Hong Kong Society for Quality

Leveraging Industry 4.0 for enhancing overall productivity and quality performance

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About Me

Dr. Vincent Fung
Non Executive Director
Kin Yat Holdings Ltd (HKEx 00638)

Hong Kong Society for Quality

Work Experience
- Non Executive Director of Kin Yat Holdings Limited in 2021
- Board Director of Kin Yat Holdings (2005-2021).
- Executive Director in Manufacturing, Operation.
- Engineering Director in Product Design, Mold Design, New Product Development Engineering.
- 40 Years in the Manufacturing Industry in Hong Kong, Mainland China and Canada.

Academic
- Doctorate Degree in Engineering in The Hong Kong Polytechnic University
- Master Degree in Engineering and Business Management in Warwick University UK.

Excellence
- A Board member for corporate strategy and new business development.
- Transformation from a conventional toy and small home electrical appliance into a highly automated, robotic manufacturing system towards smart manufacturing environment.
- Opened new business segment into Robotics products, such as iRobot Vacuum Cleaner, IoT smart devices.
- Incubation shop floor for Start-ups

Smart Manufacturing & Smart Quality

<u>Traditional quality control system</u>, which includes many "**Variables**":

1. Incoming Quality Control / Supplier Quality Assurance
2. In-process Quality Control
3. Line Production Quality Control
4. Final Quality Audit
5. Out of the Box Audit

- These are independent of each other
- Linked by individuals with no clear information on the **variables**
- Data and information are continually changing during manufacturing

<u>Industry 4.0 promotes</u>:

1. Digital Automation
2. Data Visualization
3. Intelligent Manufacturing
4. Smart Quality Control

- Meet customer expectation
- Minimize wastages in material
- Shorten manufacturing time
- Maximize production output
- Increase throughput rate

Smart Manufacturing & Smart Quality

Variables or variations manufacturing are the most common cause of product rejects whether it is **internally** or **in the field** that accounts for customer complaints.
These can be attributed to the 5 fundamental causes:

- Manpower (People) - causes are in humans, under skilled, not paying attention
- Machines - causes are in equipment, such as machinery, computers, tools, instruments, technology
- Materials - causes are in defect or material properties
- Methods - causes are in the Processes, machine setup, standards
- Management - causes are in improper management

Quality at Design

Where do Quality Starts?

- It doesn't start at Incoming Quality Control (IQC)
- or when the production line
- or injection moulding tools
- or raw materials are arriving for the start of mass production.

It actually starts at the design and development stage

1. The best design is adopted (DFMEA)- Design failure mode and effect analysis
2. The best material is selected
3. Maximising Product endurance
4. Safety and regulatory requirements
5. Manufacturability and sustainability with Quality (PFMEA)- Potential Failure Mode and Effects Analysis

Quality at Design

The design is normally verified by the Quality group, which deploy a "Six Step QA testing" regime to determine the following "Six success factors":

Six Success Factors
1. Product Enduring Test – to determine the tear and wear
2. Product Functionality Testing – to test the product function and features
3. Product Safety Test – UL/ EU Hi pot Test
4. Product Abuse Testing
5. Product Environmental thermo shock testing to determine the effects at extreme environment
6. Product Fit for use against design intent

The new product will need to pass all the **Design reviews and Gating** and also any Corrective Actions to address any outstanding issues, before it can be signed off for mass production.
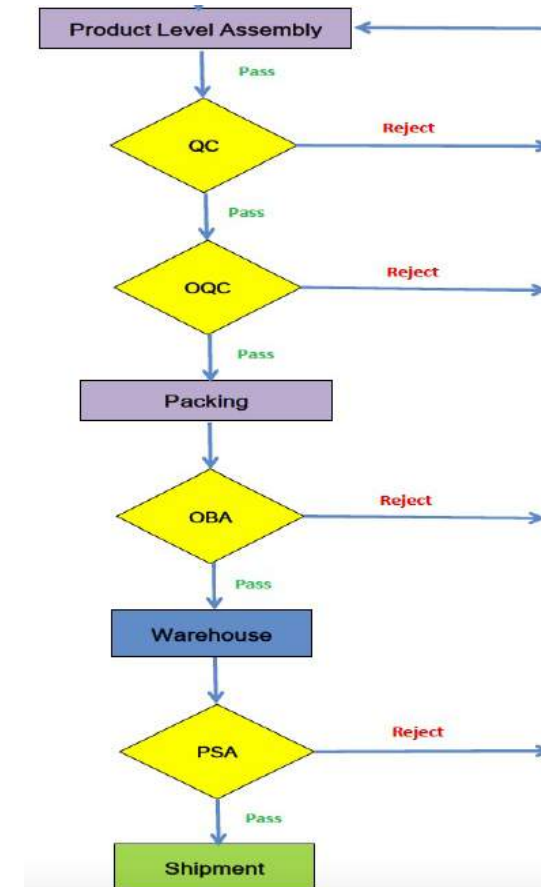
Traditional Product QC Flow

A. Material/Modular Level
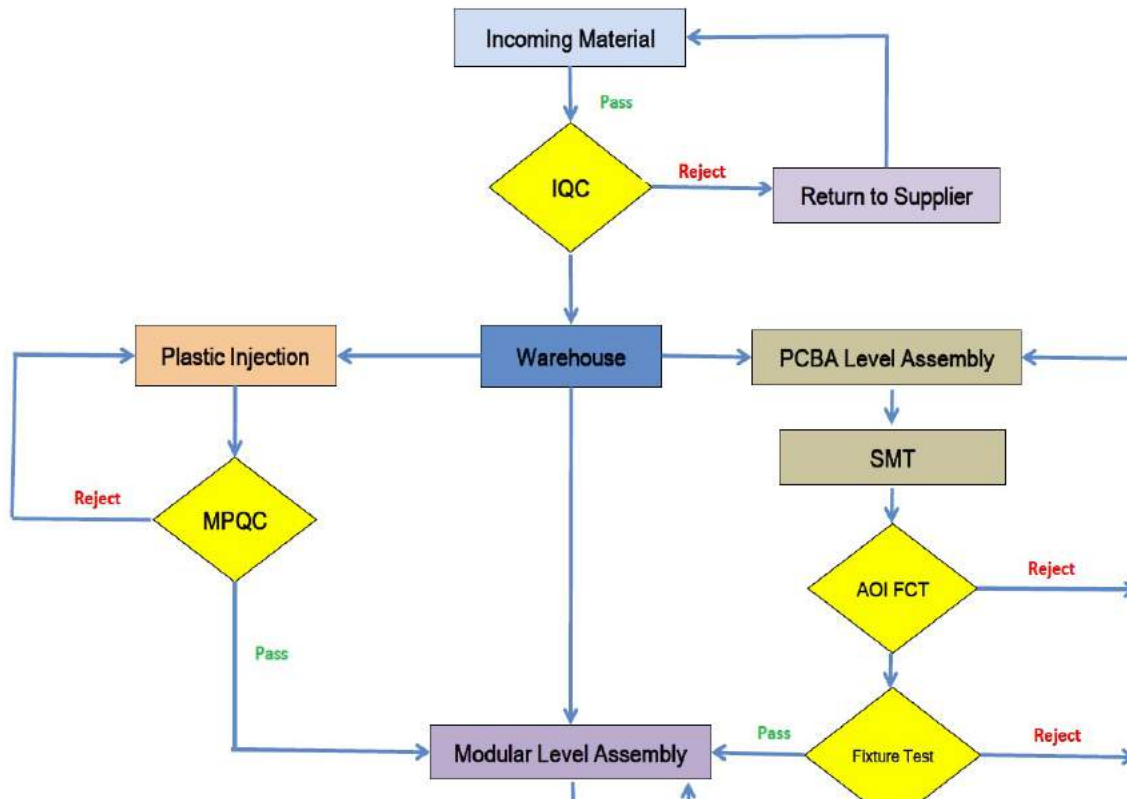
B. Product Level

Traditional Defect Analysis – 8D Report

One of the most commonly used tools for problem solving in manufacturing - The Eight Disciplines (8D)

