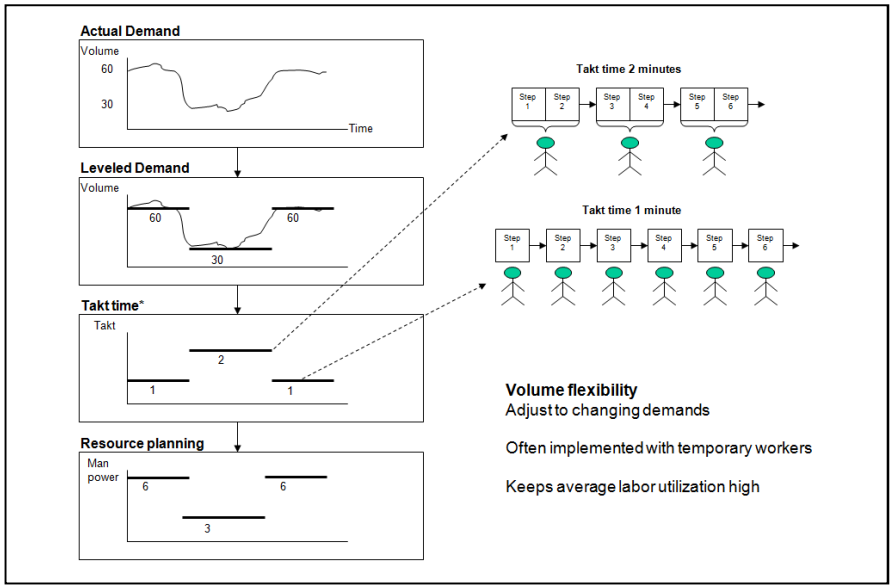
Tool 5: Balance Resources and Have Demand Drive the Process

Balance the Line



Labor content: 116 seconds / unit
Demand: 670 units per day
Work 8h shifts

Staff to Demand



Look for idle time and measure labor utilization

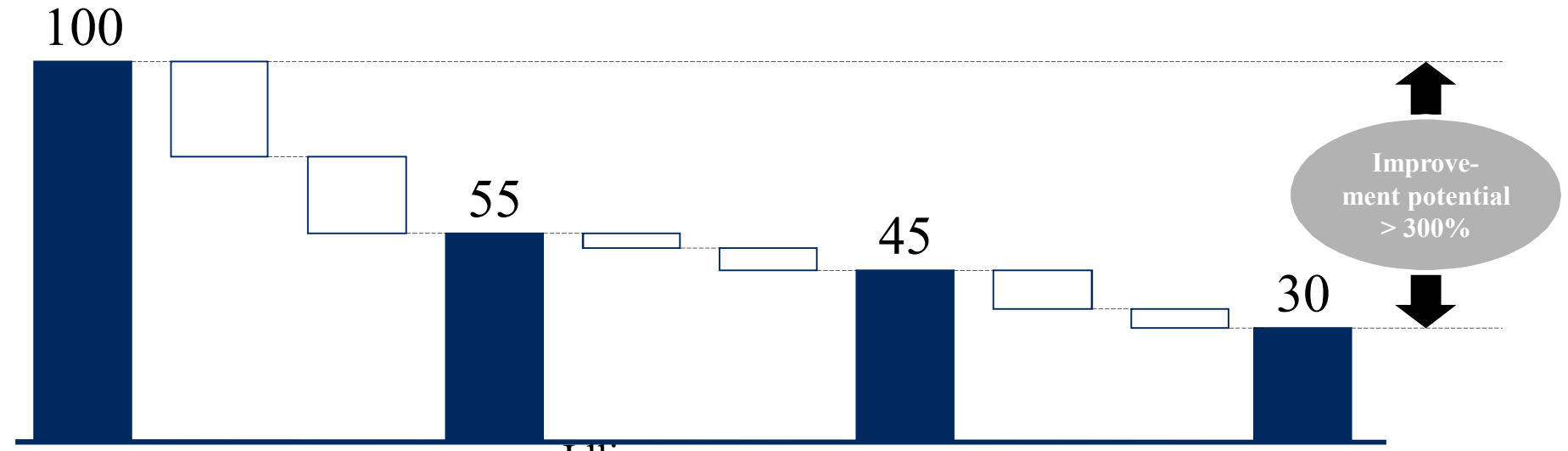
Reduce idle time by:

Staffing to demand (potentially eliminating excess process capacity)

Balancing the line (reduce idle time created by excess capacity relative to bottleneck)

Tool 6: Overall equipment effectiveness (OEE)

Identify what % of a resource's time is true, value-added time!

