SEMINAR ON LEVERAGING LEAN PRACTICES FOR MANAGING THE INEVITABLE TRANSITION TO INDUSTRY 4.0

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Company :

MALAYSIAN RUBBER COUNCIL

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Lean Management Standards

What is lean management?

Lean management

An approach to direct and control an organisation
in order to support the lean concept.

Lean concept - A systematic concept for the **elimination of waste (*muda*)** within an organisation in order to procure, produce and deliver, or provide products and/or services at the **right time**, **right price**, **right place**, **right quantity** and **right quality** according to the expected experience and requirements of interested parties.

Benefit

The benefits of lean management to organisations

Increased profitability

Stronger cash flow

Reduced operational cost

Enhanced product & service quality & safety

Better business flexibility

Talent development

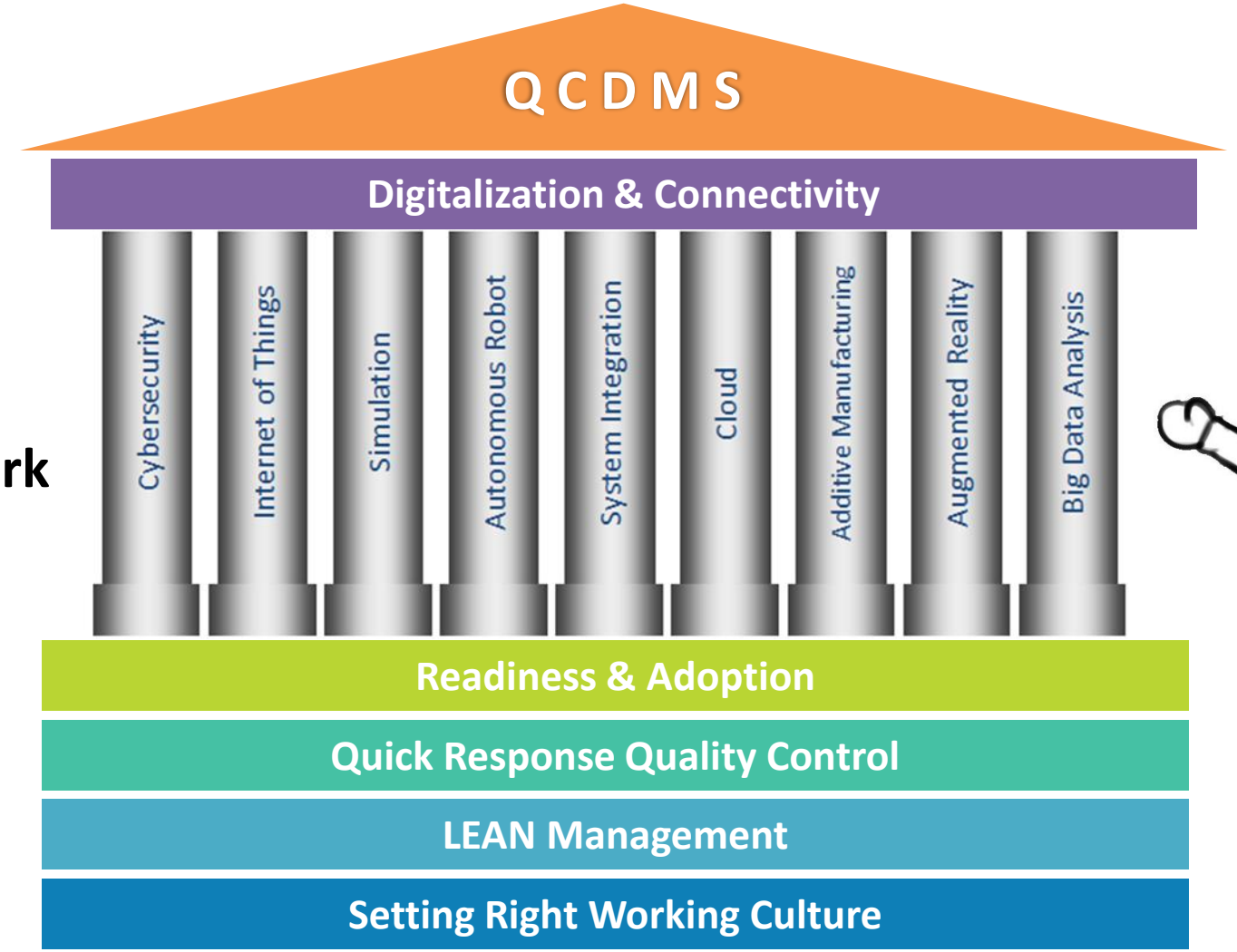
Minimised environmental harm

Improved customer satisfaction

Transitions to Industry 4.0

SIRIM - ICA 40

Industry 4.0 Framework



SIRIM 12:2017

Lean management

Part 1: Requirements for key activities

Objectives of the standard

- to provide common and structured understanding on lean management;
- to specify the requirements for key activities for an organisation to implement lean management; and
- to describe the level of implementation as benchmark towards providing value creation to the interested parties.

Outline of the standard

Clause / Subclause	Description
0	Introduction
1	Scope
2	Normative references
3	Terms and definitions
4	Principles
5	General requirements
6	Leadership and commitment
7	Cost and revenue optimization
8	Concepts, tools and techniques
9	Level of implementation
Annex A	Lean concepts, tools and techniques

Clause 1: Scope

This standard specifies the requirements for key activities in lean management implementation. This standard also specifies the required maturity levels for these activities.

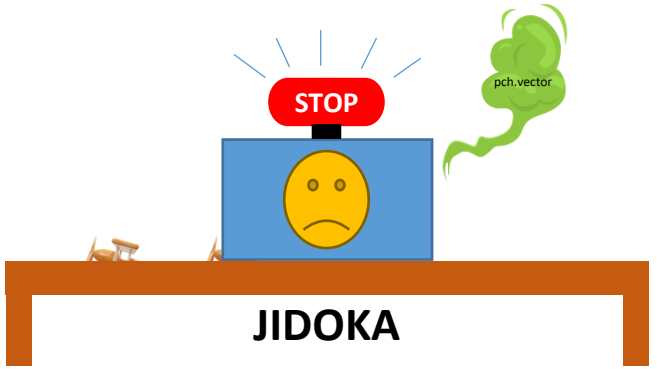
Clause 3: Terms and definitions

Terms related to concepts

art of making things (*monozukuri*) - A process of creating superior products through pride of workmanship, manufacturing excellence and continuous improvement.

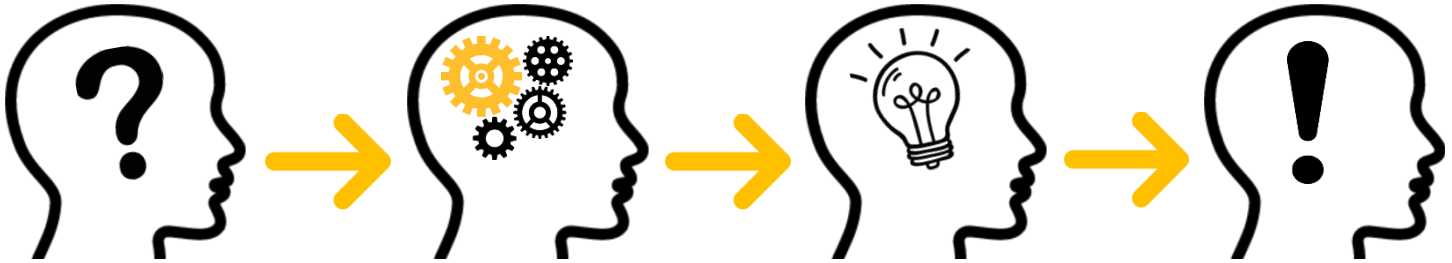
art of story telling (*kotozukuri*) - A process of making effective and impactful communication.

built in quality (*jidoka*) - A quality management concept which empowers a person performing a task to make the decision to stop the task in order to prevent the continued production of defective products and/or delivery of nonconforming services.



Clause 3: Terms and definitions (*cont.*)

human capital development (*hitozukuri*) - A lean organisation's commitment to lifelong development of the skills and knowledge of all employees.



kaizen - Continuous improvement philosophy that can be practiced everywhere, every day by everyone.

lean production - Any process of converting inputs into outputs while improving the quality level of products supplied to interested parties and optimising operational resources. This is relevant to processes in all industries, for example and not limited to, manufacturing, agriculture, mining, fishery and construction.

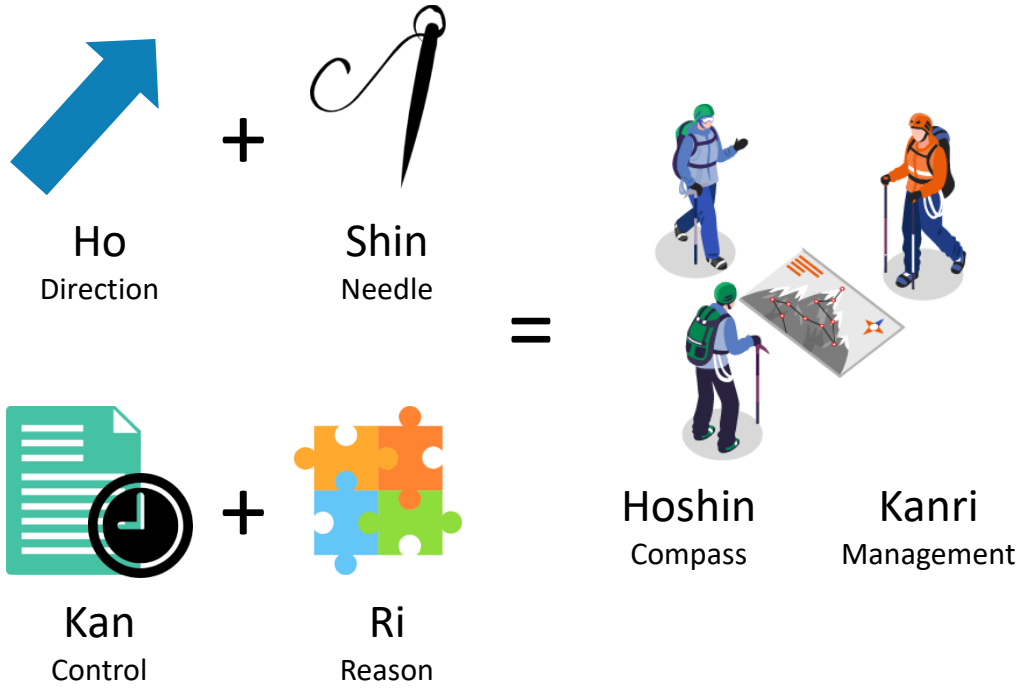
Clause 3: Terms and definitions (*cont.*)

lean service - Any process of providing the right quality services to interested parties focusing on smooth deliveries and minimal waiting time.

policy deployment (*hoshin kanri*) - A method to ensure that the strategic goals of the organisation drive progress and action at every level within the organisation.

zero defect - Performance level where all output is within specification limits.

Hoshin Kanri



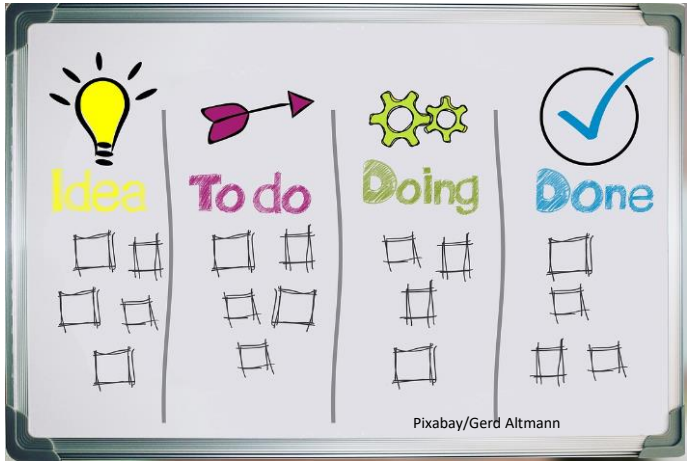
Clause 3: Terms and definitions (*cont.*)

Terms related to tools and techniques

5S - A practice to establish and maintain quality at the work station using five steps based on Japanese terms: *seiri* (structurise), *seiton* (systemise), *seiso* (shine or sanitise), *seiketsu* (standardise), and *shitsuke* (sustain or self-discipline).

autonomation (automation with a human touch) - A feature of machine or equipment designed for *jidoka*.

Kanban - A visual sign or signal that conveys a set of instructions to either procure or provide products or services.



KANBAN

Clause 3: Terms and definitions (*cont.*)

overall equipment effectiveness - A measure of the efficiency and effectiveness of an equipment, by breaking it down into three constituent components (availability, performance and quality).

$$OEE = \underbrace{\frac{\text{Working time - Downtime}}{\text{Working time}}}_{\text{Availability}} \times \underbrace{\frac{\text{Volume actual}}{\text{Volume planned}}}_{\text{Performance}} \times \underbrace{\frac{\text{Good parts}}{\text{Produced parts}}}_{\text{Quality}}$$

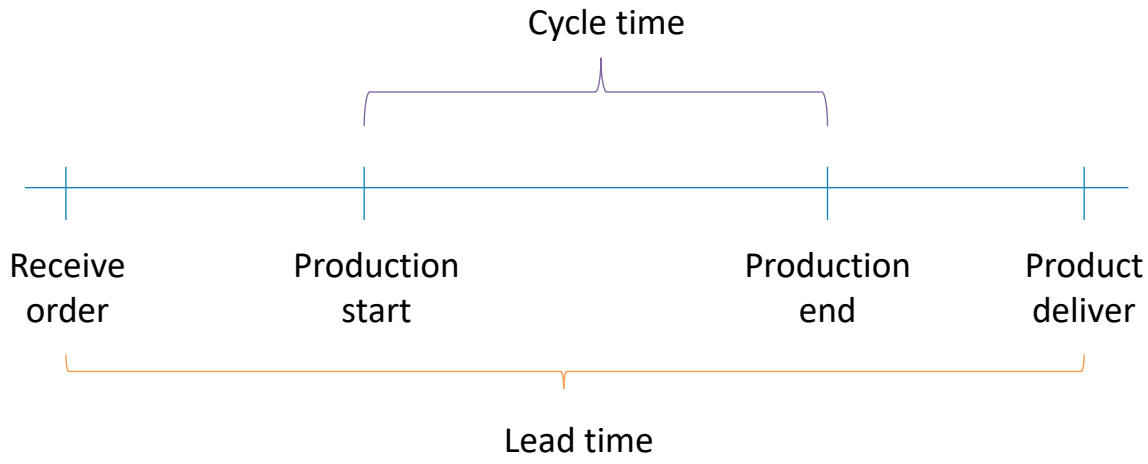
standardised work - A method of defining efficient work process that is routinely followed by workers.

Clause 3: Terms and definitions (*cont.*)

cycle time - The total time from the beginning to the end of a task. Cycle time includes process time (value-added time) and non-value added time.

process time - The amount of time spent that adds value to the work piece or job in order to bring it closer to the intended output.

lead time - The shortest possible time taken beginning from the request of a product or service and ending at delivery of the product or service.



Clause 3: Terms and definitions (*cont.*)

takt time - The time required to produce one unit of work piece or job, calculated based on the available working time and the requirements of interested parties.

$$\text{Takt time} = \frac{\text{Working time available (minus breaks)}}{\text{Number of workpieces}} = \frac{550 \text{ min}}{50 \text{ units}} = 11 \text{ min}$$

standard time - The time required to perform a specified task at an optimum working pace, using the best prescribed method.

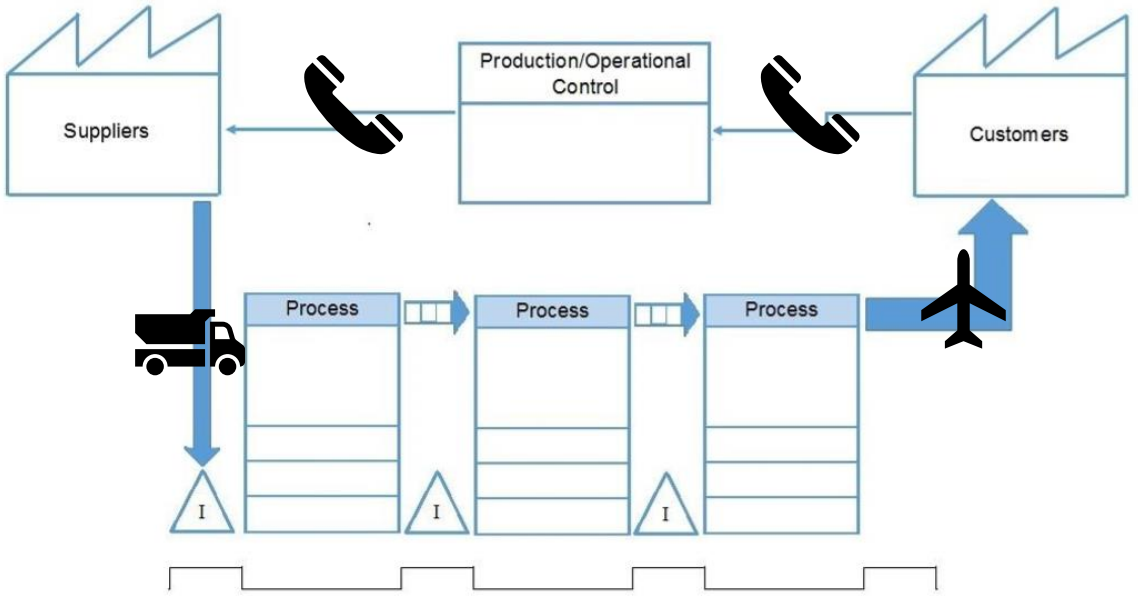
Activities	Standard time (min)
Taking order	5
Prepare raw material	5
Mix ingredient	3
Packing	3
Send to customer	3
Total	19 min

Clause 3: Terms and definitions (*cont.*)

Total Productive Maintenance (TPM) - Structured method and approach aimed at optimising the up time of devices, equipment and machineries.

training place (*dojo*) - Dedicated physical infrastructure for training which is conducive for conducting theory and practical training

value stream mapping - A tool used to document, analyse and improve the flow of information or materials required to produce a product or service for an interested party.



Clause 3: Terms and definitions (*cont.*)

visual control (*me de miru kanri*) - A method to manage visualisation (*mieruka*) for cost, stock level and daily operation control on 4M (man such as attendance and skill; machine such as down time and periodic maintenance; material such as output with respect to plan, operation rate and rejection rate; and method such as manuals or procedures).

visualisation (*mieruka*) - Visualise and simplify information to such an extent that it is interactive and easy to understand, and provides everything needed at a glance.

Freepik/stories

Clause 4: Principles

4.1: Value

- Determine scope of lean activities
- Define value through interested parties expected experience and requirements
- Identify waste within the scope of its lean activities

4.2: Value Stream

- Identify all steps in the value stream
- Eliminate steps that don't create value
- Collect and analyse data
- Establish lean concepts

4.3: Product or service flow

- Make value-creating steps occur in sequence
- Establish and perform standardised work

4.4 React to the interested parties demand

- Establish and implement a mixture of push and pull system

4.5 Strive for perfection

- Improve each step of lean management
- Methods to be performed routinely until a state of perfection is reached

Clause 5: General requirement

The organisation shall have the following minimum requirement or information already established prior to implement lean management:

Relevant documented information

Organisation's defined roles and responsibilities

Occupational safety and health management practice

Implementation of 5S practice to at least *seiri* and *seiton* steps

Clause 5: General requirement

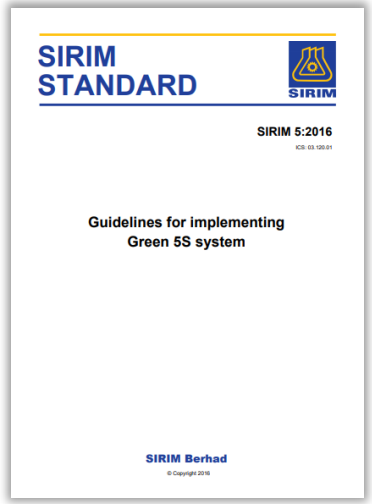
Implementation of lean management can be easier if other quality-related management system and/or standards have already been established.

MS ISO 9001

Quality management systems - Requirements

SIRIM 7

Requirements for implementing total quality management (TQM) based on SIRIM Total Quality Fast Track Model ($TQ_{FT}M$)



SIRIM 5

Guidelines for implementing green 5S system

Clause 6: Leadership and commitment

6.1: Leadership

- Direction setting
- Resources
- Integration to business operation
- Culture
- Customer focused environment
- Training
- Team player
- Motivation

6.2: Vision and mission

- Clear vision and mission
- Strategic direction and framework
- Targets

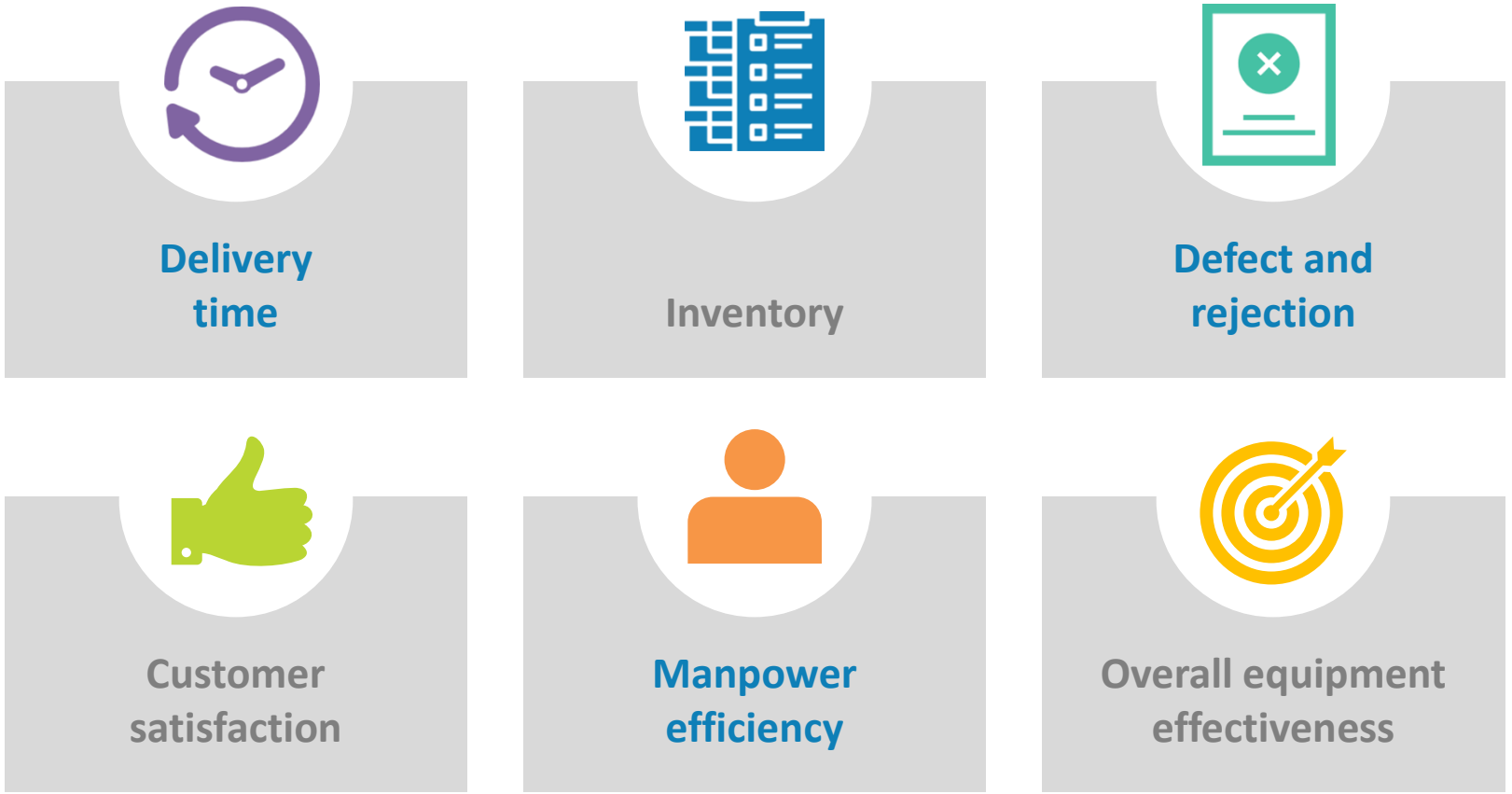
6.3 Policy development (*Hoshin kanri*)

- Drive progress and action
- Alignment of direction from top management, goal from middle management and execution
- Effectively communicated

Policy deployment (*Honshin kanri*)

Clause 7: Cost and revenue optimisation

The organisation shall optimise its cost and revenue by considering safety, environment, quality and delivery factors at each level of operation which may include:



Clause 7: Cost and revenue optimisation

Monitoring, measurement, analysis and evaluation are needed for product or service quality related at various stages:

Finished product or service inspection	End-of-process inspection	**In-process inspection (quality gate)**	Self inspection

For product or service delivery related, the control:

Delivered at the

right time

right price

right quality

right experience

right quantity

to the right place

using the right method

Clause 8: Concepts, tools and techniques

Basic requirement:

a) Standard work (work sequence);

b) Heijunka (leveling of production);

c) Kaizen (e.g. 3G (*genba, genbutsu and genjitsu*) – the real place, real thing, real condition);

d) Total Productive Maintenance (TPM);

e) Visual management; and

f) 5S

Clause 8: Concepts, tools and techniques (*cont.*)

Advanced requirement:

a) Just-in-Time (JiT):

- ✓takt time, cycle time
- ✓continuous flow/one-piece flow
- ✓changeover reduction/Single-Minute Exchange of Dies (SMED)
- ✓*Andon*
- ✓*Kanban* (pull system)
- ✓Value Stream Mapping/material information flow chart
- ✓Standard Work In-process (SWIP)
- ✓integrated logistics (lean management expanded to supplier and customer)

b) *Jidoka* - autonomation

- ✓*Andon*
- ✓*poka-yoke*
- ✓automatic stop
- ✓built-in quality
- ✓7 QC tools

Lean concepts, tools and techniques

Detailed explanation and examples for:

- 3G (*genba, genbutsu and genjitsu*) - the real place, real thing, real condition
- 5S - *Seiri* (Structurise), *Seiton* (Systemise), *Seiso* (Shine or Sanitise), *Seiketsu* (Standardise) and *Shitsuke* (Sustain or Self-discipline)
- *Andon*
- Changeover reduction/Single-Minute Exchange of Dies (SMED)
- Continuous flow
- *Heijunka* (Level scheduling)
- *Jidoka* – Autonomation
- *Poka-yoke* (Mistake proofing)
- Just-in-Time (JIT)
- *Kanban*
- One-piece flow
- Standardised work
- Takt time and cycle time
- Work sequence
- Standard Work In-process (SWIP)
- Total Productive Maintenance (TPM)
- Overall Equipment Effectiveness (OEE)
- Value Stream Mapping/Material information flow chart

3G

Genba – The actual place

(*Genchi*) *Genbutsu* – Real Location, Real thing

Genjitsu – The facts

Management level to spend time at the location where the real activities take place. This allows the person(s) to have a deep and thorough understanding of the overall processes by observing and talking to the responsible person in charge

"Toyota managers should be sufficiently engaged on the factory floor that they have to wash their hands at least three times a day"

Taiichi Ohno, founding father of the Toyota Production System (TPS)

5S

Practice of establishing and maintaining a quality environment by:

***Seiri* (Structurise):** Practice of sorting through all materials, tools, etc., in the work area and keeping only essential items in order to minimise hazards and reduce clutter that could interfere with productive work. Other items are either stored properly or discarded.

***Seiton* (Systemise):** Practice of systematically arranging tools, equipment and materials for easy access. There should be a place for everything, and everything should be in its place.

5S (*Cont.*)

***Seiso* (Shine or Sanitise):** Practice of keeping the workplace clean and neat. At the end of each working day, the work area is cleaned and everything is restored to its proper place.

***Seiketsu* (Standardise):** Practice which encourages control and consistency by having basic housekeeping standards. Responsibilities for housekeeping duties for every personnel are assigned and implemented as part of regular work routines.

***Shitsuke* (Sustain or Self-discipline):** This practice requires all employees to maintain standards and continuously keep the facility safe and efficient. Areas should be kept clean and every item is clearly identified as something that is required or that is unnecessary.

Andon

Real-time communication tool that brings immediate attention and necessary remediation action to any problems that occur.

Line 1 =	Running
Line 2 =	Stopped
Line 3 =	Running
Line 4 =	Material input

Example of *Andon*

Changeover reduction/ Single-Minute Exchange of Dies (SMED)

Changeover time: Time required to prepare for the next activity after the completion of the current activity.

Single-Minute Exchange of Dies: Concept of reducing the changeover time to less than 10 minutes from a conventional time of 1 hour in order to minimise transition time and optimise operating time.

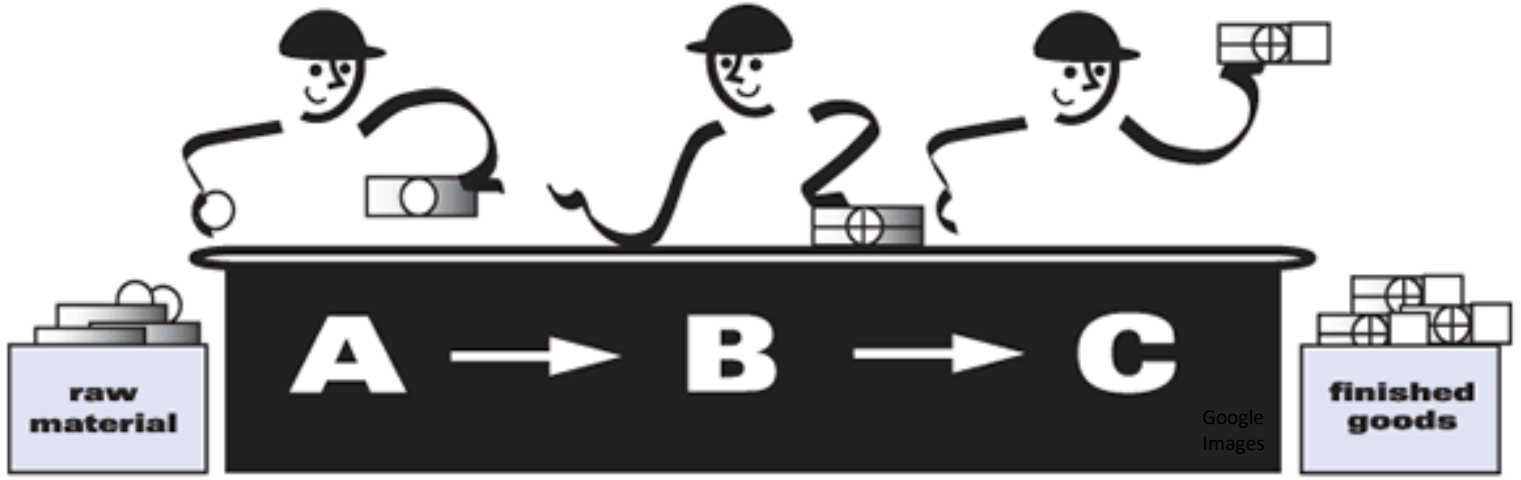
Important to reduce the mean changeover time, as well as its variability, using a standardised process

EXAMPLE: Manufacturing line changeover, maintenance operations, loading and unloading of vehicle and ships

Continuous flow

Zero waiting time between steps of processes for a product.

As one step is completed, it immediately flows into the next step in sequence with no stopping.



Heijunka (Level scheduling)

Scheduling methodology to minimise unevenness of volume and mix of activities in order to eliminate *mura, muri* and *muda,* hence optimising the usage of resources.

Levelled production is averaging customer order so that small sequenced cycles can produce the required volume and product mix.

Muda

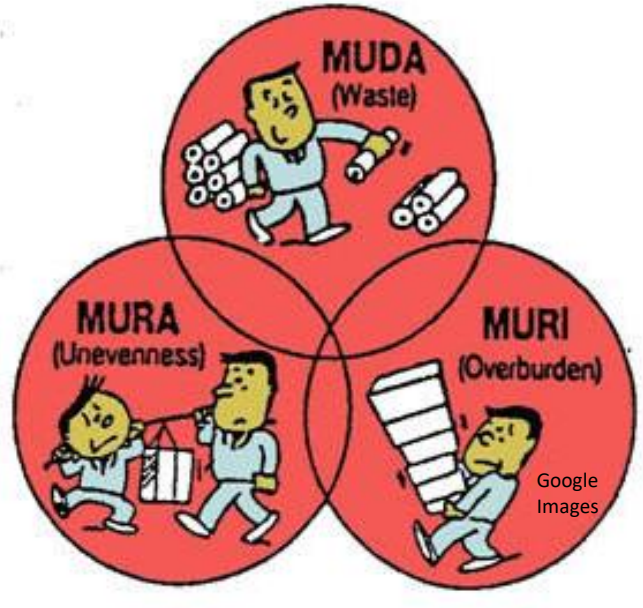
- Non value add
- Uselessness
- Wastefulness

Mura

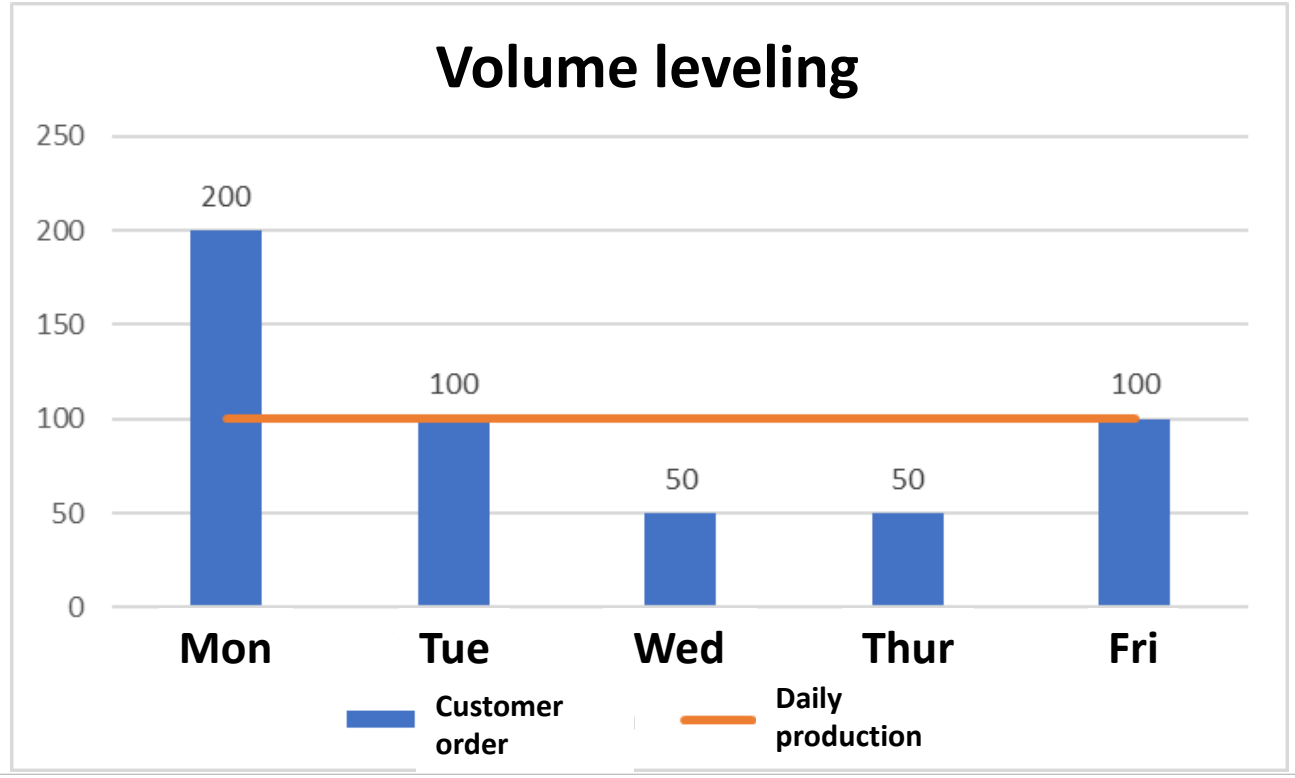
- Unevenness
- Irregularity
- Imbalance

Muri

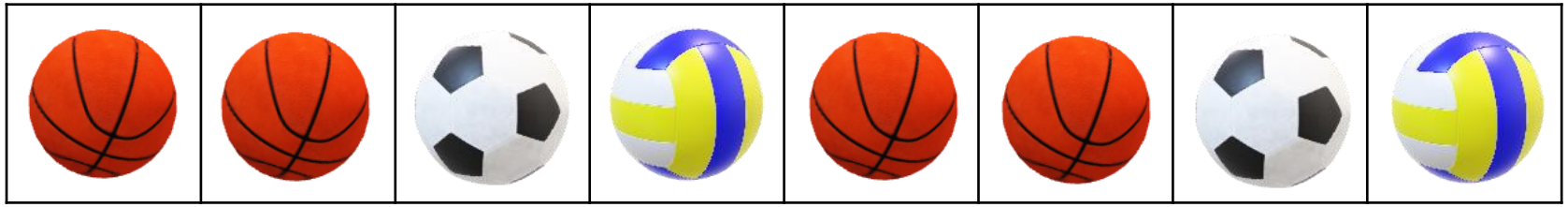
- Unreasonable
- Impossible
- Overburden



Heijunka (Level scheduling) (*Cont.*)



Product leveling



Jidoka - Autonomation

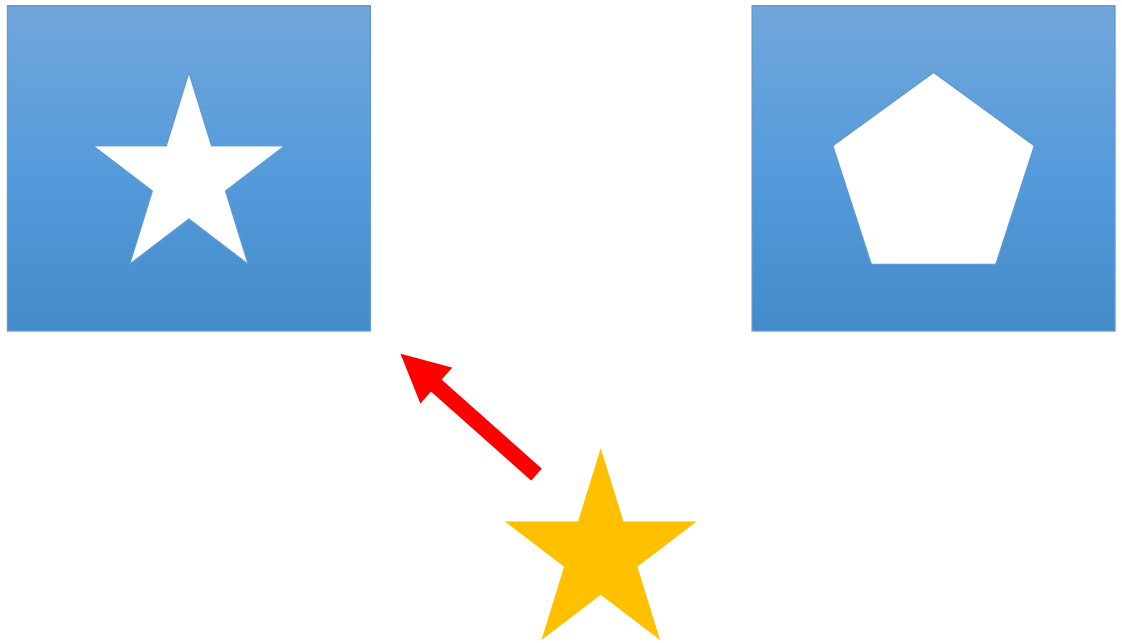
The ability of a process to be stopped in the event of problems such as equipment malfunction and quality problems (e.g. product defects).

Using machines which have the ability to sense abnormalities or employee's using their own judgement.

This prevents defects from being carried over to the next process.

Poka-yoke (Mistake proofing)

Any mechanism in a process that helps employees to avoid mistakes. Its purpose is to eliminate product defects by preventing, correcting or drawing attention to human errors as they occur.