- D1 • Establish the Team
- D2 • Defining the problem or Problem description
- D3 • Containment/Short-term/Interim Actions
- D4 • Identifying & Verifying Root Cause
- D5 • Identify/choose Permanent Corrective Actions
- D6 • Implement Permanent Corrective Actions
- D7 • Preventive Actions
- D8 • Team Recognition

8D Report Example

Six Steps QA Testing

**Quality Assurance.
Testing Laboratory**

Certified Physical Lab

Component Parts

Finished Products

Reliability Sub Assemblies

**(1)
Safety
Compliance
Testing**

**(2)
Dimensional
Analysis**

**(3)
Fit For Use. (FFU)
Transit Tests**

**(4)
Reliability Test (RT)**

**(5)
Performance Testing:
Electrical/Electronic**

**(6)
Performance Testing.
Mechanical**

- ASTMF963,
- EN71-1,
- Approbation: UL, GS, etc.
- RoHs
- PAH
- REACH

- CMM
- CMC Quick Scope
- Automatic 2D (Optical)
- Caliper, Micrometers / Gauges / Slip Gauges Height Gauge / DTI

- Humidity / Environmental Chamber.
- Sound Power Room.
- ESD
- Vibration/Transportation Testing.
- Drop / Compression.

- Reliability Testing
- Test to failure (Abuse Test)
- Mobility Test
- Straight Line
- Cleaning Test

- IPC-A-610
- Hi Pot Testing.
- Battery Life Simulation Test.
- ICT Test Fixtures
- Thermal Shock test
- ESS (Environmental Stress Screening)

- Hardness Testing.
- Power Cord Flex testing.
- Push / Pull Force Testing.
- Compression / Pressure Tests.

Smart Quality

In an intelligent or automated manufacturing industry, the business management system is generally composed of FOUR integrated management systems

1. **PLM** – Product Lifecycle Management (Technical Syst)
2. **ERP** - Enterprise Resource Planning (Business Mgt Syst)
3. **MES** – Manufacture Execution System (Production Syst)
4. **Smart Quality** – Measurement and Quality System (Quality Syst)

Real time quality tracking data and product traceability are the most critical closed-loop data for 5M adjustments during mass production to reduce rejects are wastage.

- **Manpower** - causes are in humans, people
- **Machines** - causes are in equipment, such as machinery, computers, tools, instruments, technology
- **Materials** - causes are in defect or material properties
- **Methods** - causes are in the rules, regulations, laws or standards
- **Management** - causes are in improper management

Smart Quality

A. Quality Information System (QIS)
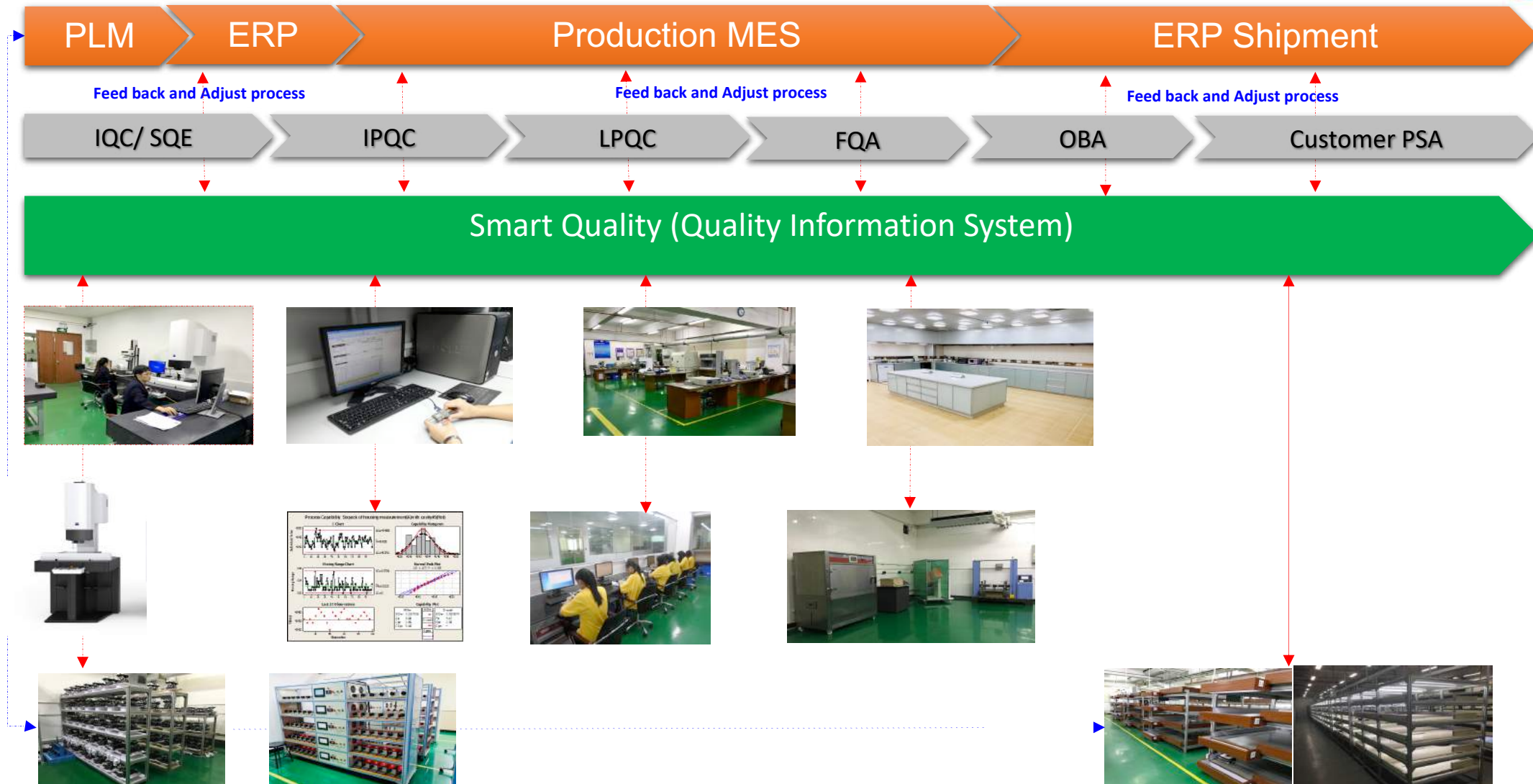## B. Integrated close loop Smart Quality System

	Function	Advantages
1	System Management	Document management system, based on customer Quality Specification Requirements in Digital Format
2	Data Collection	Auto alarm if data is abnormal, it also has Auto- collect data on some measuring equipment. Eliminate paper work (hardcopies)
3	Chart Analysis	>200 different charts and graph including CP, CPK, PPK . For tracking and process adjustment in Digital Format
4	Quality Monitoring	Allows Management to "Real Time" manage the processes by 24/7
5	Quality Improvement	Automatically follow through improvement on discrepancies with CAP/8D
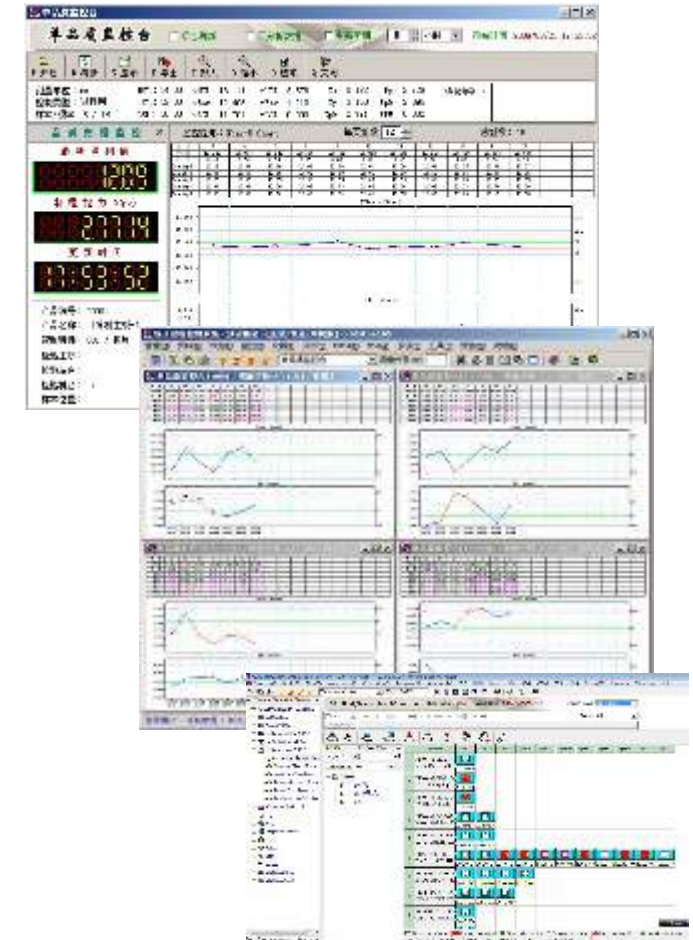
•Ishikawa diagrams also known as cause-and-effect or fishbone diagrams.
•Pareto charts or Pareto diagrams.
•5 Whys.
•5W and 2H (who, what, where, when, why, how, how many or how much)
•Statistical process control.
•Scatter plots.
•Design of experiments.
•Check sheet.