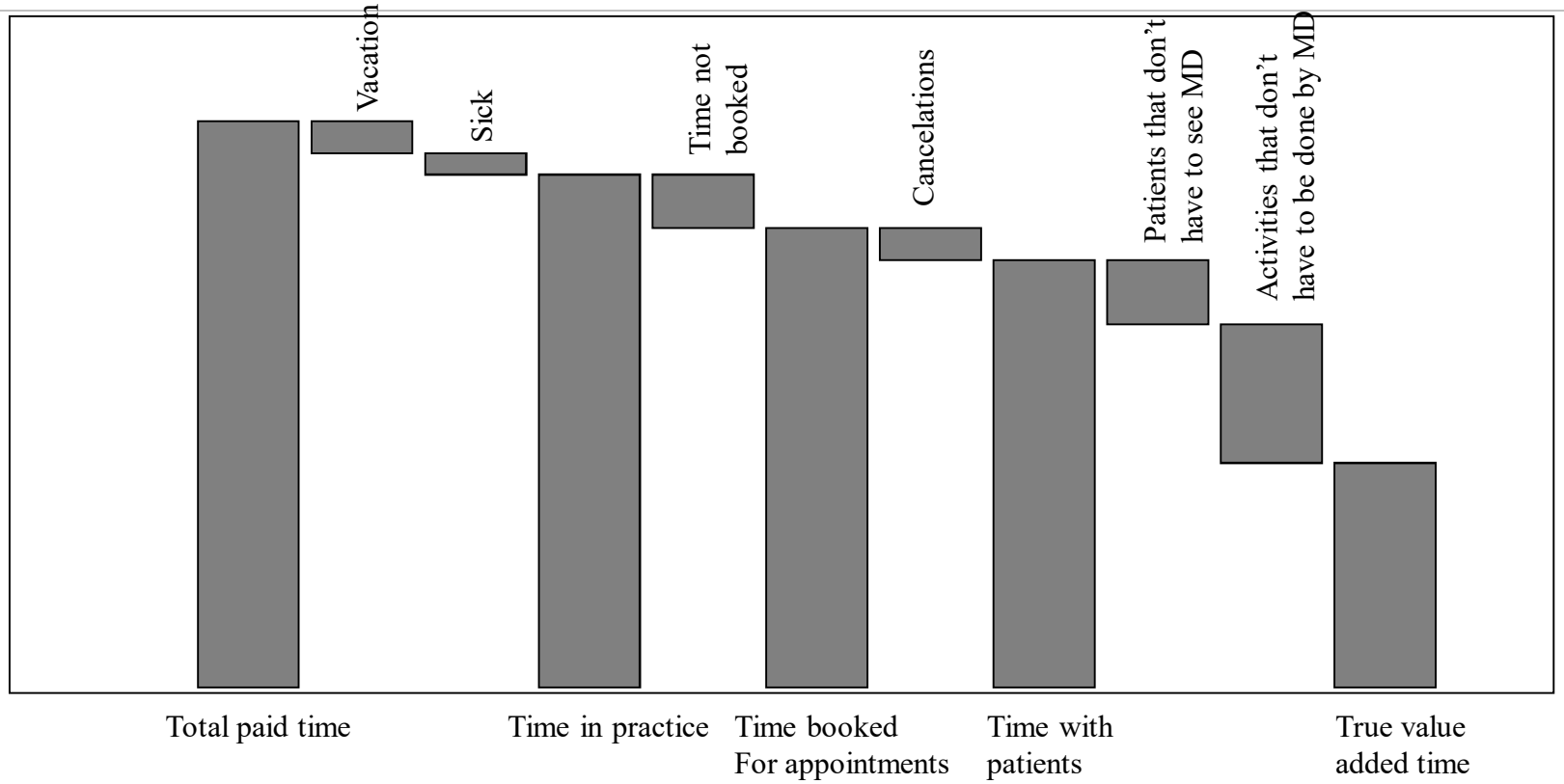


click.

$$\frac{\textbf{Downtime losses}}{\text{Availability rate}}\ \textbf{X}\ \frac{\textbf{Speed losses}}{\text{Performance rate}}\ \textbf{X}\ \frac{\textbf{Quality losses}}{\text{Quality rate}}\ \textbf{=OEE}$$

55 % 82 % 67 % **30 %**

Tool 6: Overall equipment effectiveness (OEE)



Step 1: start with the "book-ends" (very left and very right bar)
Step 2: Include the results from the previous steps

- Wasted capacity
- Customer wait time (can show up in the form of cancelations and complaints)
- Idle time

The Toyota Production System – An alternative to traditional mass production

Taylorism: Standardized parts and work patterns (time studies)

Moving line ensuring working at the same pace

Process driven by huge, rapid machinery with inflexible batch production

Ford

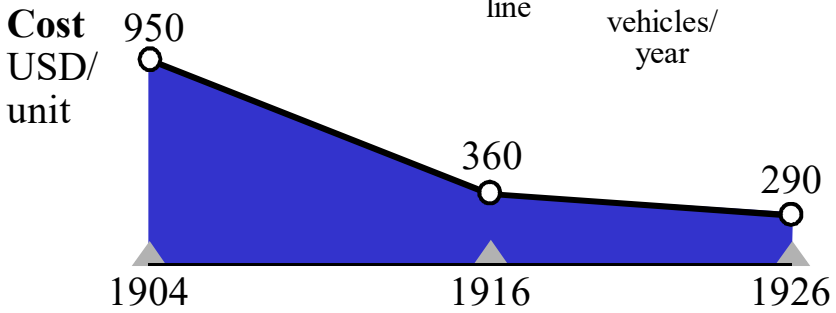
1903 1st car

1908 1st Model T

1911 F.W. Taylor

1913 1st moving line

1923 2.1 million vehicles/ year



Key idea of Ford: cost reduction through cheap labor and economies of scale

Mass production driven by economies of scale impossible

– Low production volume (1950): GM 3,656,000 – Toyota 11,000

– Low productivity (Japan 1/9 of US)

– Lack of resources

Toyota

1933 Founded

1946 Major strike

1950 Start of TPS

1960s Supplier develop- ment

1980s Trans- plants

Key idea of TPS: systematic elimination of non-value-added activities

Source: McKinsey

JIT: Matching Supply with Demand

1. Achieve One-Unit-at-a-Time Flow
   (e.g. escalator vs. elevator)
   mixed-model production, 

piece-by-piece transport 

2. Produce at the Rate of Customer Demand
   JIT process should follow the takt time imposed by demand!

3. Implement Pull Systems

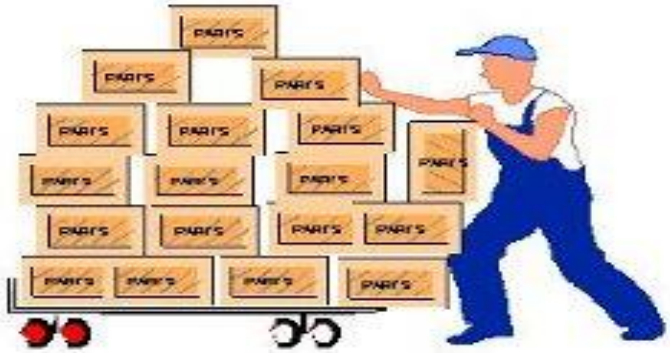
(1) Kanban-based pull ⇒ the upstream replenished what demand has withdrawn from the downstream

(2) Make-to-order (vs. Make-to-stock)

Push System vs. Pull System

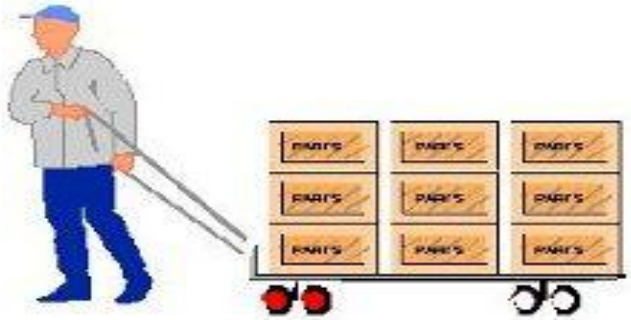
Push vs. Pull

Make all we can just in case.