Just-in-Time (JiT)

Making:

only what is needed

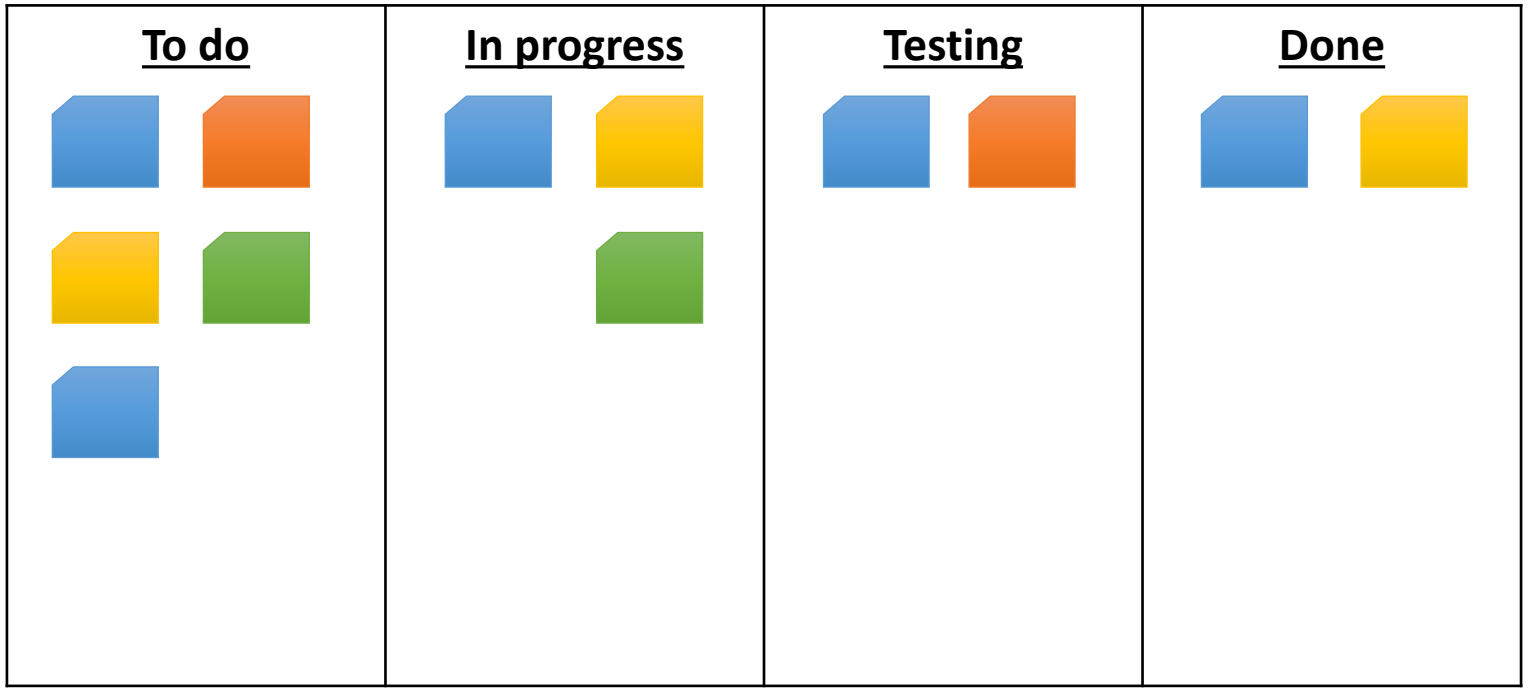
when it is needed

in the amount needed

This concept can result in effective reduction of inventory levels, improvement in cash flow and reduction of space requirements.

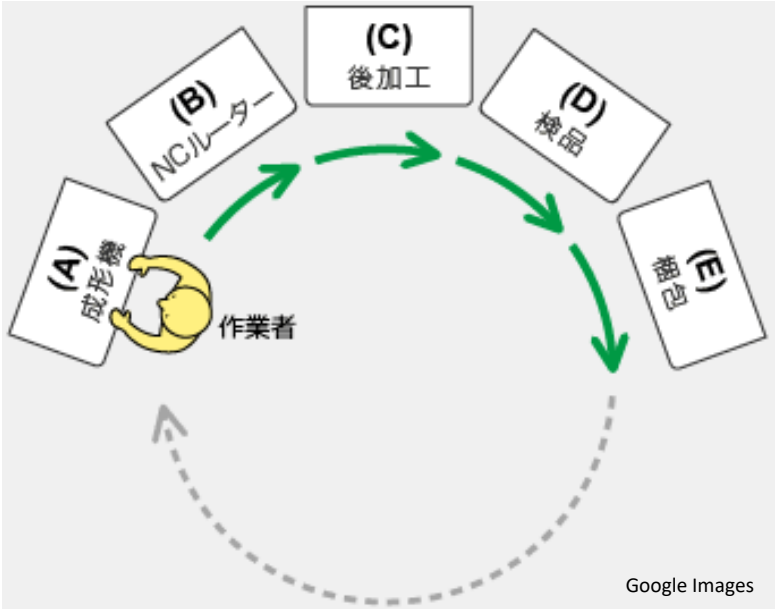
Kanban

Communication method to convey information from one process to another. *Kanban* signals can be generated for example by cards, lights, coloured balls down a tube or a computer network.



One-piece flow

The sequence of product or transactional activities through a process, one unit at a time.



The advantages of one-piece flow include:

a) reduced customer order to shipment times;

b) reduction of work in progress;

c) early detection of defects;

d) increased flexibility for customer product/transactional demands; and

e) reduced operating costs through elimination of non-value-added waste.

Standardised work

The three components of standardised work are:

- **Takt time**
- **Work sequence**
- **Standard work in-process**

Standardised work should improve safety through safe motions; help quality through repeatable processes; increase efficiency through elimination of unnecessary steps and form a foundation for kaizen.

Takt time and cycle time

Takt time: The time in which one part needs to be produced based on available time and interested parties requirements. Takt time is only based on interested parties demand.

Cycle time: The amount of time to process one unit of product including the time for human and machine work, walking time and waiting time. This also refers to actual time.

If takt time and cycle time is not the same, there will be imbalance in operating system.

Cycle time < takt time □ production will satisfy interested parties requirements.

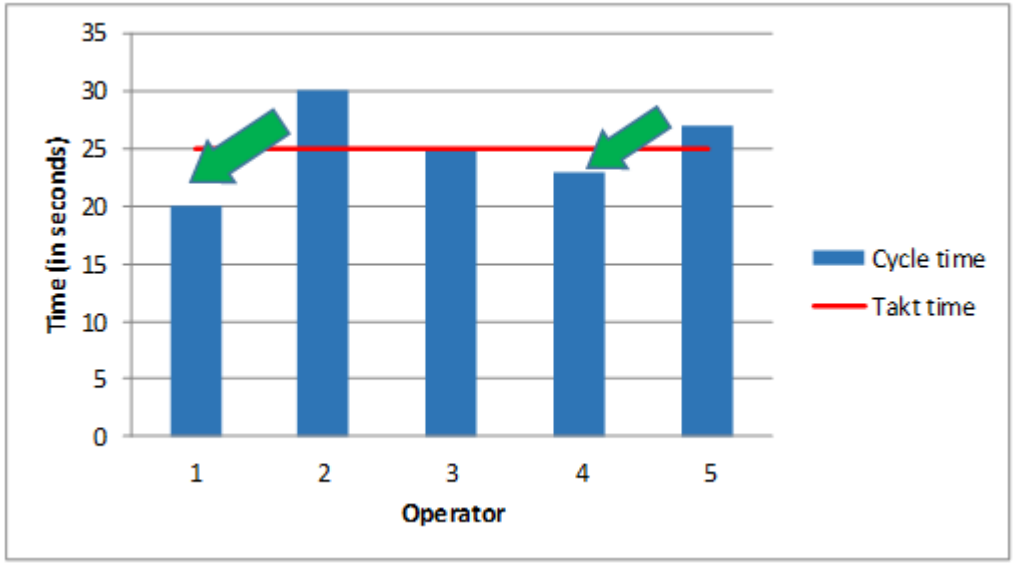
Cycle time > takt time □ production will not be able to satisfy interested parties requirements.

Takt time and cycle time (*Cont.*)

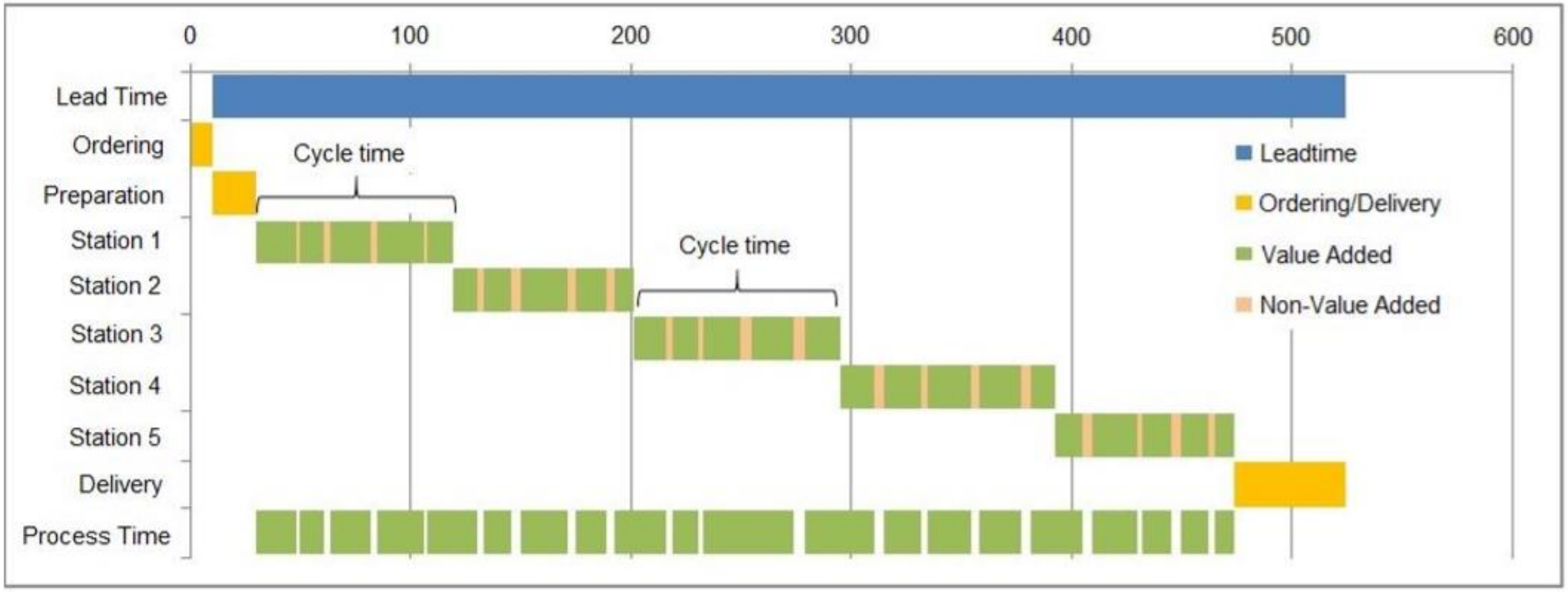
EXAMPLE

Initial condition (given takt time of 25s):

Operator	Cycle time (s)	Remark
Operator 1	20	-
Operator 2	30	More than takt time
Operator 3	25	-
Operator 4	23	-
Operator 5	27	More than takt time



Takt time and cycle time (*Cont.*)



Work sequence

A series of steps in a single process that is fastest, most efficient, safe and produces output of acceptable quality.

When the work sequence is carefully followed, the cycle time will be constant with no occurrence of missing steps and the chance of equipment damage or other major problems can be minimised.

Another consideration when setting up work sequence is ergonomics. The process should be set up so that the employee performs the function in the most ergonomic manner possible.

Standard Work In-process (SWIP)

The last major step in standardised work is Standard Work In-process (SWIP). Keeping to the concept of Just-in-Time, the parts between operations should be minimal.

For a continuous process where parts move from one operation to the next, the target in-process stock should be one unit.

The actual number of parts between processes will depend on the actual operations.

The better the line balancing, the less parts will be required between operations.

The key is to ensure that the bottleneck process (slowest process) always has a supply of parts to process. Any lost time here will be unrecoverable without overtime.

Standard Work In-process (SWIP) (*Cont.*)

Total Productive Maintenance (TPM)

A holistic approach to maintenance that focuses on proactive and preventive maintenance to maximise the operational time of equipment.

TPM puts a strong emphasis on empowering production operators to help maintain their equipment.

TPM creates a shared responsibility for equipment and encourages greater involvement of plant floor workers. Hence, TPM is an effective approach in improving productivity (increasing up time, reducing cycle times and eliminating defects).

Total Productive Maintenance (TPM)

Total	Productive	Maintenance
• Total Involvement from Top management to shop floor personnel • Aim to eliminate all accidents, defects and breakdowns	• Reduce Wastes • Creates Cost Saving • Actions are performed while production goes on	• Maintenance Best Practices : Tighten, Lubrication, Inspection, Cleaning, Repair (TLICR) • From reacting to failures to preventing failures

Common misconception of maintenance
Someone who repair our equipment when it breaks.

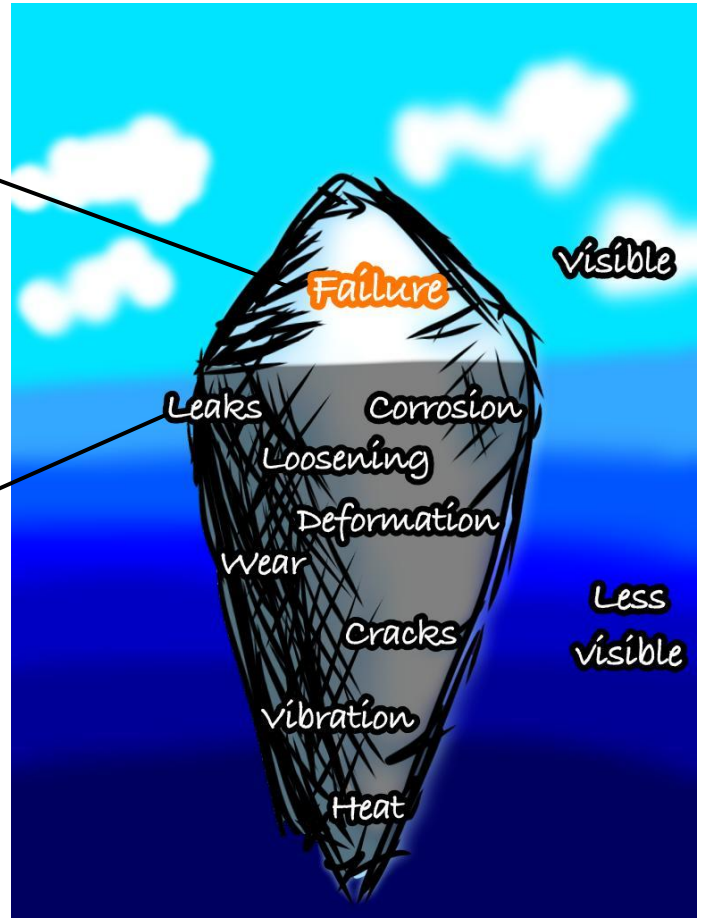
Keep Equipment in Good Condition.

Total Productive Maintenance vs. TQM

Machine failure have many hidden causes

Failure is what we see

Minor machine defects are generally unnoticed but are the cause of almost all machine failures

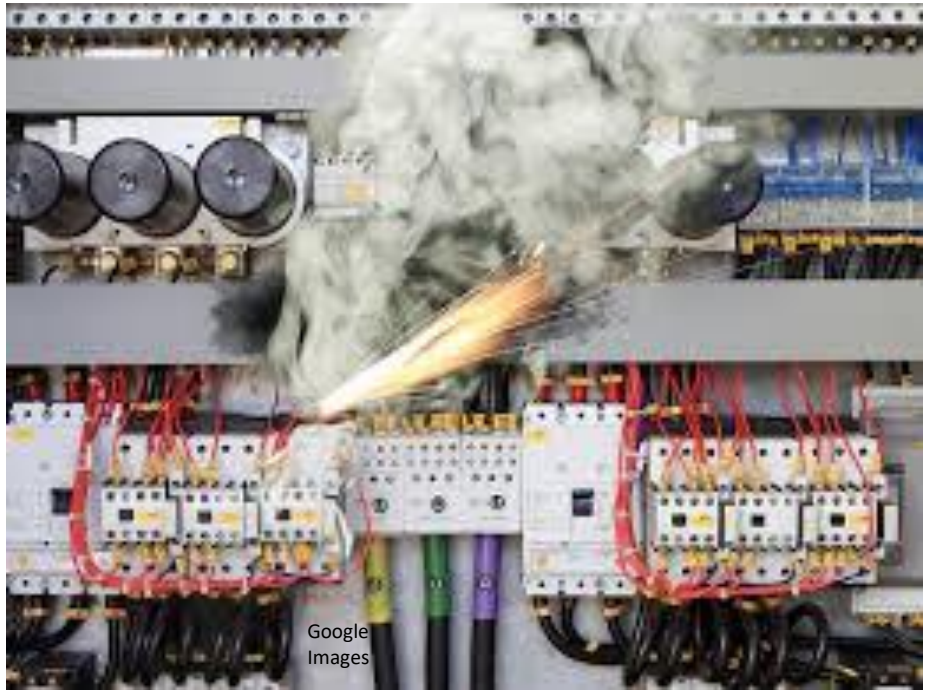


Types of maintenance

1. Breakdown maintenance
2. Autonomous maintenance
3. Preventive maintenance
4. Corrective maintenance
5. Predictive maintenance
6. Plan maintenance

Types of maintenance

1. Breakdown maintenance (reactive)
   - Performed when equipment has broken down / not useable
   - Fire Fighting



Types of maintenance

2. Autonomous maintenance (AM)

- Performed by the machine operators who are trained and competence to have unique knowledge about the machines and the skills to maintain it.
- Operators accept and share responsibility (with Maintenance) for the performance and health of their equipment.
- It is a principal component TPM

Types of maintenance

3. Preventive maintenance

- Routine Maintenance performed to maintain the basic equipment conditions
  - ➢Replace deteriorating parts
  - ➢Maintain equipment in on-spec condition
- It is carried out at predetermined periods, to ensure equipment reliability
- Maintain to healthy condition and prevent failure.

Types of maintenance

4. Corrective maintenance

- Task performed to identify, isolated and rectify a fault so that the failed equipment, machine or system can be restored to an operational condition within the tolerances of limits established for in-service operations.

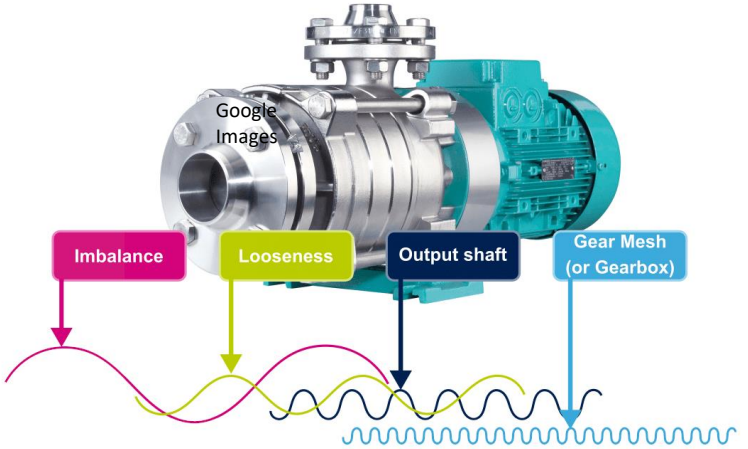
- Redesign the equipment to improve reliability and maintainability.

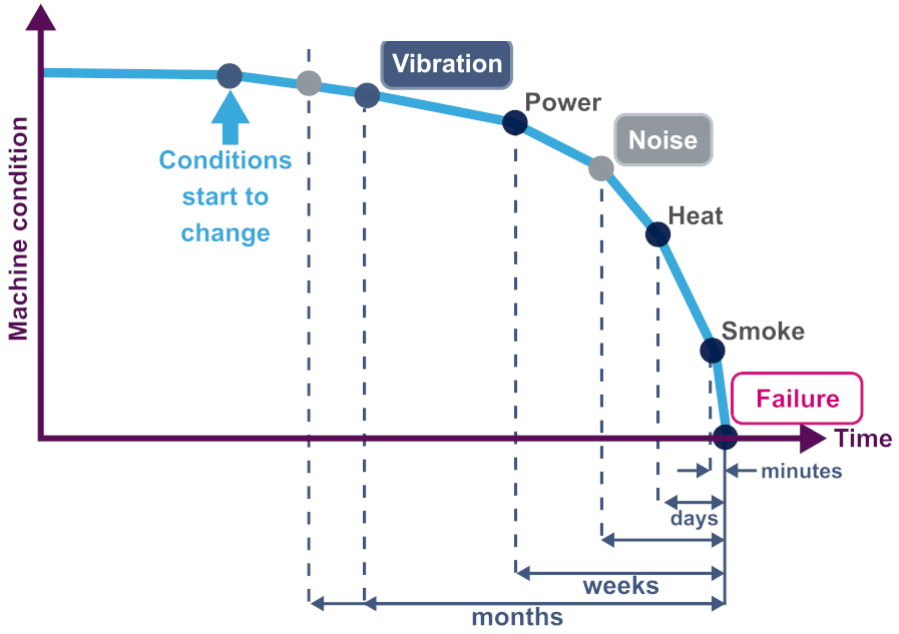

Google Images

Types of maintenance

5. Predictive maintenance (condition-based)

- Performed to corrects equipment deterioration by condition monitoring to predict when maintenance should be performed.
- It uses wear rated, measurement data during inspection, past failure to generate trends and predicts the remaining life of a part.
- Imaging / ultra-sound / vibration…



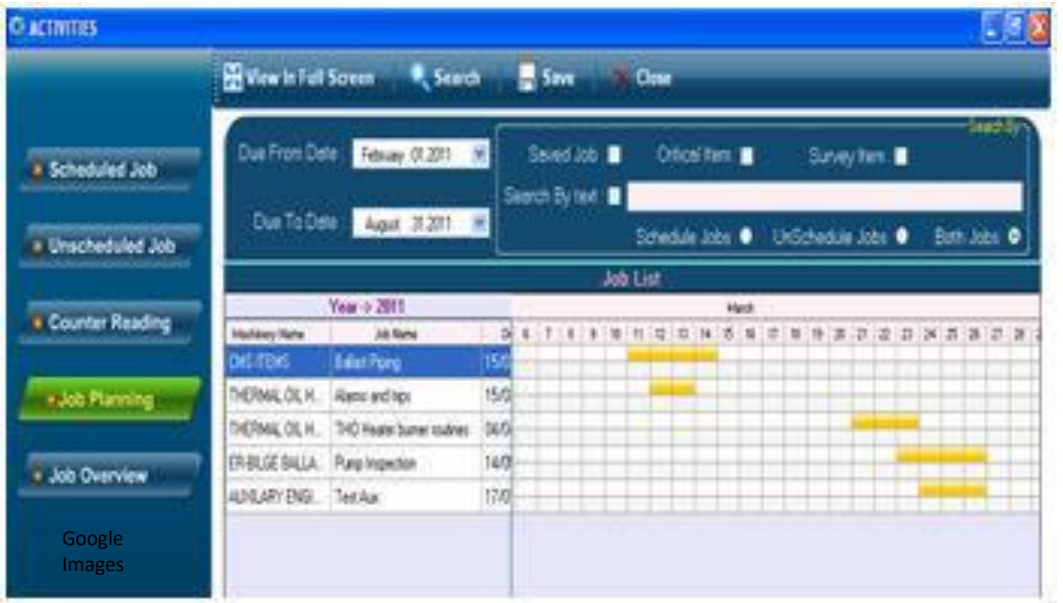


Types of maintenance

6. Planned maintenance (PM)

- A Scheduled maintenance

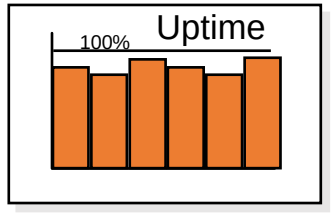
- PM is performed while the equipment is still working, so that it does not break down unexpectedly



The Six Big Losses

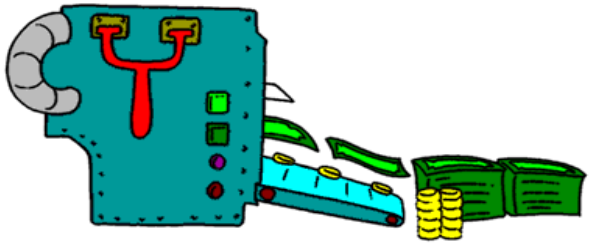
DOWNTIME

1 Breakdowns due to equipment failure
2 Set-ups, teardowns & adjustments



MACHINE PERFORMANCE

3 Idling & minor stoppages
4 Reduced running speed



Images

QUALITY

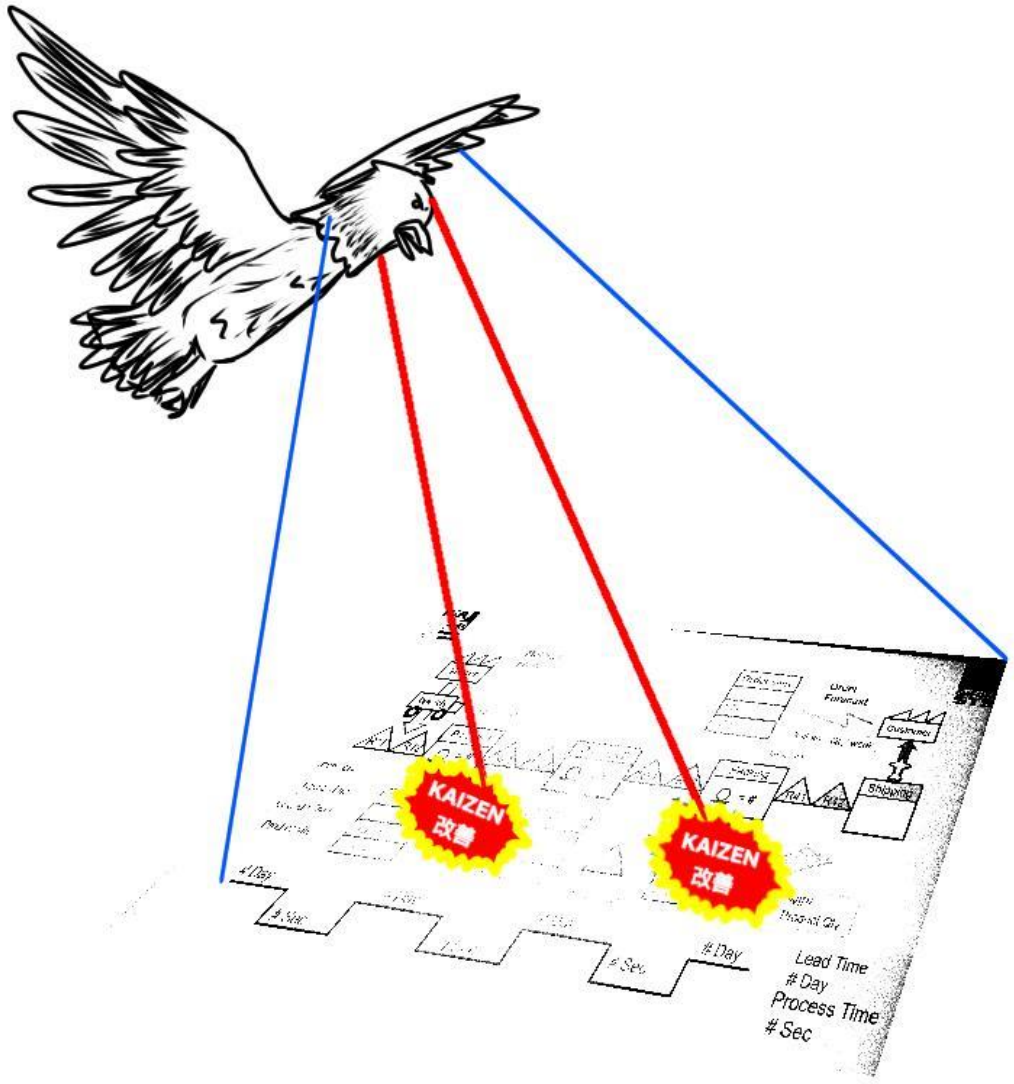
5 Start-up losses until stable production achieved
6 Process losses (scrap, rework & non-conformance)

Value Stream Mapping/ Material information flow chart

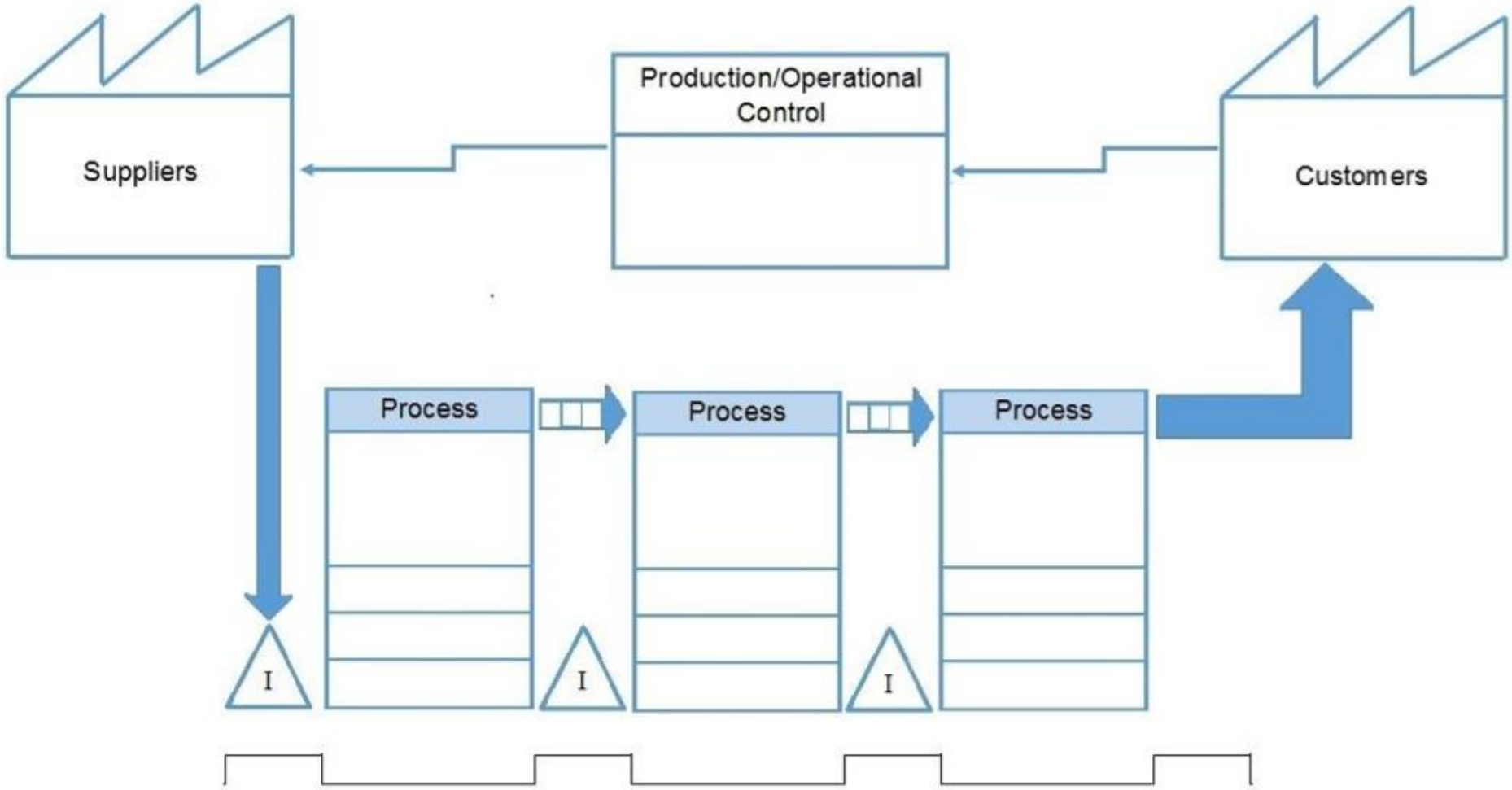
A tool used to document, analyse and improve the flow of information or materials required to produce a product or service for an interested party.

A value stream map (end-to-end system map) takes into account not only the activity of the product, but the management and information systems that support the basic process.

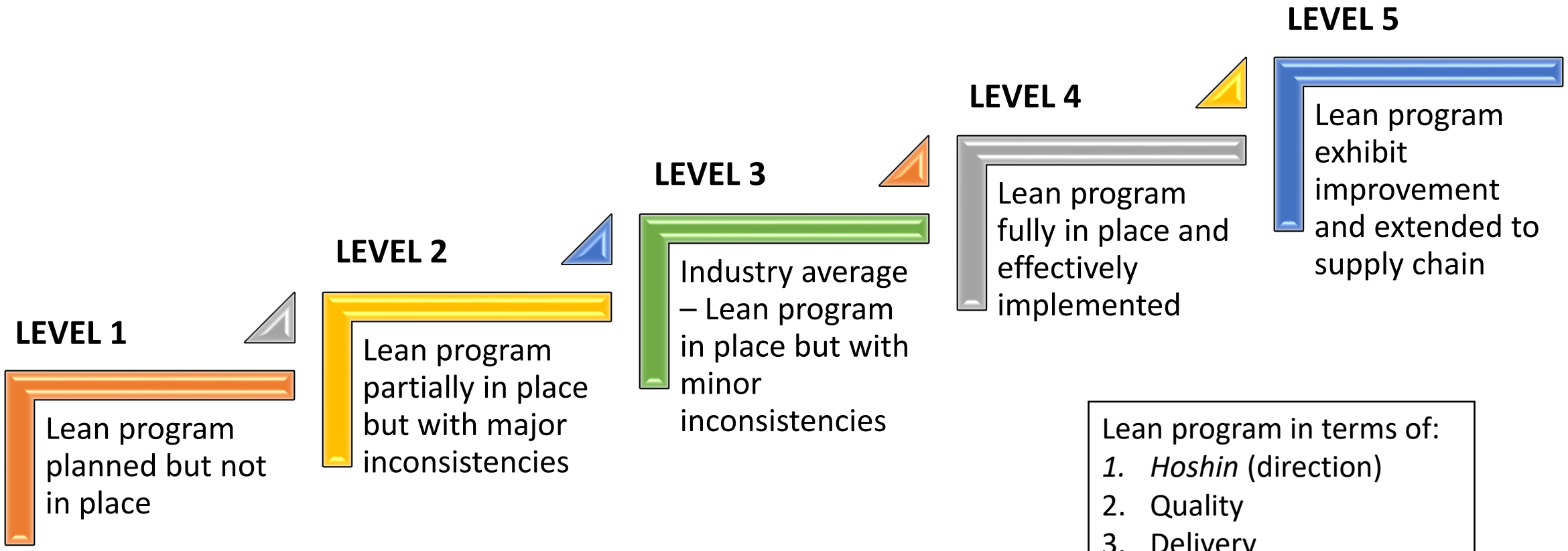
This is especially helpful when working to reduce non-value added time, because it gains insight into the decision making flow in addition to the process flow.



Value Stream Mapping/ Material information flow chart (*Cont.*)



Clause 9: Level of implementation



Lean program in terms of:

1. *Hoshin* (direction)
2. Quality
3. Delivery
4. Lean metrics
5. *Hitozukuri*
6. *Hitozukuri* requirement

Clause 9: Level of implementation

Level of implementation (maturity)	*Hoshin* (direction)	Quality	Delivery	Lean metrics	Human capital development (*hitozukuri*)	*Hitozukuri* requirement
Level 1 (The component is planned but not in place)	i. Management commitment ii. Vision & Mission iii. Lean committee (Steering) iv. Risk awareness	i. Basic documented information on the process ii. Interested parties specification iii. Finished product/service inspection	i. Establish safety rules ii. Identify lead time iii. Interested parties requirement/ demand iv. 2S	i. Quality and delivery data collection and analysis for core processes ii. Opportunities for improvement identified	Top management at Beginner level, in accordance to SIRIM 13	Dependent on external training facilities/ trainers
Level 2 (The component is partially in place but there are major inconsistencies in implementation)	i. Business plan ii. Improvement team iii. Risk-based thinking	i. Detailed documented information on the process ii. Monitor defect and rejection iii. End-of-process inspection	i. Standard time (current operation) ii. Visualisation (*mieruka*) - safety, quality, delivery, attendance, daily operation control (4M – man, machine, material, method)	i. Identify safety, quality and delivery targets and activities ii. Material and information flow chart iii. Process time mapping iv. Suggestion scheme v. Improvement projects at process/area level	i. Full time coordinator (person to coordinate kaizen activities) for the company at Practitioner level ii. Intermediate (minimum 10 % of direct workers) iii. Beginner (minimum 50 % of direct worker)	i. Less dependency towards external training facility/ trainer ii. Internal training facility (classroom)

Clause 9: Level of implementation (*cont.*)

Level of implementation (maturity)	*Hoshin* (direction)	Quality	Delivery	Lean metrics	Human capital development (*hitozukuri*)	*Hitozukuri* requirement
Level 3 - Industry average (The component is in place but there are minor inconsistencies in implementation)	i. Strategic plan	i. In-process inspection (Quality gate) ii. Customer service management iii. Root cause analysis	i. Takt time and cycle time ii. Workload balancing iii. 3S iv. Pull system - establish *Kanban* system with supplier v. Optimise batching/single-piece flow vi. Visual control (*me de miru kanri*) including cost	i. Cost saving ii. Improvement projects at functional (departmental) level	i. Full time coordinator (person to coordinate kaizen activities) for the company at Leader level ii. Departmental coordinator at Practitioner level for departmental kaizen activities iii. Intermediate (minimum 25 % of direct worker) iv. Beginner (100 % of direct worker)	Internal training facility (Dojo step 1)
Level 4 - Good (The component is fully in place and effectively implemented)	i. Long-range plan ii. Economy and environment	i. Standardised work ii. In-process inspection (self inspection) iii. TPM iv. Mistake proofing (*poka-yoke*)	i. Standard WIP ii. Manpower efficiency iii. 4S iv. Pull system - establish internal *Kanban* system v. Green practices	i. Significant trend of improvement in lead time ii. Improvement projects at functional (organisation) level	i. Full time coordinator for the company at Expert level (person to coordinate kaizen activities) ii. Departmental coordinator at Leader level for departmental kaizen activities iii. Practitioner (minimum 10 % of all employees) iv. Intermediate (minimum 25 % of all employees) v. Beginner (100 % of all employees)	Internal training facility (Dojo step 2)

Clause 9: Level of implementation (*cont.*)

Level of implementation (maturity)	*Hoshin* (direction)	Quality	Delivery	Lean metrics	Human capital development (*hitozukuri*)	*Hitozukuri* requirement
Level 5 - Exceptional (The component is fully in place, effectively implemented, exhibits improvement in execution and lean practice extended to the supply chain)	i. Sustainable (Economy, environment and society) ii. Contribute to develop lean management within the supply chain iii. External provider Development Programme	i. Zero defect ii. Overall Equipment Effectiveness (OEE) based on industry best practice iii. Sustained improvement	i. 5S ii. Sustainable development activities	i. Improvement projects at value chain level ii. Reduction in employee turnover	i. Coordinator for integrated logistic at Expert level	Internal training facility (Dojo step 3)

NOTES:

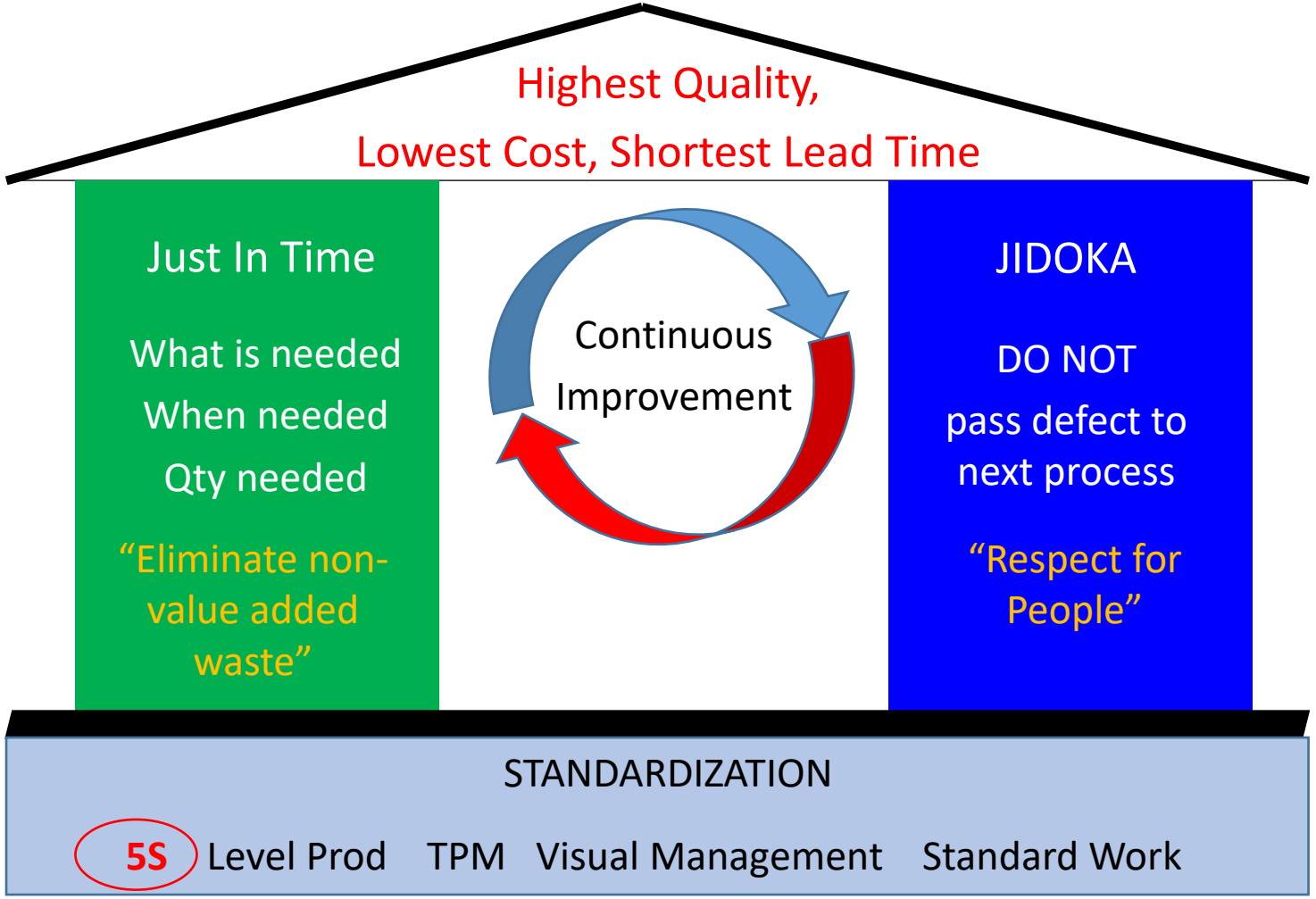
1. Basic documented information include useful guidelines to produce product or service e.g. flow chart. Detailed documented information contains comprehensive work instruction including process requirements.

2. Improvement projects can be described as:

   a) Process/area level – involving a single process flow, e.g. filling process in packaging system.
   b) Departmental level – involving more than one inter-related process, e.g. filling, sealing and labelling in packaging system.
   c) Organisation – involving more than one system, e.g. production and IT systems.
   d) Value chain – involving more than one related organisations in the upstream and downstream chain.