Smart Quality – Close Loop Integration

PLM ➤ **ERP** ➤ **Production MES** ➤ **ERP Shipment**

Feed back and Adjust process   *Feed back and Adjust process*   *Feed back and Adjust process*

IQC/ SQE ➤ **IPQC** ➤ **LPQC** ➤ **FQA** ➤ **OBA** ➤ **Customer PSA**

Smart Quality (Quality Information System)

Smart Manufacturing –
Digital Transformation

	Traditional Manufacturing	Smart Manufacturing
Prototype (NPI)	Back and forth review	Digital prototypes Customer Integration
Injection	Rely on daily report	Real-time OEE monitoring
SMT	Non-predictive maintenance	SPI / AOI / ICT / MES
Assembly	Skillset rely on workers	Smart Factory Additive Manufacturing
Inspection	Knowledge rely on inspector	Digital Twin Big Data and Analytics

Smart Manufacturing –
Injection Workshop Transformation

- MES deployment for data collection
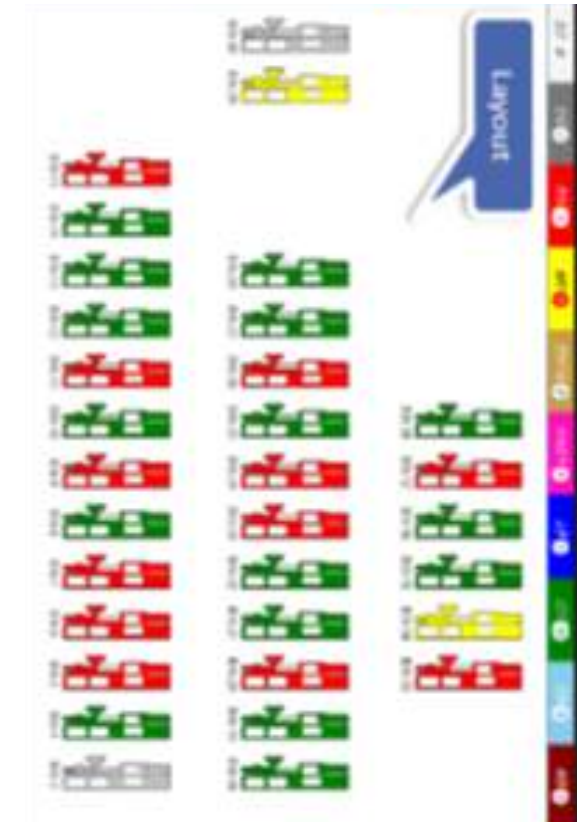
Smart Manufacturing –
SMT Floor Transformation

Automated Production Systems with data integration

- ❖ SPI (Solder Paste Inspection)
- ❖ AOI (Automated Optical Inspection)
- ❖ ICT (In-Circuit Tester)

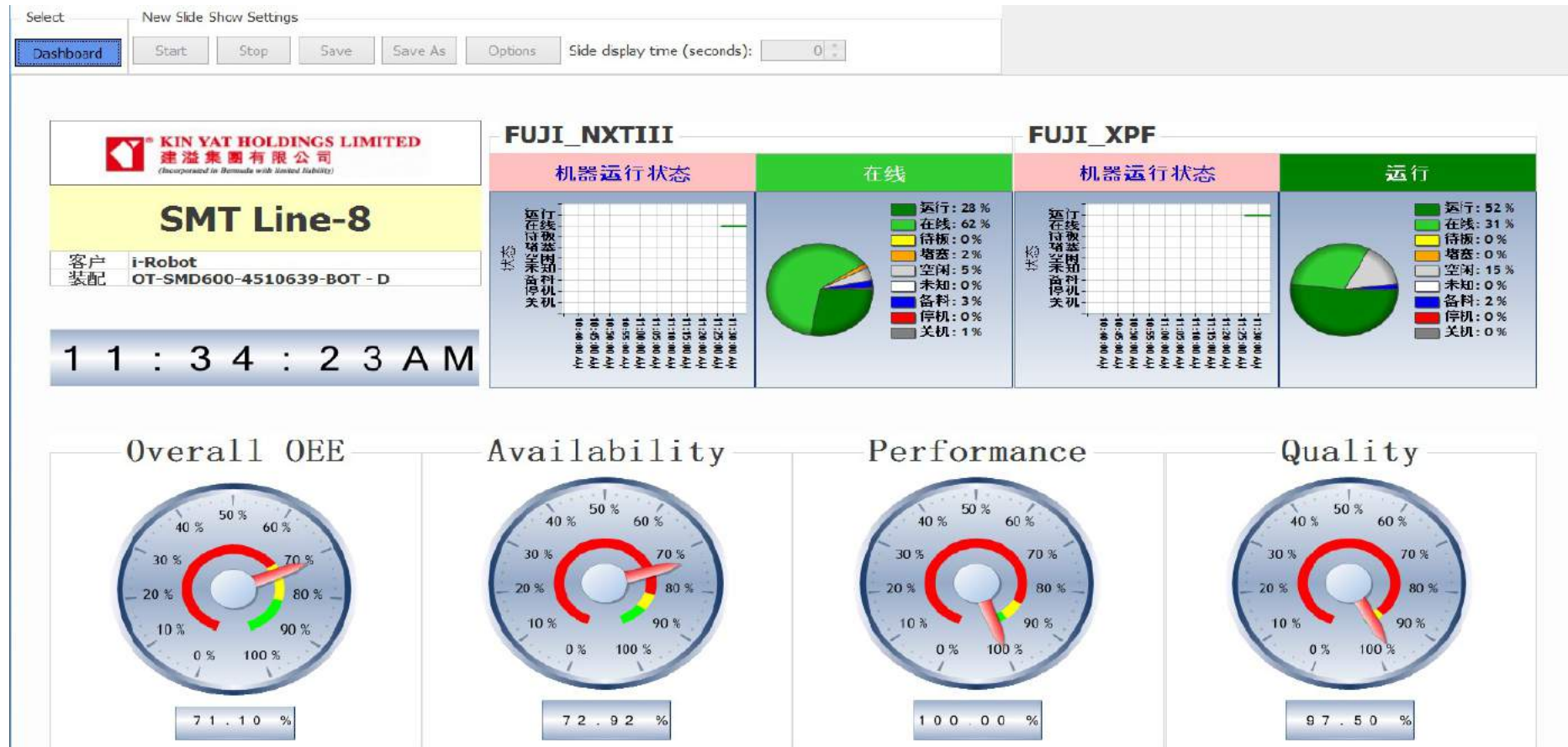Connect (16) SMT lines into private cloud