- Production Approximation
- Anticipated Usage's
- Large Lots
- High Inventories
- Waste
- Management by Firefighting
- Poor Communication

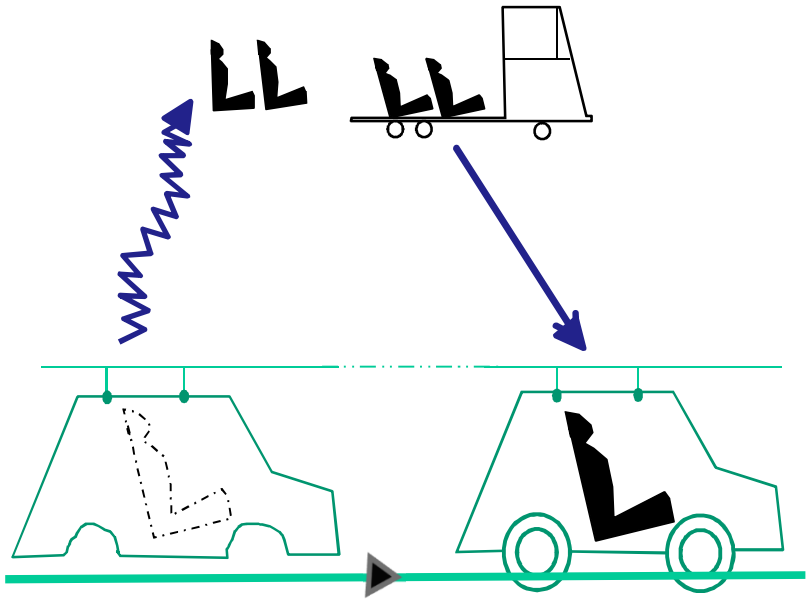
Make what's needed when we need it



- Production Precision
- Actual Consumption
- Small Lots
- Low Inventories
- Waste Reduction
- Management by Sight
- Better Communication

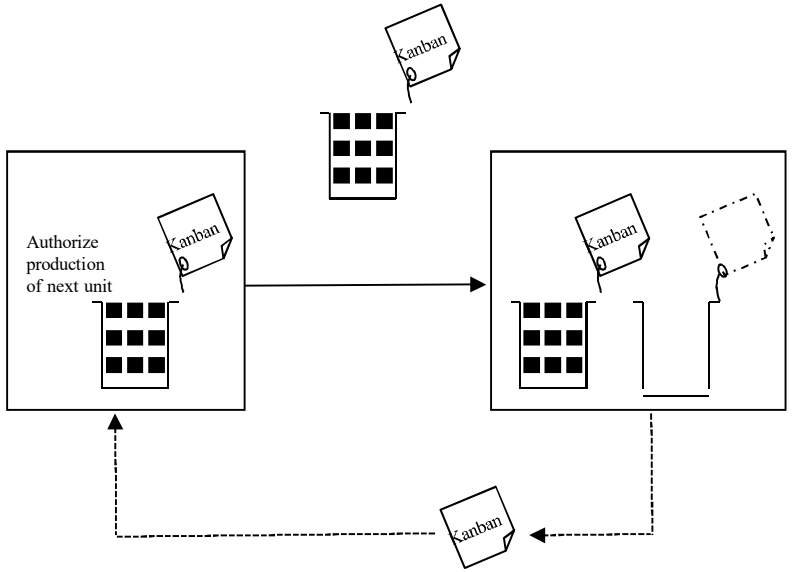
Implement Pull Systems

Pull: Synchronized production



- Part produced for specific order (at supplier)
- shipped right to assembly
- real-time synchronization for large parts (seat)