Lean Concepts, Tools & Techniques

House of Toyota production system



TPM forms the Basic Stability for Lean Transformation

Introduction to 5S

1.1 **What is 5S and the benefits**

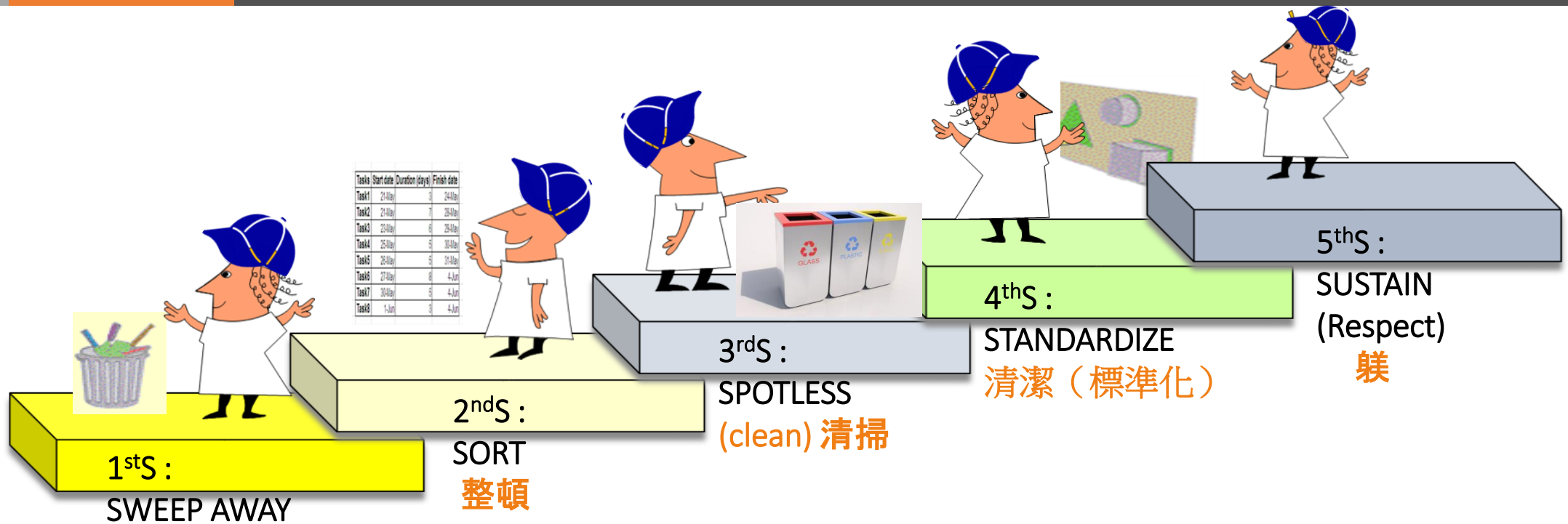
1.2 **Implementation of 5S(1S) activities**

What is 5S?

Is it possible to ask operators to reach

- **0 SAFETY ACCIDENT**
- **0 QUALITY ISSUE**
- **BE EFFICIENT**

What is 5S?



PREPARATION

The benefits of 5S

- Improve the work environment,
- Work in a safe place,
- Improve quality,
- Save time,
- Work in teams,
- Make things easy…
- To be efficient!

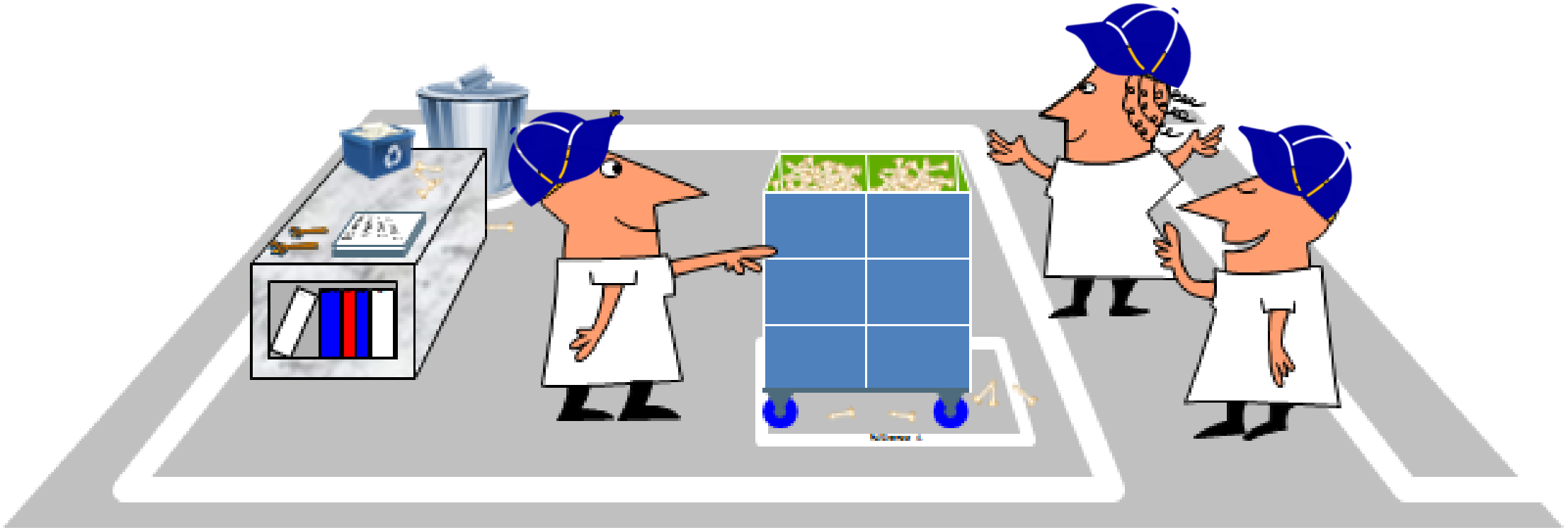
AFTER

Sweep away 整理

1st S

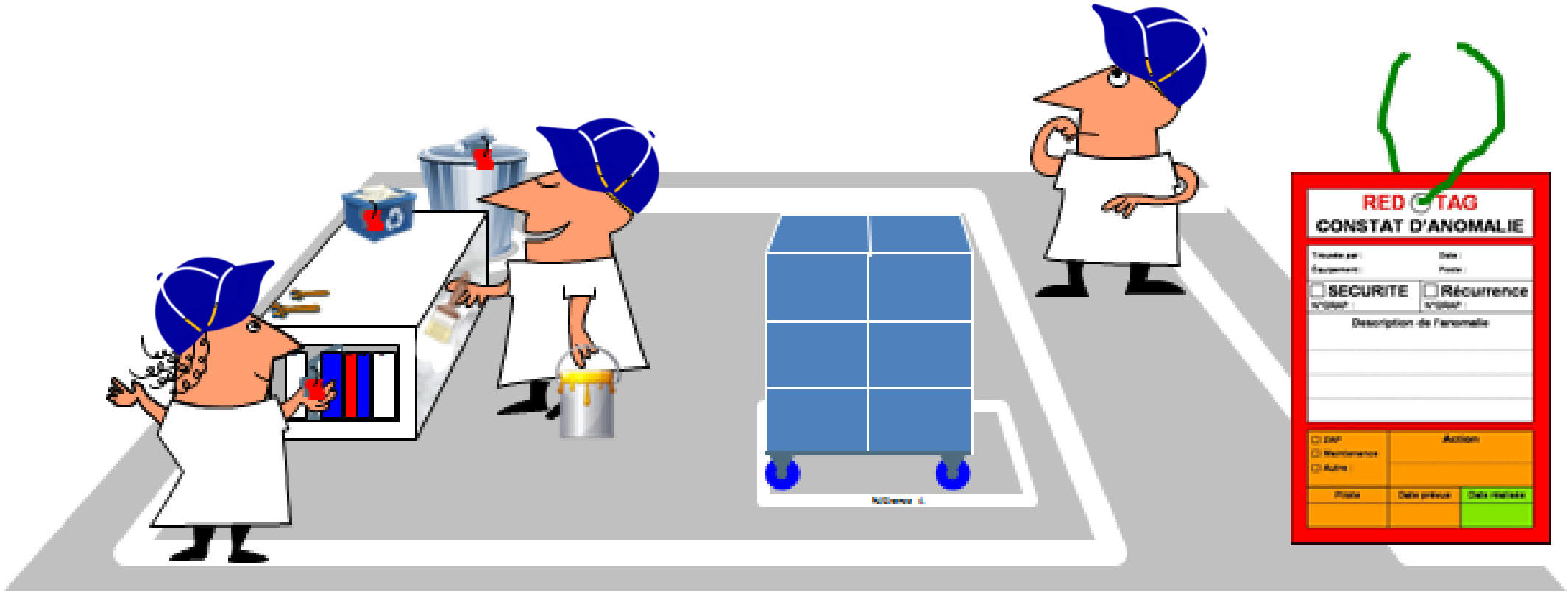
Sort 整頓

2nd S



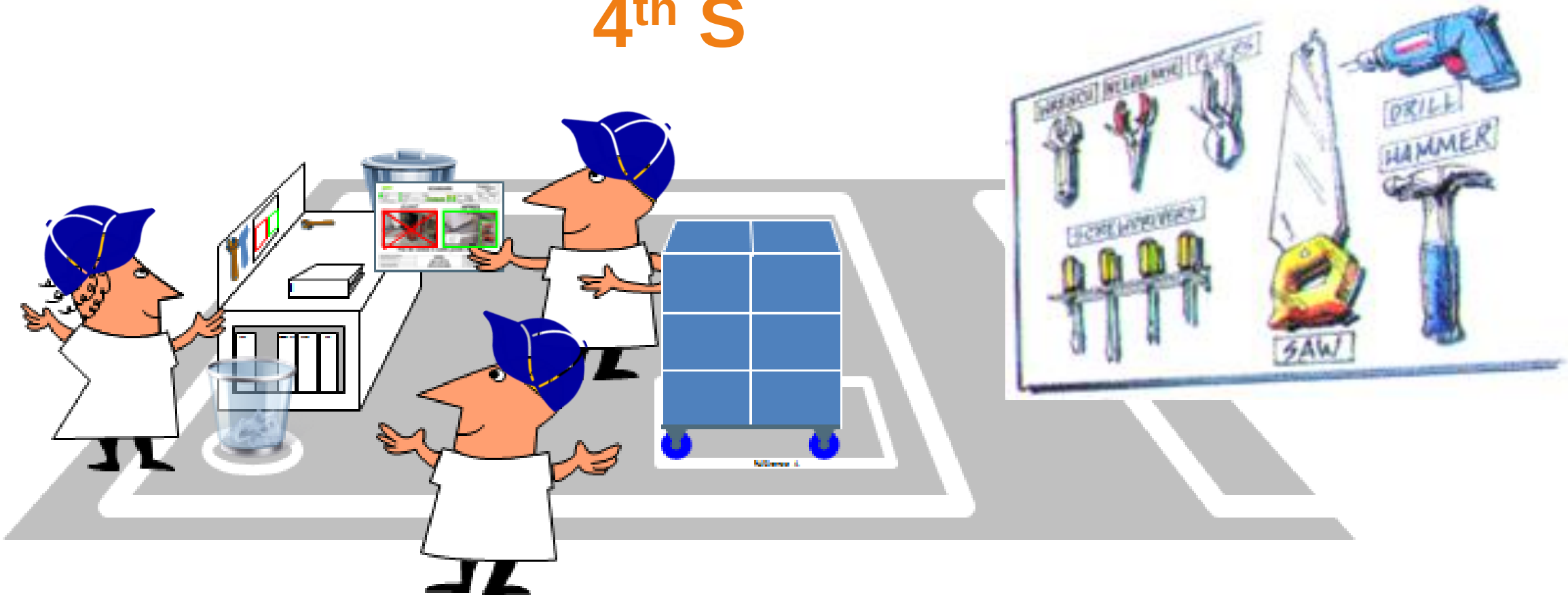
Sportless (clean) 清掃

3rd S



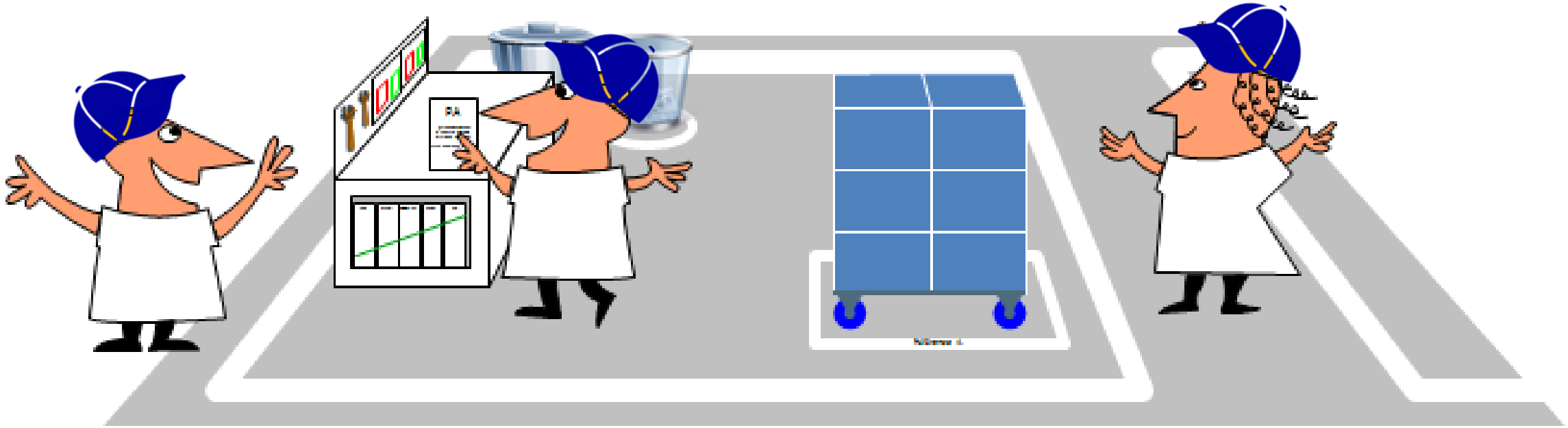
Standardize 清潔(標準化)

4th S

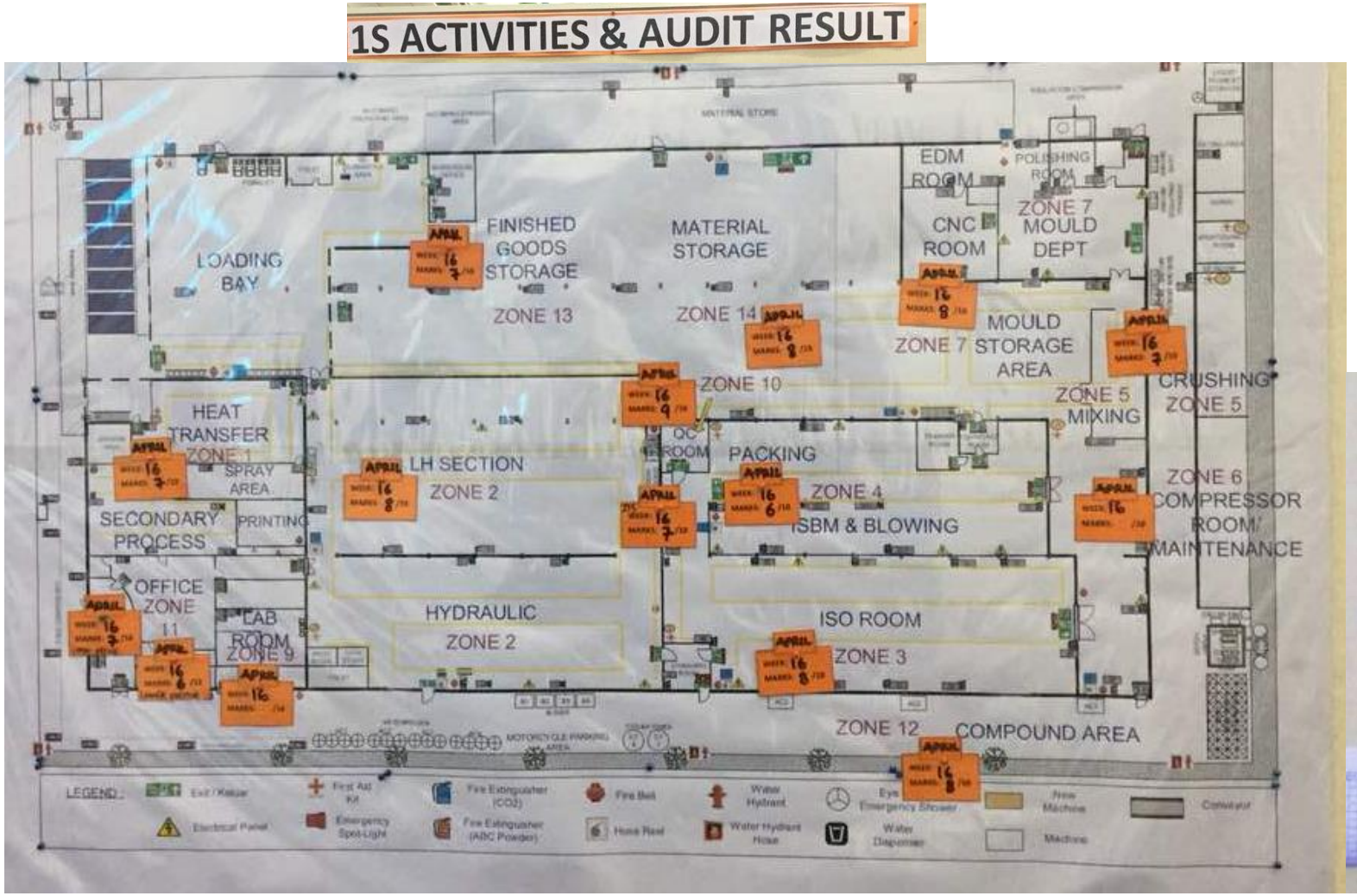


Sustain (respect) 躾

5th S



Weekly 1S self-assessment results & 5S mapping

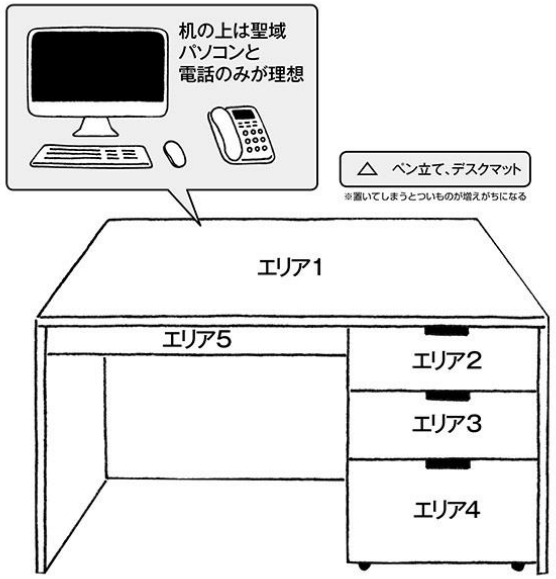


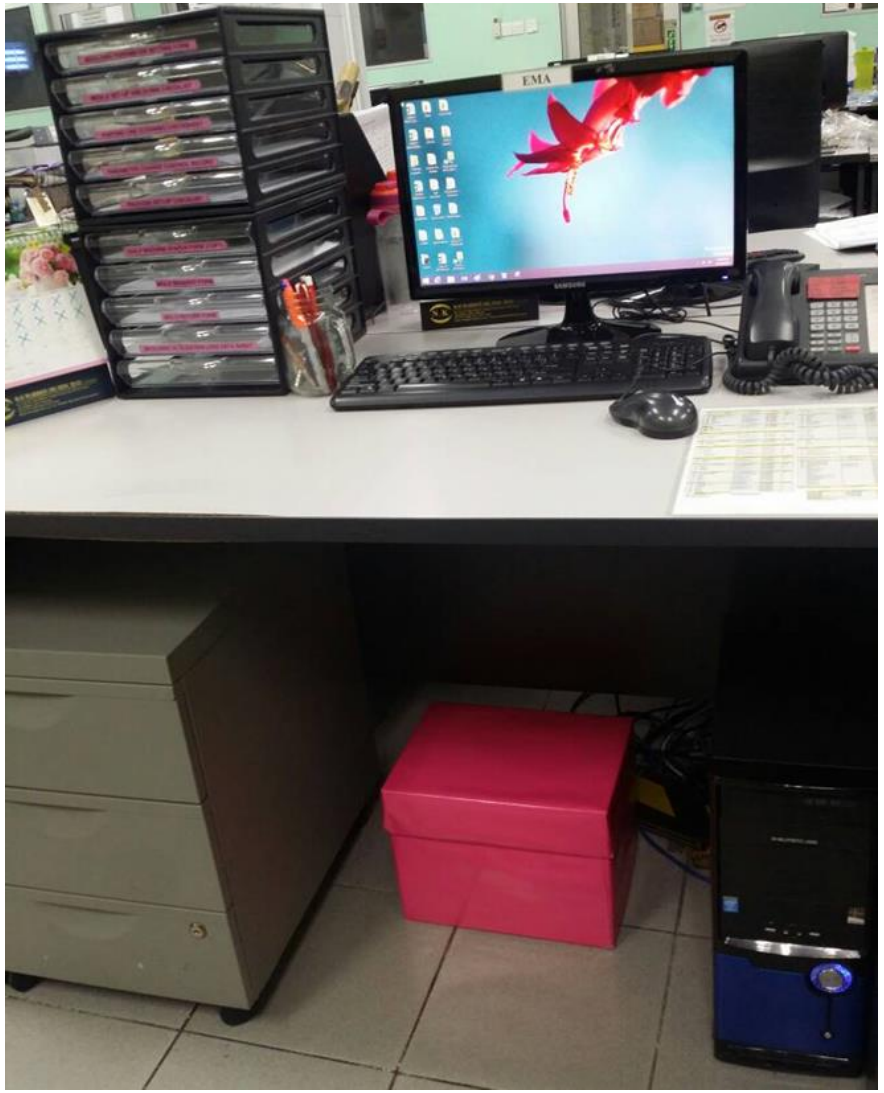
5S Mapping

Is 1S needed in the office?

What's happened?

How should I create this standard?





Introduction to
Total Productive Maintenance (TPM)

2.1 **Total Productive Maintenance (TPM)**

2.2 **Pillars and enablers of TPM**

2.3 **Value stream**

Total Productive Maintenance

Total Productive Maintenance (TPM) is a management system for maximizing the Overall Equipment Effectiveness (OEE) and condition of an asset throughout its entire life.

TPM is one of the Lean Six Sigma (LSS) standards for improving the Quality Process.

Total Employee Involvement

Management + Operators + Maintenance

Total Productive Maintenance

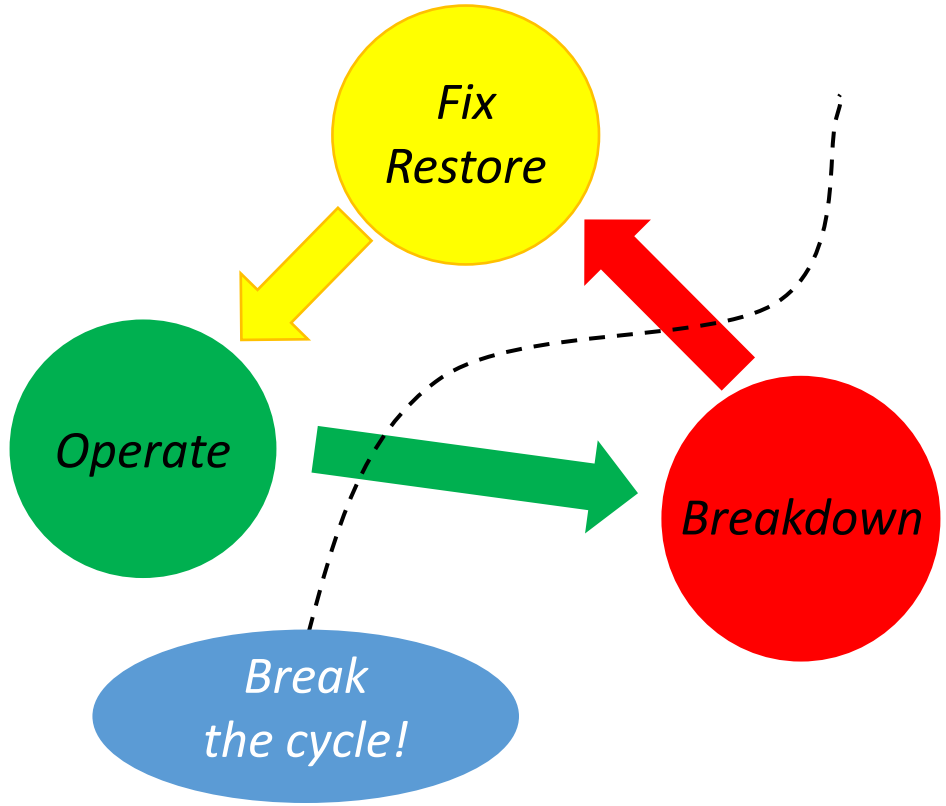
Total	Productive	Maintenance
• Total Involvement from Top management to shop floor personnel • Aim to eliminate all accidents, defects and breakdowns	• Reduce Wastes • Creates Cost Saving • Actions are performed while production goes on	• Maintenance Best Practices : Tighten, Lubrication, Inspection, Cleaning, Repair (TLICR) • From reacting to failures to preventing failures

Common misconception of maintenance
Someone who repair our equipment when it breaks.

Keep Equipment in Good Condition.

Total Productive Maintenance

Traditional Maintenance Cycle



Loss in Production Opportunities

Scrap of defective parts

Cost for recovery to meet shipment

Why Total Productive Maintenance?

Evolution of maintenance

1st Generation

- Fix it when it broke

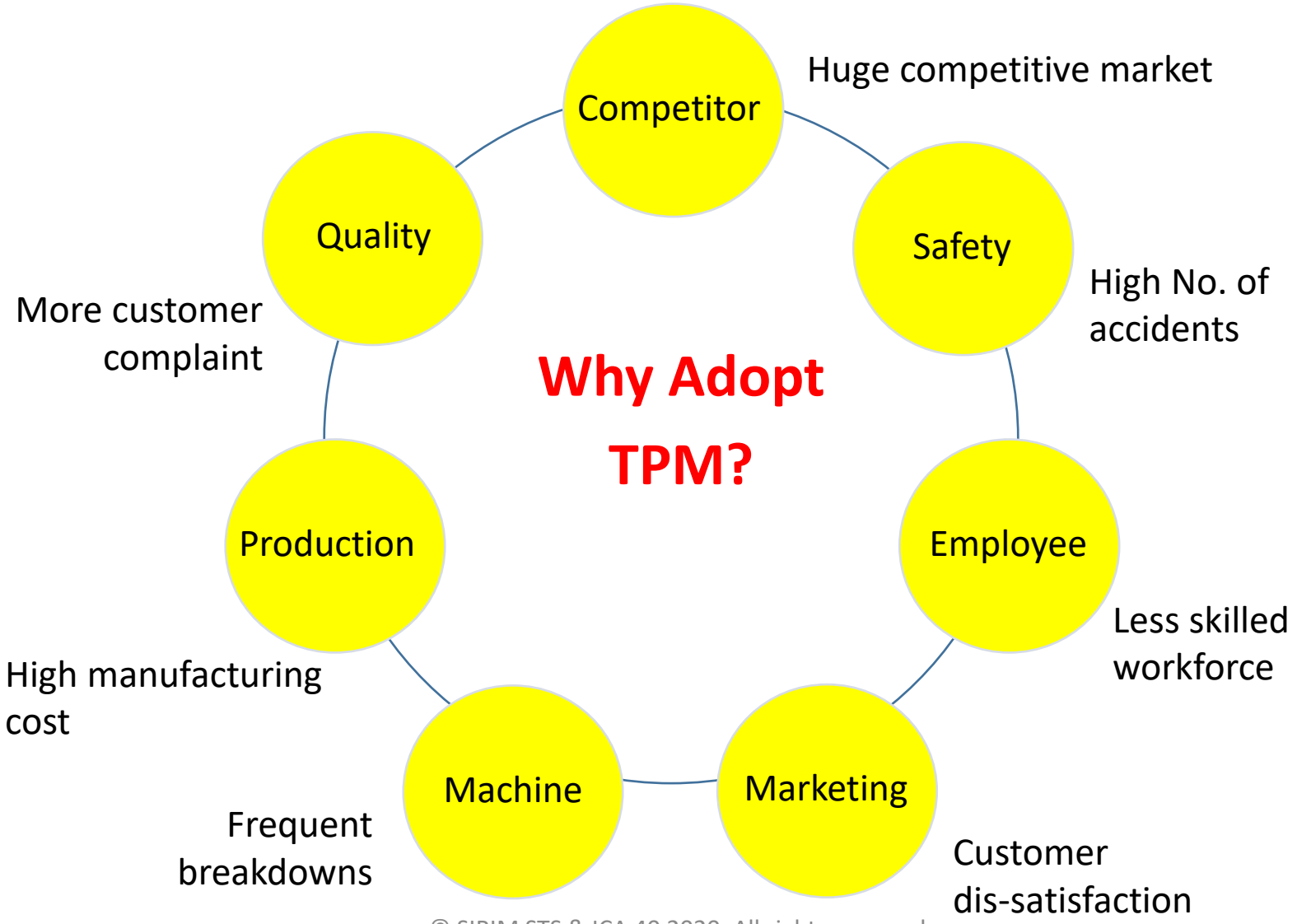
2st Generation

- Plant availability
- Increase equipment life
- Lower cost

3rd Generation

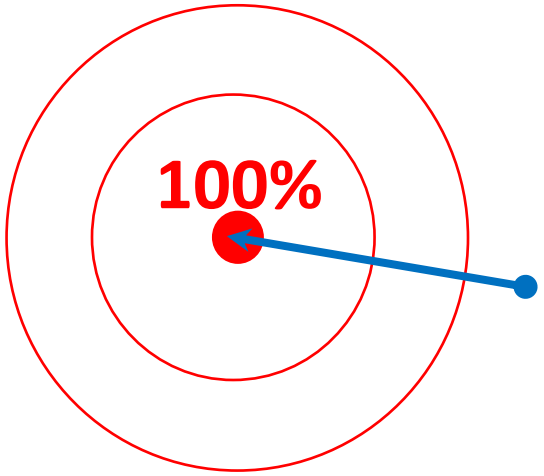
- Higher Plant availability
- Higher Reliability
- Increase safety
- Better Quality
- No damage to environment
- Increase equipment life
- Greater cost effectiveness

Why Total Productive Maintenance?



3 major goals of Total Productive Maintenance

1. Zero equipment breakdowns
2. Zero quality defects
3. Zero accidents



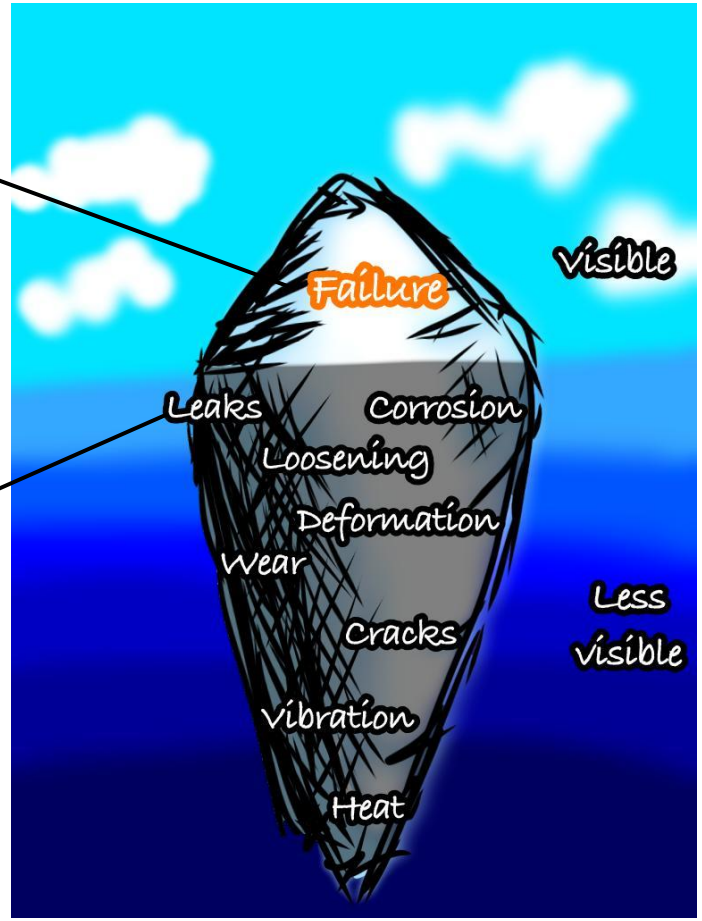
Zero Waste!

Total Productive Maintenance vs. TQM

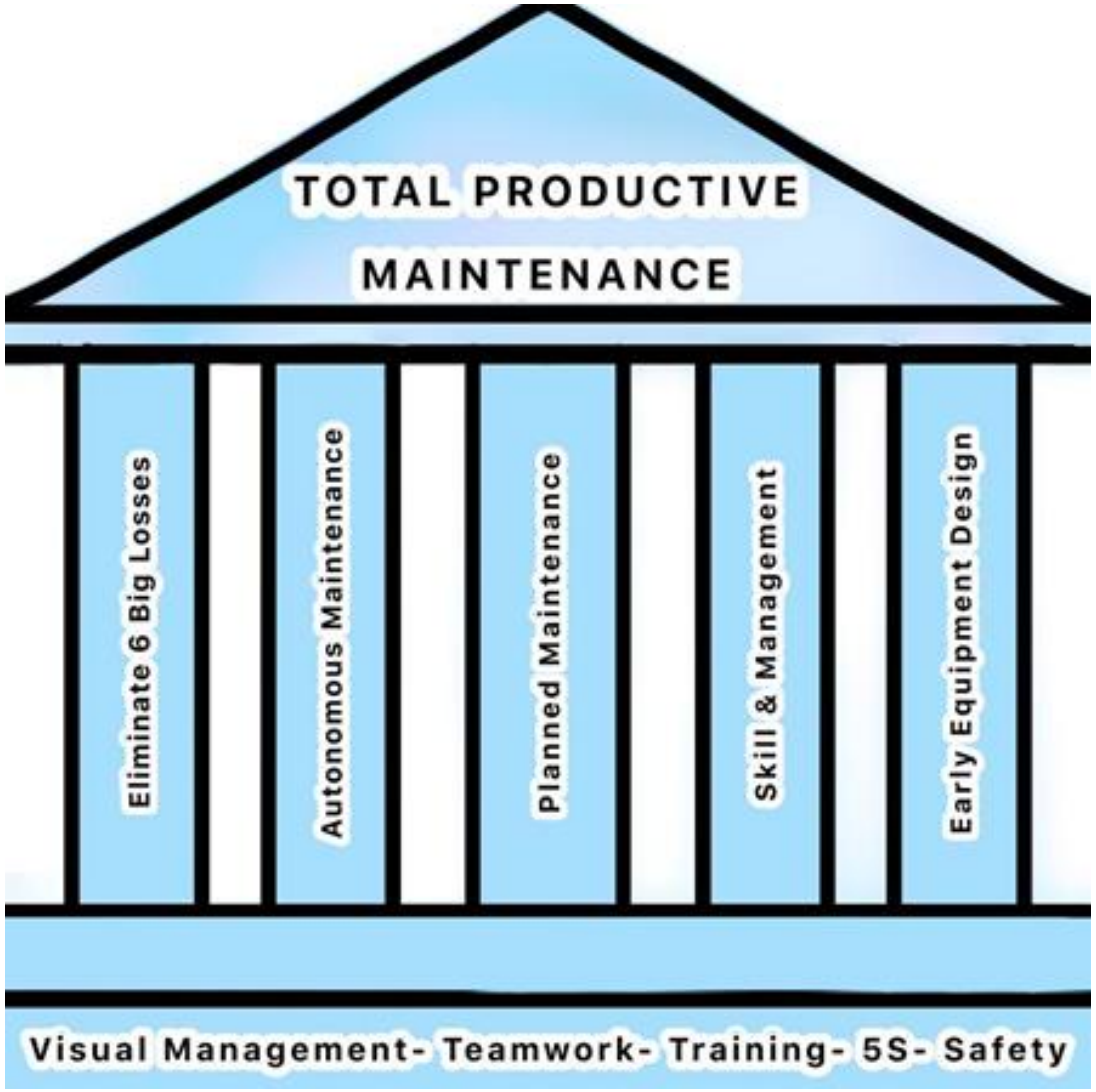
Machine failure have many hidden causes

Failure is what we see

Minor machine defects are generally unnoticed but are the cause of almost all machine failures



5 pillars and enablers of Total Productive Maintenance

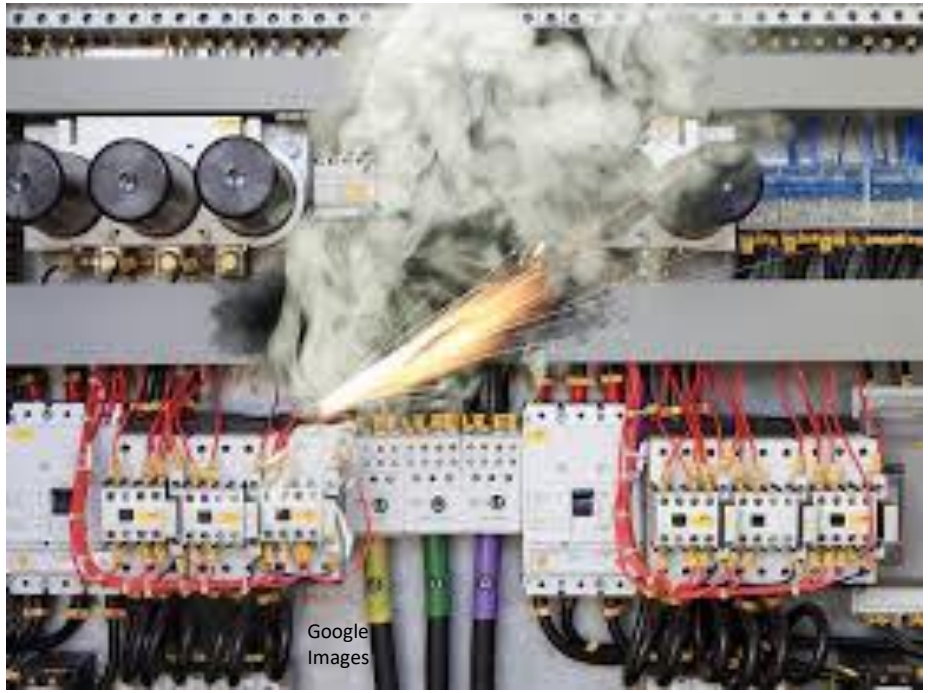


Types of maintenance

1. Breakdown maintenance
2. Autonomous maintenance
3. Preventive maintenance
4. Corrective maintenance
5. Predictive maintenance
6. Plan maintenance

Types of maintenance

1. Breakdown maintenance (reactive)
   - Performed when equipment has broken down / not useable
   - Fire Fighting



Types of maintenance

2. Autonomous maintenance (AM)

- Performed by the machine operators who are trained and competence to have unique knowledge about the machines and the skills to maintain it.
- Operators accept and share responsibility (with Maintenance) for the performance and health or their equipment.
- It is a principal component TPM

Types of maintenance

3. Preventive maintenance

- Routine Maintenance performed to maintain the basic equipment conditions
  - ➢Replace deteriorating parts
  - ➢Maintain equipment in on-spec condition
- It is carried out at predetermined periods, to ensure equipment reliability
- Maintain to healthy condition and prevent failure.

Types of maintenance

4. Corrective maintenance

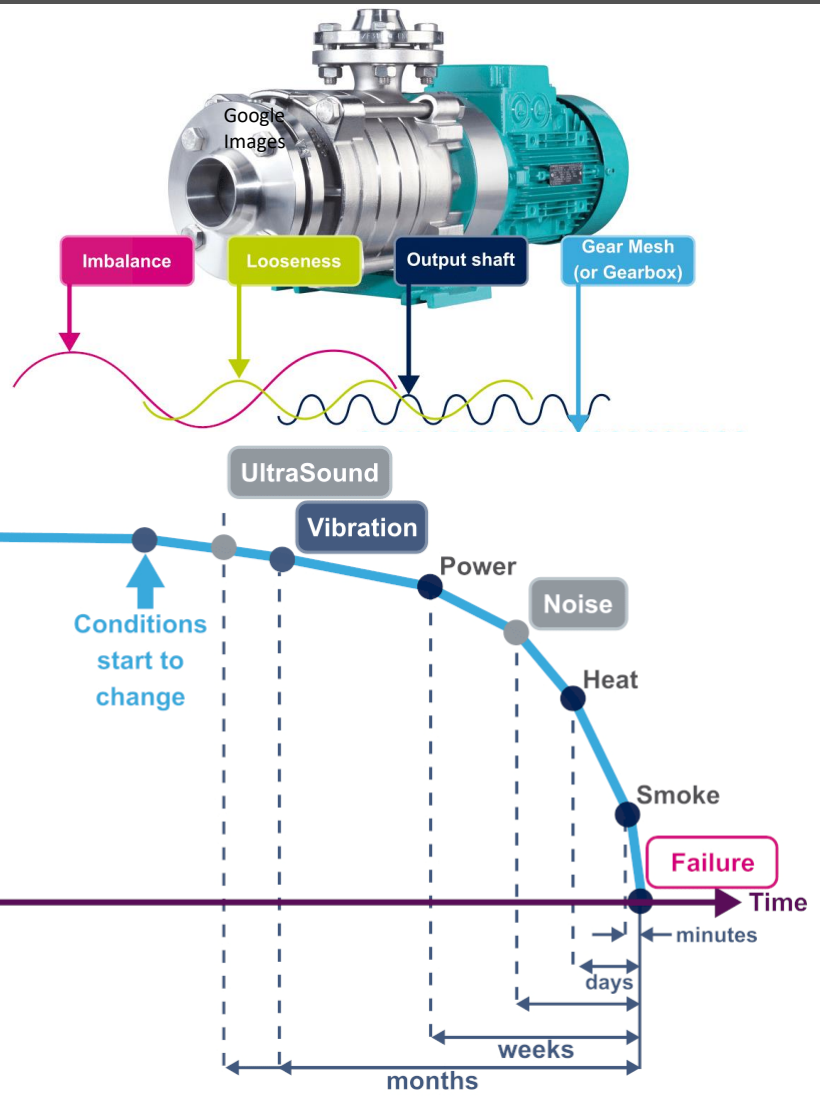
- Task performed to identify, isolated and rectify a fault so that the failed equipment, machine or system can be restored to an operational condition within the tolerances of limits established for in-service operations.