Smart Manufacturing –
SMT Floor Transformation
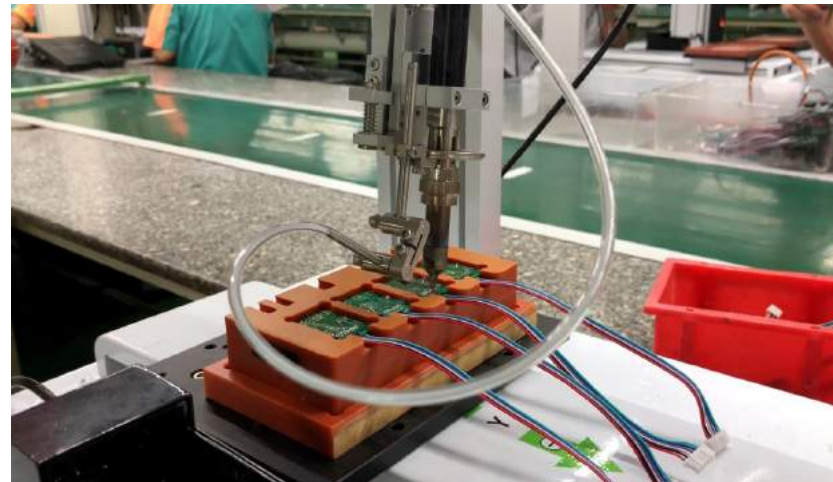
MES Deployment

- Traceability is possible, connect individual work station

Smart Manufacturing –
Assembly Line Transformation

Auto / Semi-auto
Lead & Data Integration

Smart Manufacturing –
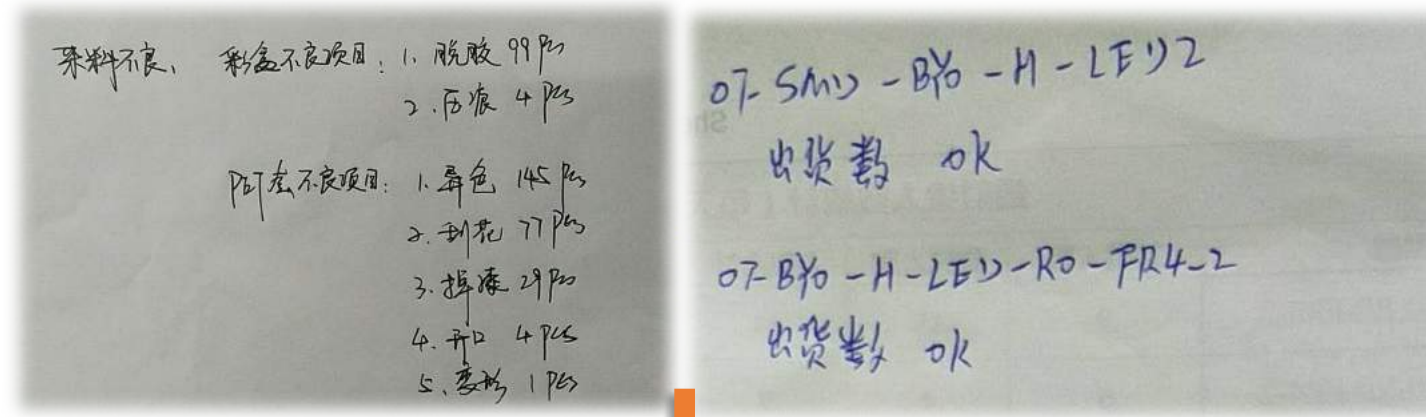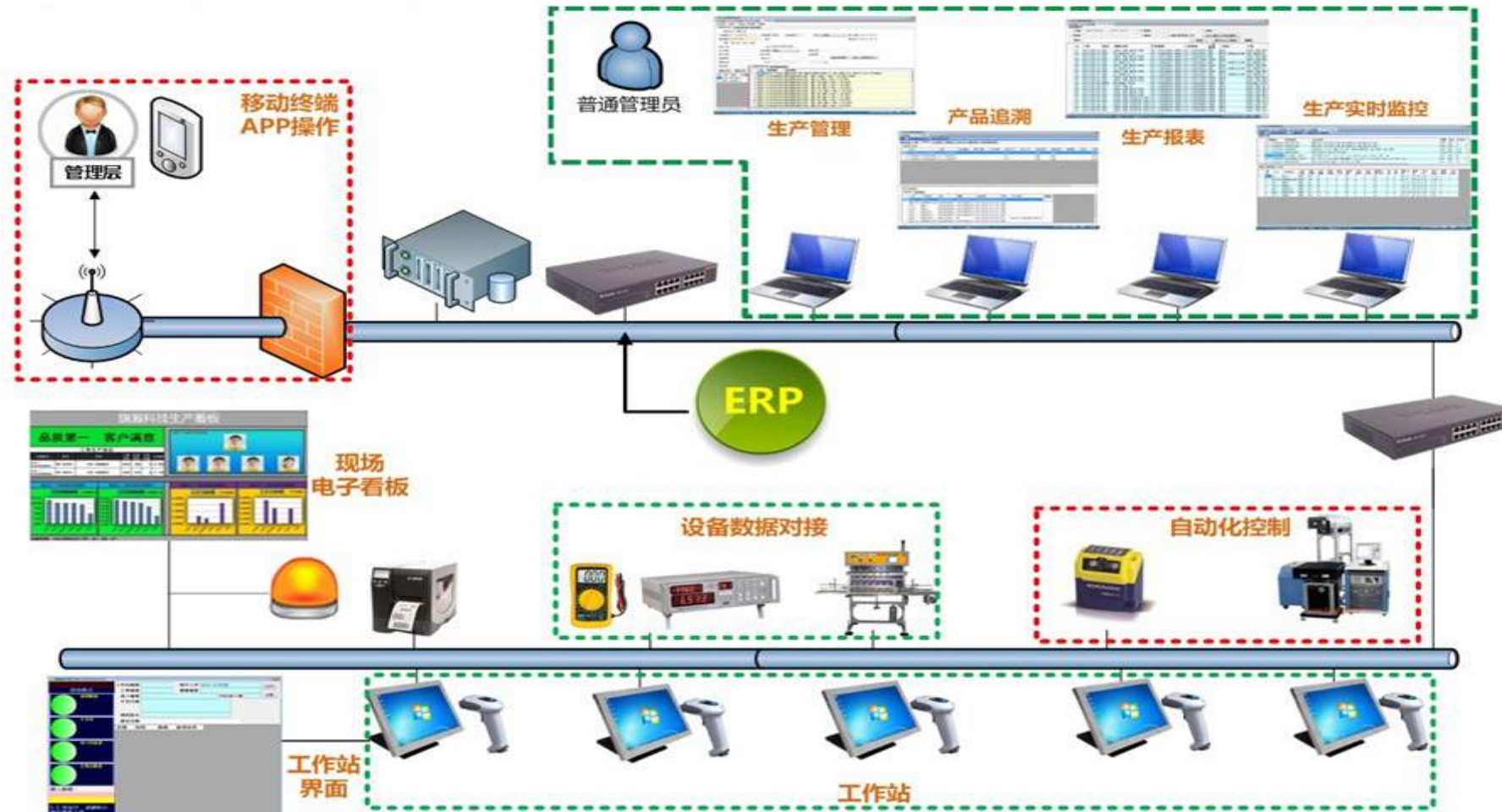## Data Integration (Hand Script)

Fig.: Record production data on paper

Fig.: Later documented in electronics format

Smart Factory –
Data Integration (Shop Floor Information System -SFIS)

Smart Factory & Smart Quality

Experience Sharing (1)

Smart Manufacturing – Jenga (1)

- Low product value
- High Play value
- Evergreen item
- Over 35 years at the same price
- Competitive production cost to other countries via Smart Manufacturing
- From 120 workers to 24. Target to cut to less than 10.
- Quality up to 95% while human was 85-90%