Pull: Kanban

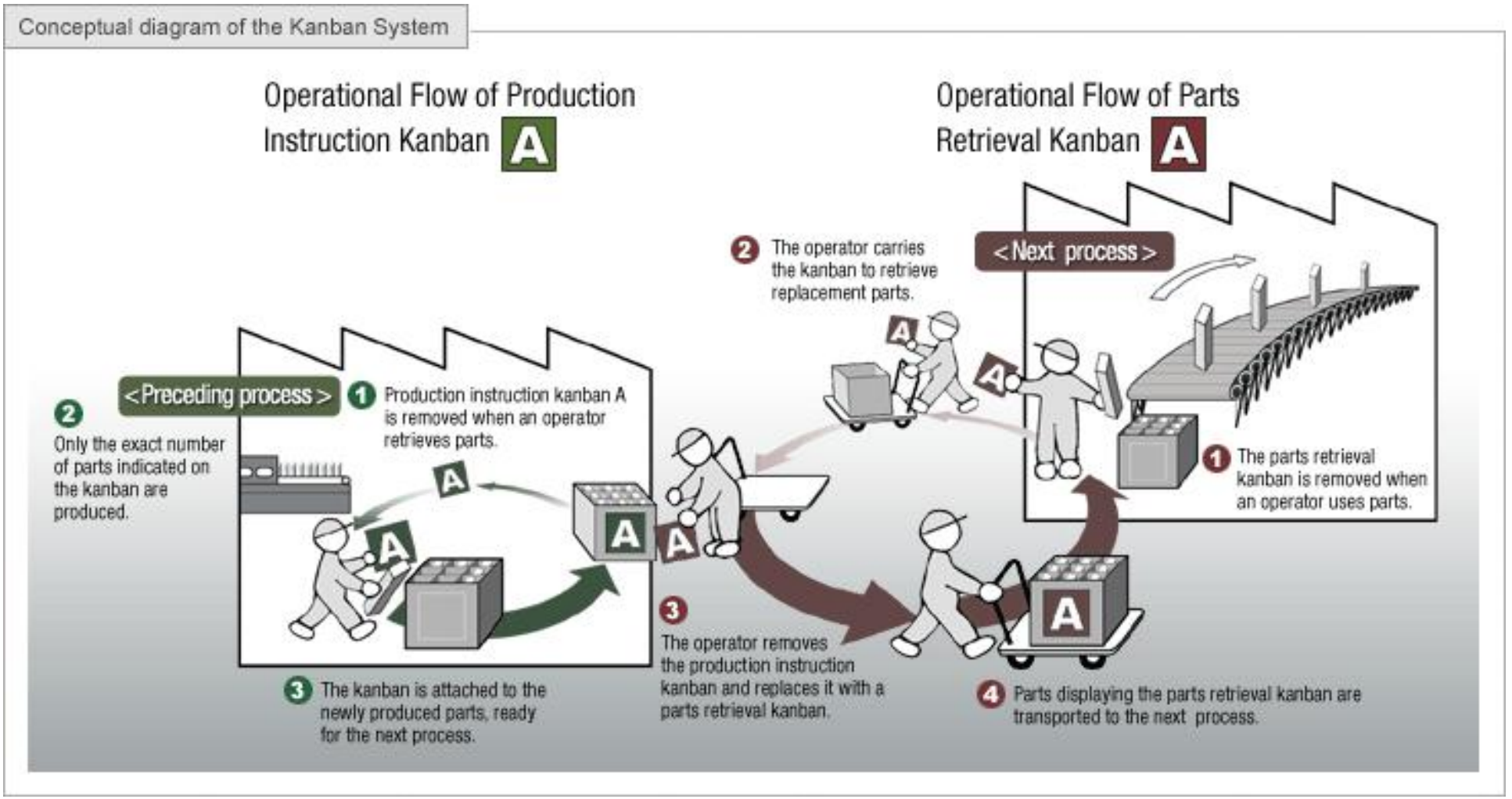


- Visual way to implement a pull system
- Amount of WIP is determined by number of cards

click.

- Kanban = Sign board
- Work needs to be authorized by demand

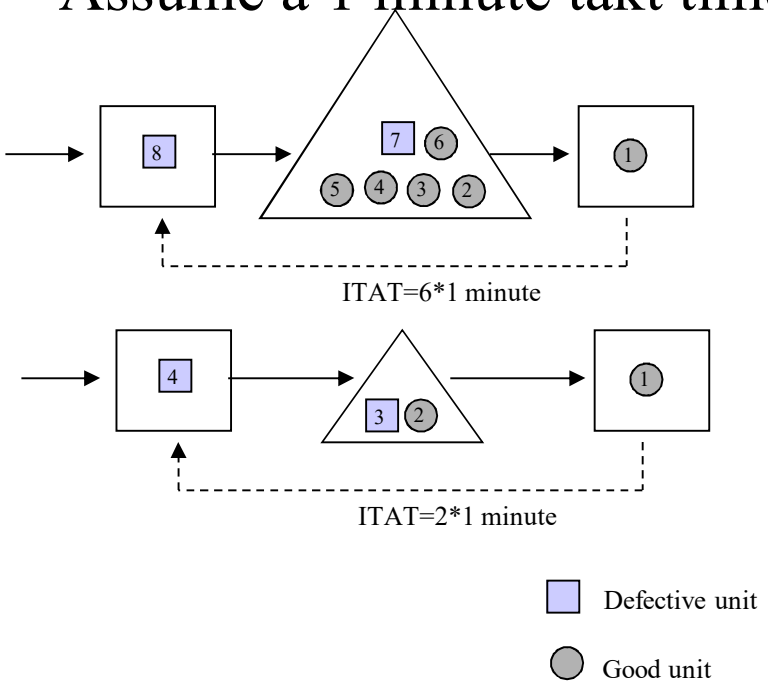
Conceptual Diagram of the Kanban System



http://www.toyota-global.com/company/vision_philosophy/toyota_production_system/just-in-time.html

The Impact of Inventory on Quality

Assume a 1 minute takt time



Fool(Mistake)-proofing=Poka-yoke

click.

Jidoka=stop the process immediately whenever a defect is detected

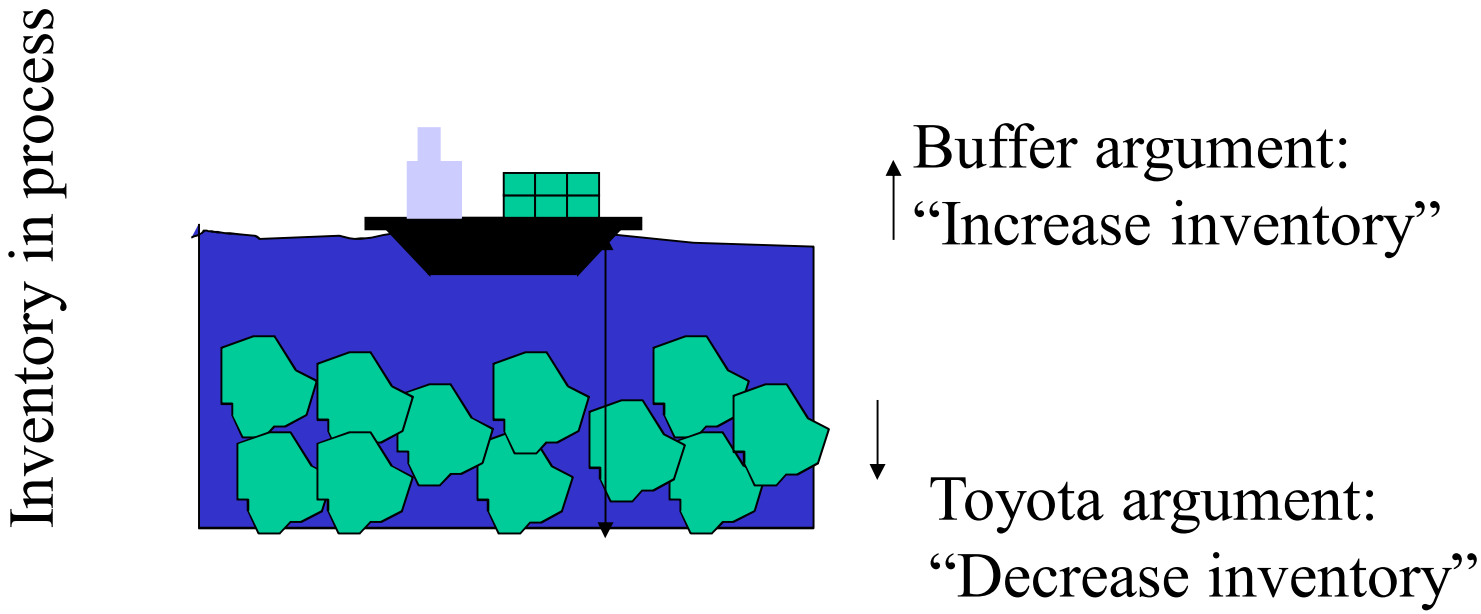
click.