- Redesign the equipment to improve reliability and maintainability.

Types of maintenance

5. Predictive maintenance (condition-based)

- Performed to corrects equipment deterioration by condition monitoring to predict when maintenance should be performed.
- It uses wear rated, measurement data during inspection, past failure to generate trends and predicts the remaining life of a part.
- Imaging / ultra-sound / vibration…



Types of maintenance

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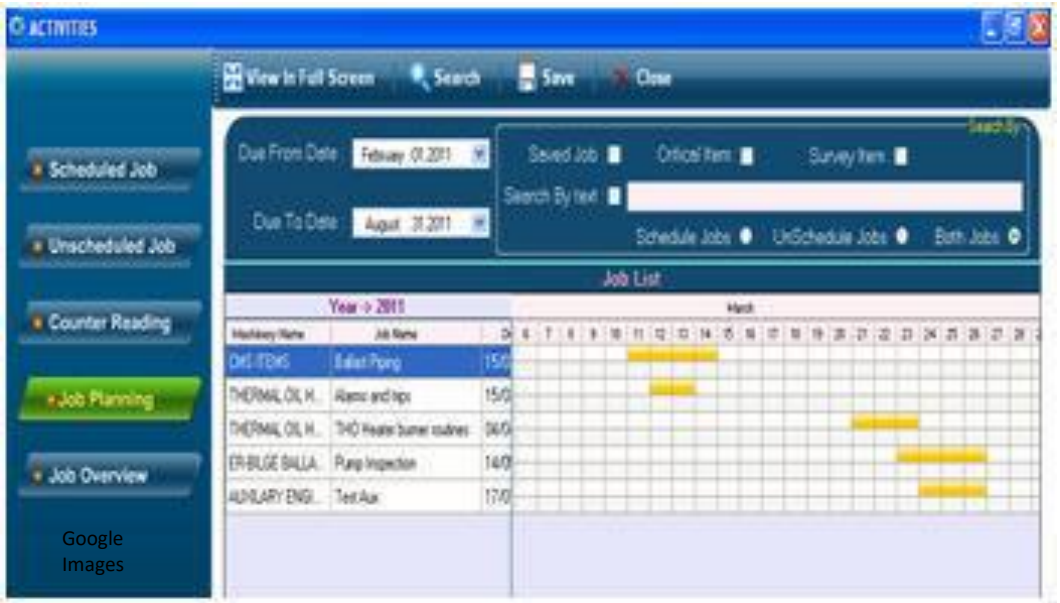
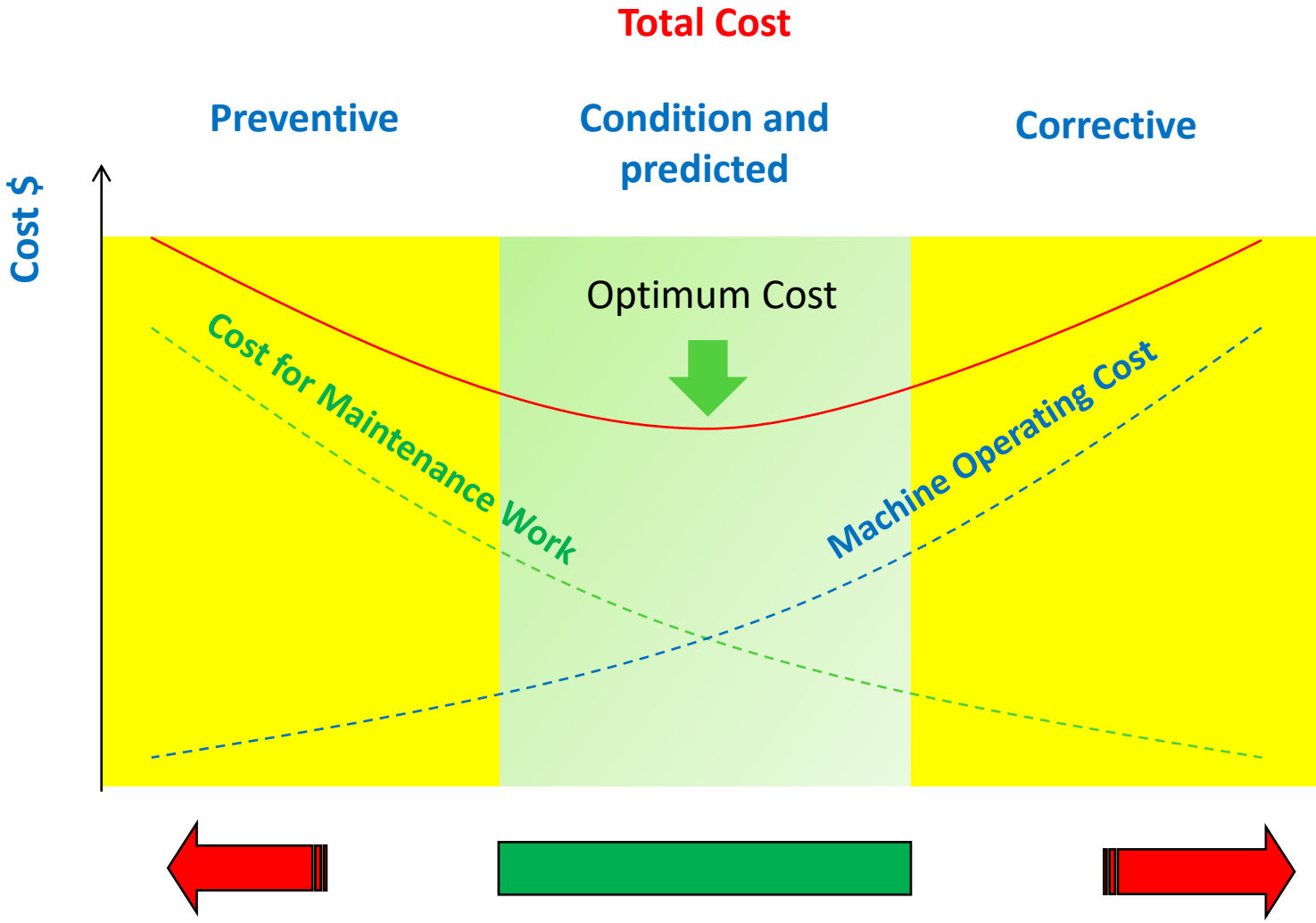
- PM is performed while the equipment is still working, so that it does not break down unexpectedly

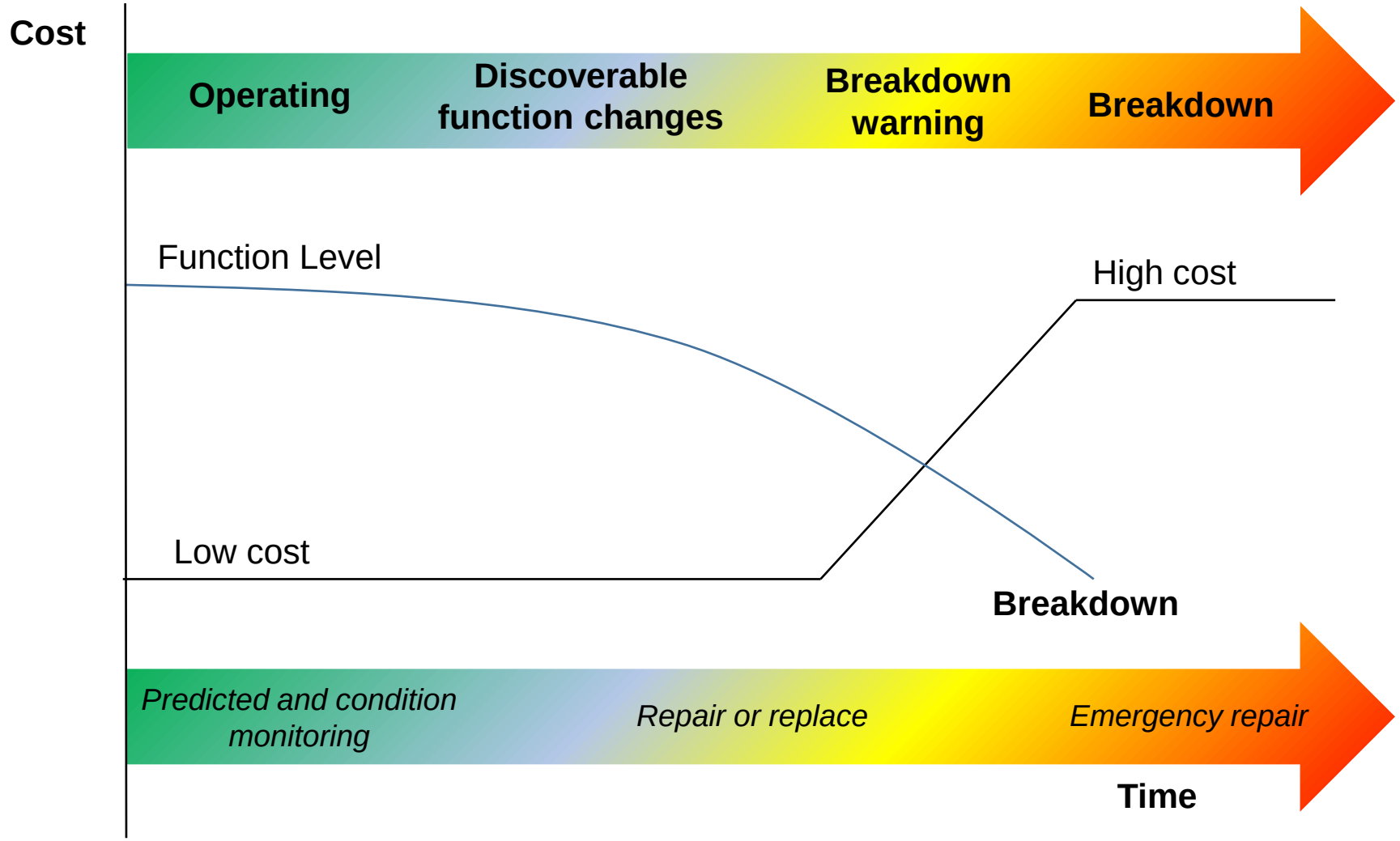


Google Images

Maintenance cost



Maintenance cost

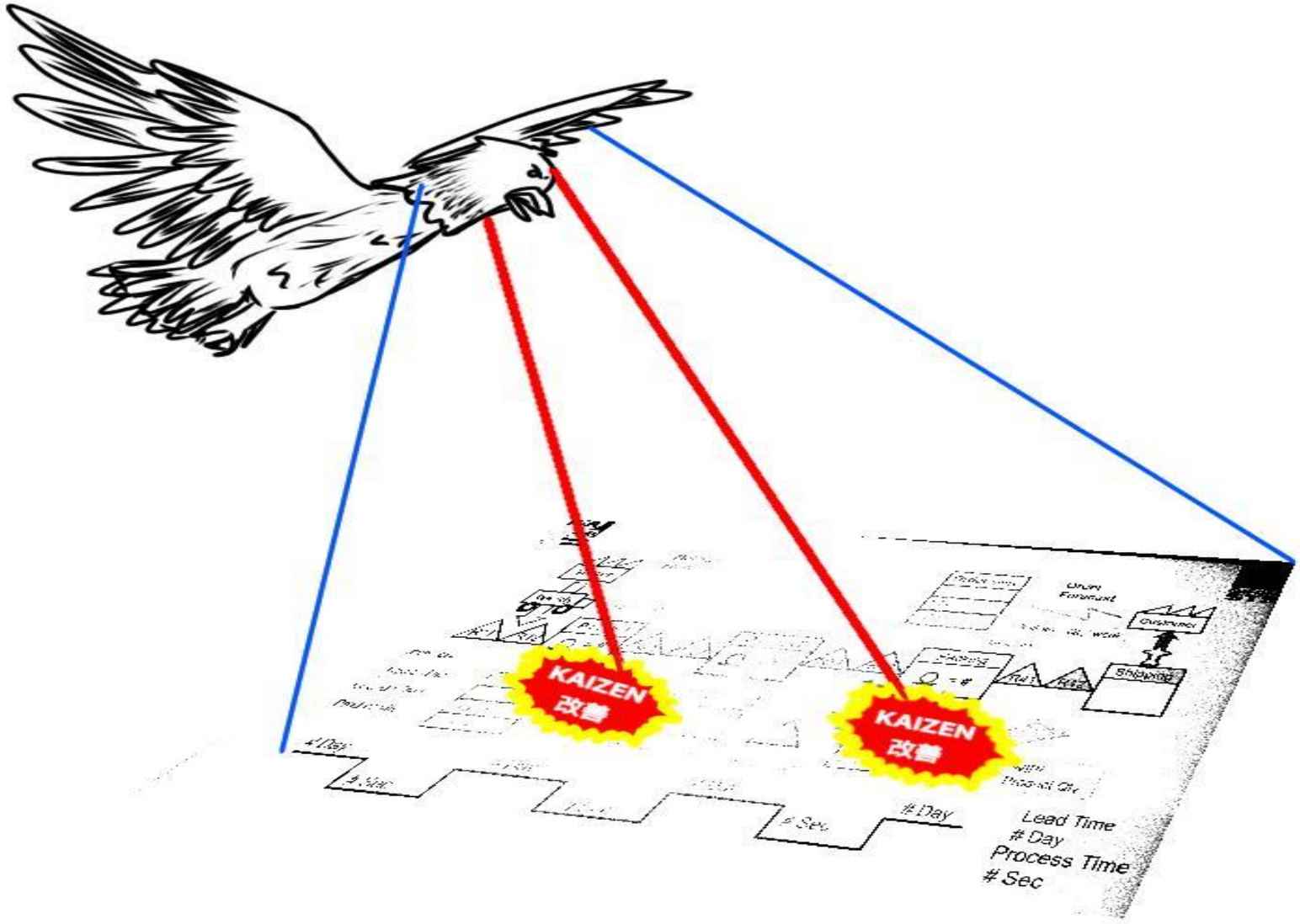


Production systems 製造システム

The LEAN management System is aimed at reducing cost of our value chain by continuously eliminating Muda in the way we use our resources.

MUDA is WASTE！ ！

“MUDA” ムダ hunting？



What is “MUDA” ムダ？

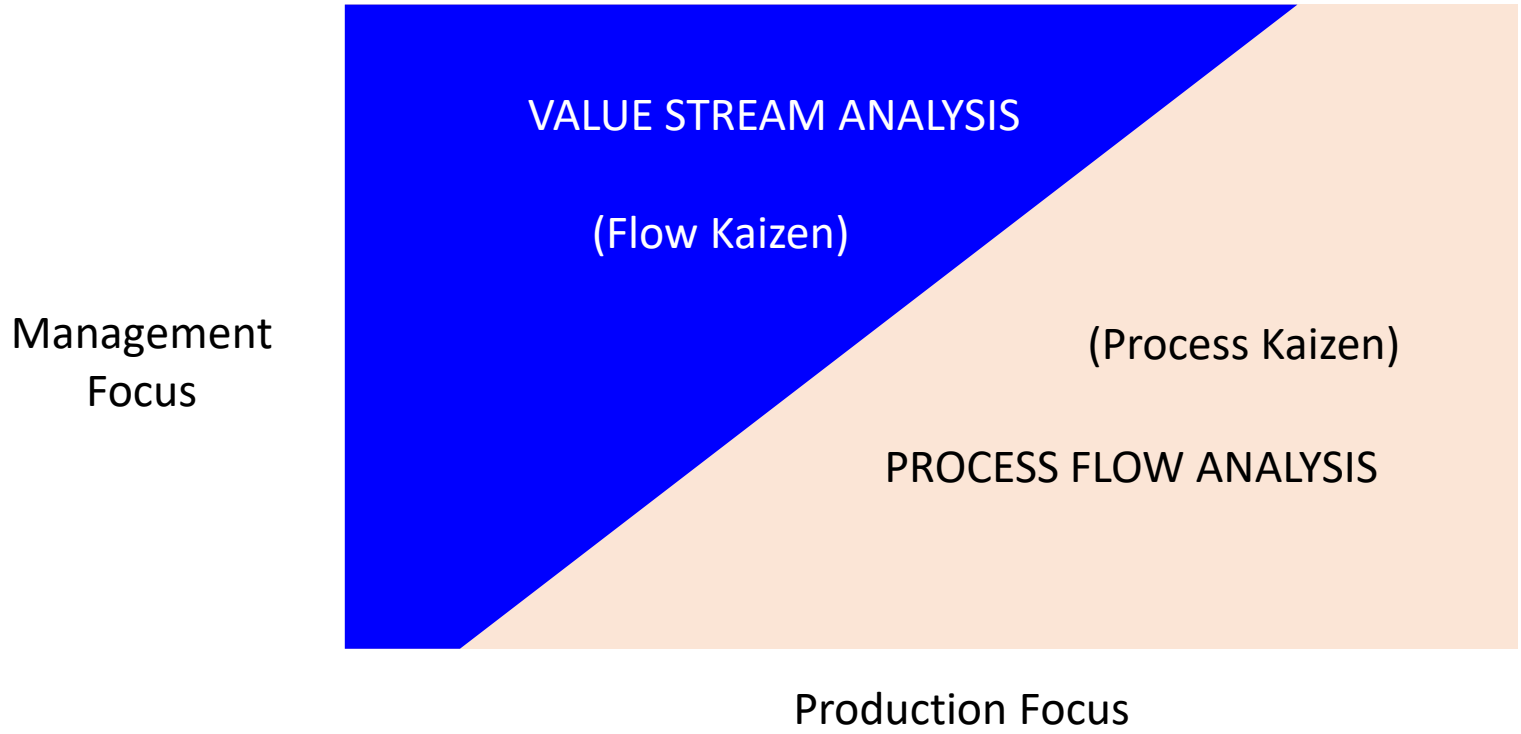
“MUDA” is any activity that, from the customer’s point of view, does not add value to the product or the service.

7 Muda responsible for the excess costs:

不良・手直しのムダ	Non Quality
造りすぎのムダ	Over Production
手待ちのムダ	Waiting
運搬のムダ	Transports
在庫のムダ	Inventories
動作のムダ	Motions
加工のムダ	Excess Processing

KAIZEN

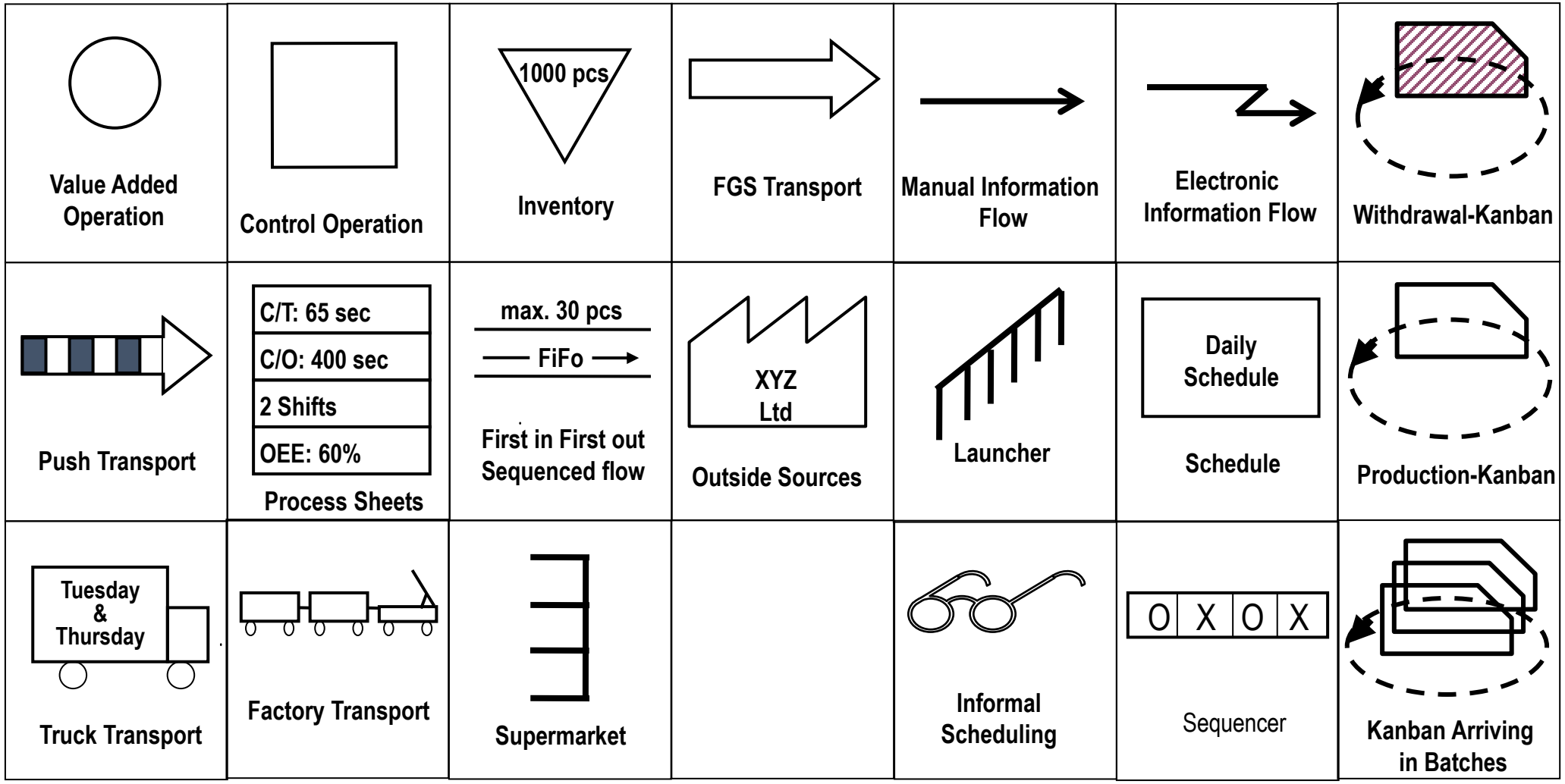
KAIZEN	ANALYSIS	WHO
FLOW KAIZEN	Value Stream Analysis	Top Management Front lines
PROCESS KAIZEN	Process Flow Analysis	Production



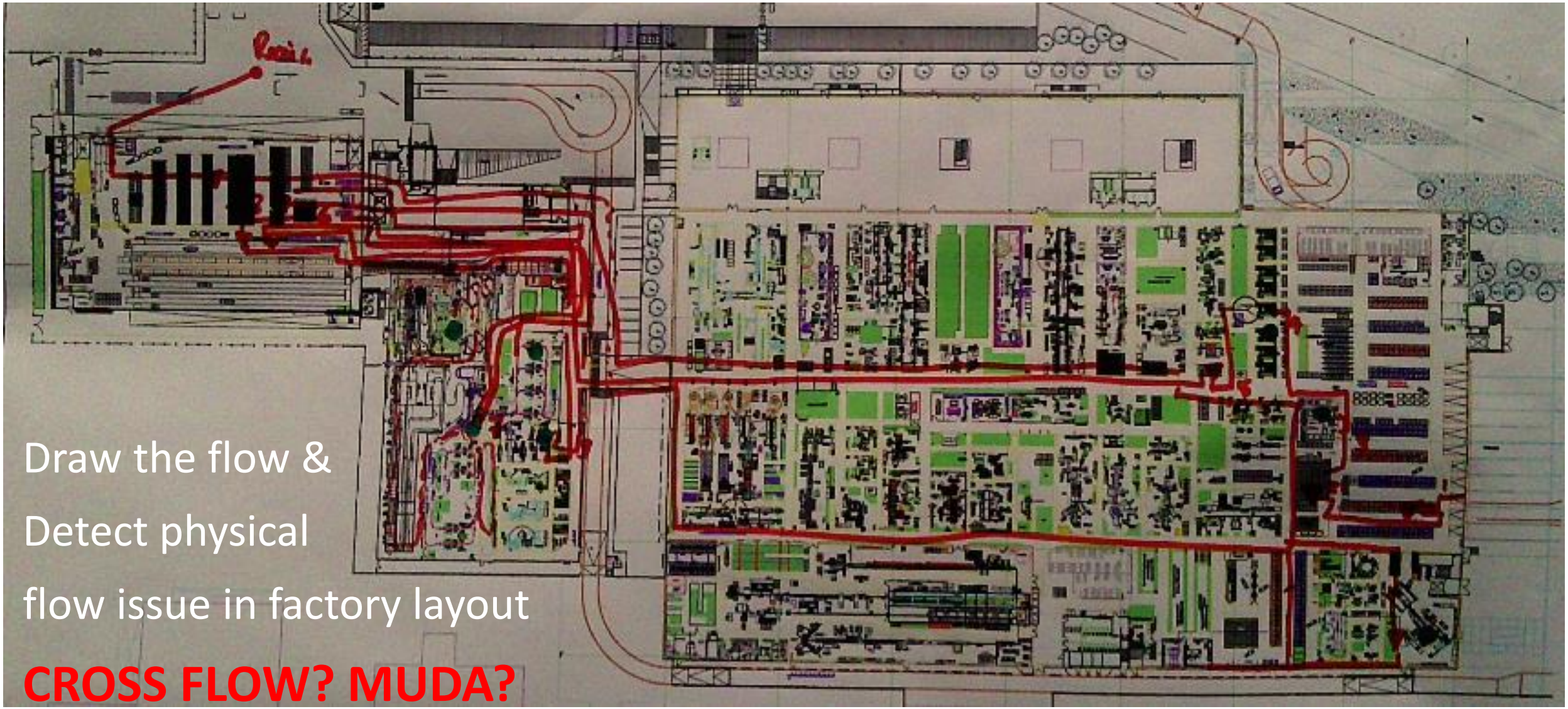
Value stream symbols

Material Flow Icons

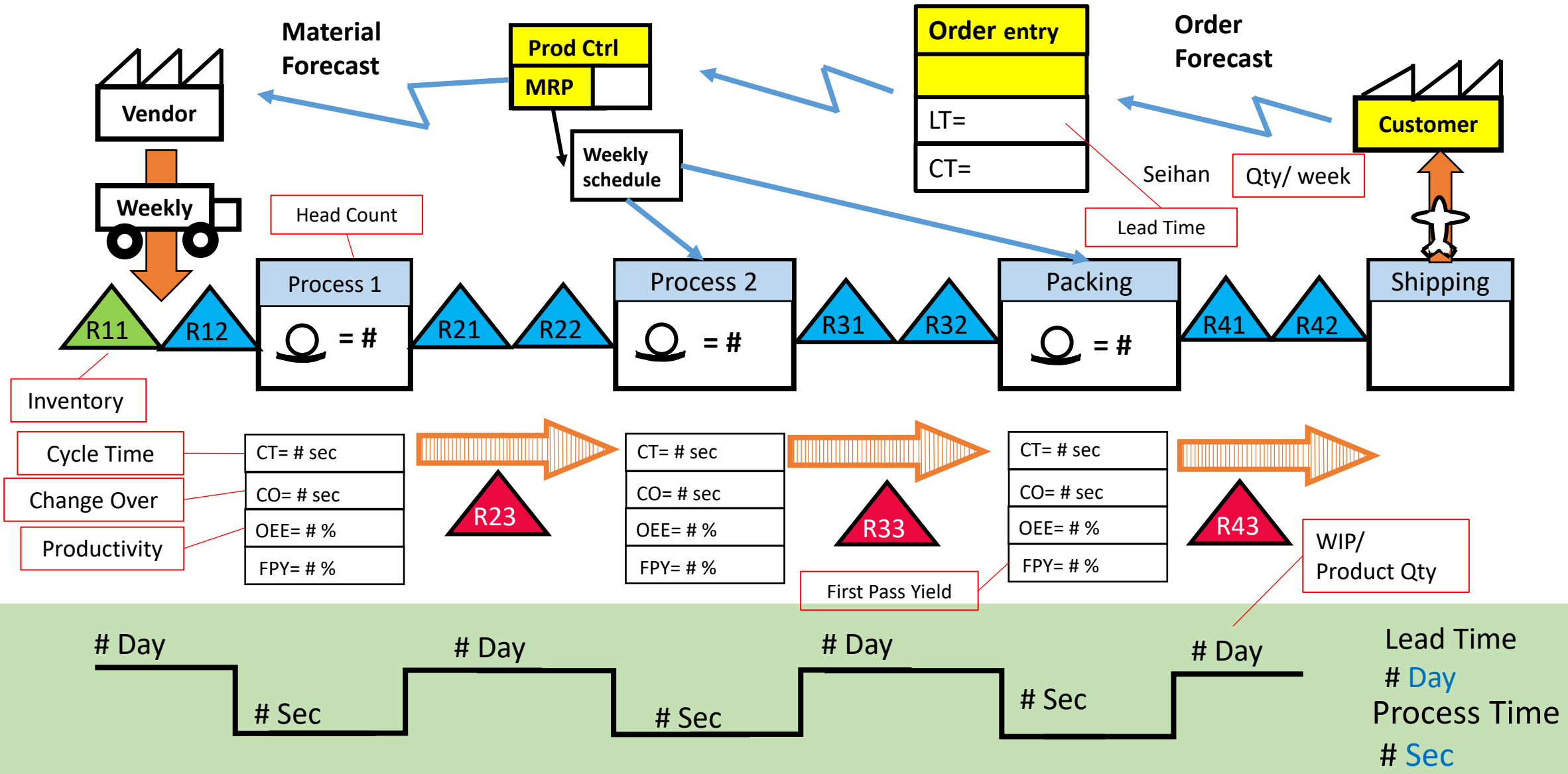
Information Flow Icons



Value stream mapping spaghetti diagram



Value stream



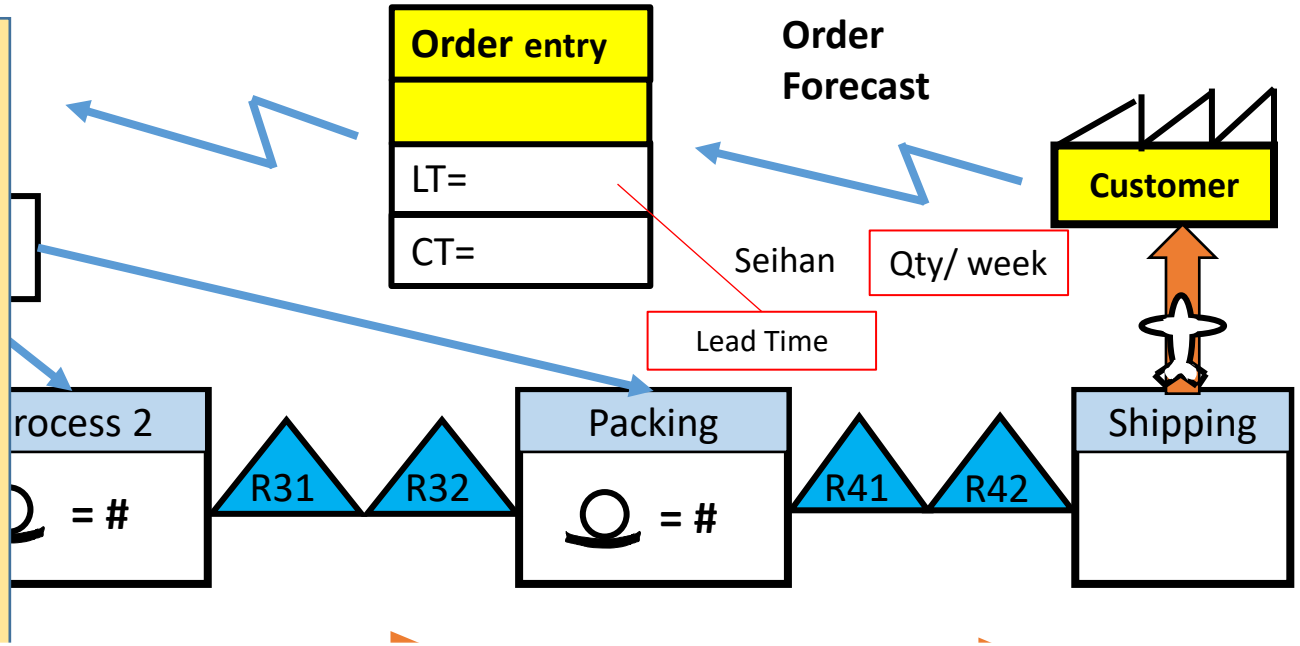
Exercise

Customer Order = 120k / week

Planner took 1 day to confirm the order and complete the data entry in 30 minutes

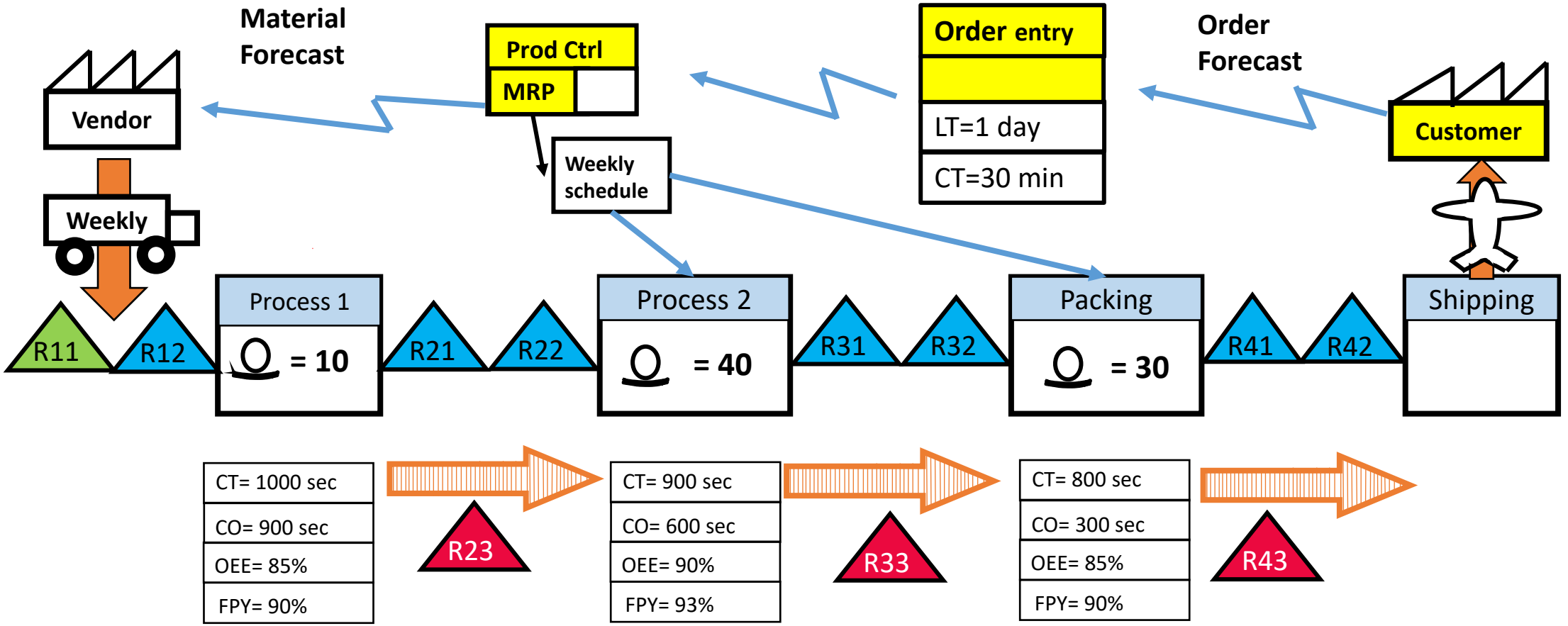
Inventory

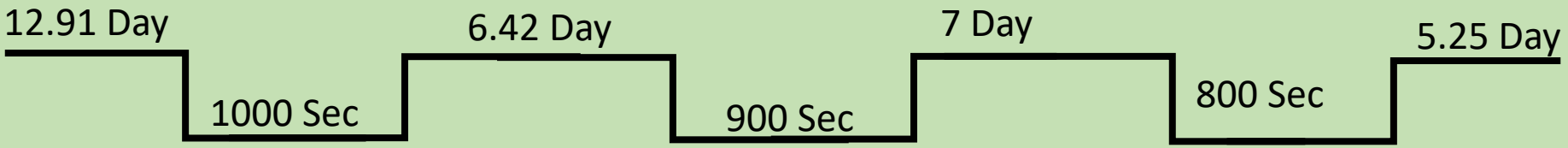
Warehouse R11	160K
WIP in Assy#1 R12	60K
SFG for Assy#2 R21	60K
WIP in Assy#2 R22	40K
Reject from Assy#2 R23	10K
SFG for Packing R31	70K
WIP in Packing R32	30K
Reject from Packing R33	20K
Finished Goods R41	60K
Pending Container R42	20K
Customer return R43	10K



Process	Assy#1	Assy#2	Packing
H/count	10	40	30
Cycle Time	1000 [sec]	900 [sec]	800 [sec]
Changeover	900 [sec]	600 [sec]	300 [sec]
OEE	85%	90%	85%
1st Pass Yield	90%	93%	90%

Exercise





Lead Time
31.58 Day
Process Time
2700 Sec

Introduction to Fundamentals of work

3.1 **Fundamentals of work**

3.2 **Defect cases**

Fundamentals of work (作業の基本)

Quality system
QA firewall
Fool proof etc.
品質システム、監視の強化、
ポカヨケなど

Product good parts at reasonable costs
良いものが安く作れる

Practice of
“Fundamental of work“
作業の基本を徹底的に
実施

Obey Fundamentals of work to eliminate defects

7 fundamentals of work (作業の基本)

1. Obey working standards at the storage area for finished parts and at WIP for semi-finished parts.
2. When the work is completed, check the performance and workmanship.
3. Do not leave the NG parts for a while, but place them in the NG box (Red box).
4. If you detect any abnormality, contact your leader immediately.
5. During model change and setup, check the products and parts are fully discharged.
6. Do not neglect maintenance of equipment and jigs.
7. Increase the sensitivity towards abnormalities.

1. 作業完了品置き場と標準手持ちを守る
2. 作業が完了したら、出来栄えのチェックを行う。
3. 不良品はチョイ置きせず、不良品箱（赤箱）に入れる。
4. 異常を感じたら、すぐに連絡する。
5. 段取り時は、製品・部品の払い出しを確実にする。
6. 設備・治具のメンテを怠らない。
7. 異常に対する感度アップをする。

Eliminate defects by following the Fundamental of work

Defect cases (不具合事例)

Examples of cases where defects could be prevented

if the “Fundamentals of work" was strictly followed

- Case 1 Unpierced mounting hole
- Case 2 Connector lock abnormal shape

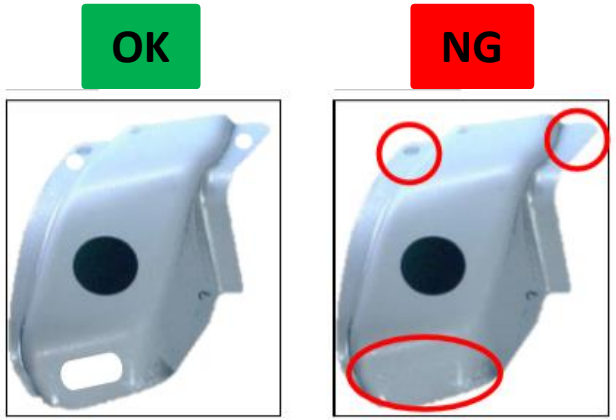
事例1 取付穴未加工

事例2 コネクタ・ロック形状異常

Case 1: Unpierced mounting hole

< Defect details >

No mounting hole



< Process outline and cause of occurrence>

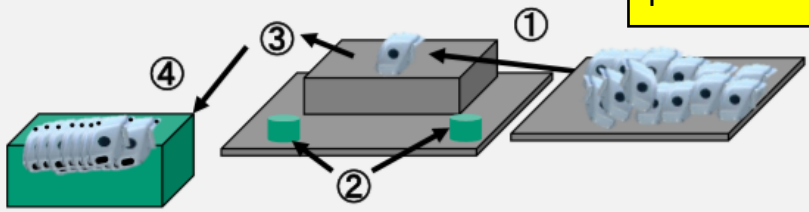
Press (outer shape, bending, drawing) => Press (piercing) => Degreasing =>
In-process inspection => Shipping inspection (1/box) => shipping

Single shot press (piercing). . . . One cycle work

1. Take one workpiece with the right hand and set it in the mold
2. Press the push button with both hands
3. Take out the finished part from the mold with the left hand and check the dents.
4. If there is no issue, put the part in the finished parts box.

Operator left the seat without move the workpiece from the mold

Inadvertently put unpierced part into finished part box



< Cause of occurrence>

With the part set in the mold, the work was interrupted when the worker left the machine. The operator assumed that the piercing process was completed when he returned to work, and the operator put inadvertently the unpierced part in the finished part box without checking the quality.