Manual Inspection

Video : Traditional Method to sort and quality check on the Jenga
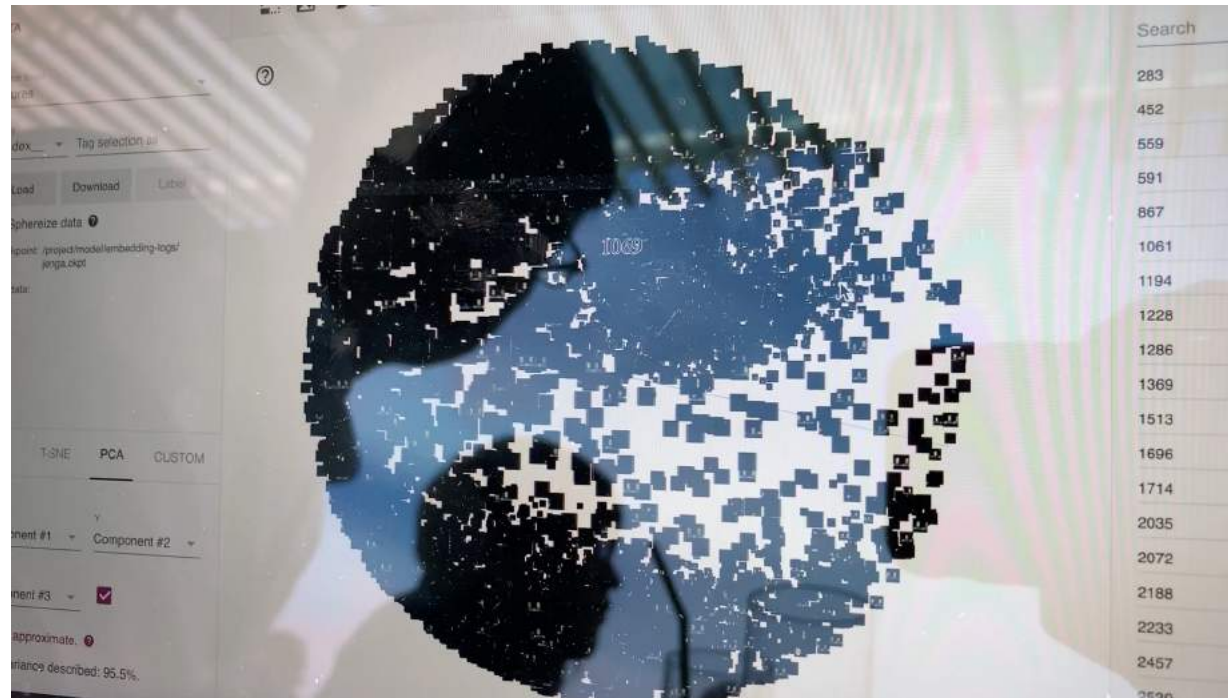
Manual Inspection – Problems

1. In-consistency and objectivity from inspector

2. Low efficiency and limitation in capacity

3. Cost of labor

Smart Manufacturing - AI Inspection

Unsupervised Learning by K-means Clustering

Smart Manufacturing - Labelling

Stain	Fungal Stain	Heat-stamp Color Deviation	Machine Bite	Rough Surface

Wavy Grain	Heat-stamp Blurry	Dent	Wormholes	Grain Color Variance

Torn Grain	Live Knot	Dead Knot	Chip Mark	

Smart Manufacturing - Manual vs AI Inspection

AI Inspection:

- **Improved the level of consistency in quality conformity**

- **Reduced false-defective rate**

Manual Inspection:

- **Human eyeball lost concentration and being fatigue upon long hours focusing**

- **Human eye adapts to the stimuli, cannot hold alert to dynamic production flow**

Comparison of Throughput Rate bewteen Manual and AI Inspection

TH Rate

- AI Inspection
- Manual Inspection

Hours passed
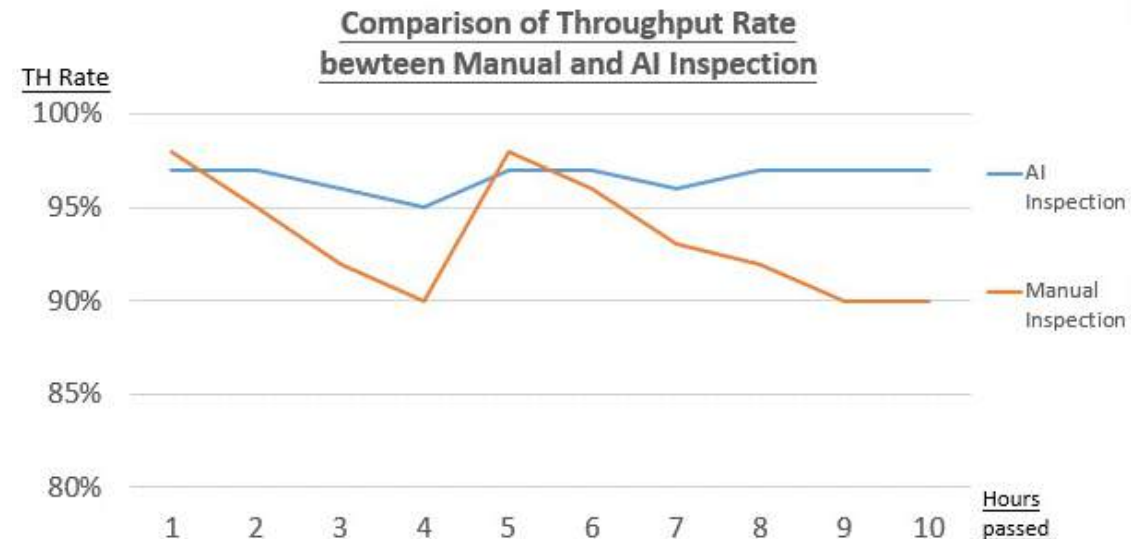
Smart Manufacturing - Jenga

Automated production line & intelligent inspection system

Technology Adoption:
- Image recognition
- Machine Learning
- Deep Learning
- ANN, Data Analytics, AI

Results,
- Reduce of no. of workers (Lean)
  -> Lower labor cost
- Reduce human errors
  -> Higher production efficiency and less wastage,
  -> Low O/H cost

Smart Manufacturing - Jenga

Video : Jenga - fully automated production line with intelligent inspection system

Smart Factory & Smart Quality

Experience Sharing (2)
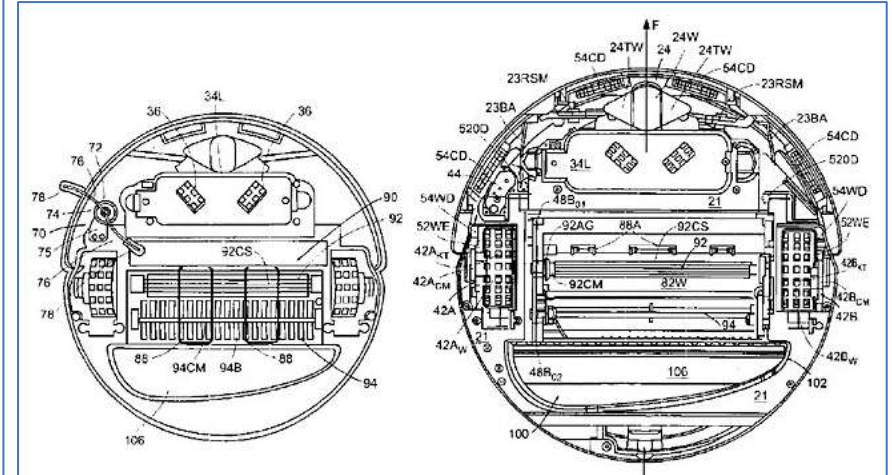
Smart Manufacturing – Roomba (2)

Smart Manufacturing - Roomba

Smart Manufacturing in NPI

1. Cost estimation and financial budget (Tooling Investment).
2. Tooling build via "Freeform" software.
3. <u>Quality team - product testing by simulation software.</u>
4. Manufacturing team - machine allocation and human resource.