Andon Cord

Inventory leads to a longer ITAT (Information turnaround time)

⇒ slow feed-back and no learning

Exposing Problems through Inventory Reduction



1st approach: Increase the water level (inventory).

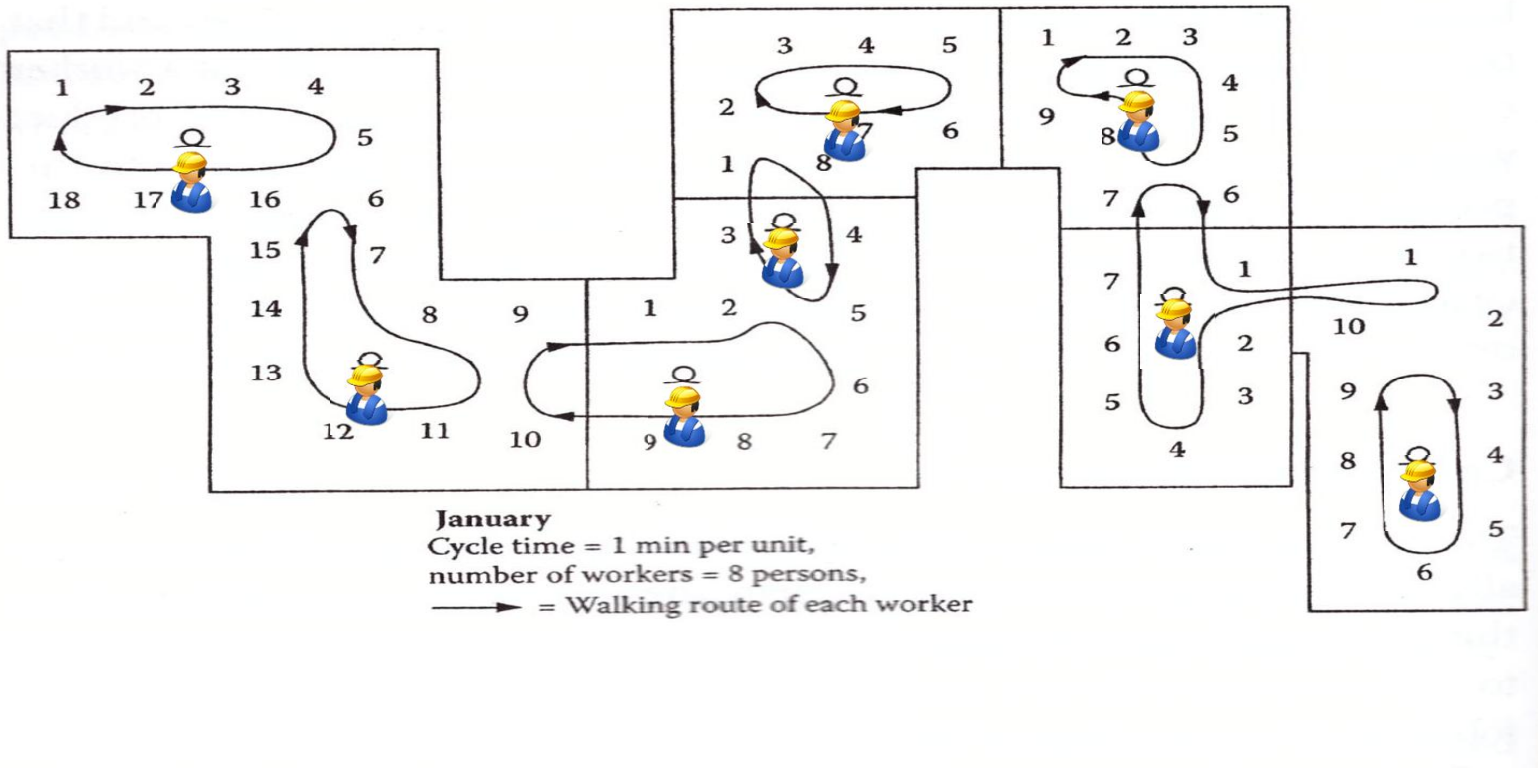
2nd approach: Reduce the water level

⇒Expose problems instead of hiding them

Despite potential short-term losses in throughput, it moves the process to a better frontier.