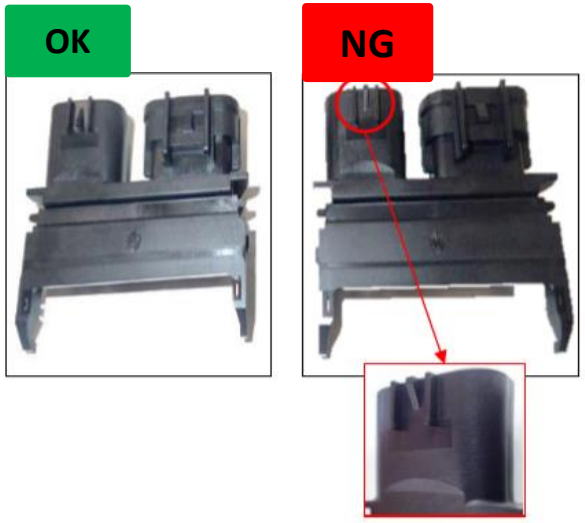
< Lesson learned >

- Suspended work without keeping one cycle work. Fundamental of work 1
- Neglect to check the workmanship of the processed product. Fundamental of work 2

Case 2: Connector lock abnormal shape

< Defect details >

Shape of the lock area is different



< Process flow and cause of occurrence>

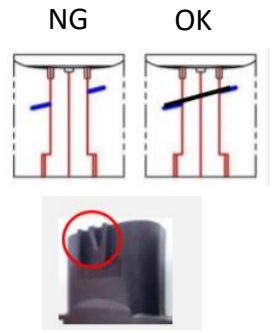
Molding => Terminal press-in => Ion blow => Electrical inspection => FF inspection => Product inspection => Shipping

-Mold overhaul procedure-

1. Mold dismantling
2. Mold cleaning
3. Mold inspection
4. Mold assembly
5. Mold check
6. Molding
7. Checking the finished product

Work quality check (mark alignment) after assembling has been neglected

Non-detection after molding



< Cause of occurrence>

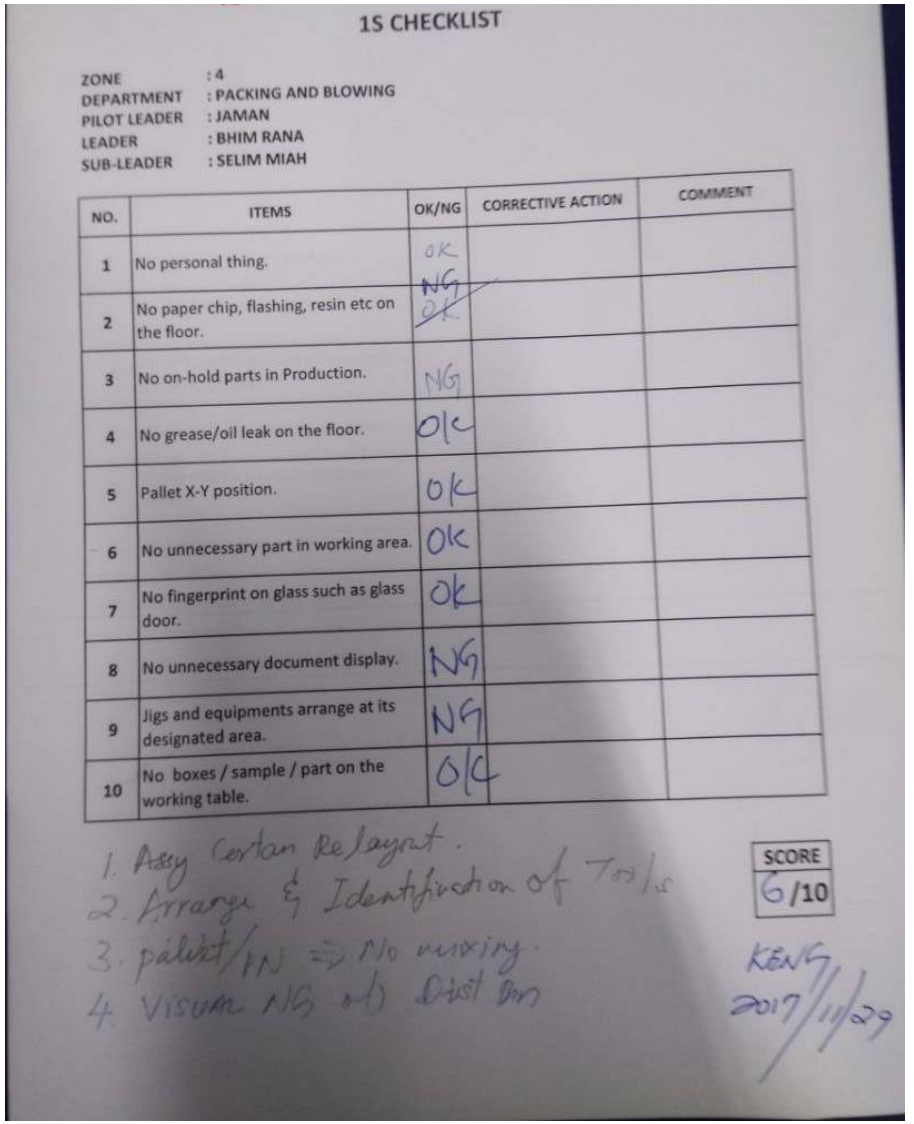
An "I" Mark was attached in order to prevent from the wrong mold assembly, but the confirmation was neglected.
Also, when checking the work quality of the molded part after the overhaul, it was not noticed that the lock shape was inver ted.

<Lesson Learned>

• The workmanship confirmation after mold assembly was insufficient.	Fundamental of work 2
• Non-detection even checking workmanship was done after molding.	Fundamental of work 7

10 Questionnaires for 1S Assessment

No	General Questions
1	No personal thing
2	Pallets and Trolleys in X-Y position
3	No chip/reject part/polybag/box on the floor/ machines
4	No box/sample/part on the working table
5	No oil/water/grease leak on the floor/machine
6	No on-hold parts in production.
7	No unnecessary document display
8	Machines/Equipment are clean
9	Molds/Jigs/ are placed at its designated area.
10	No placing of products/trolleys/jigs on the top of yellow line/ hazardous area.



1S CHECKLIST

ZONE : 4
DEPARTMENT : PACKING AND BLOWING
PILOT LEADER : JAMAN
LEADER : BHIM RANA
SUB-LEADER : SELIM MIAH

NO.	ITEMS	OK/NG	CORRECTIVE ACTION	COMMENT
1	No personal thing.	OK		
2	No paper chip, flashing, resin etc on the floor.	NG OK		
3	No on-hold parts in Production.	NG		
4	No grease/oil leak on the floor.	O/C		
5	Pallet X-Y position.	OK		
6	No unnecessary part in working area.	OK		
7	No fingerprint on glass such as glass door.	OK		
8	No unnecessary document display.	NG		
9	Jigs and equipments arrange at its designated area.	NG		
10	No boxes / sample / part on the working table.	O/C		

1. Assy Certain Relayout.
2. Arrange & Identification of Tools
3. pallet/WI ⇒ No mixing
4. Visual NG ⇒ Dust Bin

SCORE 6/10

KENG
2017/11/29

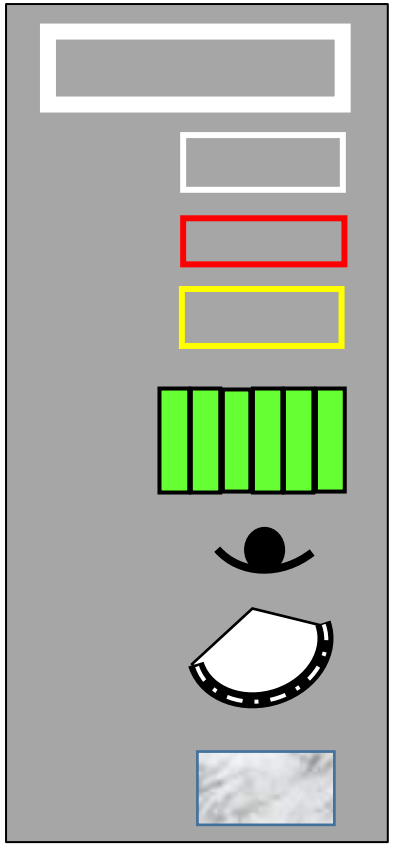
10 Questionnaires for 2S Assessment

No	General Questions	Y/N	Findings
1	All moving objects such as folders, documents, equipment, etc. have an identified location to storage after use or transfer. The sorting is facilitated by specifying the location on the moving object itself if the place of storage is not visually obvious.		
2	The frequently used items are located close to their point of use.		
3	All electrical and IT cables are organized. All safety covers are installed in the desks at their standard position. Electrical cabinets or small boxes are closed and locked.		
4	All drawers are organized using rules, such as : 1st Objects using frequently, 2nd documents using frequently, 3th personal items and Safety equip., 4th Documents storage. The cabinets are using the A-Z folders and organizers.		
5	In areas of storage of documents, the containers are aligned		
6	Storage, scrap & waste locations are defined.(E.g. Wastebaskets)		
7	All objects in the cabinets & desks have an identified location (by object/ family)		
8	Communication area is organized. All corridors included in perimeter or surrounding the perimeter are free of any object.		
9	Information to be kept after posting is defined.		
10	Personal belongings (clothes, bags) are placed in a defined location, with appropriate storage mean, but never laying on the ground.		

Zoning

< The Island >

- Operator is person in-charge
- Dedicate to one-piece flow
- Common equipment
- Aisles must always clear



Island : 100 [mm] - White

Object : 50 [mm] - White

Non conformity : 50 [mm] - Red

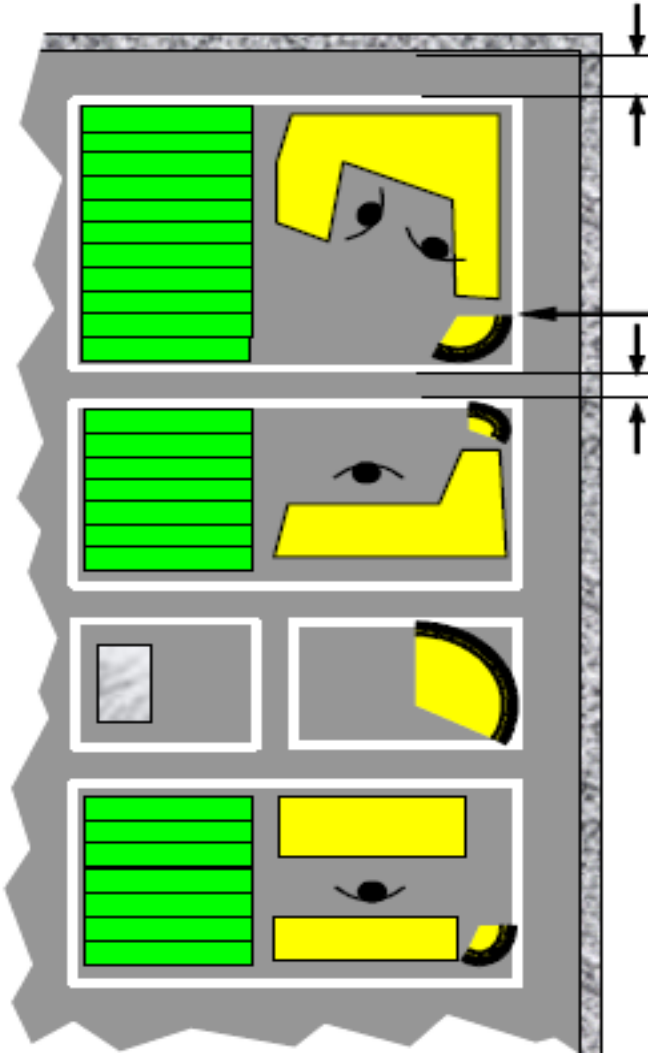
Safety : 50 [mm] - Yellow

End of Line Stock

Operator

Communication Space

Quality Area



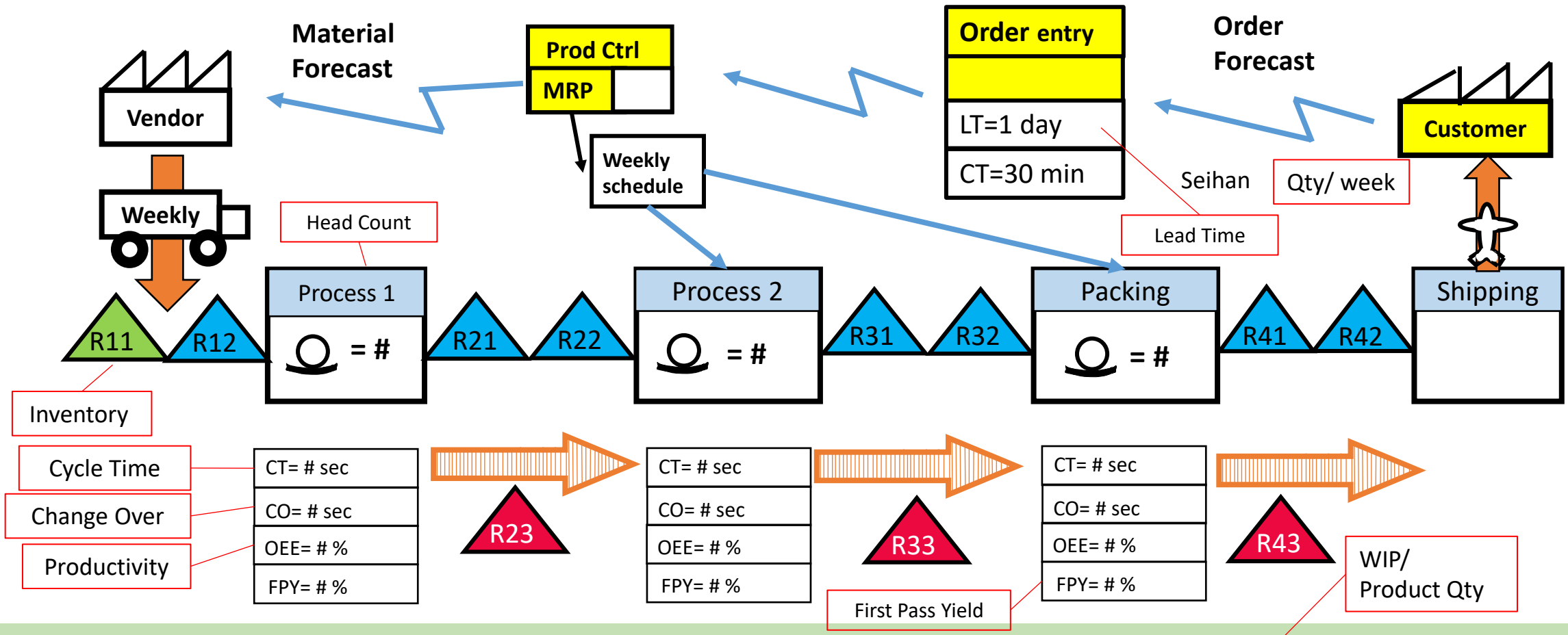
7 WASTE IDENTIFICATION (TIM-WOODS)

PROCESS		DATE	
AREA		PIC	
	FINDING / EXAMPLE		SUGGESTION / PLAN FOR CORRECTION
TRANSPORTATION			
INVENTORY			
MOTION			
WAITING			
OVER PRODUCTION			
OVER PROCESSING			
DEFECTS			
SAFETY			

7 fundamentals of work

No	Fundamentals of Work	Findings
1	Obey working standards at the storage area for finished parts and at WIP for semi-finished parts.	
2	When the work is completed, check the performance and workmanship.	
3	Do not leave the NG parts for a while, but place them in the NG box (Red box).	
4	If you detect any abnormality, contact your leader immediately.	
5	During model change and setup, check the products products and parts are fully discharged.	
6	Do not neglect maintenance of equipment and jigs.	
7	Increase the sensitivity towards abnormalities.	

Value stream



Basic calculation

- Ave Customer demand

=120k/week

=120k/7

=17.14k/day

- Lead Time

= (warehouse + WIP +NG parts) / Ave customer demand

(160k+60k)/ 17.14=12.91 day

(60k+40k +10k)/ 17.14=6.42 day

(70k+30k+20k)/ 17.14=7 day

(60k+20k+10k)/ 17.14=5.25 day

- Cycle Time

Process 1

CT =10 [hr]*60*60/ (120k/7/10)= 21 [sec]

Process 2

CT =10 [hr]*60*60/ (120k/7/40)= 84 [sec]

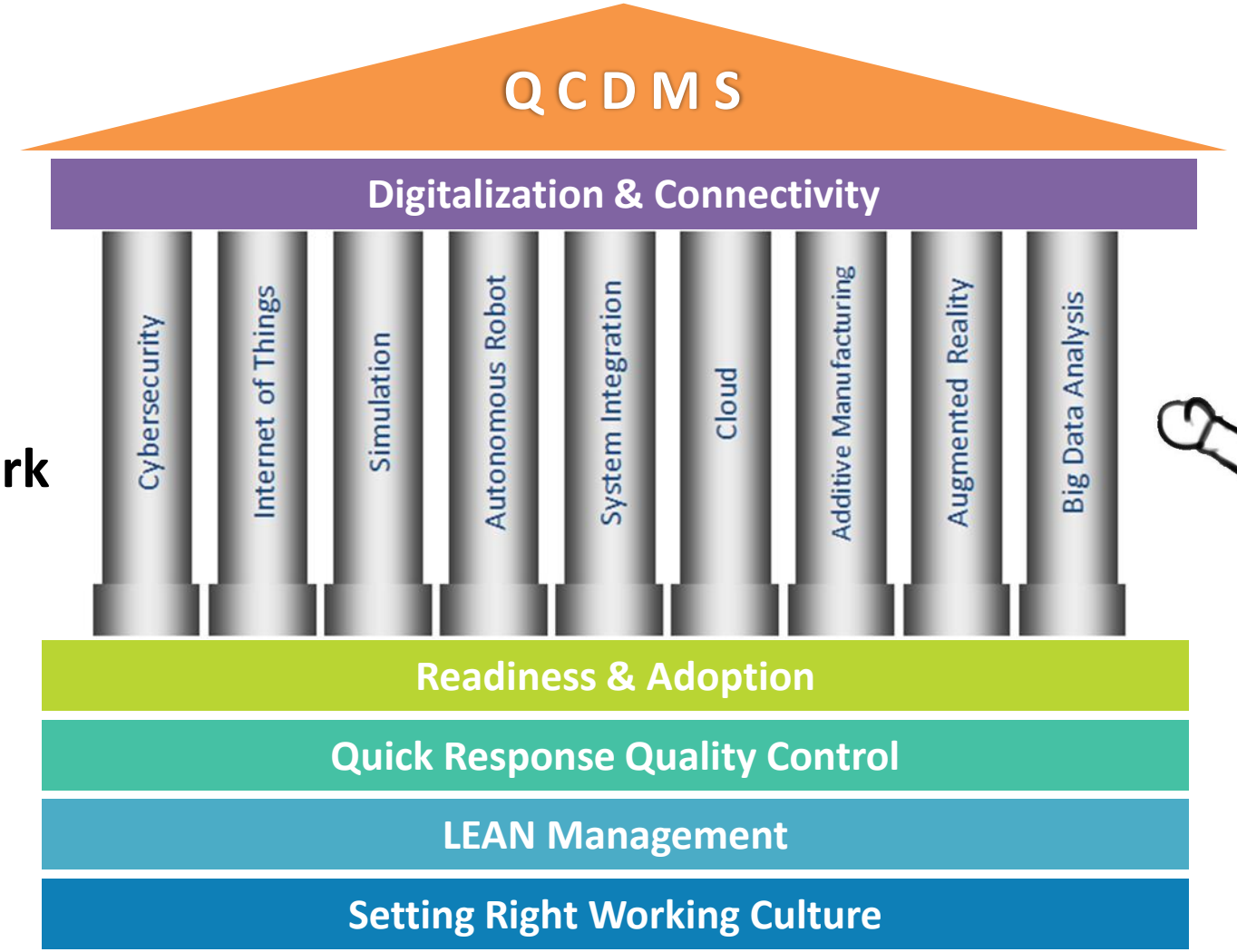
Packing

CT =10 [hr]*60*60/ (120k/7/30)= 63 [sec]

Transitions to Industry 4.0

SIRIM - ICA 40

Industry 4.0 Framework



SEMINAR ON LEVERAGING LEAN PRACTICES FOR MANAGING THE INEVITABLE TRANSITION TO INDUSTRY 4.0

Date :

6 – 7 JUNE 2023

Company :

MALAYSIAN RUBBER COUNCIL

Presented by :

PN. NORFAIZAH NASIR
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Your Partner for Innovation

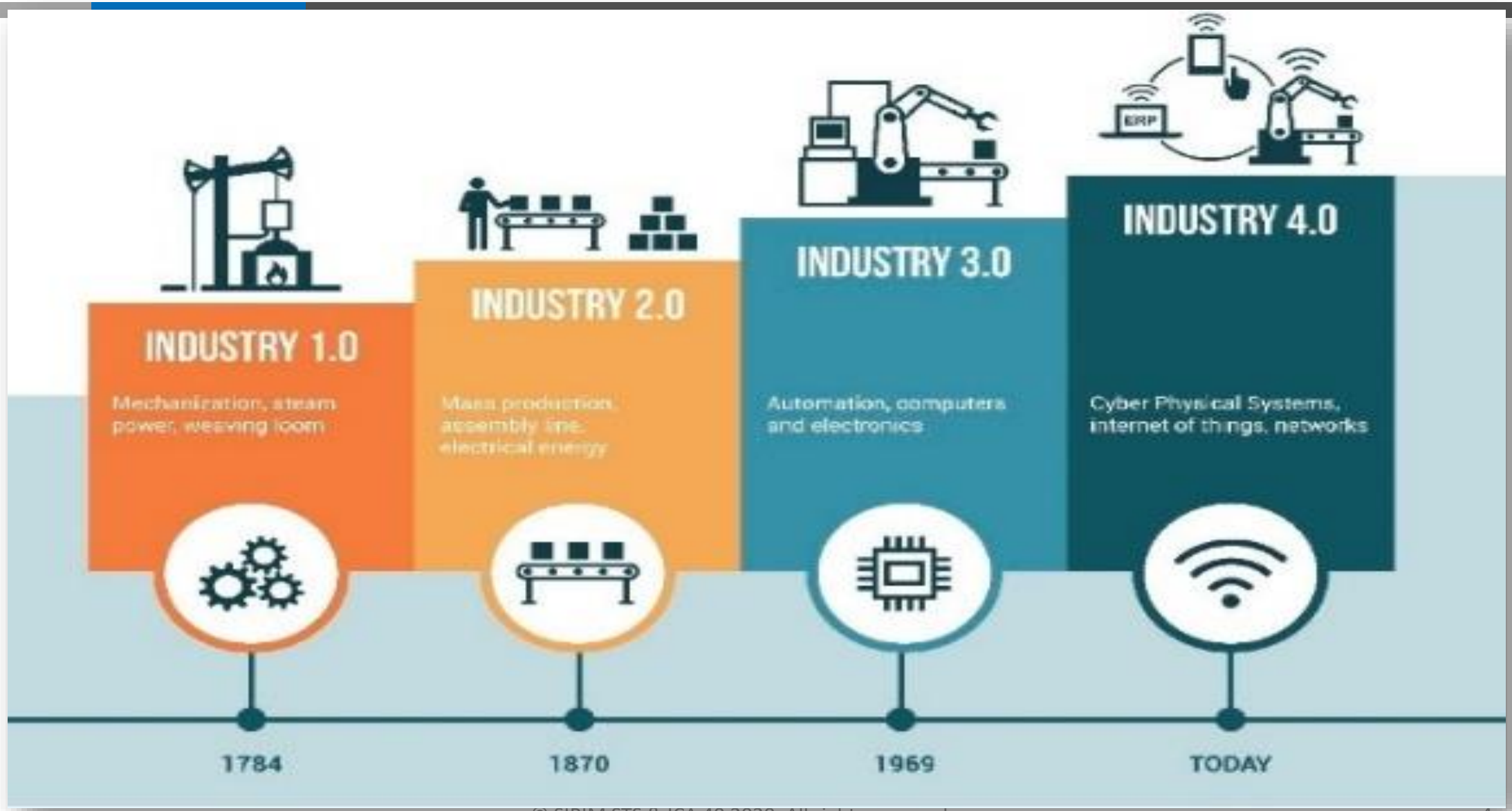
Industry 4.0

Learning objectives

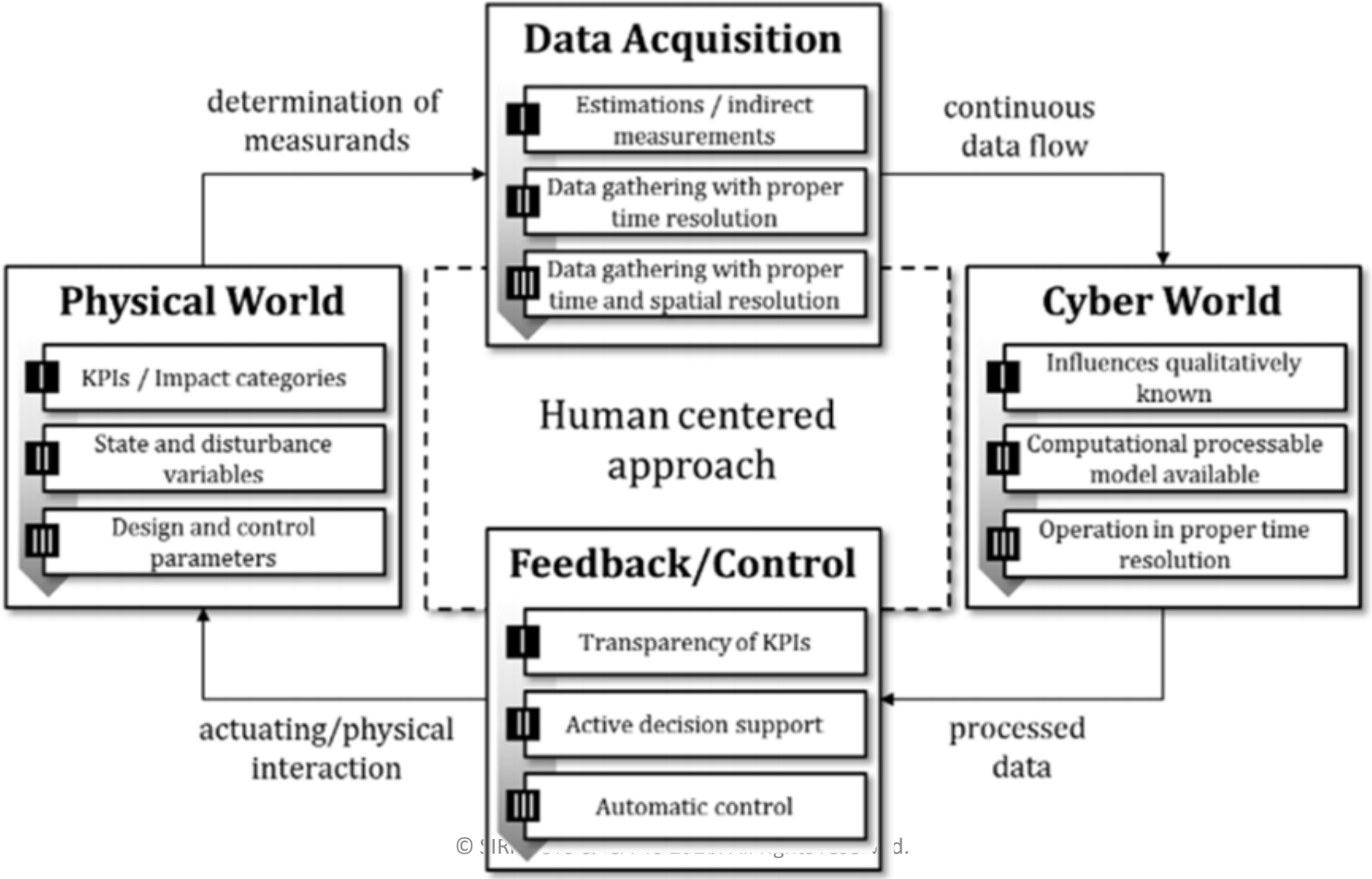
- to provide common understanding of Industry 4.0 and its related technology pillars
- to provide the key activities for an organisation to implement Industry 4.0
- to demonstrate the application on Industry 4.0 technologies
- to provide requirement for Total Productive Maintenance according to Industry Standard

Industry 4.0 concept & enabling technologies

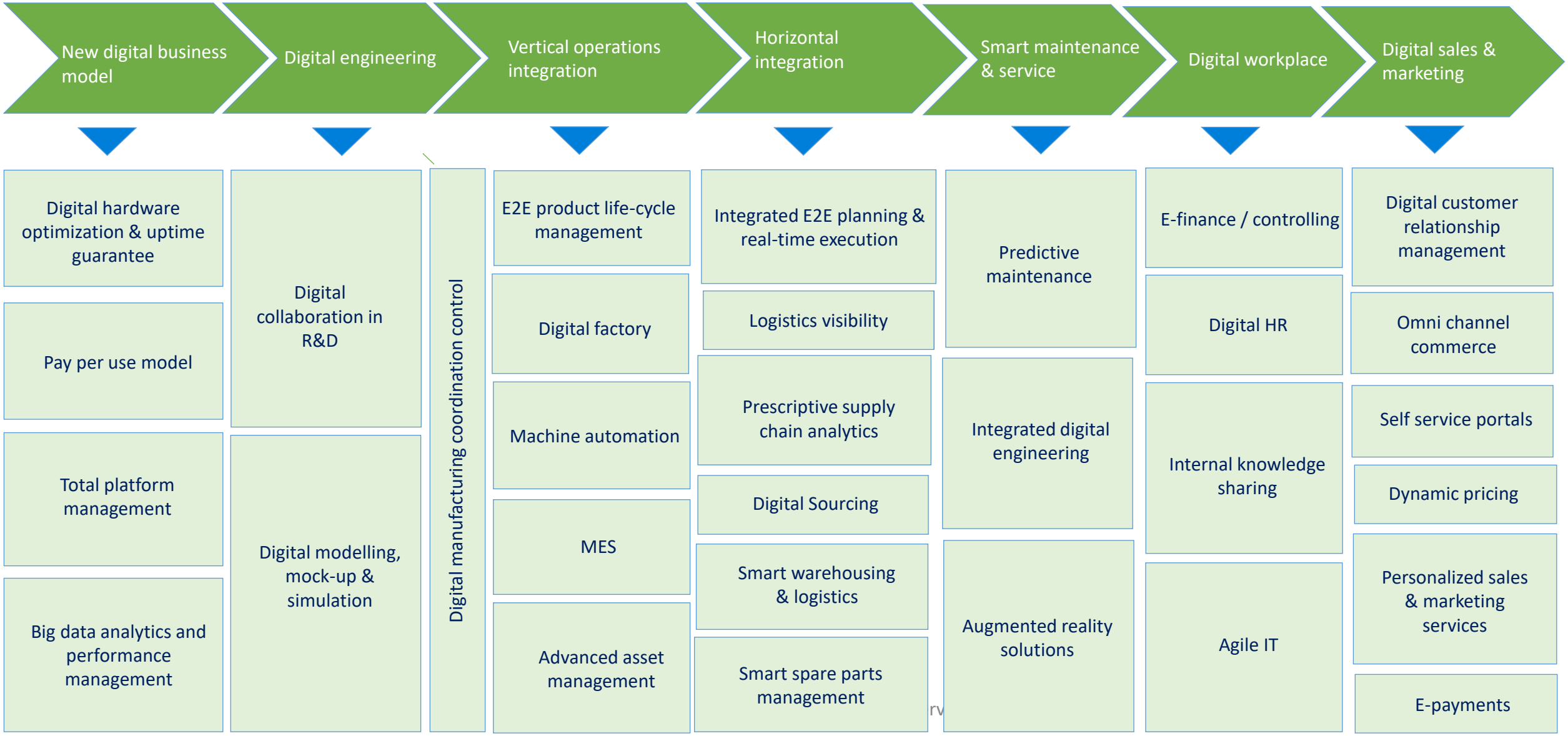
Industry 4.0



Cyber-physical system



Industry 4.0 along value chain



Industry 4.0 Enabling Technologies

Additive Manufacturing

Technologies of building complex **3D geometrics** from 3D computer images by adding layer-by-layer material until the final desired 3D images are constructed.

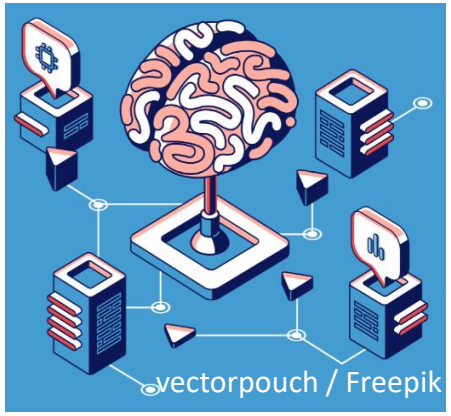
The material can be plastic, metal, concrete or special material such as polymer or food.

upklyak / Freepik

Artificial Intelligence (AI)

Computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, problem solving and decision-making.

Example of application: Robotic vehicles, speech recognition, autonomous planning and scheduling, game playing, spam fighting, logistics planning, robotics, machine translation.

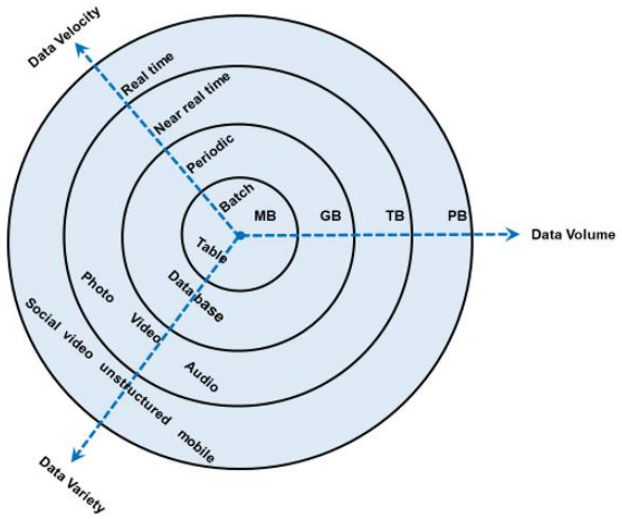

vectorpouch / Freepik

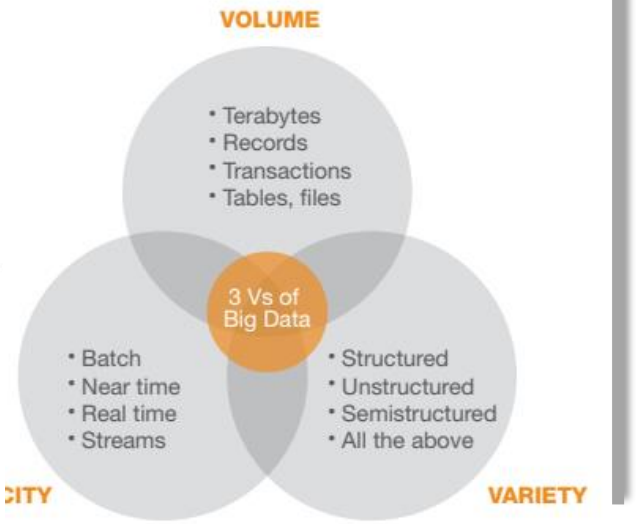
Industry 4.0 Enabling Technologies

Big Data Analytics

Complex process of **examining large amount of data** to uncover information that can help organisations to make informed business decision.

Big data is defined by 3Vs - Volume, Variety, Velocity, with additional 1V, Veracity.





SOURCE: TDWI Research

Advanced Materials

New or modification of materials to obtain superior performance in one or more characteristics that are critical for specified application, e.g. shape retention and thermoelectric efficiency.

Together with additive manufacturing technologies, use of advanced material allows for **massive customisation** and development of products.

The development of new and more advanced materials is a core element in the evolution of additive manufacturing technologies.

Industry 4.0 Enabling Technologies

People, process and technology that comes together to **protect** organisations or networks from digital attacks.

Cyber threats include theft of intellectual property, phishing/pharming malware penetration, as well as mobile devices and mobile network vulnerabilities

Industry 4.0 cybersecurity control: Risk management - user account, credentials, authentication and authorization - secure remote service - using secure protocols - network segmentation - safeguarding wireless technology - endpoint protection - virtualization and cloud security - monitoring and threat detection - components and integrated testing – recovery - determine security requirements for vendors and suppliers – documentation - operational security training

An **approximate imitation** of the operation of a process or system; that represents its operation over time. Inventory, assembly, transportation and production can be considered in a simulation model.

Benefit of simulation:

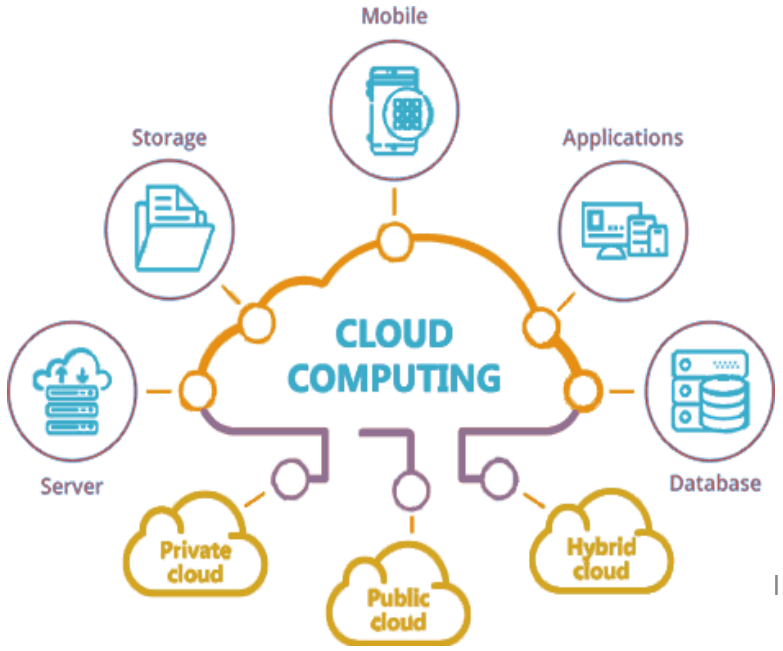
- Investment risk reduction
- Waste minimisation
- Efficiency improvement
- Reduce energy consumption and save resources
- Detects risk, therefore protect human lives

Industry 4.0 Enabling Technologies

Cloud Computing

Practice of using a **network of remote servers** hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer

Type of cloud services including Software as a Service (SAAS), Platform as a Service (PAAS) and Infrastructure as a Service (IAAS)



Augmented Reality

An **enhanced version of reality** created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera)

Source: Merriam-Webster

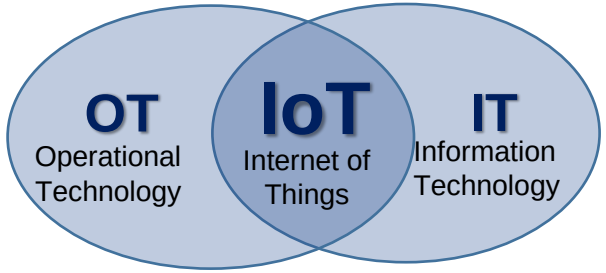
Image: Adobe Stock

Industry 4.0 Enabling Technologies

Internet of Things (IoT)

All smart physical entities are connected seamlessly together and sharing vital information. Information that is processed to create valuable insights, utilized into the creation of new value in applications and solutions.

The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together



Autonomous Robots

An **intelligent robot** that can perform tasks by themselves, without explicit control by human. The purpose is for a machine that is capable of performing helpful tasks in a real-world setting.

Automated Guided Vehicle (AGV) - A guided vehicle follows fixed routes, usually along wires or magnets embedded in the ground. AGV can avoid hitting obstacles that pop up in its way, but it's not clever enough to go around them.

Autonomous Mobile Robot (AMR) - Packed with sensors and powerful on-board computers that help it to understand its operating environment. Rather than being restricted to fixed routes, an AMR can instead navigate dynamically using a map.

Industry 4.0 Enabling Technologies

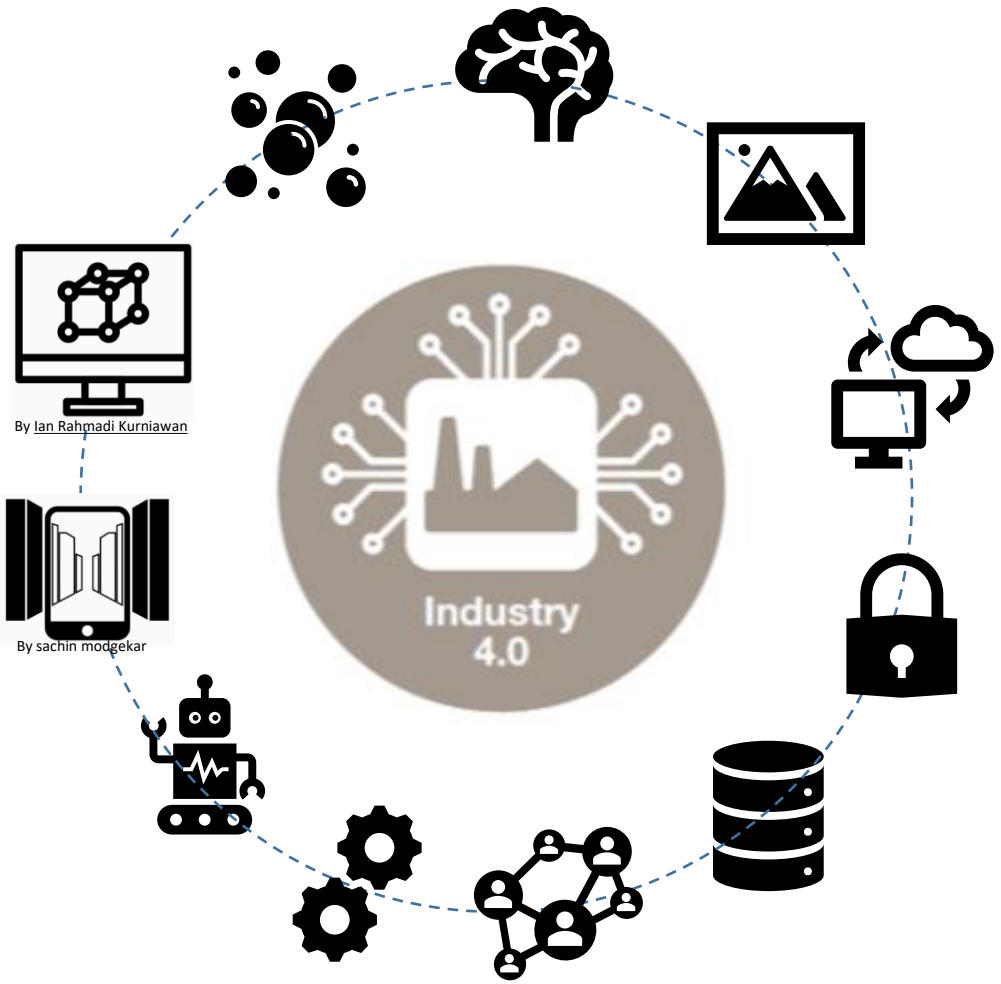
System Integration

Process to **integrate physical and virtual components** into one large system to deliver the overarching functionality.