Smart Manufacturing - Roomba

Smart Manufacturing - Roomba

Smart Manufacturing – Roomba
with smart quality implementation

Video: Robots to replace the operator on functional test station in quality control

34 tests consolidated into 6 categories of sensing devices.
1. Cleaning Head (CH) Module
2. Side Brush (SB) Module
3. Wheel (WM) Module
4. Vacuum Bin (VB) Module
5. Bumper Module (BM)
6. Sensor Modules (SM)

Smart Manufacturing - Roomba

Smart Manufacturing - Roomba
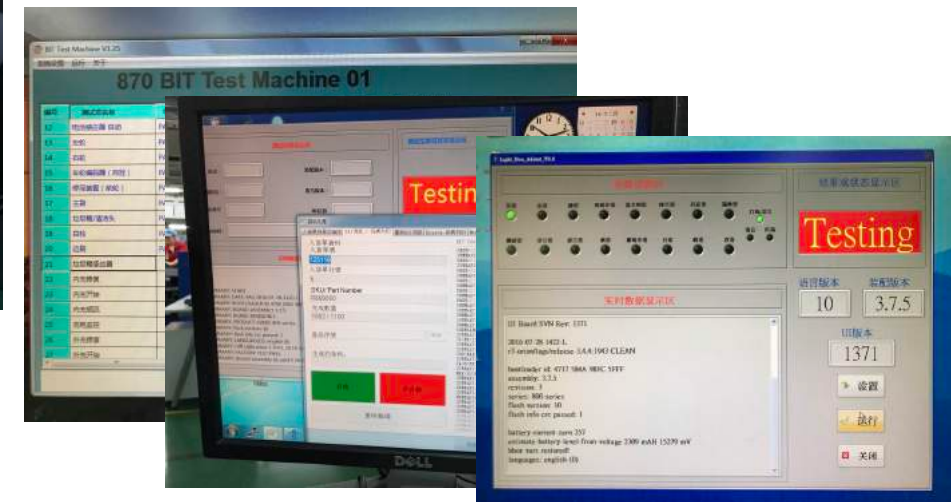
Video: In Line Assembly Process
– Mitsubishi Robot Arms
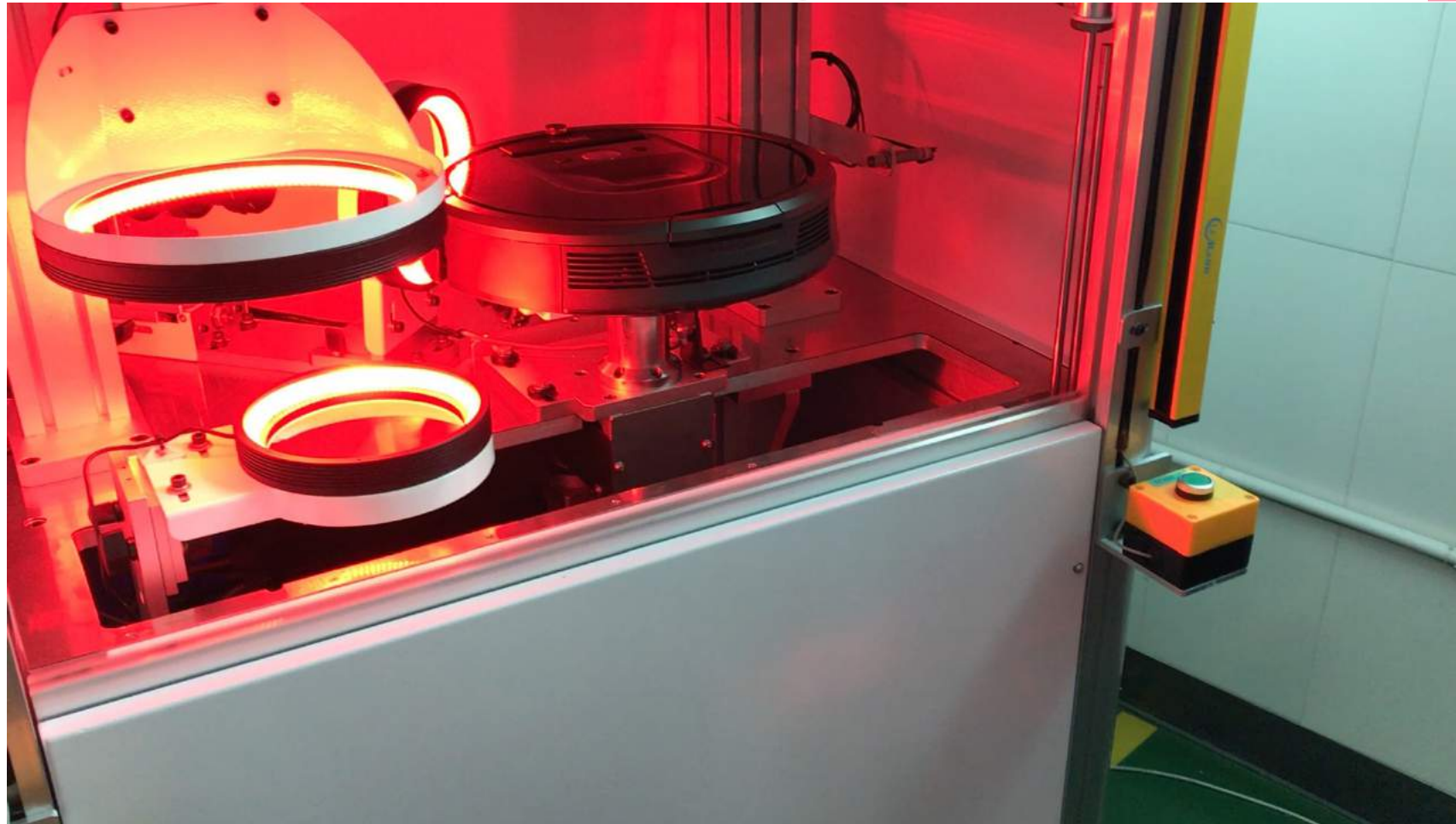
Video: Single Work Station
– Automatic Nuts and Bolts assembly with a
tight quality control tolerance