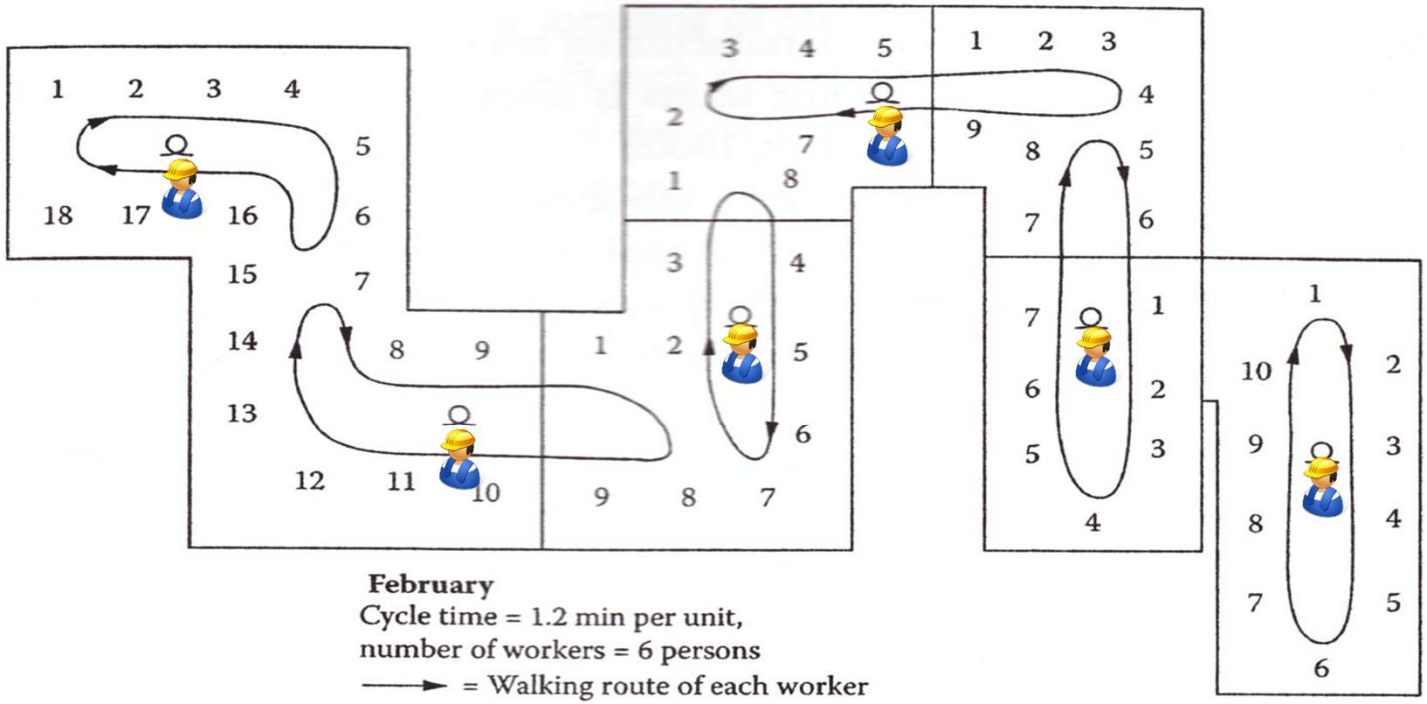
Flexible Cycle Time through Multi-function Workers

- According to the monthly demand in January, the cycle time of this combined process is 1 minute per unit and 8 workers are involved.

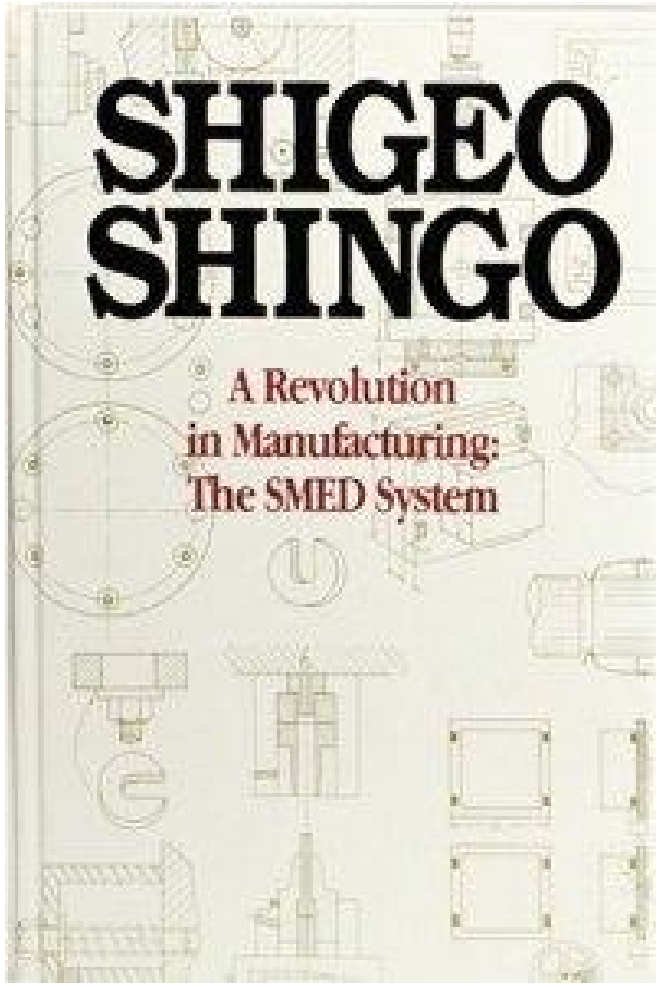


Flexible Cycle Time through Multi-function Workers

- In February, the monthly demand is decreased and cycle time is increased to 1.2 minutes.



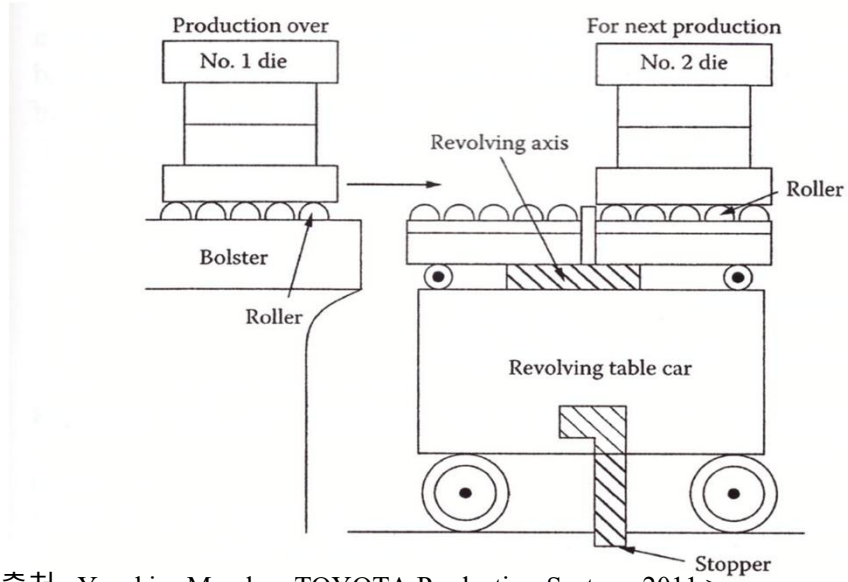
- ***Shingo Prize*** is the highest manufacturing excellence award in the U.S. The prize is given both to companies and individuals who contribute to the development of manufacturing excellence.