Smart manufacturing is based on a **common, secure network infrastructure** that allows a dialogue – or even better, convergence - between operational and information technology.

System integration challenges:

- Keeping existing systems up to date
- Access to latent data
- System secure from cyber threats



SIRIM INDUSTRY STANDARDS FOR INDUSTRY 4.0

Industry 4.0 Maturity Level and Criteria for Adoption

Introduction

Focus for advances in manufacturing efficiency takes place in an individual firm rather than the whole supply chain, lead to significant but isolated gains

Advances are seen at organizational level (e.g. lean), manufacturing level (e.g. robotics, AM), material level (e.g. advanced material) and information level (e.g. RFID)

Significant efficiency gain needs digital integration and intelligence

Therefore, integration needs to take place horizontally (across value chain) and vertically (across all layers of automation)

Introduction

Fully integrated and networked factory can act in an intelligent and autonomous way with minimal human intervention

These advances also lead to an increased complexity of manufacturing process

Companies, especially SMEs, are uncertain about the actual cost of technology acquisition and the impact to the company

They may also have problem to determine their state-of-development with regards to Industry 4.0 implementation

Industry 4.0 Maturity Level

Industry 4.0 refers to 'technological advances where internet and embedded system serve as backbone to integrate physical objects, human, machines, production line and process across organizational boundaries to form intelligent, networked and agile value chain' (A. Schumacher, S. Erol & W. Sihn)

Maturity refers to 'state of being complete, perfect or ready' (The Oxford English Dictionary)

Agile refers to 'quick and well-coordinated'

Industry 4.0 Maturity Level

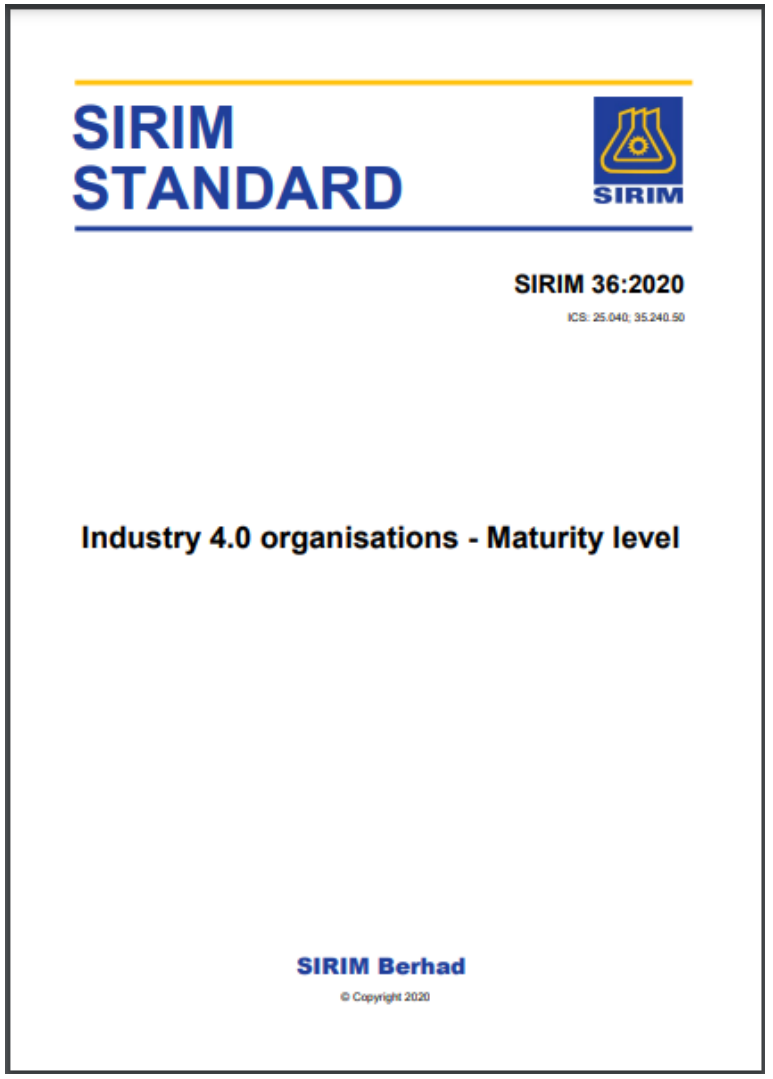
Maturity model used as instrument to conceptualize and measure maturity of an organization or a process regarding some specific target state.

Goal is to capture the starting-point and allow for initializing the development process.

Readiness assessment takes place before engaging in the maturing process, while maturity aims to capture the as-it-is state during the maturing process

Industry 4.0 Maturity Level

The required maturity for each activity to implement Industry 4.0 (I4.0) in a manufacturing organisation.


SIRIM STANDARD

SIRIM

SIRIM 36:2020

ICS: 25.040; 35.240.50

Industry 4.0 organisations - Maturity level

SIRIM Berhad

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Industry 4.0 Maturity Level

The purpose of maturity level:

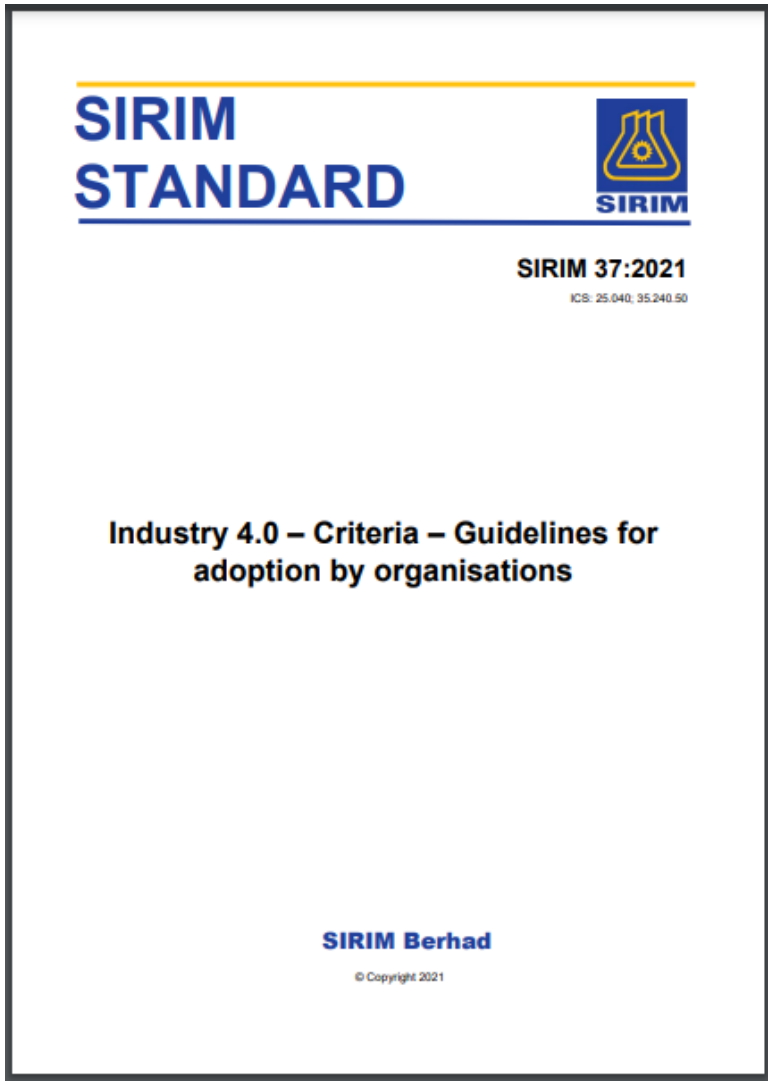
a) to provide benchmark to gauge an organisation's readiness and its maturity level;

b) to act as guideline to organisations for implementing and further improvement in achieving higher level of I4.0 implementation; and

c) to enable organisations to evaluate their own Industry 4.0 maturity and reflect the effectiveness of its strategies

Industry 4.0 Criteria - Guidelines for adoption by organisations

The criteria to provide guideline for organisations in the implementation of Industry 4.0.



Industry 4.0 Criteria - Guidelines for adoption by organisations

The purpose of criteria for adoption:

a) to provide understanding of the key criteria for an organisation to be considered as an Industry 4.0 organisation;

b) to provide a checklist of related technologies and traits of Industry 4.0 which serves as a quick guide for organisations; and

c) to provide guidelines for organisations to implement and progress towards becoming more efficient, market-responsive and customer focused Industry 4.0 organisations.

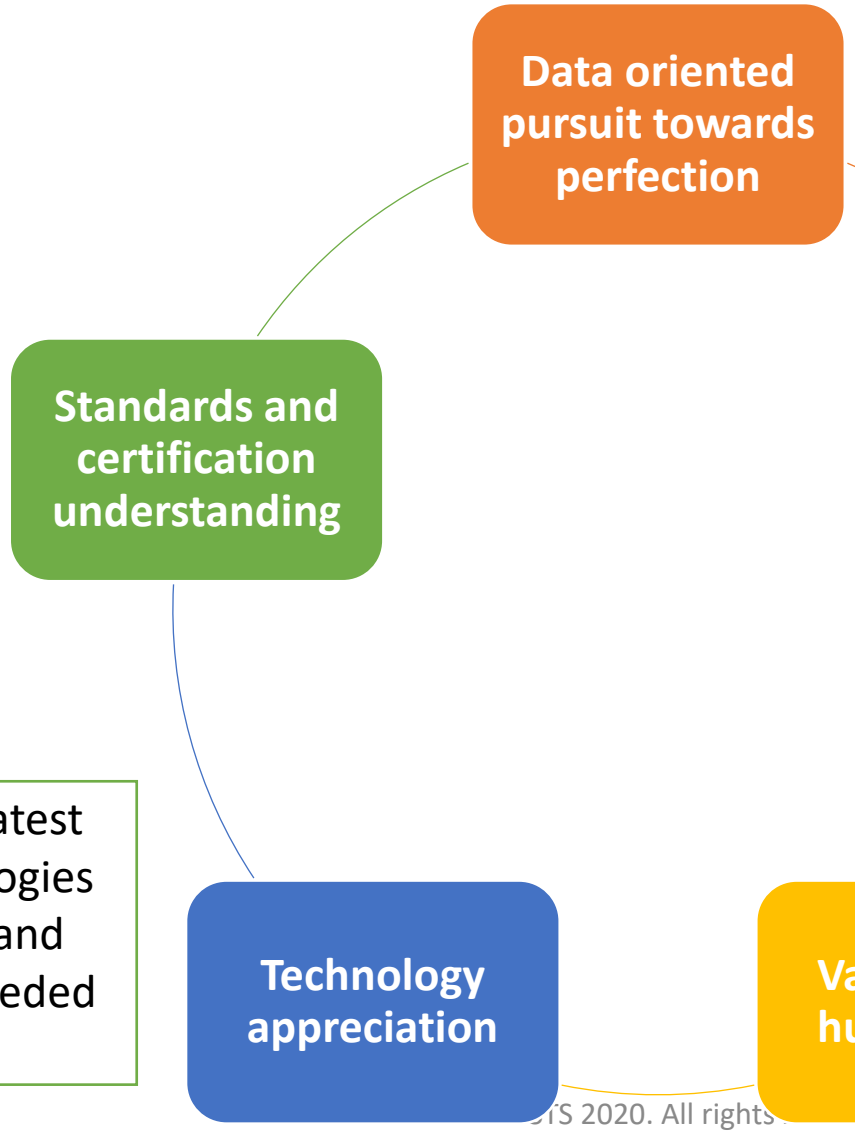
Industry 4.0 for manufacturing organization

Industry 4.0 takes manufacturing process to a new level by introducing enabling technologies for agile production using:

- ✓ cyber-physical systems (CPS)
- ✓ Industrial Internet of Things (IIoT)
- ✓ Edge and cloud computing
- ✓ Big data analytics
- ✓ Artificial intelligent
- ✓ Augmented reality
- ✓ Additive manufacturing
- ✓ System integration
- ✓ Autonomous robots
- ✓ Advance materials
- ✓ Simulation

Industry 4.0 implementation principles

Insist on a specific standard and/or certification whenever acquiring new technology to prevent expensive investment which may not needed, or be misled into an investment in a solution which is wrongly packaged as an Industry 4.0 solution



Continuously improve performance and needs to be data oriented, where decision making by management is based on actual operational performance

Focus beyond just making profits but should include environmental and societal impact in tandem with economic performance

Reskill and upskill its workforce as well as implement a continuous competency development programme

Keep abreast with latest Industry 4.0 technologies to correctly select and implement much-needed improvements

Industry 4.0 implementation principles

The journey towards Industry 4.0 adoption is anchored on three shift factors:

Technology | People | Process

Based on the Industry 4.0 readiness assessment model, this Industry 4.0 maturity level consists of 8 strategic thrusts and 24 focus areas

Terms and definitions

TERM	DEFINITION
agile production/ manufacturing	Processes, tools and training to enable manufactures to respond quickly to customer needs and market needs while controlling costs and increase quality
automation	Conversion of processes or equipment to automatic operation, or the results of the conversion, to monitor, control and execute tasks
connectivity	Interconnection of Information Technology (IT) and Operational Technology (OT) to enable communication and seamless data exchange
co-creation	Act of bringing external parties, usually customers or suppliers, into a company's creative process
collaborative robot	robot designed for direct interaction with a human within a defined collaborative workspace

Terms and definitions

TERM	DEFINITION
customisation	Action of making or changing something according to the buyer's or user's needs
mass customisation	Act by a company of producing large numbers of products, but with each product designed for a particular customer
cybersecurity	Preservation of confidentiality, integrity and availability of information in the cyberspace
digital twin	an evolving digital profile of the historical and current behavior of a physical object or process that helps optimize business performance
digitisation	process of converting analogue materials into digital form
digitalisation	Conversion of data into a structured sequence of bits/bytes that represents information content

Terms and definitions

TERM	DEFINITION
cybersecurity	Preservation of confidentiality, integrity and availability of information in the cyberspace
individualisation	Product or service customised to suite individual demand
integration	System condition or activity to realise the condition in which components of a system are organised to collaborate, coordinate and interoperate while exchanging items, as needed, to perform a system's task
horizontal integration	The integration of enterprise processes across organisations and with stakeholders along the supply chain
vertical integration	The integration of processes and system across all hierarchical levels of the automation pyramid within a facility to establish a connected, end-to-end data thread

Terms and definitions

TERM	DEFINITION
intelligence	Acquisition, processing and analysis of data by machine and equipment to make decisions in line with Cyber-Physical System (CPS) levels
Interoperability	Ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together
Legacy robots/machine/ device	Any device that is in silo, proprietary that is not able to be connected without any retrofitting of external devices
Product lifecycle	Description of all stages of the product throughout its life starting from the expression of its need until the disposal, whatever the form is
Real time	Communicated, shown, presented, etc. at the same time as events actually happen

Maturity level

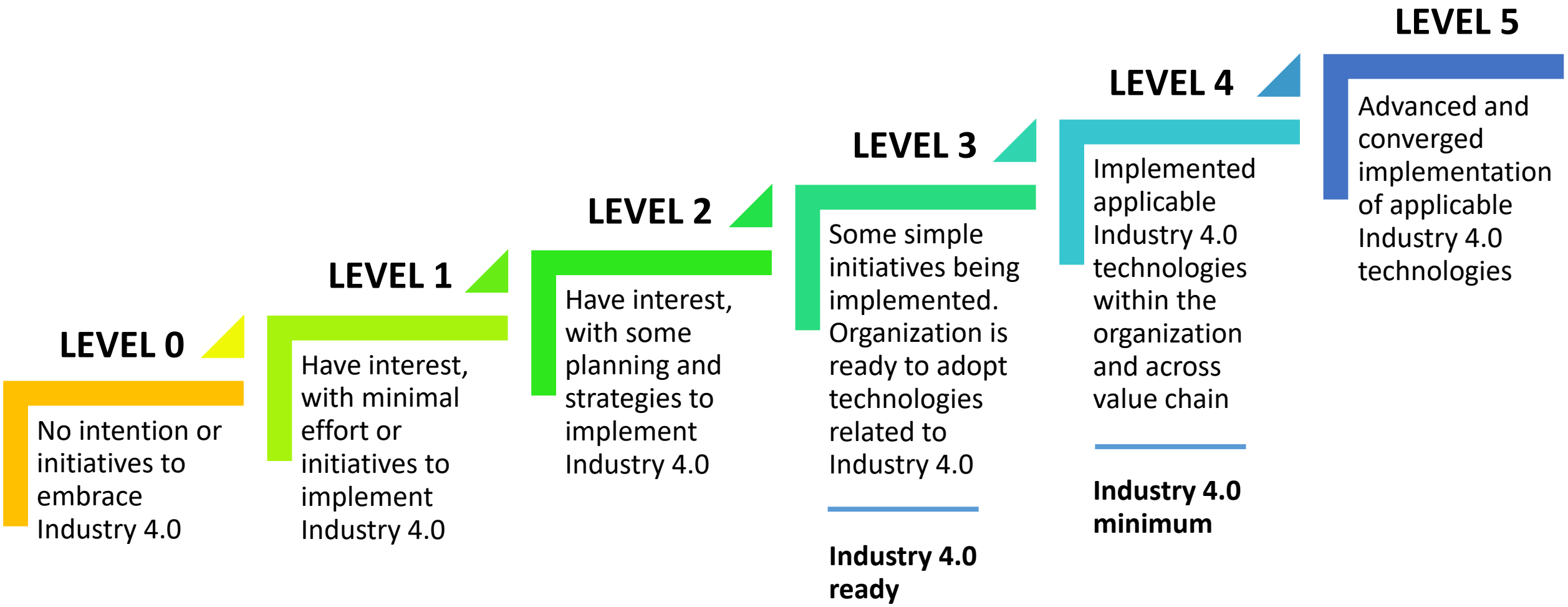
The following table describes the **different levels of implementation** of Industry 4.0 based on the depth and maturity of the activities that an organisation implements.

Organisations shall have the initiative to **upgrade** their level of implementation based on the key activities given in each level. If an organisation has achieved a certain level of maturity, it shall be deemed to have already fulfilled the requirements of the lower levels.

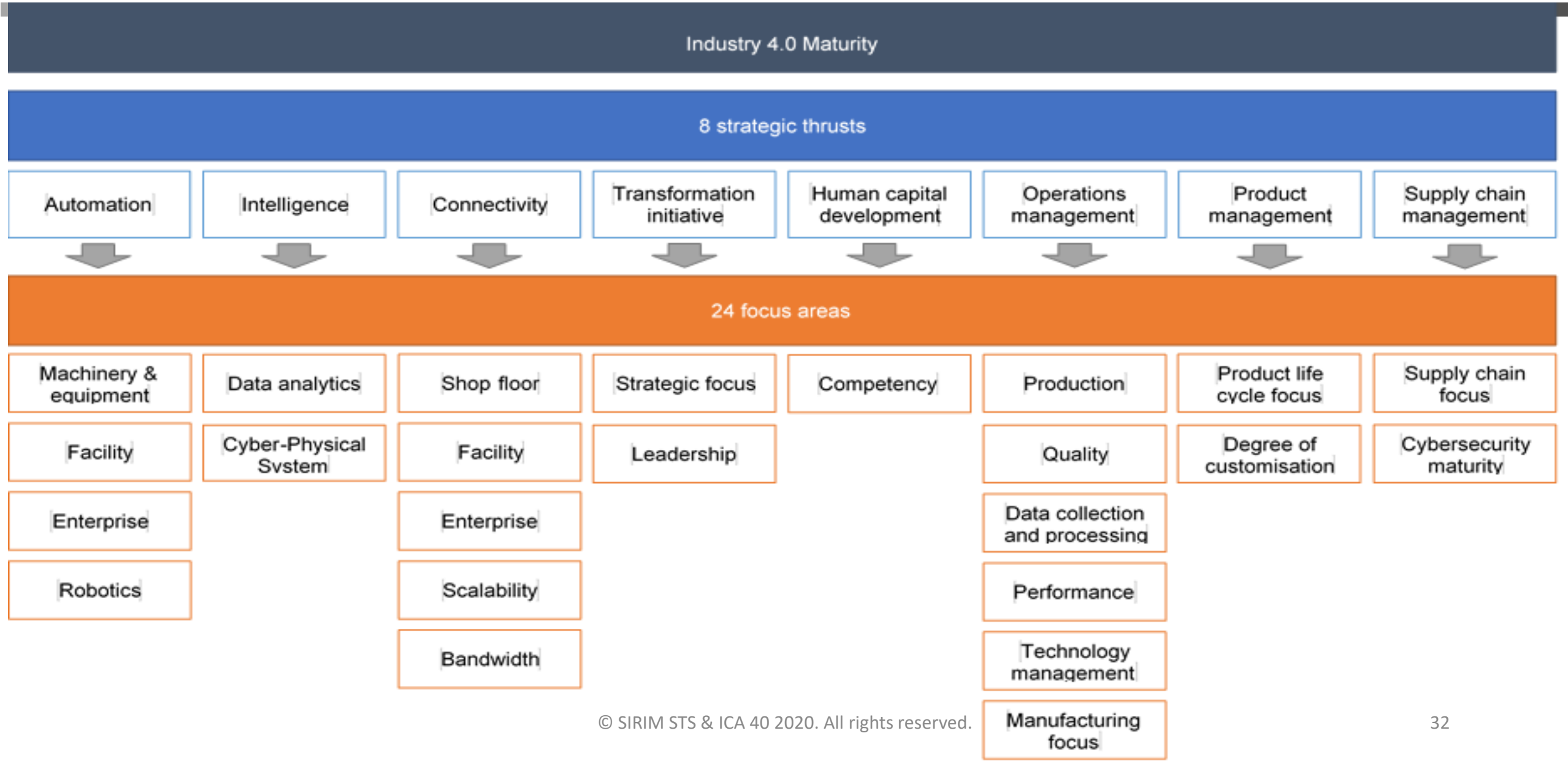
However, organisations **need to realise the level required** by their business operations. Higher level of maturity may not be feasible or beneficial for them.

In implementing Industry 4.0, organisations need to consider the **economic, environmental and social aspects** relatable to them.

Level of implementation



Strategic thrusts and focus areas



Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Automation	Machinery and equipment	Legacy machine/device	Manual operated	Semi-auto operated	Fully automated	Connected and remotely operated	Machine-to-machine intelligence
	Facility (e.g., chiller, HVAC)	NA	Manual control	Semi-auto control	Fully automated control	Connected and remote operate	Self-optimisation
	Enterprise (e.g., human resource, accounts)	No formal system	Manual input	Stand-alone software system	ERP	Interconnected (e.g. ERP, MES, PLM, LIMS)	Business Intelligent (analytics with modelling)
	Robotics	No robots	Legacy robots	Robots with human intervention	• Widespread industrial robots • AGV	Autonomous	Cognitive robots

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Intelligence	Data analytics	No data analysis	Information (data visualisation)	Knowledge (use data for operation management)	Insight (big data analysis and root cause analysis)	Wisdom (data driven culture and decision making)	Business intelligence impact (Quality, flexibility, speedy, scalability, reliability, optimisation)
	Cyber-physical system (CPS)*	No any electronic or digital system	Pre-programmed logic and able to perform tasks Non-IP connectivity	Machine interaction/ connectivity over IP CPS ready	CPS Level 1 – Connection (e.g. Sensor network, standard report) CPS Level 2 – Conversion (e.g. visualisation, alert)	CPS Level 3 – Cyber (e.g. digital twin, statistical analysis forecasting and extrapolation)	CPS Level 4 – Cognition (e.g. analytic information for decision making) CPS Level 5 – Configuration (e.g. self optimised)

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Connectivity	Shop floor	Not capable to connect	Non IP connectivity (e.g., RS-232, Bluetooth, RF)	Device-to-device	Local Area Network (LAN)	Private Wide Area Network (WAN)	Public shared IP network
	Facility (e.g., air compressor)	Not capable to connect	Non IP connectivity (e.g., RS-232, Bluetooth, RF)	Serial/parallel connection	Local Area Network (LAN)	Private Wide Area Network (WAN)	Public shared IP network
	Enterprise	Not capable to connect	Non IP connectivity (e.g., RS-232, Bluetooth, RF)	Device-to-device (direct communication between 2 or more devices)	Local Area Network (LAN)	Private Wide Area Network (WAN)	Public shared IP network
	Scalability	No connectivity	Fixed connection/ Not scalable	Multiple connection/ Not scalable	Flexible and scalable connection	Scalable and interoperable	OPC Unified Architecture
	Bandwidth	NA	< 2 Mbps	2 Mbps	100 Mbps	Capable of handling max rate of data transfer - ideally > 100 Mbps	More than 1 Gbps

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Transformation initiative	Strategic focus*	• Basic safety and health • Basic procedure/ WI • Code of conduct • 5S • Online	• Safety and health indicator • Management system (e.g., ISO 9001) • Online presence (company website and social media)	• Total Production Management • Green management • Lean management (manually managed) • Business continuity (threat and recovery, E-commerce) • Problem solving methods (PDCA, 7 QC tools)	• Sustainable management • Lean management (cost reduction, efficiency, OEE, FIFO, WIP, Quality, fool-proof) • Business continuity (threat and recovery) • Innovation management (Kaizen, continuous improvement)	• Real time* • Lean digital (e.g., WIP link to ERP, MES, AGV) • Customer behaviour analysis (market, sales, risk prediction) • Servitisation* • Value added across entire sequence of activities or parties through innovation management (product, services) • Agility • Gig economy* to support flexibility, agility, scalability for adaptive manufacturing • Business continuity (Reputation economy)	• Convergence of factory operations with other industry 4.0 ecosystem • Adaptive business model • Flexible manufacturing

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Transformation initiative	Leadership	• Unfamiliar with the concept of the Industry 4.0/ technology trends • Do not have designated personnel/ department and do not plan to have any • Traditional leaders (reactive/ reluctant to change/no business demand)	• Aware but not implemented • Understanding Industry 4.0 adoption • Trying to implement and do not have proper plan • Do not have designated personnel but planning to have one or outsource	• Plan for adoption • Drafting a plan • Fast follower	• Basic implemented • Implementing based on plan • Have designated personnel	• Pace setter • Designated team • Role model	• Designated department • Visionary
Human capital development	Competency	• Ad-hoc • No awareness • No gap analysis	• Newcomer • Limited	• Learner • Informed	• Experience • Proficient	• Expert	• Mentor • Multidiscipline

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Operations Management	Production	NA	Standardised work	• Human-machine interaction • Autonomation	• Human-machine integration • Remote monitoring and control (i.e. production and production planning)	• Human-machine collaboration • Automation of Non-Value-Added (NVA) activities	Autonomous
	Quality	NA	Manual SPC	Semi-automated quality inspection	• Remote monitoring and control (i.e. quality) • Automated quality control	• Automated quality management • Real time quality, yield optimisation	Adaptive quality management, production planning
	Data collection and processing	No data	Manual data	Semi-automated data	Automated data	Processed data	Intelligent data
	Business performance	No monitoring and measuring system	Manual or partial digital monitoring and measuring system	Managed by electronic or a digital management system	Well-integrated performance and information management system (close to real time)	Decision making based on analysed performance data (single data set)	Autonomous rule-based decision-making and process mappings based on intelligent performance data

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Operations Management	Technology management	• No technology management plan* • Reactive technology implementation	• Identify related technology • Technology related studies • Developed plan but not comprehensive and not fully optimised	• Plan is available & implementable • Relate to enterprise sustainable plan • POC/POT • implementation (e.g., outcome used as input for plan improvement)	• Technology Roadmap (aligned to business strategy) • Comprehensive technology management plan based on POC result	• Technology according to technology roadmap (areas of operation) • Adaptable technology management (upgrading, scalable, flexible, building blocks) • Address future trends • Yokoten (sideways expansion/ horizontal deployment) EXAMPLE: Use of cloud computing and blockchain to adapt for different use cases or product line	• Well optimised (automation, connectivity, intelligence) • Integrated technology management and planning • Technology convergence • Technology supporting sustainable business outcome

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Operations Management	Manufacturing focus	• No documented standard with normal practice (based on internal and external influences) • No or insufficient data for process control	• Standardised work process • Methodological monitoring, measurement and analysis system (e.g., SPC)	• Lean management (Industry average) • SPC (Below 3 sigma)	• Automated work process with human intervention • Automated measurement system • Diagnostic statistical analysis	• Connected work process and real time monitoring with limited human intervention • Automated and self-diagnostic statistical analysis • Predictive analytics	• Autonomous work process • Adaptive quality management, production planning • Prescriptive analytics

Strategic thrusts and focus areas

Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Product Management	Product life cycle focus*	Product life cycle not defined	Product life cycle defined and managed manually	Defined product life cycle processes with the support of product data management systems.	• Digitalised product life cycle processes and systems at certain stage of product development. • Alignment of product life cycle with cost and sales data.	Digitalised product life cycle processes and systems are securely integrated across all stages.	Fully integrated and intelligent product life cycle environment with seamless integration and support of the whole product life cycle process from idea management until end-of-life.
	Degree of customisation		Mass production (no customisation)	Identical or mass customised (visual personalisation such as colour, shape, surface, texture, material)	Mass customisation (performance personalisation)	• Co-created • Individualised (full personalisation)	Predictive individualisation

Strategic thrusts and focus areas

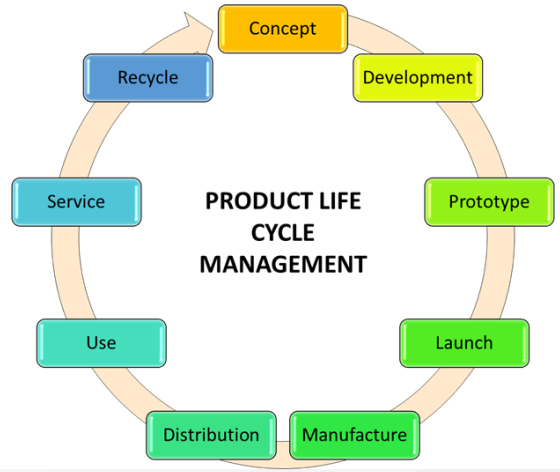
Thrust	Focus area	Level 0	Level 1	Level 2	Level 3 (Industry 4.0 ready)	Level 4 (Industry 4.0 minimum)	Level 5
Supply chain management	Supply chain focus*	No system	Manual operation (e.g. email, paper based)	• Traceability system (e.g. barcode, excel) • Pull delivery process (e.g., Kanban)	ERP	Interconnected ERP, SCM and CRM	• Dynamic supply chain optimisation • Business Intelligent (Analytics with modelling) • Smart Logistics • Autonomous Intelligent Vehicle (in warehouse only)
	Cybersecurity maturity*	No or minimal/ limited security	Ad-hoc or not formalised	• Reactive • Blocking and Tackling	• Compliance driven • Information security management practices	• Proactive • Behaviour analytics • Multi-layered	Cyber threat intelligence and incident management

Explanation on concept

Strategic focus

- ✓ The organization's **overall strategy** towards implementing Industry 4.0 technologies.
- ✓ Relates to the **design and execution of a sustainable plan** to achieve long-term goals.
- ✓ It includes identifying priorities, formulating roadmap, and developing a system of rules, practices and processes to translate a vision into real business value.

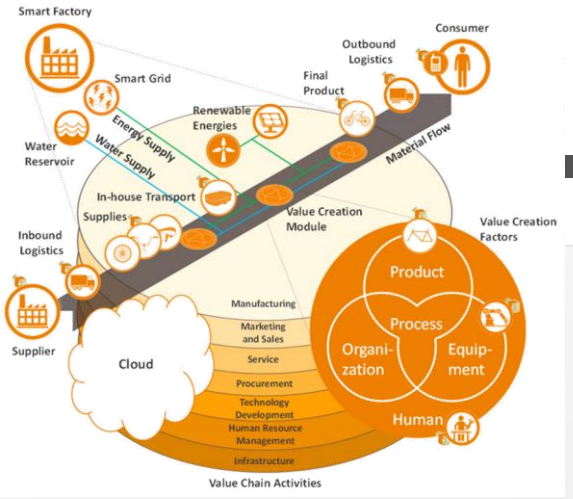
Explanation on concept



Product life cycle focus

- ✓ Description of all stages of the **product throughout its life**, encompassing the stages of design and development, engineering, production, customer use, service and disposal, whatever the form.
- ✓ Organization needs to **manage its product life cycle** by integrating man, machine, method and material along the entire product life cycle.
- ✓ Data collection along product life cycle allows for **improvement** in product quality, product design and development, production management, production cost and increases manufacturing flexibility.

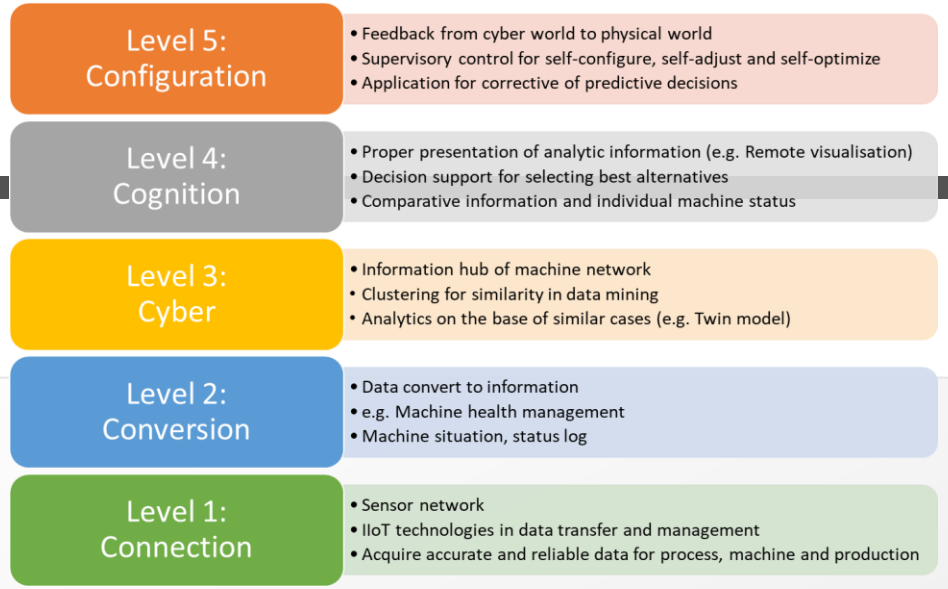
Explanation on concept



Supply chain focus

- ✓ **Horizontal integration** of enterprise processes across the organisation and with other stakeholders along its supply chain and the cybersecurity element of an organisation.
- ✓ It is a requirement for an organisation to have a **connected supply chain processes** and a **centralised data management**.
- ✓ Allow for the supply chain system to be **flexible** and **personalized,** and decisions on cost, inventory and operations can be made quickly, efficiently and in a more transparent manner.

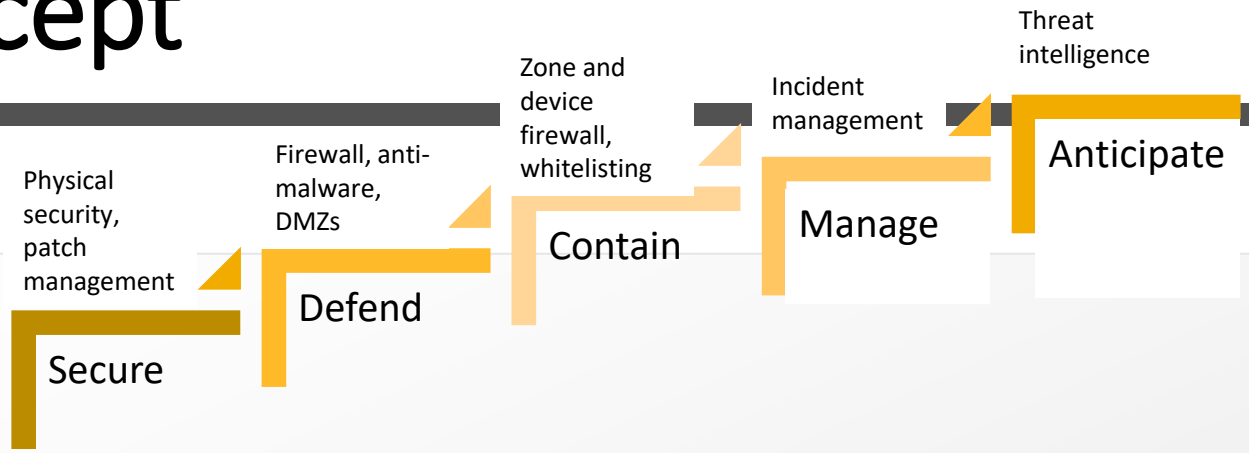
Explanation on concept



Cyber-physical system (CPS)

- ✓ Consists of two main functional components:
  - i. the **connectivity** to achieve real time data acquisition from physical world and the feedback on information from cyber space; and
  - ii. the things that happen in cyber space which includes **intelligent data management**, **analytics** and **computational capability**.
- ✓ For Industry 4.0, machines and equipment should be able to **acquire, process and analyze** data along the manufacturing value chain based on the Cyber-physical system (CPS) levels.

Explanation on concept



Cybersecurity maturity

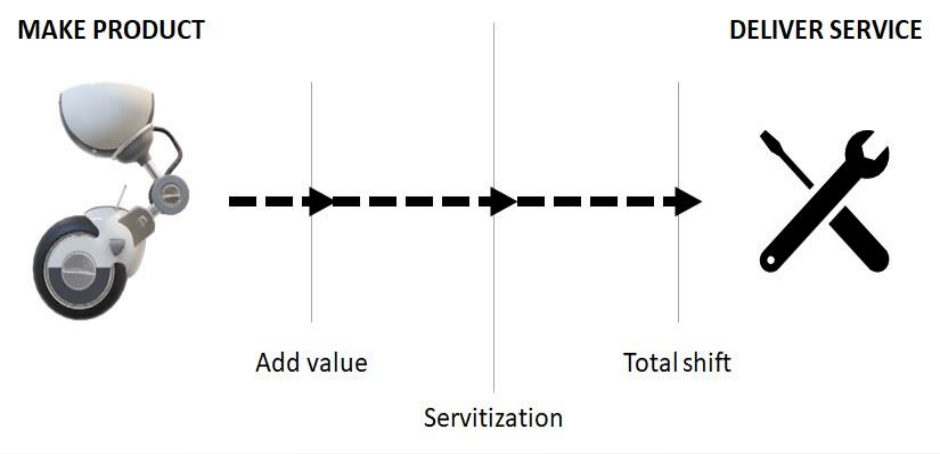
- ✓ Organisation needs to have a **cybersecurity framework** suitable to its system and comply to relevant regulations and standards, to assess and improve ability to identify, protect, detect, respond and recover to cyber-attacks.
- ✓ Needs to continuously **review and upgrade** its cybersecurity framework in order to be able to recover from more sophisticated cyber-attacks.
- ✓ The organisation needs to continuously analyse the **risk and identify** the cybersecurity requirement suitable to its business operation.

Explanation on concept

Device-to-device

- ✓ Two or more devices can be **directly connected** and can communicate with each other over IP networks or the internet.
- ✓ Device-to-device communication is generally **non-transparent** to the mobile network and it can occur on the cellular frequencies or unlicensed spectrum.

Explanation on concept



Servitization

- ✓ Delivery of a service component as an **added value**, when providing products.
- ✓ The manufacturing company provides **after sales activities** including consultancy, servicing, repairing and maintenance of a product.
- ✓ Use of IoT and sensors allow the manufacturing company to monitor the products it provides and its maintenance schedule.

Explanation on concept

Gig economy

- ✓ Free market where **temporary and flexible jobs** are common and organizations tend to hire independent workers, such as independent contractors, freelancers, project-based workers and temporary staff, for a specified period of time instead of full-time employees.
- ✓ Digitisation allows **work mobility** and decoupling of job and location.
- ✓ Industry 4.0 requires wide range of skill and expertise to manage their technology and gig economy allows organizations to hire experts specific to their requirement.

Explanation on concept

Real time

- ✓ Real time data processing refers to the abilities of computer system and machines to process collected data continuously and automatically to provide real time or near real time **outputs or insights**.
- ✓ Industry 4.0 requires real time insight across people, process, product and value chain in order to make **better and immediate decision** in operation.
- ✓ Real time capability requires the use of **digitization** and **digitalization**, Industrial Internet of Things and Cyber-Physical Systems (CPS) with the support of good infrastructure.