Smart Manufacturing – Roomba

Database — reference data for optimal parameters

Collect parameters, data, defect rate

machines

Collect parameters, data, defect rate

adjust the parameters to optimal base on clustering result

Computers

Clustering, Visualization of result

Operators
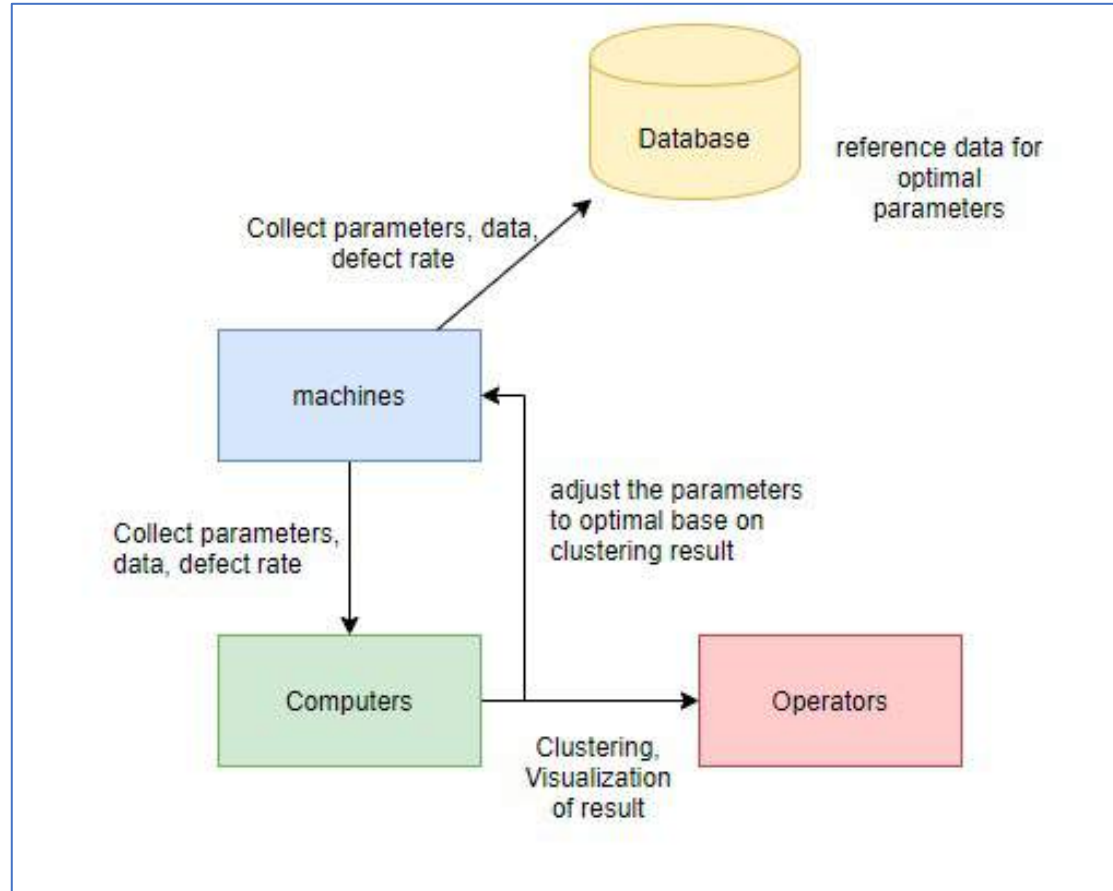
CPS Readiness

Monkey Brain

Private Cloud

Edge Computing

Enable Digital Twin formation

Quality Performance monitoring

Dynamic Data Collection

Real Time access remote / off shore

Immediate software update / upgrade

Immediate Engineering Changes

Smart Factory & Smart Quality

Experience Sharing (3)

Smart Manufacturing – SMT (3)

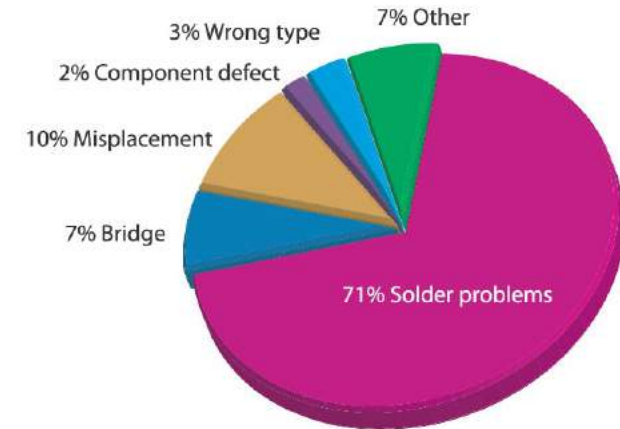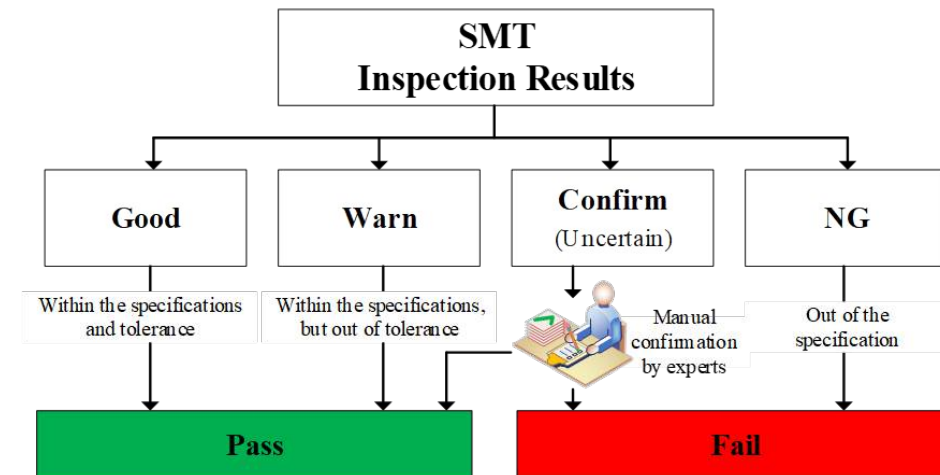Figure : Average defective rate (71%) in Solder Paste Printing process (MEK)

Smart Manufacturing – SMT

Smart Manufacturing – SMT
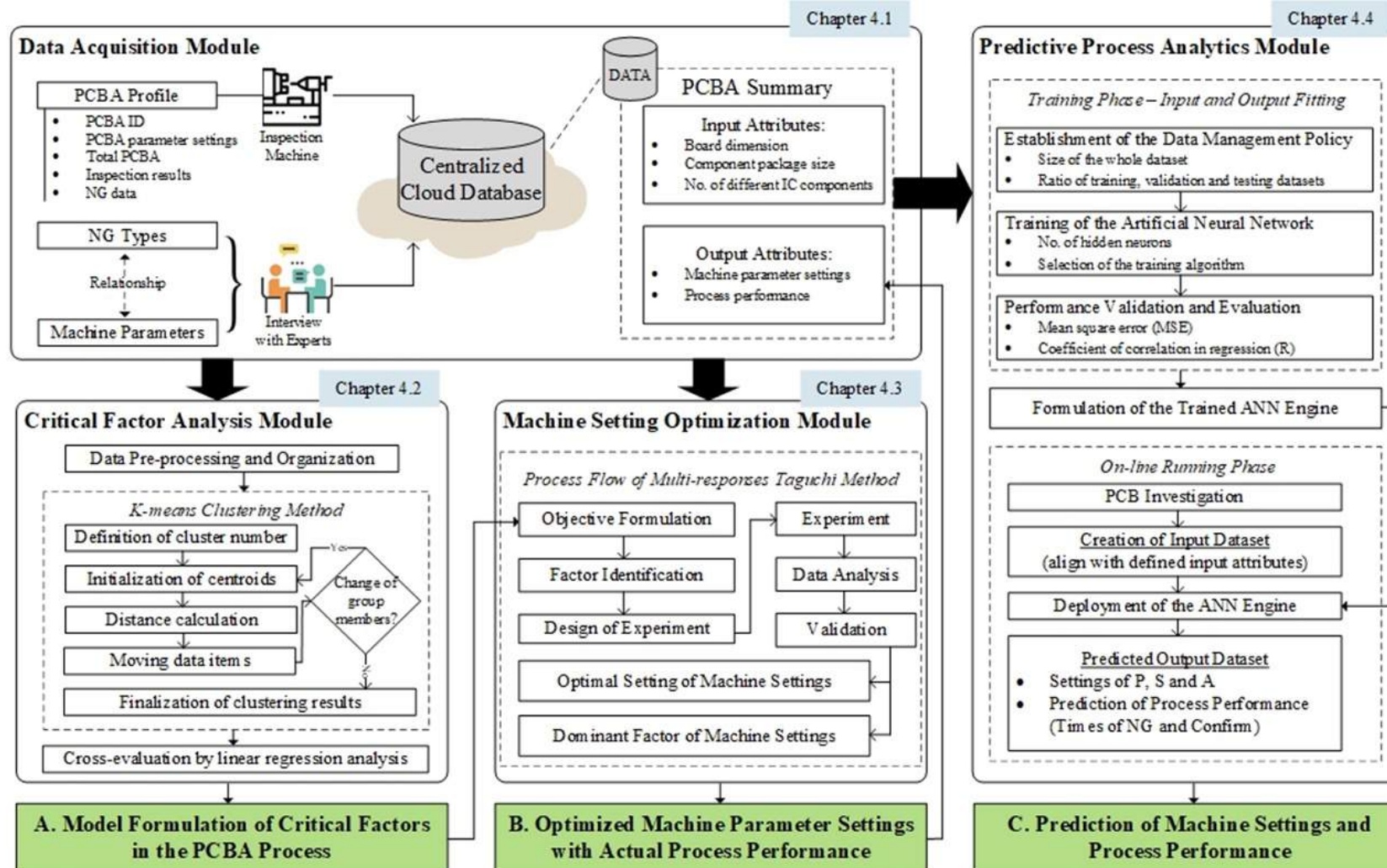
- **14 types of NG defect,**
- **unstructured machine dataset,**
- **data cleaning**
- **Taguchi, signal-to-noise ratio**
- **Training, validation and testing**