SHIGEO
SHINGO
A Revolution
in Manufacturing:
The SMED System

준비작업시간 단축

- 준비작업시간 단축의 예제

  ✓ Stamping 기계의 다이(die)를 교체하기 위해, 회전테이블 대차를 활용



<출처 : Yasuhiro Monden, TOYOTA Production System, 2011 >

▪ 준비작업시간 단축의 예제

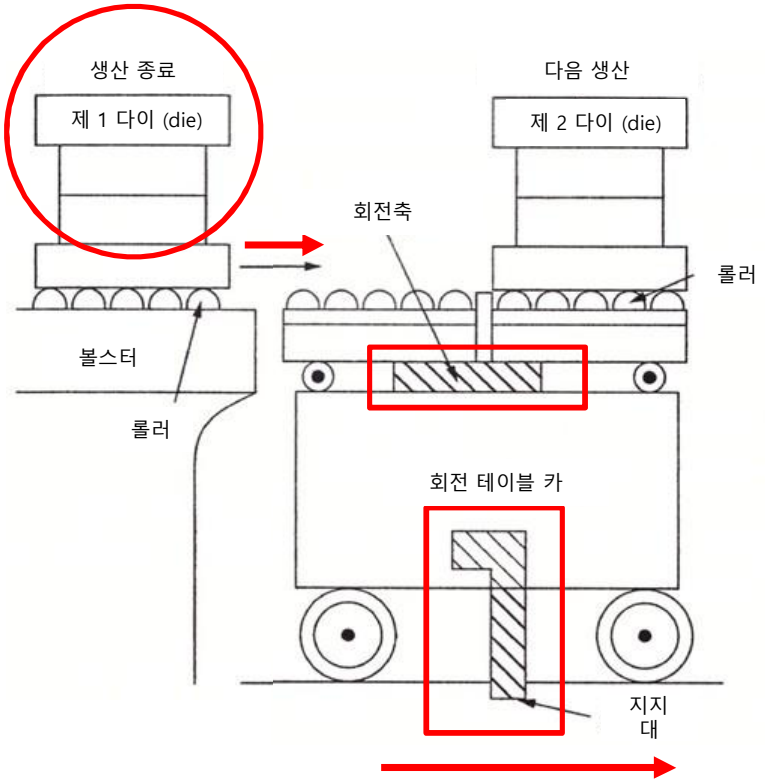
1. 홀더에서 1번 다이 분리

2. 회전 테이블 대차를 설비에 붙이고, 스토퍼로 고정

3. 1번 다이를 회전 테이블 대차에 옮김

4. 2번 다이를 회전축과 롤러를 이용해 볼스터로 옮김

5. 스토퍼를 분리하고, 회전 테이블 대차를 설비에서 떼어내고, 2번 다이를 설치

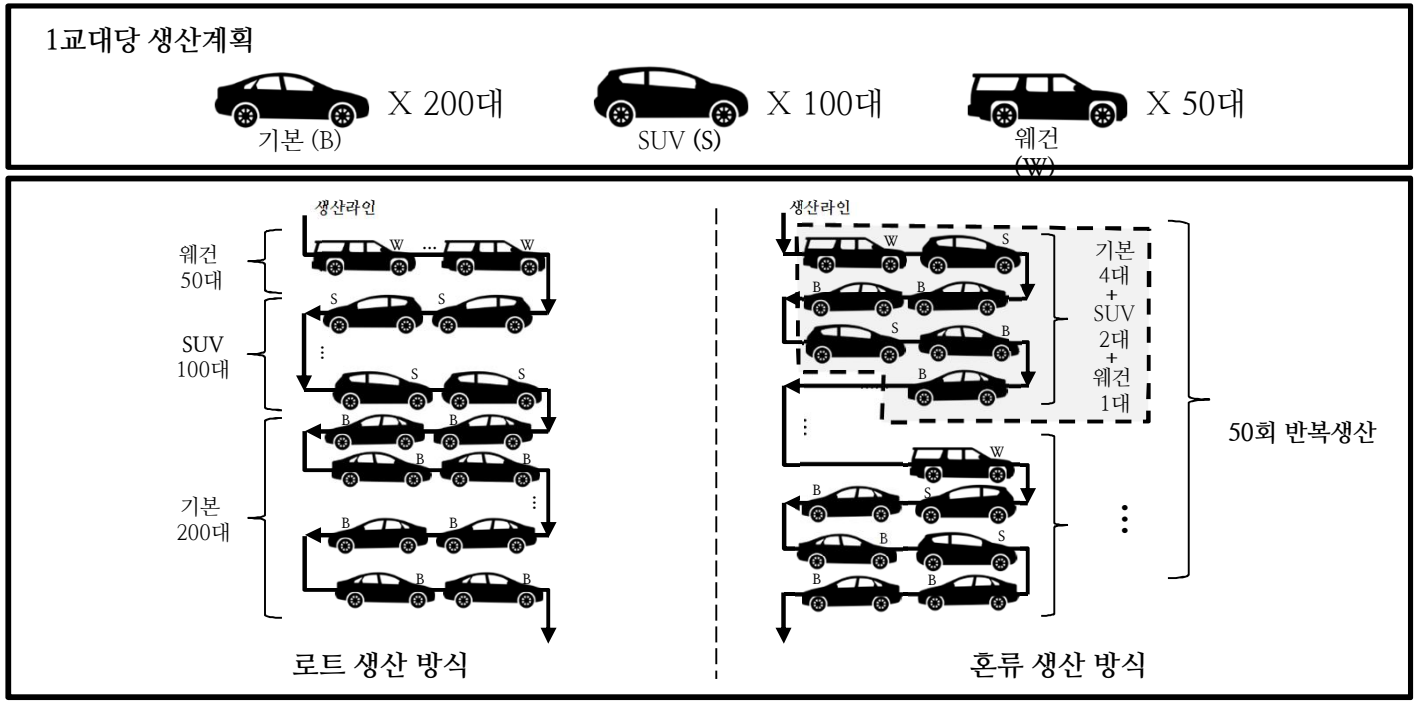


<출처 : Yasuhiro Monden, TOYOTA Production System, 2011 >

생산 평활화

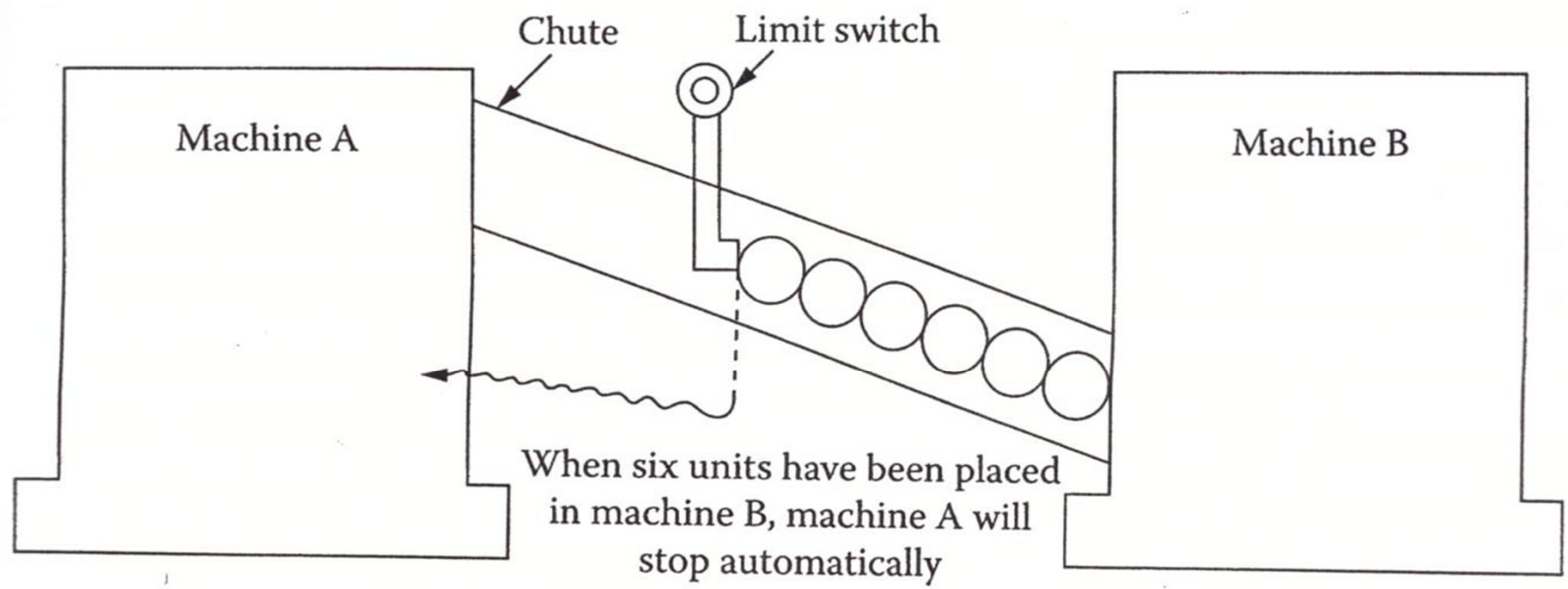
생산 평활화

- **예시를 통한 로트 생산과 혼류 생산의 비교**



Full Work System