Explanation on concept

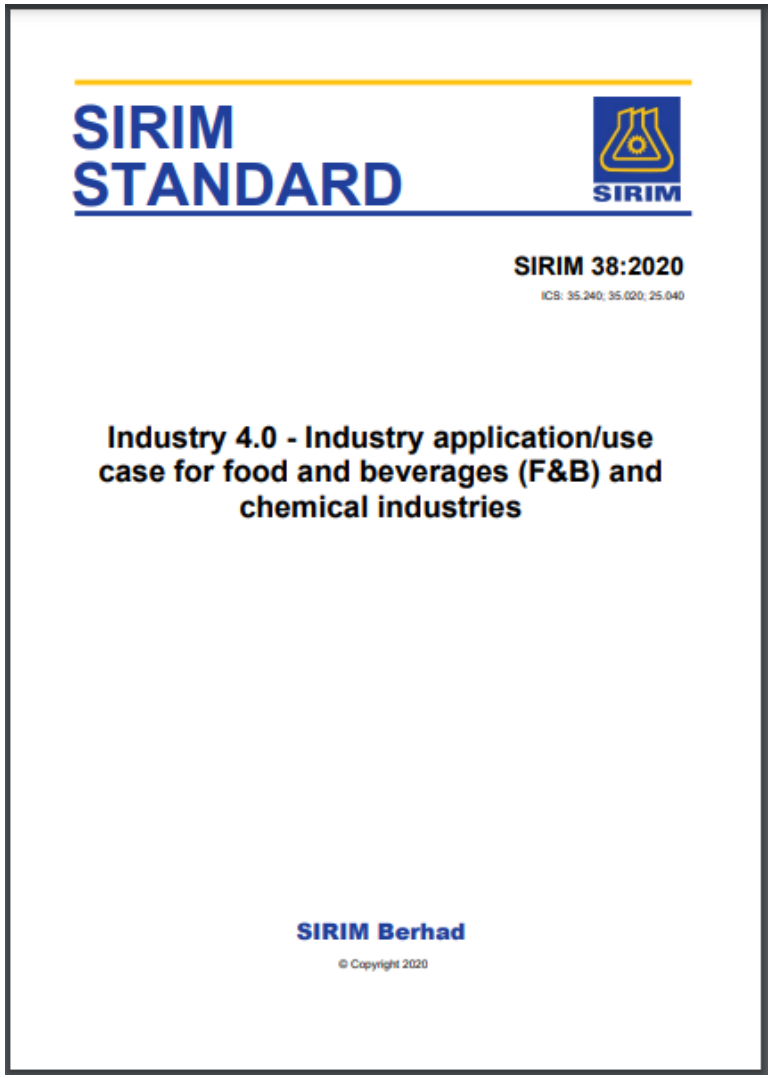
Technology Management Plan

- ✓ Involves the planning, design, optimization, operation and control of technological products, processes and services.
- ✓ Technology management is used to understand the **value** of certain technology to an organization.
- ✓ The organization would be able to justify if an **investment for a technology** is required or not, based on the value obtained by the customer through the implementation of the technology.
- ✓ When an organization determines the need for changes in its technology management, the changes should be carried out in a **planned manner**.

Industry 4.0 Industry application/use case

Industry 4.0 Industry application/use case

Application of Industry 4.0 enabling technologies in terms of use cases based on real-world applications and requirements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ICS: 35.240; 35.020; 25.040

Industry 4.0 - Industry application/use case for food and beverages (F&B) and chemical industries

SIRIM Berhad

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Industry 4.0 Industry application/use case

The purpose of Use Case:

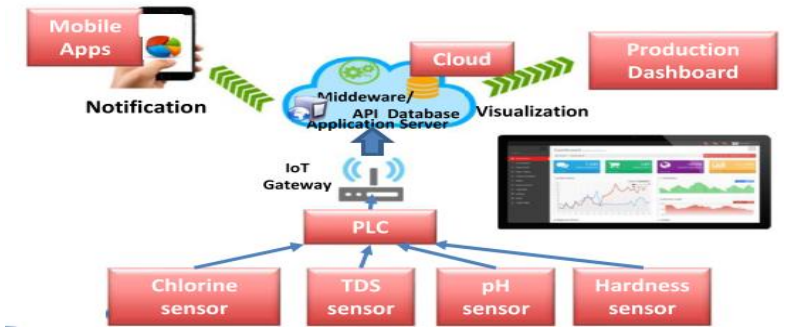
a) to provide examples that demonstrate the utilisation of Industry 4.0 enabling technologies by manufacturing companies and research institutions in day to day operations;

b) to assist manufacturing organisations to select and use the examples applicable within their own manufacturing environment; and

c) to provide guidelines for organisations to implement the relevant enabling technologies and progress towards becoming more efficient market-responsive value chain and customer-focused Industry 4.0 organisations.

Water treatment plant health monitoring

Food & Beverages Industry



Problem

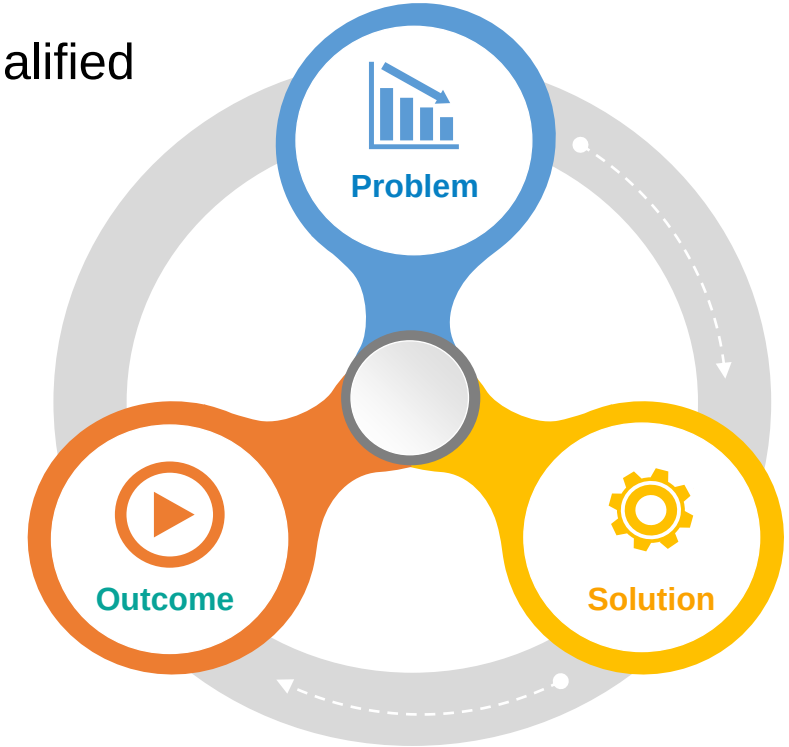
- Depend on labour field inspection by seeing, hearing, touching, smelling, and oversight of the machine and ambient environment in the plants.
- Low efficient methods and lack of qualified workers, problem cannot be solved

Solution

- Various types of sensor network collects information of device status and running environment of the water treatment plant and transmit this data to the IoT gateway which collects and formats the data.
- All data stored in cloud base system can easily be visualised for monitoring purposes either through a personal computer (PC) or smartphone.

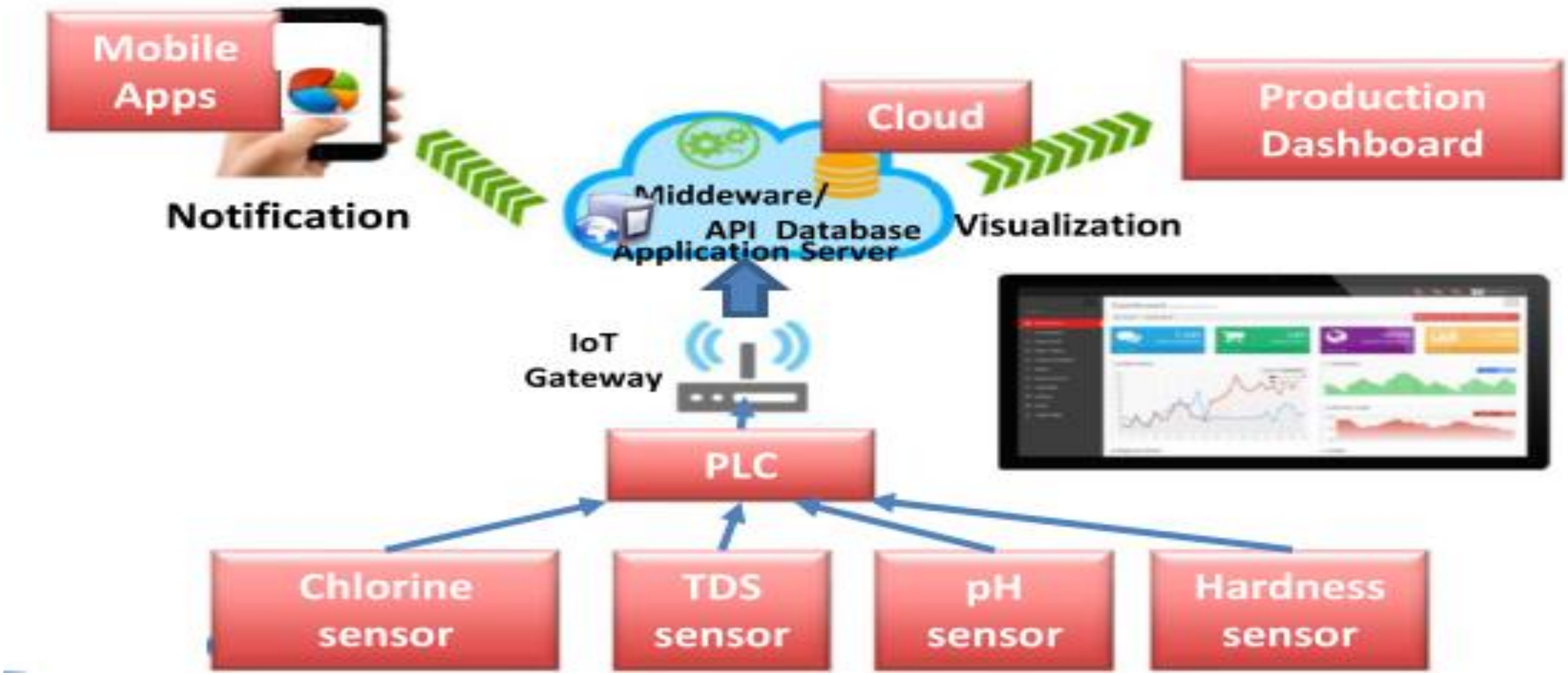
Outcome

- Real time data
- Reduce workload
- Improve quality & operation
- Maximize OEE



SOURCE: SIRIM 38:2020

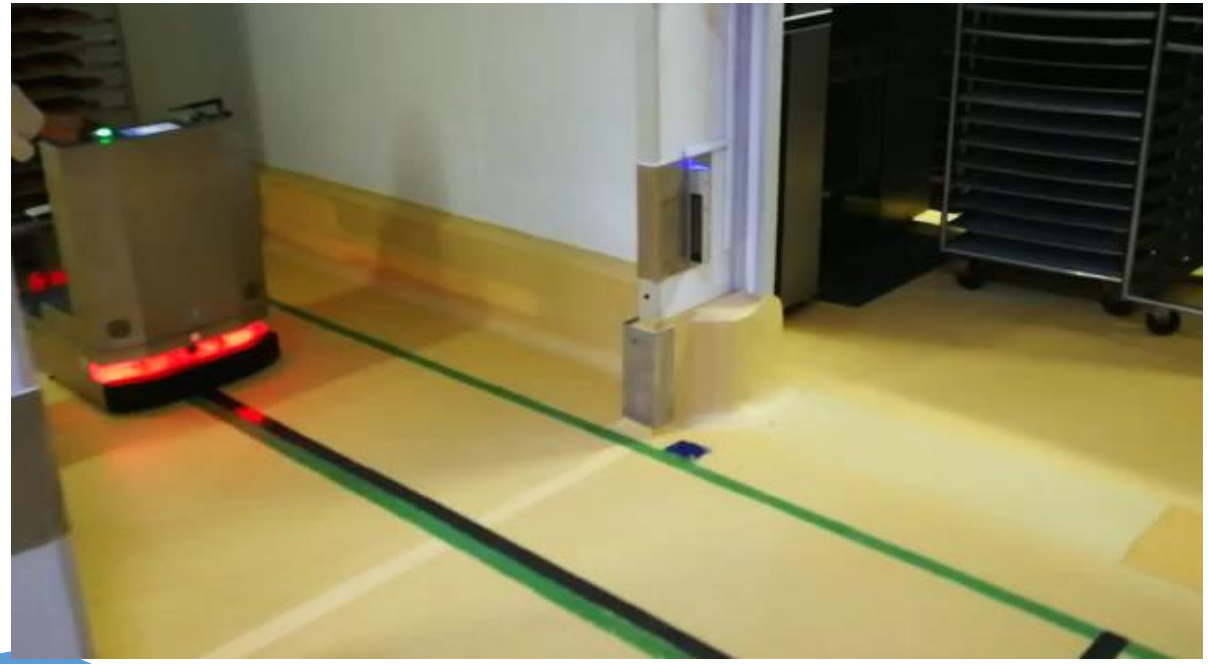
Water treatment plant health monitoring



SOURCE: SIRIM 38:2020

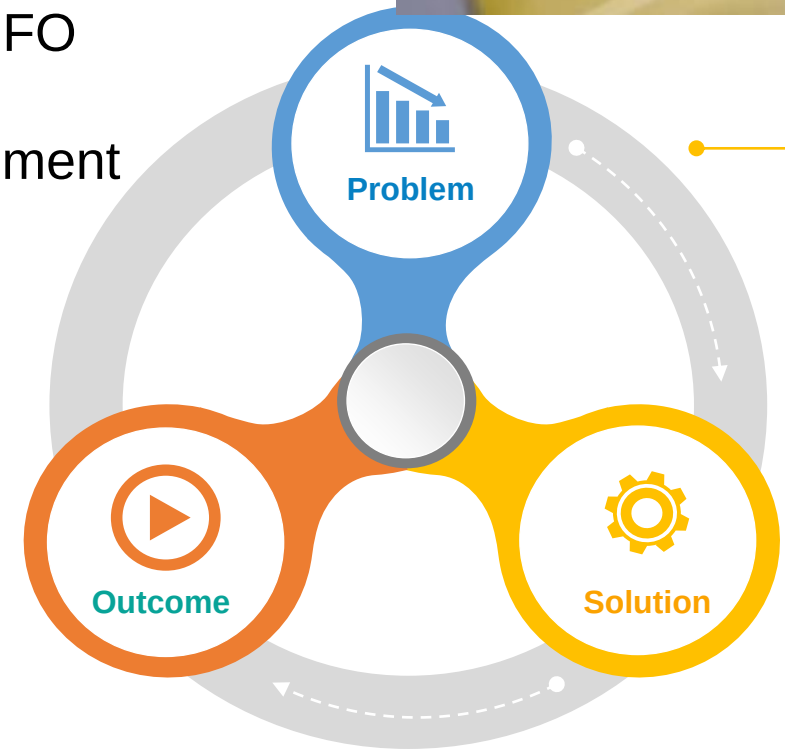
Automated Trolley Flow Management System using Auto Guided Vehicle

Food & Beverages Industry



Problem

- Labour Intensive way of handling semi-finished products
- Inconsistent handling of trolleys (FIFO issue)
- Ineffective production flow management



Outcome

Reduce Manhour
830 hrs of operators time

Eliminate Rejection
2% or 6460 pcs per day

Improve Product Quality
Production Time Management

Maximize OEE
Seamless production flow

Solution

- Deploy 100kg AGV with fleet management system to transfer semi-finished products from Production Line to Proofer and return (Route A) and from Proofer to Blast Freezer and return (Route B)

SOURCE: SIRIM 38:2020

Automated trolley flow management system using AGV

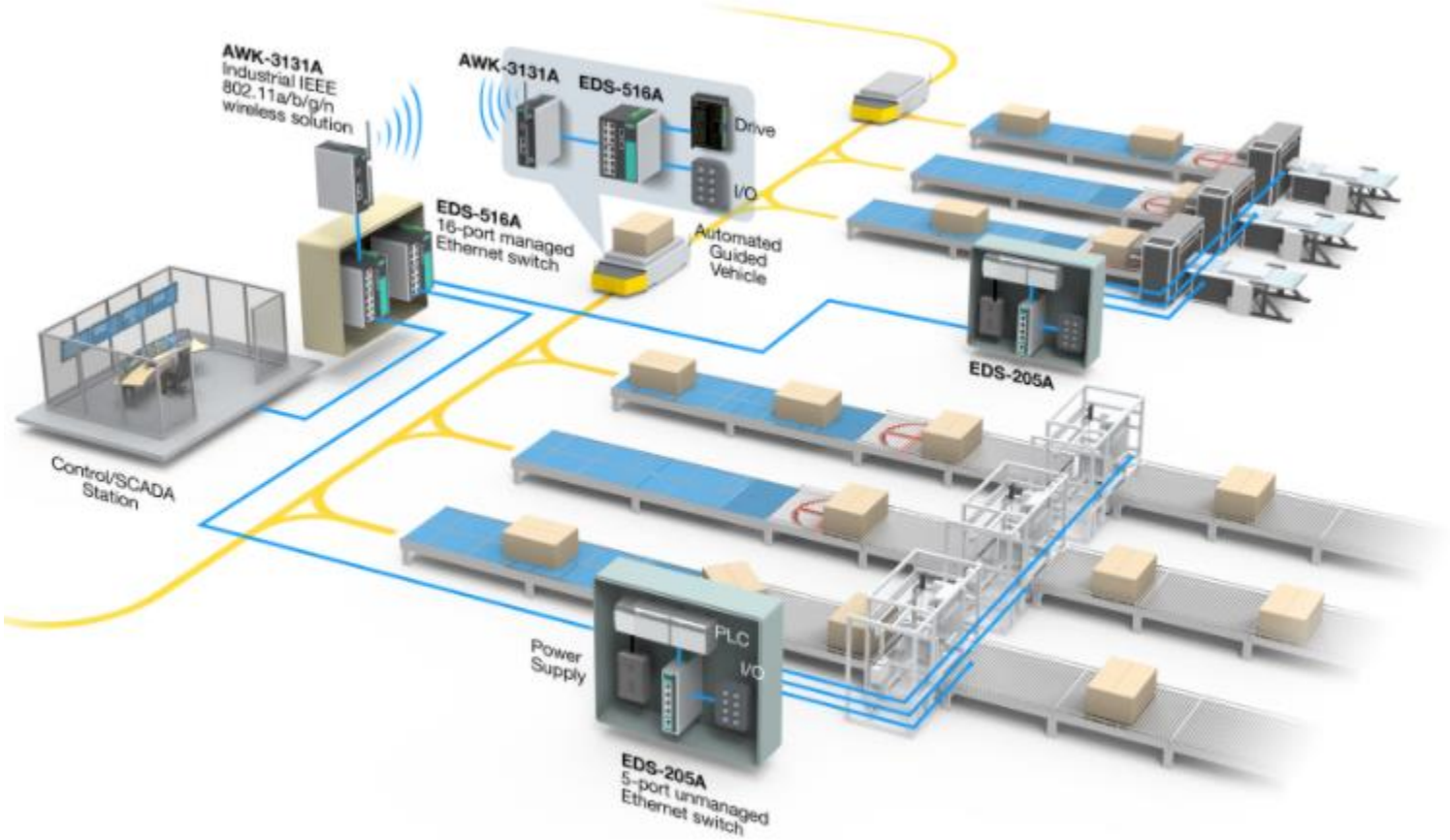
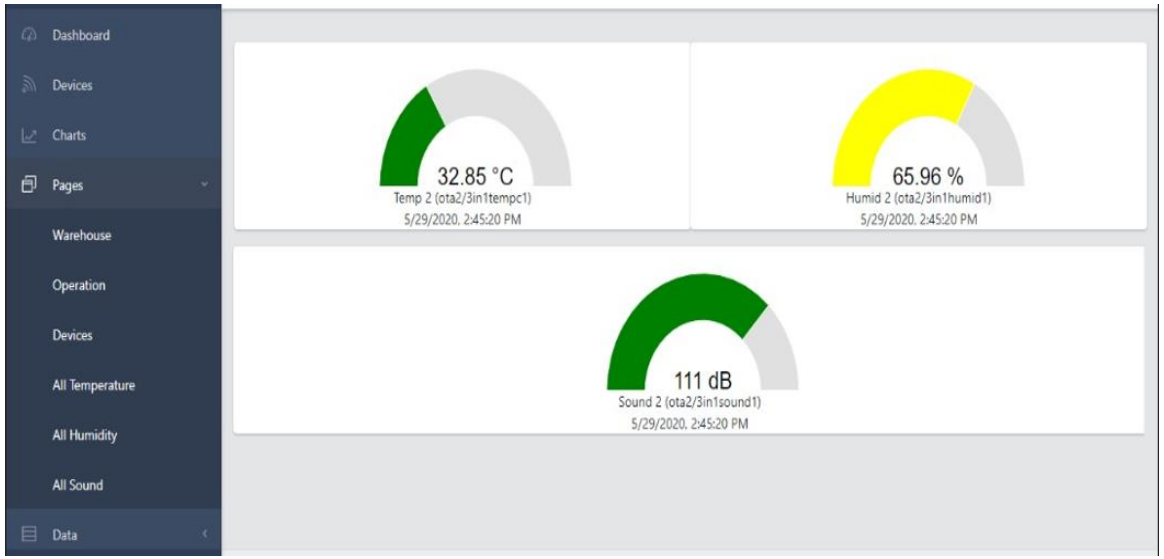


Image from MOXA Inc.

SOURCE: SIRIM 38:2020

Temperature, humidity and sound sensor

Food & Beverages Industry

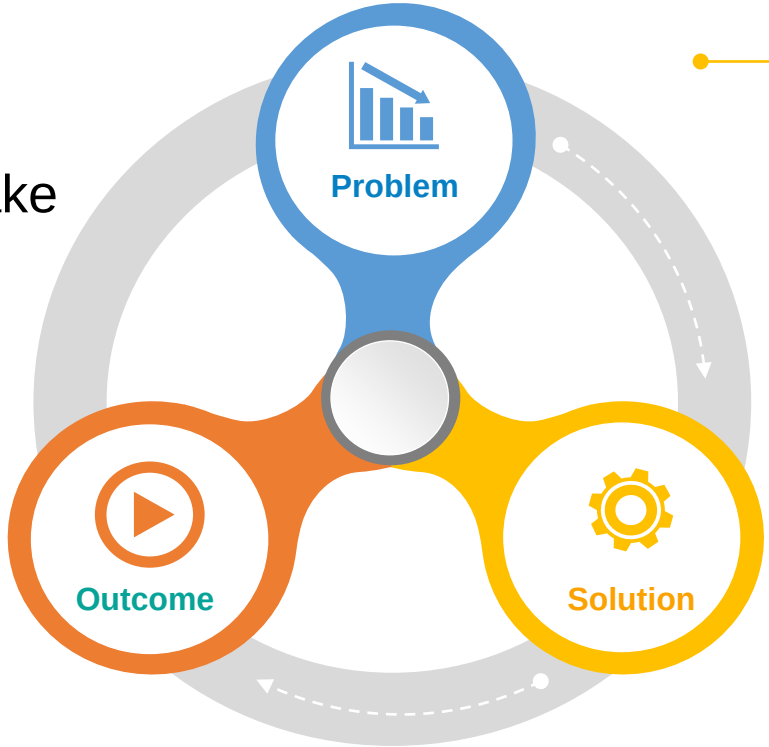


Problem

- Temperature and humidity affect product quality and are vital information in HACCP food safety standards
- Too much time used and labour intensive to collect, tabulate and analyse the data
- Periodic analysis cannot help to make timely decisions

Outcome

- Efficient manpower utilisation
- Good quality data
- Real time data collection & analysis
- Quality product



Solution

- Install temperature, humidity and sound sensor in various locations
- Uses wireless technology, battery powered, wifi connectivity and cloud
- Data compared using line chart analysis, real-time and without human intervention

SOURCE: SIRIM 38:2020

Artificial Intelligence (AI) sorting machine

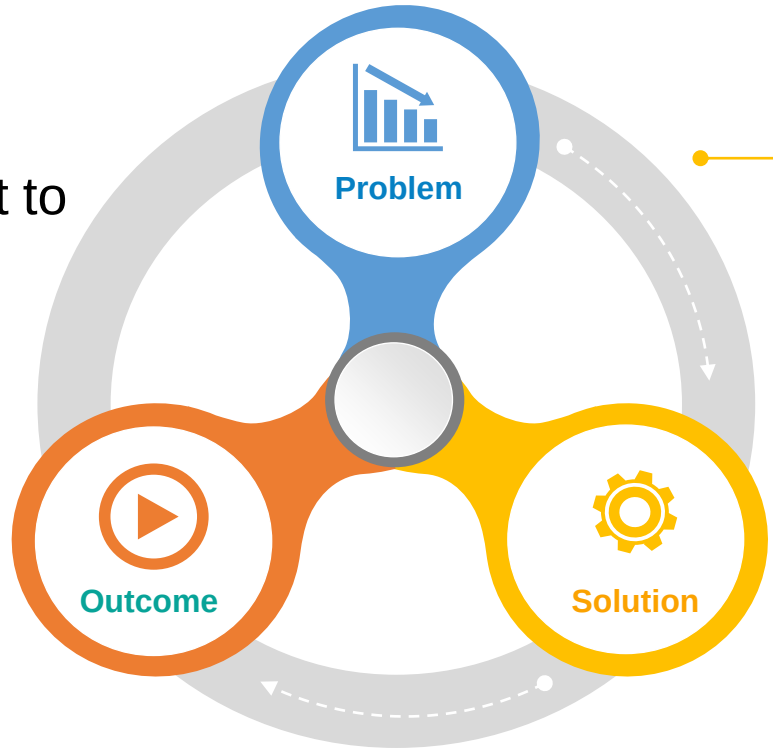
Food & Beverages Industry

Problem

- Challenges in food quality include consistency in colour, taste and aroma
- Selection of raw materials within specifications is a very important to maintain product quality and consistency
- Process done manually and subject to operator biasness

Outcome

- Efficient manpower utilisation
- Consistent quality
- Improve OEE
- High speed sorting

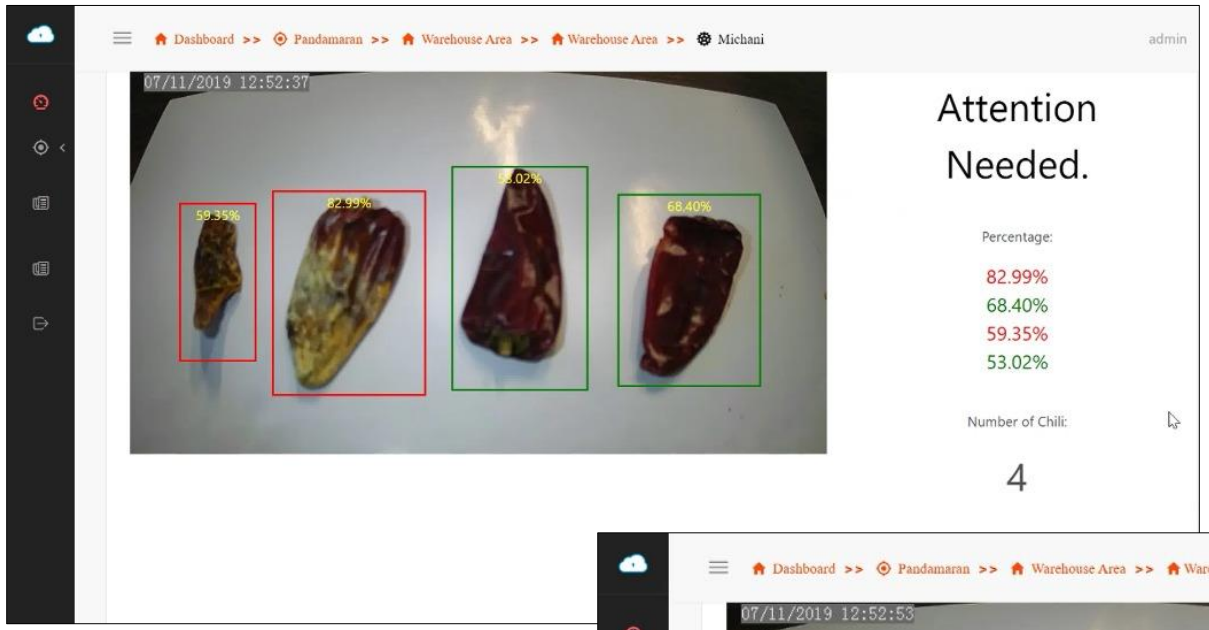


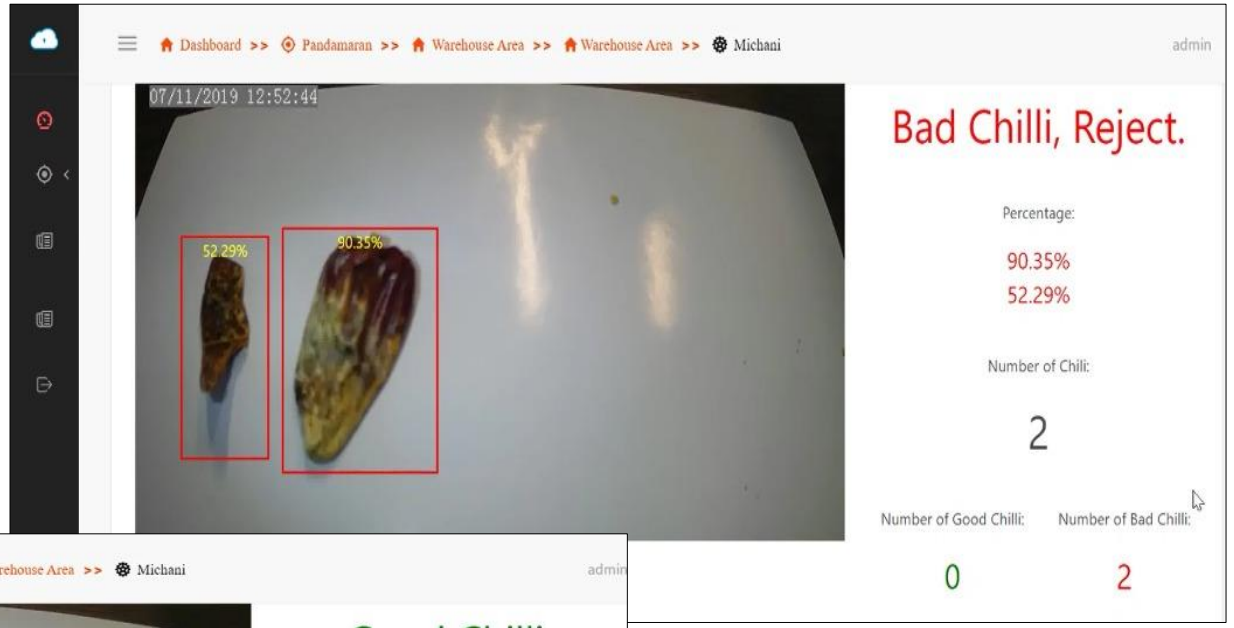
Solution

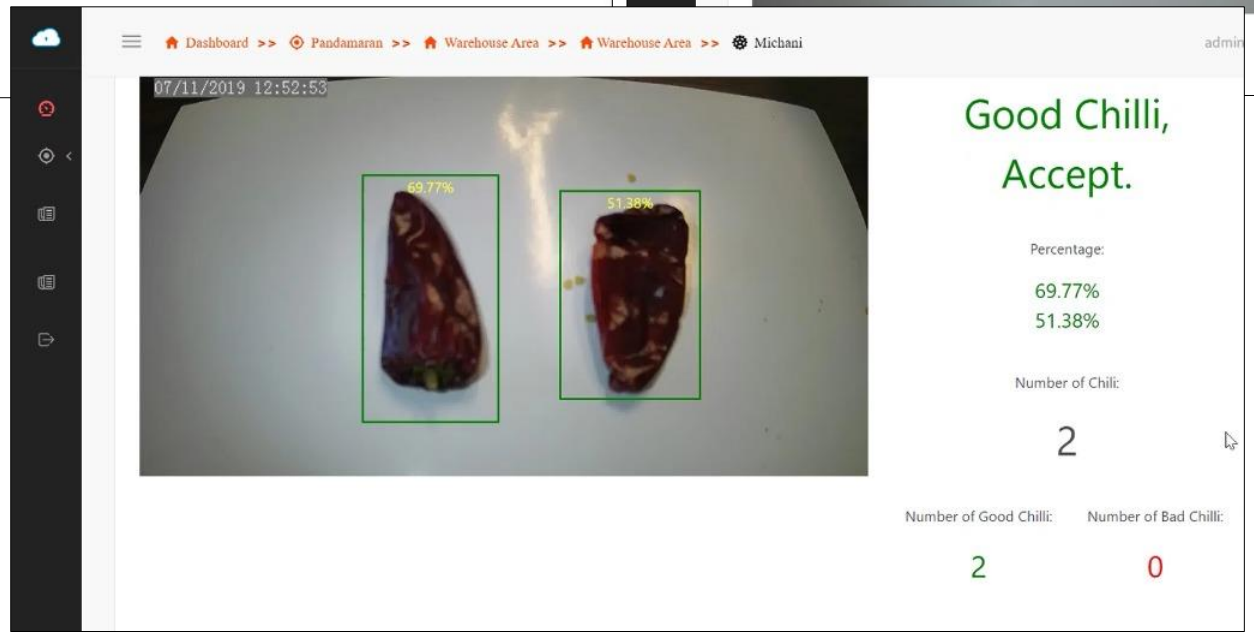
- Use of AI sorting machine will increase the sorting speed with higher accuracy
- Rejection rates can be known instantly which can help to improve OEE

SOURCE: SIRIM 38:2020

Artificial Intelligence (AI) sorting machine



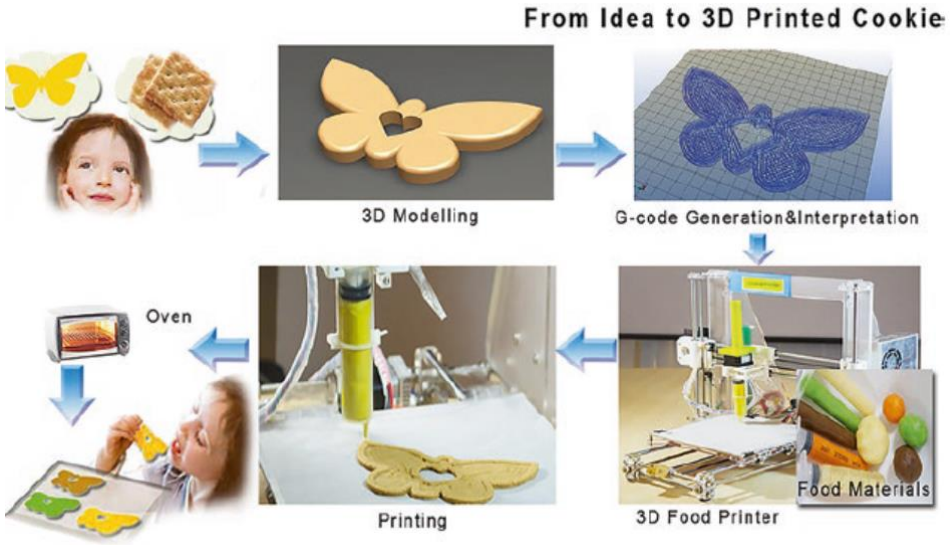




SOURCE: SIRIM 38:2020

3D food printing

Food & Beverages industry

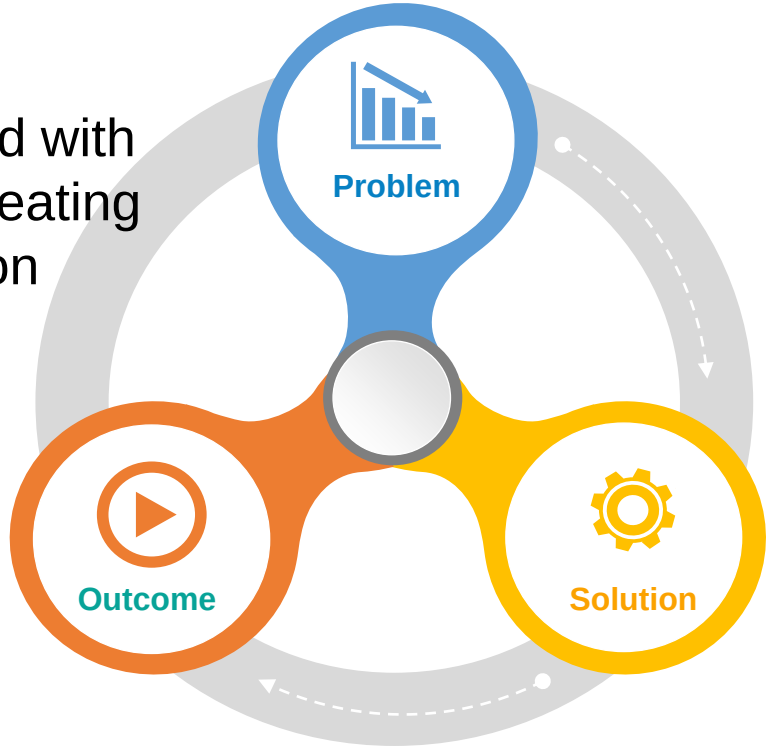


Problem

- Common eating disorders associated with the elderly is dysphagia (unable to swallow).
- Condition may lead to malnutrition and loss of the quality of life among the elderly.
- Need texture modified food; the food with properties that are adapted to their eating capabilities, but with needed nutrition

Outcome

- Reduce labour to mmeasure
- Increase productivity
- Improve OEE, reduce plant shutdown
- Increase prediction on equipment failure



Solution

- 3D food printing incorporates 3D printing technology and digital gastronomy
- 3D food printing vending machine are examples of 3D food printing future potentials which offer consumers personalised meals to support their individual needs associated to health and well-being

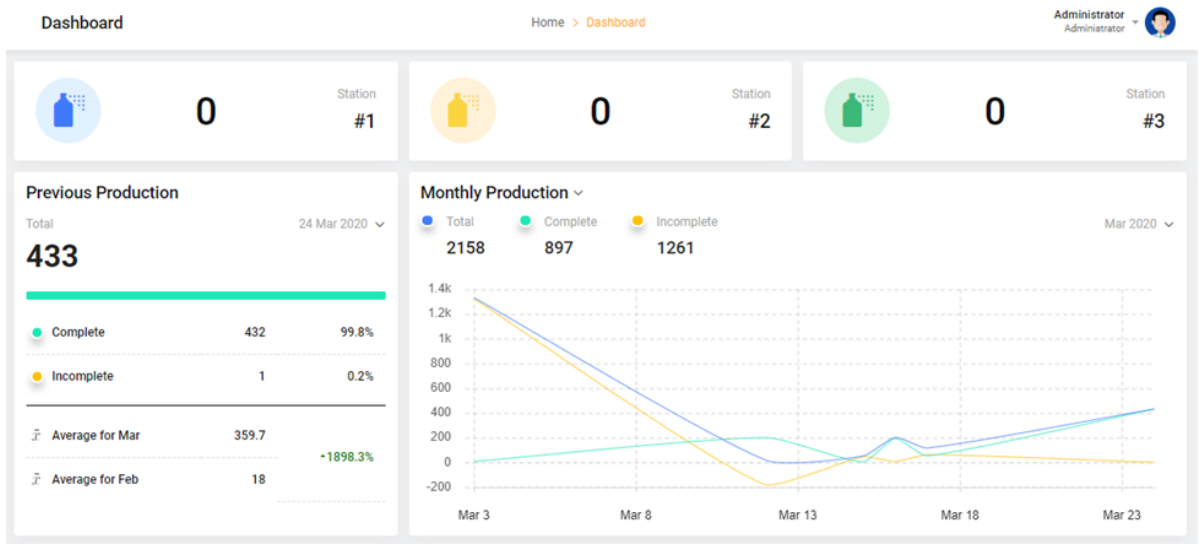
SOURCE: SIRIM 38:2020

Chemical product tracking system

Chemical Industry

Problem

- Bottles stuck at each process due to machine speed, conveyor speed, chemical spillage, inadequate filling, etc
- Difficult to indicate in real-time which contributes more to the delay in the production cycle
- Productivity, quality & OEE recorded manual.
- Time consuming and results in the loss of machine availability & delay in decision



Outcome

- **Less time consuming for data collection**
- **Good quality data**
- **Real time data collection & analysis**
- **Decision making**

Solution

- Capture real-time data on the production status
- Uses sensors and IoT devices installed at each process
- Machine adjusted accordingly
- Reporting is easier and arrangement for the next raw materials purchasing

SOURCE: SIRIM 38:2020

Predictive maintenance

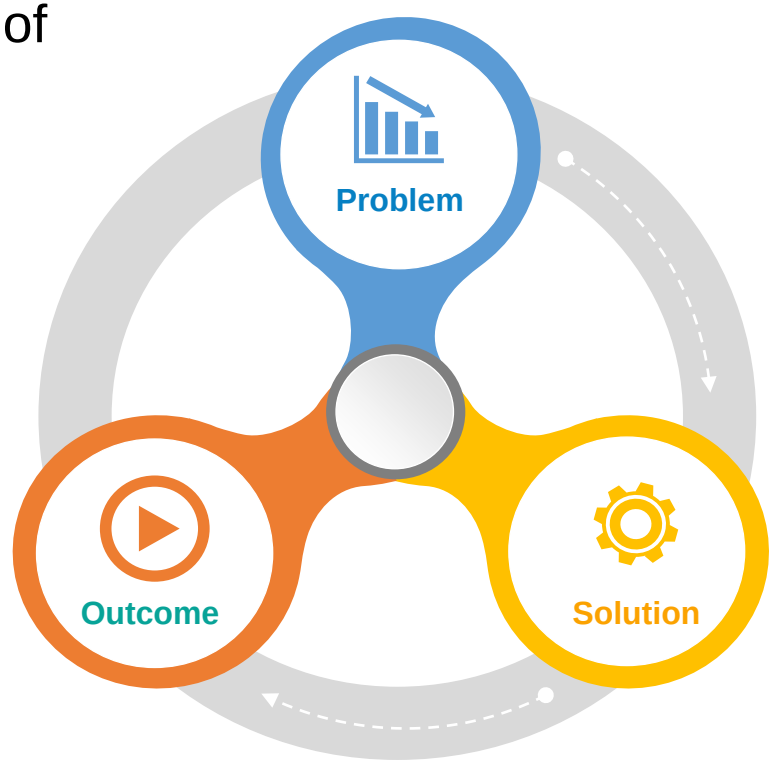
Chemical industry

Problem

- Equipment has to be in good shape in order for production to run continuously to meet customer demand
- One of the ways is to manage this by conducting predictive maintenance of each critical equipment manually
- But this prove to be very labour intensive and time consuming, but equipment may be missed out