- Line balancing problem ← capacity differences
  ⇒solve using the full-work control system



Example of a Kanban (看板)

Poka-Yokes in Everyday life

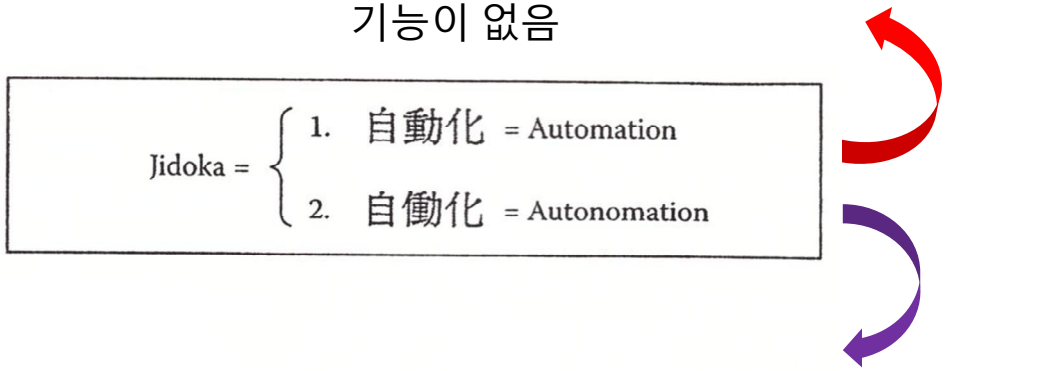
(Sequence method): (i) ATM card is returned to you before cash is supplied.
(ii) Airplane restroom lights only come on when the door lock is engaged

(Contact method): Diesel and petrol cars have different fuel inlet

자동화(Jidoka)

- 현재 도요타의 생산 시스템에서 모든 작업자는 본인의 작업에 대한 품질 관리의 책임이 있음
- 문제가 발생하면 작업자는 이를 곧바로 인식하고 해결할 수 있음

기계가 스스로 작동하지만 스스로 오류를 인식하고 작업을 멈추는 피드백 기능이 없음



기계가 스스로 오류를 인식하고 제어함

자동화(Jidoka)

- Autonomation 기계 예시