Outcome

- Reduce labour to mmeasure
- Increase productivity
- Improve OEE, reduce plant shutdown
- Increase prediction on equipment failure

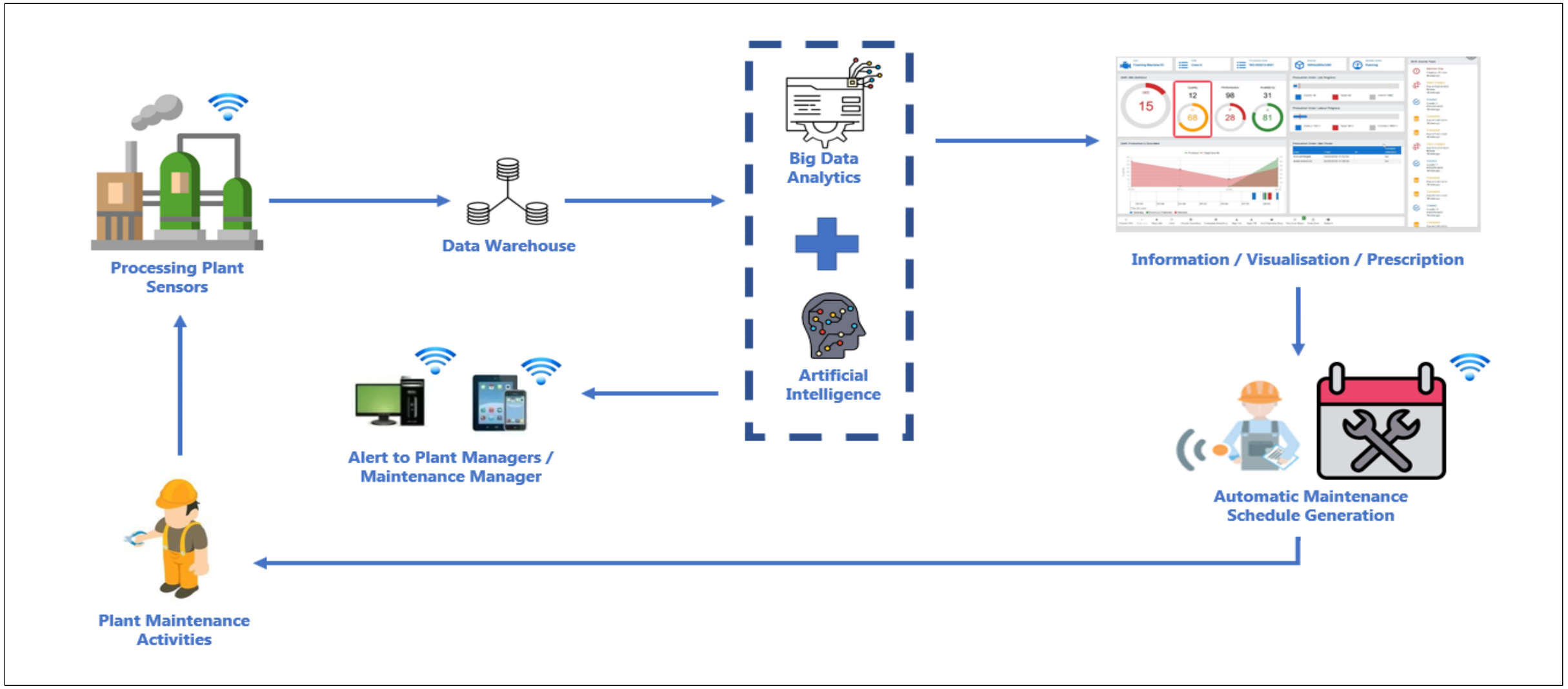


Solution

- Installation of sensors on each critical equipment to measure the main parameters of the equipment, coupled with other sensors around the process area, provides data analytics models which will give real-time assessment
- Enhances the detection of anamoly, prediction of mean-time-between-failures and performance deterioration accuracy, and automatically triggers the preventive measures

SOURCE: SIRIM 38:2020

Predictive maintenance



SOURCE: SIRIM 38:2020

Optimisation of ethane supply chain

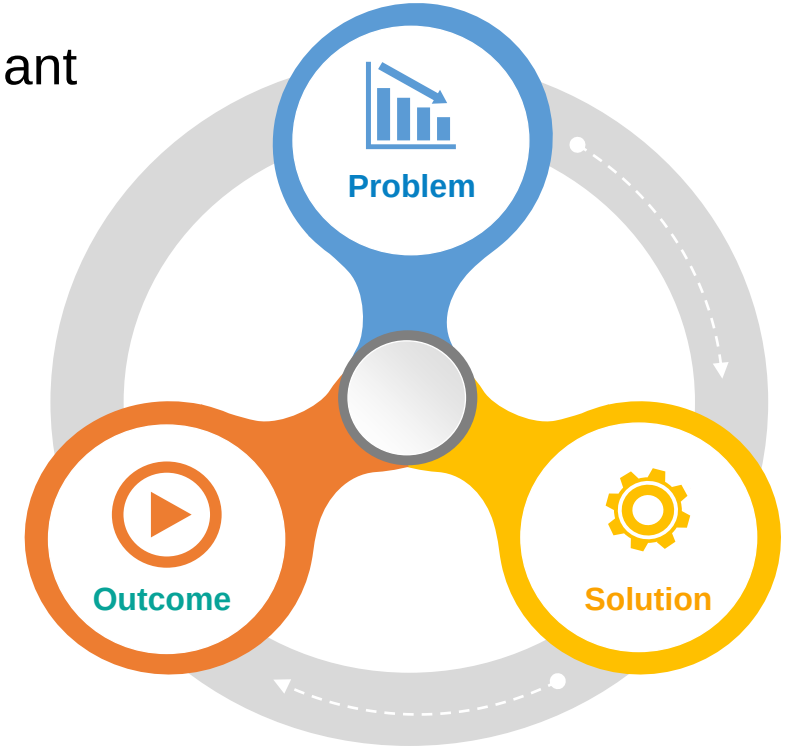
Chemical Industry

Problem

- Price of polyethylene drives ethylene plants to optimise plant processing conditions in order to maximise ethane utilization
- This has to be done manually by plant operators
- “leakage” of ethane can happen

Outcome

- **Less manual job**
- **Real time data collection & analysis**
- **Effective operation adjustment**

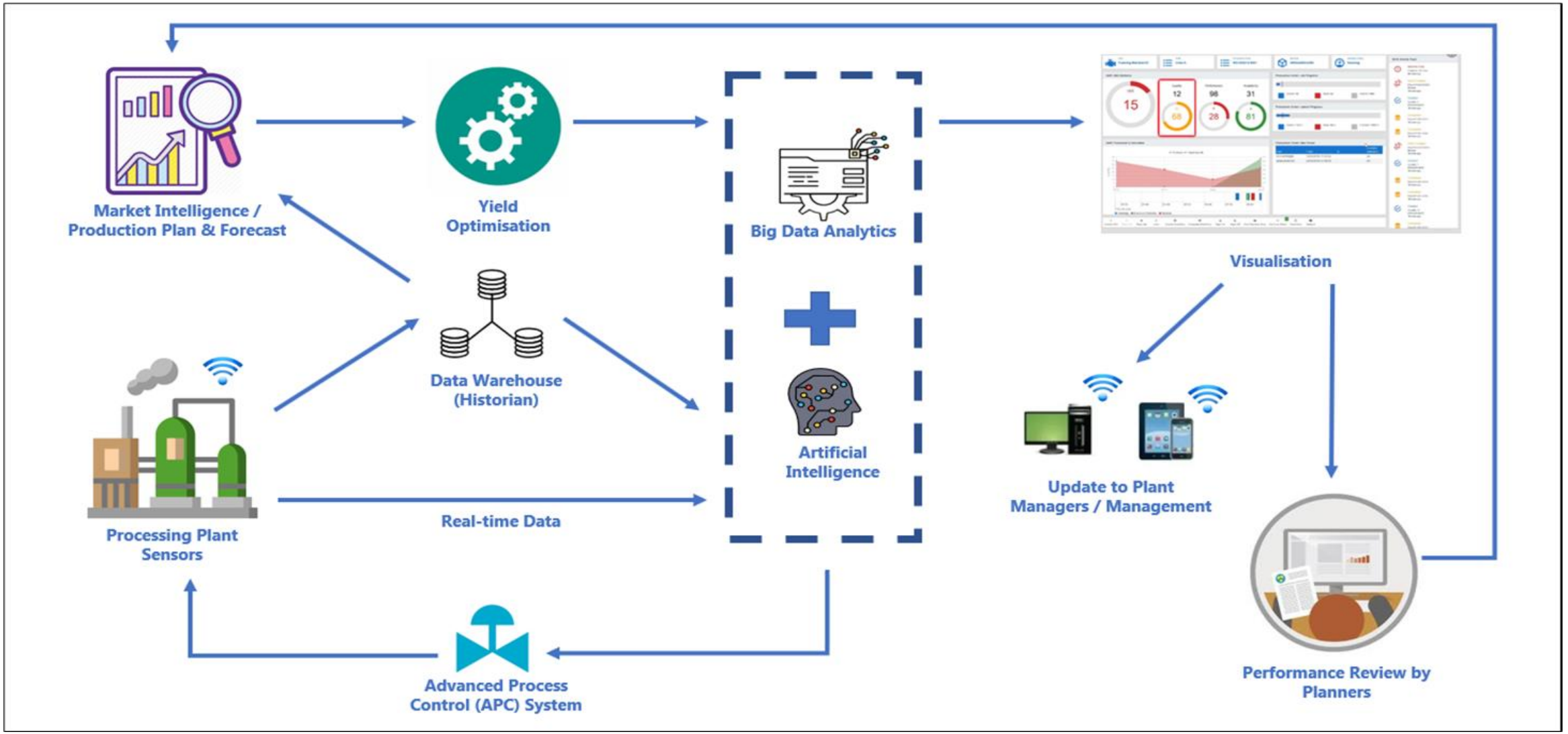


Solution

- Applies big data analytics and artificial intelligence in improving and automating certain aspects of day-to-day operations for ethane supply
- Application of Advanced Process Control (APC), coupled with machine learning models in the plant control system enables the prediction of optimum process parameters in order for the plant to optimise ethane supply, and controls the plant’s Distributed Control System (DCS) automatically to reduce human errors and increase efficiency

SOURCE: SIRIM 38:2020

Optimisation of ethane supply chain



SOURCE: SIRIM 38:2020

Optimisation of energy usage

Chemical Industry

Problem

- With the ever-rising cost of energy in addition to environmental concern on the importance of energy conservation
- Performance of heat exchangers deteriorate, making heat integration less effective and causing energy loss to the surroundings

Outcome

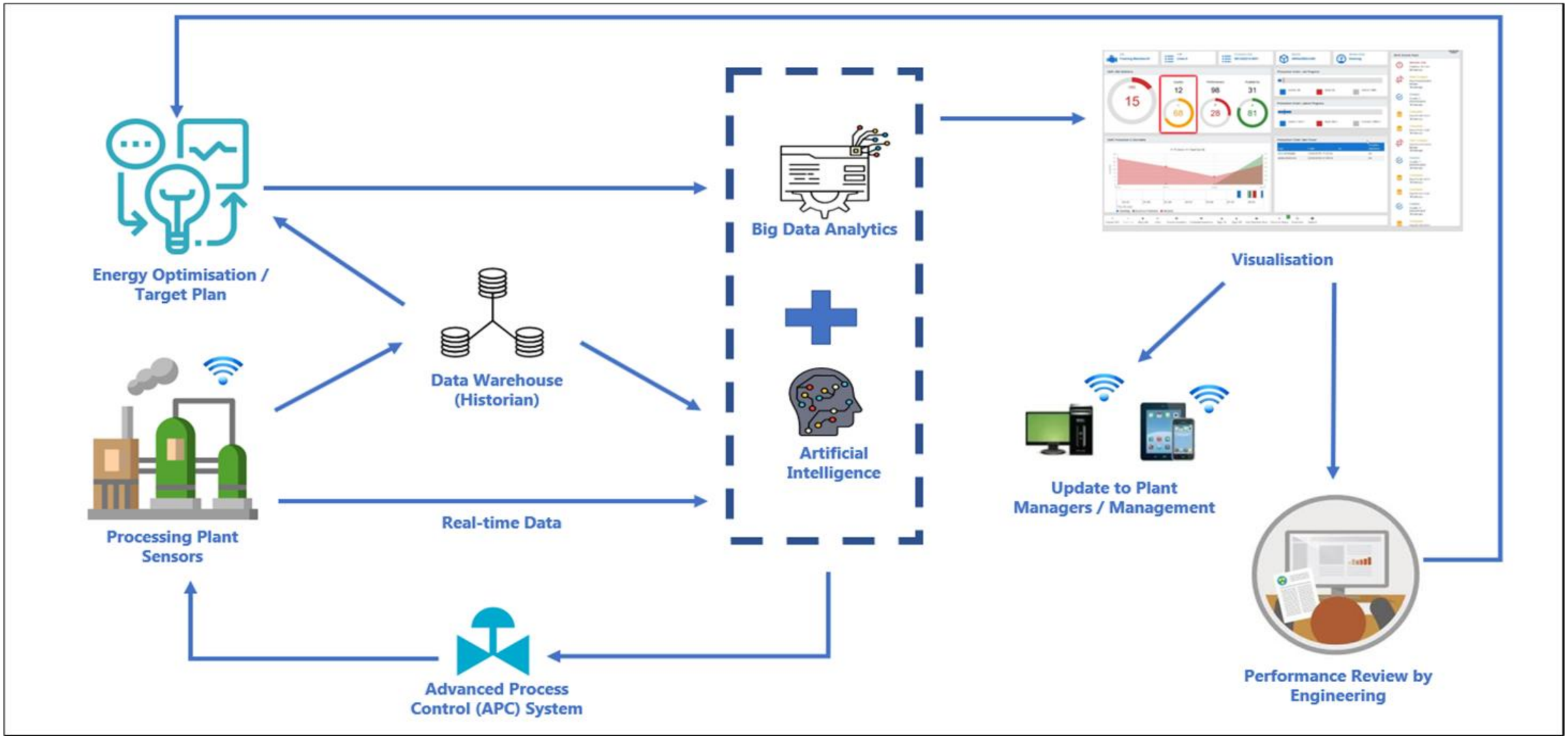
- Efficient manpower utilisation
- Real-time alert
- Real time data collection & analysis
- Efficient energy usage

Solution

- Real-time data from sensors connected to these heat exchangers fed into machine learning models to predict the best plant setting for energy optimisation
- Able to detect sources of energy leakage and raise the alarm to operators to conduct repair and maintenance of the affected equipment or process unit
- Notification of alerts sent directly to mobile devices of the plant manager, shift superintendent and supervisors

SOURCE: SIRIM 38:2020

Optimisation of energy usage



SOURCE: SIRIM 38:2020

HSE for transport safety

Chemical Industry

Problem

- Safety behaviour of its truck drivers when transporting hazardous chemicals beyond company's plant area are sometimes in question
- HSE culture should also be inculcated to its drivers especially when there is no one around to monitor their actions

Outcome

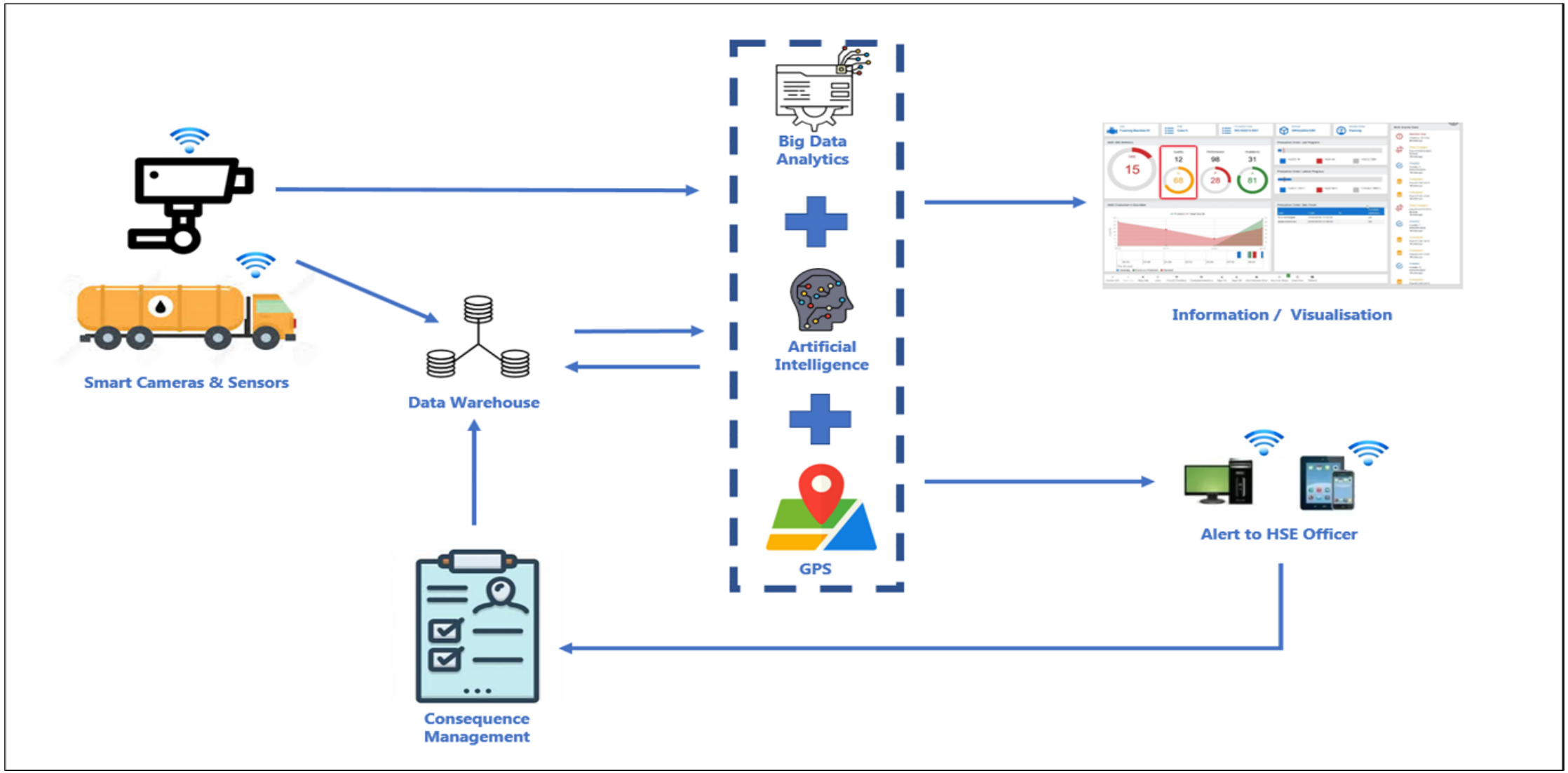
- Efficient manpower utilisation
- Good quality data
- Real time data collection & analysis
- Quality product

Solution

- Special cameras and sensors which are able to track the driving behaviour and pattern of the drivers are installed onto the chemical trucks
- Data collected from these devices sent to the cloud to machine learning models for the Transport Safety
- Model will predict the driver's behaviour
- Prediction sent to control centre as alarm and alerts designated personnel so appropriate actions can be taken

SOURCE: SIRIM 38:2020

HSE for transport safety

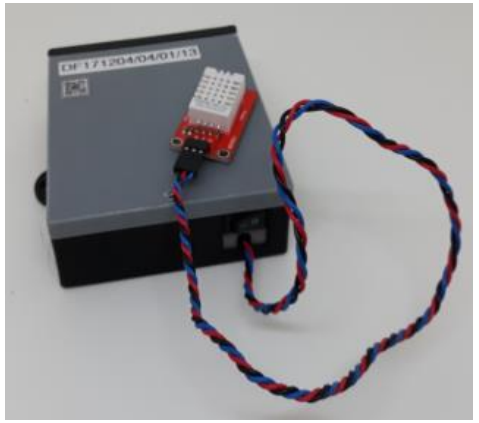


SOURCE: SIRIM 38:2020

IoT Application – Kelulut Integrated Information System (KIIS)

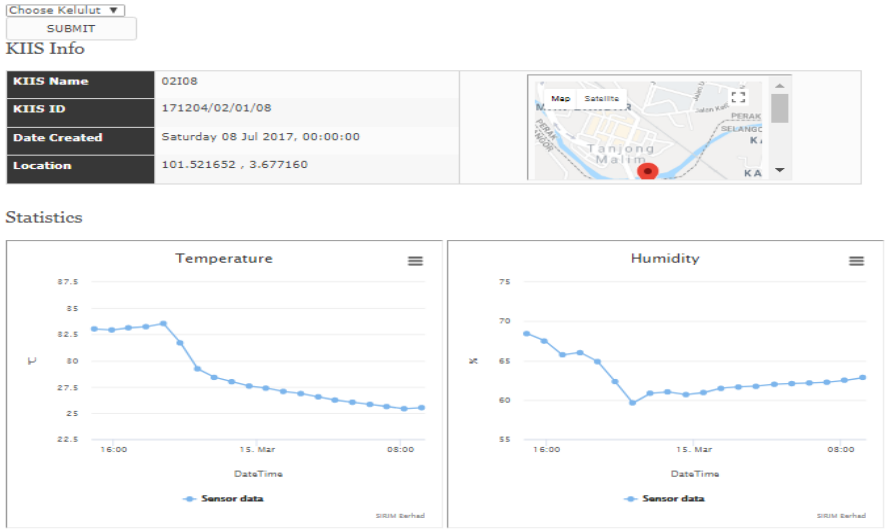
Uses digital sensor to measure the temperature and humidity of stingless bee (Kelulut) hive automatically, periodically and in real time

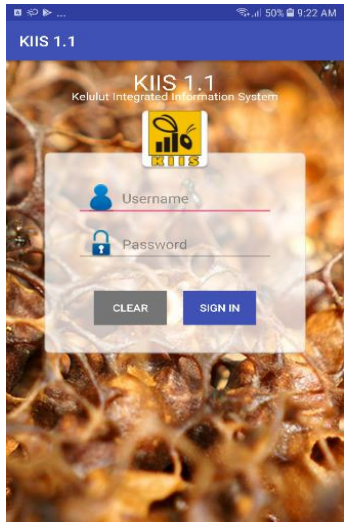
1. KIIS IoT device

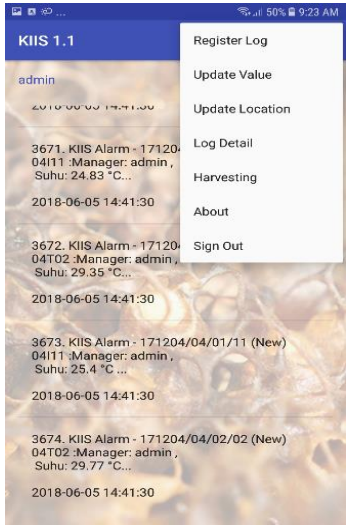


2. KIIS WEB

registration, parameter setting, transaction, reporting







3. KIIS APPS

notification, registration, harvesting

The device sends these data wirelessly to the base station via wireless sensor network (WSN) and subsequently to the cloud server via gsm/gprs module before they can be accessed via Web PC and android based smartphone

SOURCE: SIRIM Industrial Research

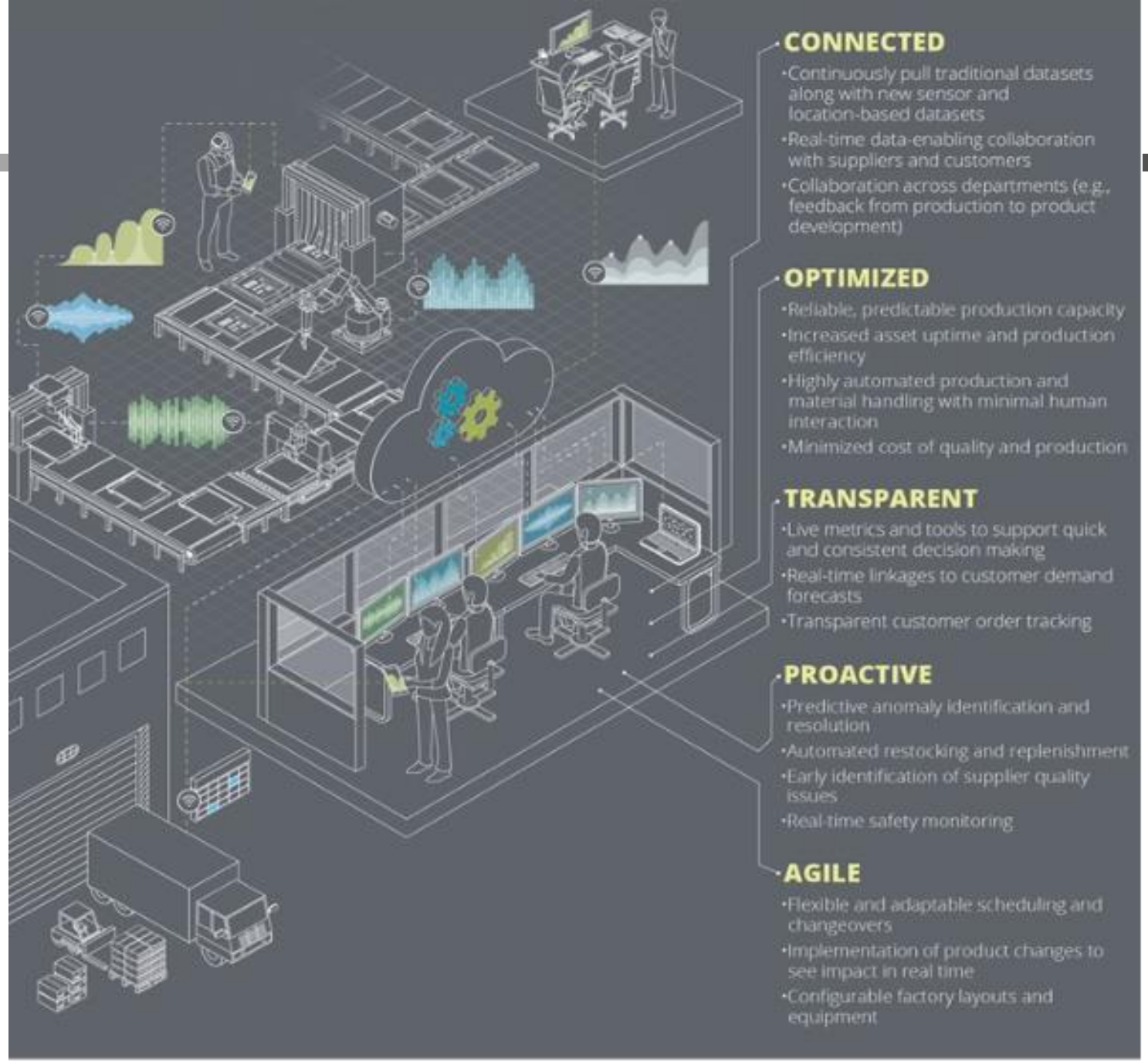
7 aspects of Warehouse Digitalization

1. Real-time data gathering and increased interconnectivity
   - ✓ Internet-of-Things - RFID, GPS, sensors, barcodes and warehouse management system to collect information on package location, package content, etc.
   - ✓ Blockchain - Collects data and store in blockchain which protect from malware
2. Warehouse mobility solutions
   - ✓ Mobile technology - Use of mobile phone to monitor inventory
3. Autonomous Guided Vehicles (AGV)
   - ✓ AGV and drones - Automate the product retrieval process by physically delivering requested items to the human for packaging the orders
4. Smart analytics and machine learning
   - ✓ Predictive analytics - Stock level, understock, overstock, etc.
   - ✓ Artificial intelligence - Robots can use AI to find the most efficient way to find and pick products
5. People-Technology Connection (Wearable Technology)
   - ✓ Smart watch & Smart glasses - Enable workers to move all over the facility and continuously access information instead of relying on an unmoving workstation
6. Robotics & Automation
7. Real-time inventory management
   - ✓ IoT - Allows robots in the smart warehouse system to communicate with all the other necessary technology and complete their tasks
   - ✓ RFID - Tracking with digital tags
   - ✓ RFID, wearables and sensors - Provides real-time monitoring of the progress and location of all inventory

Components of Smart Warehouse

1. Robotics & Automation
   - ✓ mainly handle the picking and packing of goods/goods on trolley
   - ✓ identify the optimal route for picking up the necessary products (with help of AI)
2. Radio-frequency identification (RFID)
   - ✓ organize and control inventory
   - ✓ tracking with digital tags
3. Artificial Intelligence
   - ✓ allows machines to collect, analyze, and learn from data
   - ✓ helps warehousing robots find the most efficient route for picking products
   - ✓ pack products, using AI to pack them in the most space-efficient manner
   - ✓ gather data to create a holistic strategy for the warehouse (with help of IoT)
4. The Internet of Things
   - ✓ involves several Internet-enabled devices communicating with each other and sharing data
   - ✓ robots can communicate with all of the tech it needs to, including a warehouse management system (WMS)
5. Warehouse Management Systems
   - ✓ gather valuable data
   - ✓ help users manage warehousing processes
   - ✓ inventory receiving and put-away, optimizes picking and shipping of orders and advises on inventory replenishment

Smart factory



Source: Deloitte analysis.

Deloitte University Press | dupress.deloitte.com

Let's watch

Table 1. Processes within a smart factory

Process	Sample digitization opportunities
Manufacturing operations	• **Additive manufacturing** to produce rapid prototypes or low-volume spare parts • **Advanced planning and scheduling** using real-time production and inventory data to minimize waste and cycle time • **Cognitive bots and autonomous robots** to effectively execute routine processes at minimal cost with high accuracy • **Digital twin** to digitize an operation and move beyond automation and integration to predictive analyses
Warehouse operations	• **Augmented reality** to assist personnel with pick-and-place tasks • **Autonomous robots** to execute warehouse operations
Inventory tracking	• **Sensors** to track real-time movements and locations of raw materials, work-in-progress and finished goods, and high-value tooling • **Analytics** to optimize inventory on hand and automatically signal for replenishment
Quality	• In-line quality testing using **optical-based analytics** • **Real-time equipment monitoring** to predict potential quality issues
Maintenance	• **Augmented reality** to assist maintenance personnel in maintaining and repairing equipment • **Sensors** on equipment to drive predictive and cognitive maintenance analytics
Environmental, health, and safety	• **Sensors** to geofence dangerous equipment from operating in close proximity to personnel • **Sensors** on personnel to monitor environmental conditions, lack of movement, or other potential threats

Source: Deloitte Analysis.

Benefit of Smart Factory

1. **Asset efficiency**

By using network of sensors, manufacturing plant is able to **generate huge volumes of data** that can be analyzed to display any **asset performance issues**. It is entirely possible for such factories to take **corrective measures and optimization** by itself through **predictive analytics and machine learning**. An increase in asset efficiency translates to lower downtime, optimized capacity, and reduced changeover time.

2. **Quality improvement**

By having analyzed data, manufacturing plant can **predict and detect quality defect trends** much earlier along with their cause. By this early detection, will **lower scrap rates** and **lead times**; thereby, increasing production rates and yield. As a result, **optimized quality process** will ensure quality improvements.

Benefit of Smart Factory

3. Lower cost

Manufacturing plants can operate with **lower inventory levels**, which can lowers their costs related to sourcing and supply networks. **Material handling** costs also drastically decrease alongside wastages and downtime, which directly translates to cost-savings.

4. Flexibility

Smart factory systems are equipped to handle different **manufacturing environments**, **production setups** and **operational tasks**, allow maximum flexibility for the manufacturing plant operation. Use of advanced sensors allow for **automatic recognition** of production demand, which then allows the manufacturing supply chain to quickly respond to the change.

Benefit of Smart Factory

5. Safety and sustainability

Smart factory benefits for **labor wellness** and **environmental sustainability**. Operational efficiencies can result in a smaller environmental footprint. Semi-automated or automated or human-machine collaborated process flow may provide for less potential for **human error**, including **industrial accidents** that cause injury. The smart factory's relative self-sufficiency will likely replace certain roles that require repetitive and fatiguing activities.

Training needs in implementing Industry 4.0

General

Competences are the **knowledge**, **skills**, displaying **professional attitudes**, and **behavior** that relate to a **successful performance** of people in their work, functions or responsibilities.

Competence can be developed by:

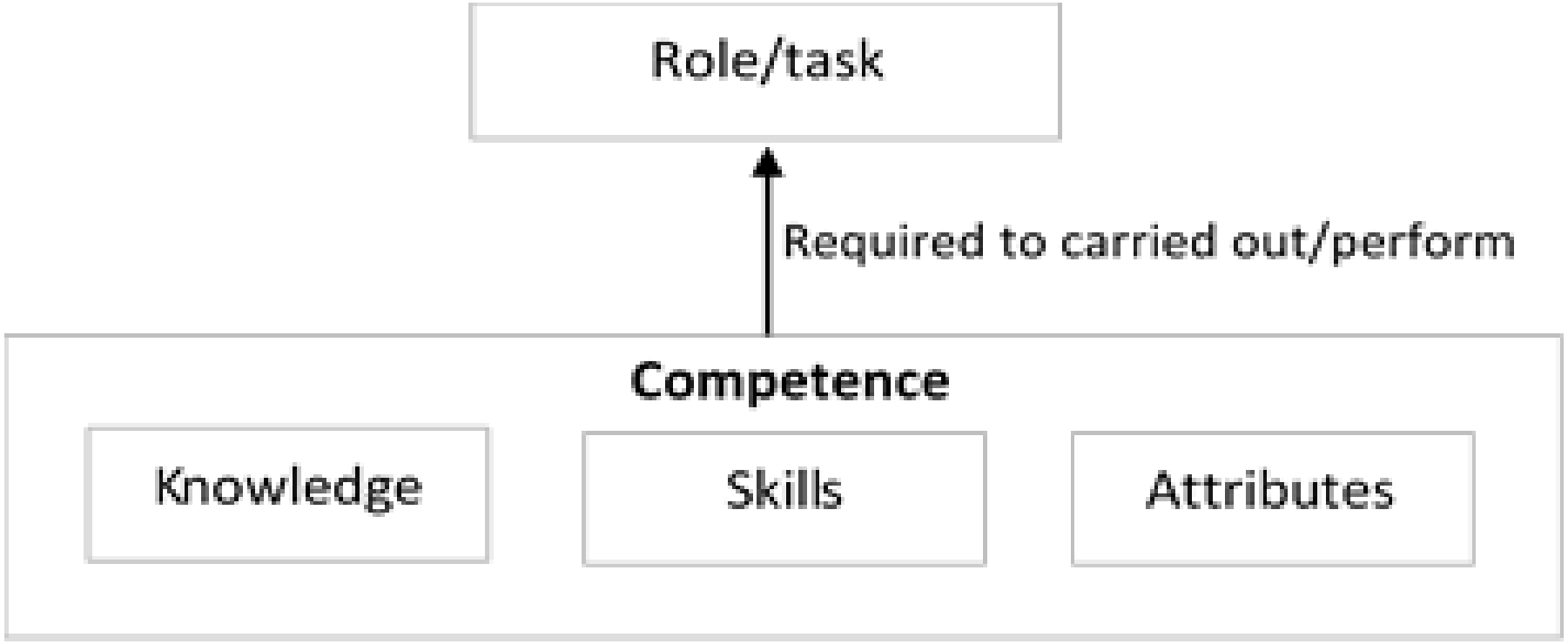
- **learning**, which can be formal, non-formal and informal or a combination of each.
- **training** and **experience.**
- combining knowledge and skills with a professional **attitude**.
- **experiential learning**.

General

The idea behind industry 4.0 is to blend systems and people – creating an integrated smarter workforce that achieves more. One of the challenges involved in making this into reality is making sure the teams have the skills needed to work alongside the machines. The four (4) main categories of identified competencies are:

- ✓ **Technical competence**: Competences in Information system and operational system.
- ✓ **Methodological competence:** Creativity, entrepreneurial thinking, problem solving, conflict resolution, decision making, and analytical skills.
- ✓ **Social competence:** Intercultural skills, language skills, communication skills, networking skills, and ability to work in a team, ability to be compromising and cooperative, ability to transfer knowledge and leadership skills
- ✓ **Personal competence:** Flexibility, motivation to learn and sustainable mindset.

Industry 4.0 competencies



General skill & competencies

Fundamental understanding of ICT systems, automation technology & data analysis

Being aware of issues concerning data abuse & ICT security

Interdisciplinary knowledge & understanding of interconnected systems

Decision-making for automation of processing steps & planning and controlling tasks

Organisation's role

Determine necessary competencies for its key personnel

Provide training to achieve the necessary competencies

Evaluate competencies through effectiveness in implementing enabling technologies

Maintain competencies at appropriate levels

Recommended type of knowledge

- **Information system and technology** (big data analytics, cloud-based services, smart operation technology)
- **Operational technology** (cyber physical system, smart factory)
- Managing and developing **people**
- Data collection, **data** extraction and data analytics
- Managing and maintaining **digital systems** and networks
- Managing **analytics**
- **Cybersecurity**
- Management of **software** and interfaces that support operations management (resources, people, production)
- Management of **simulation** system
- **Lean** manufacturing methodologies, technique and tools
- Management of **software** and interfaces
- **Statistics**

Recommended skill sets

Ability to:

- understand the **enabling technology** for integration between OT & IT
- analyse **data** and the use of tools for understanding the business
- use and interact with **computers and smart machine** like robots, tablet etc.
- translate **vast amounts of data** into abstract concepts and to understand **data-based reasoning**
- process and **analyse data and information** obtained from machines or equipment
- understand **visual data output** and making decision based on the data
- understand machine to machine **communication**, IT **security**, **data** protection and data integrity
- effectively **collaborate** between virtual team members via technology
- filter **information** by importance and **maximise cognitive functions**
- convey **concepts** and be able to sense and **stimulate reactions**

Attitudes or attributes of workforce

- **Adaptability** and **flexibility** (to adjust readily to changes and open to innovation)
- **Analytical** and **critical** (evaluate information effectively, articulate and analyze the information)
- **Decisive** (data-based decision making)
- Be **perceptive**, (aware and capable of understanding situations and able to analyse data behaviours)
- **Responsible** and **accountable** (willing to learn from mistakes)
- **Observant**
- **Collaborative**/cooperative (able to communicate and exchange information)
- **Optimistic**
- Be **creative** and **innovative** (creativity in designing strategies to introduce new practices or solution)
- **Globally** minded and teamwork (able to work with people worldwide)

Role of management personnel/manager

Management person tasks include:

- ✓ Identify strategy needed by the organisation
- ✓ Managing risk
- ✓ Assessing organisation's current technical capabilities
- ✓ Identifying potential Industry 4.0 enabling technologies for implementation
- ✓ Formulating the technology roadmap
- ✓ Designing sustainable implementation plan
- ✓ Developing a system of rules, practices, cultures and processes to translate the industry 4.0 vision into real business value.

Role of technical middle management

The tasks of engineers include:

- ✓ Product development and design.
- ✓ Coordination, planning and feasibility studies.
- ✓ System integration and development (architecture of Industry 4.0).
- ✓ Control, monitoring, and handling of disturbances based on data-driven decision making (i.e. assuring normal operations and high quality).
- ✓ Handling of data-based systems.

Role of supervisor

The role of a supervisor includes:

- ✓ Ensuring supplies and materials are in a positive flow.
- ✓ Ensuring that all equipment are functional and safe for use.
- ✓ Maintaining a clean and safe working environment.
- ✓ Monitoring and prioritizing workflow of production to meet deadlines.

Role of operator

- ✓ The task of operators are upgraded when compared to traditional jobs.
- ✓ Smart and skilled operators perform cooperative work with robots and work-aided machines.
- ✓ Operators should have essential knowledge of data science activities & ability to work with IT solutions (such as manufacturing execution systems, MES)

Fundamental technical competence

Operator

- Able to adopt new models of work and organization.
- Able to understand, use and interact with computers and smart machines like robots, tablets, etc.
- Possess generic knowledge about the technology used

Fundamental technical competence

Supervisor

- Possess inter-disciplinary & generic knowledge about the technology used.
- Possess intermediate knowledge and understanding of the implementation of lean manufacturing.
- Able to understand and manage software and interfaces.
- Possess the ability of logical thinking & problem solving (including skills to compare, evaluate and select logical framework)
- Able to see & understand the data in granular scale.
- Able to process & analyse data and information obtained from machines/equipment.
- Able to understand visual data output and making decision based on data.

Fundamental technical competence

Technical middle management (Engineer)

- Possess knowledge & understanding on implementation of lean manufacturing.
- Able to adopt & use new or existing IT to analyse, select and critically evaluate digital information in order to investigate & solve work-related problems, and develop a collaborative knowledge body.
- Able to create valuable insight & utilize it for creation of new value in application & solutions.
- Able to understand visual data output and making decision based on data.
- Able to understand open communication protocols, open collaboration concept & approach, network protocol & CPS configuration.
- Able to understand & control machine to machine communication.

Fundamental technical competence

Manager

- Able to define functional needs and priorities.
- Able to assess & analyse potential contribution of technology to future organization.
- Able to understand the value creation of technology adopted.
- Able to integrate cultural sensitivity & relevance, problem-based learning & advanced technology with real-world applications.
- Able to create valuable insight & utilize it for creation of new value in application & solutions.
- Possess the ability to analyse data & the use of tools for understanding the business.

Thank You