Smart Manufacturing – SMT

Wastes from Traditional and Proposed Approaches

- Traditional Approach
- Adoption of the SMPIS (n=3)
- Adoption of the SMPIS (n=5)
- Adoption of the SMPIS (n=10)
- Adoption of the SMPIS (n=15)

Number of Expected NG (y-axis): 0, 20, 40, 60, 80, 100, 120, 140, 160

Number of PCBs to be handled (x-axis): 0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000
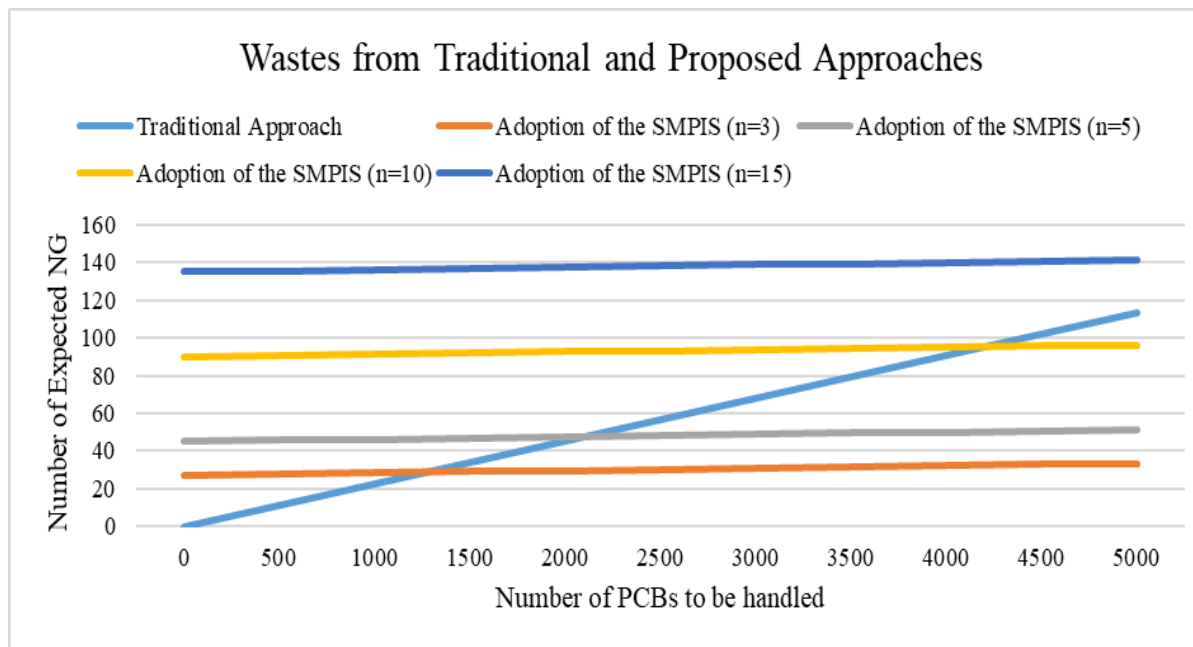
- Before: the average yield loss was approx. <u>2.265%.</u>

- After: the average yield loss was approx. <u>0.126%</u> with $9n$ number of PCBs for trials.

Conclusion

quality management

coordinated activities to direct
and control an organization
with regard to quality

continual improvement

recurring activity to increase
the ability to fulfil
requirements

quality planning
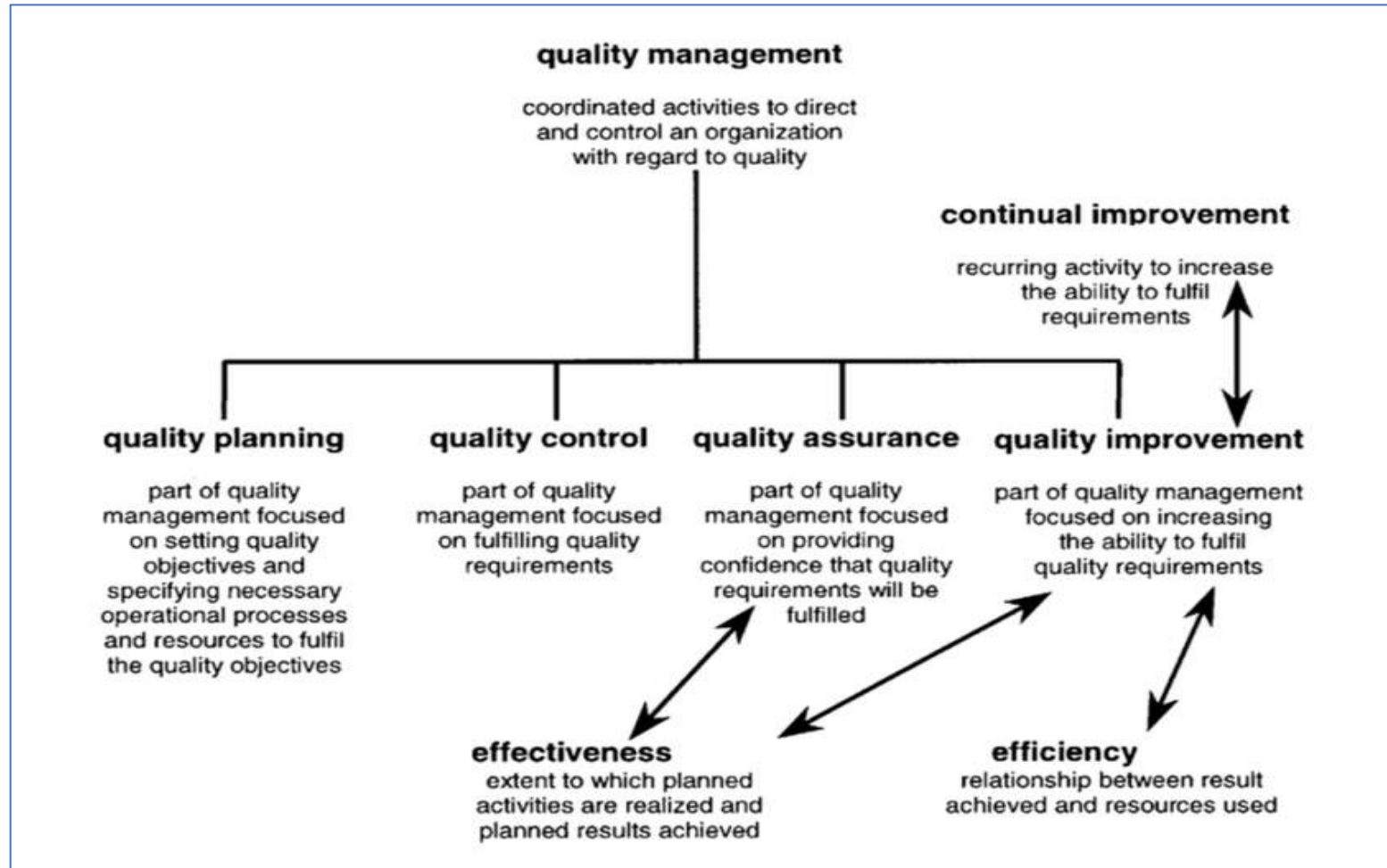
part of quality
management focused
on setting quality
objectives and
specifying necessary
operational processes
and resources to fulfil
the quality objectives

quality control

part of quality
management focused
on fulfilling quality
requirements

quality assurance

part of quality
management focused
on providing
confidence that quality
requirements will be
fulfilled

quality improvement

part of quality management
focused on increasing
the ability to fulfil
quality requirements

effectiveness
extent to which planned
activities are realized and
planned results achieved

efficiency
relationship between result
achieved and resources used

Last but not least......

Industry 4.0
1. Digital Automation
2. Data Visualization
3. Intelligent Manufacturing
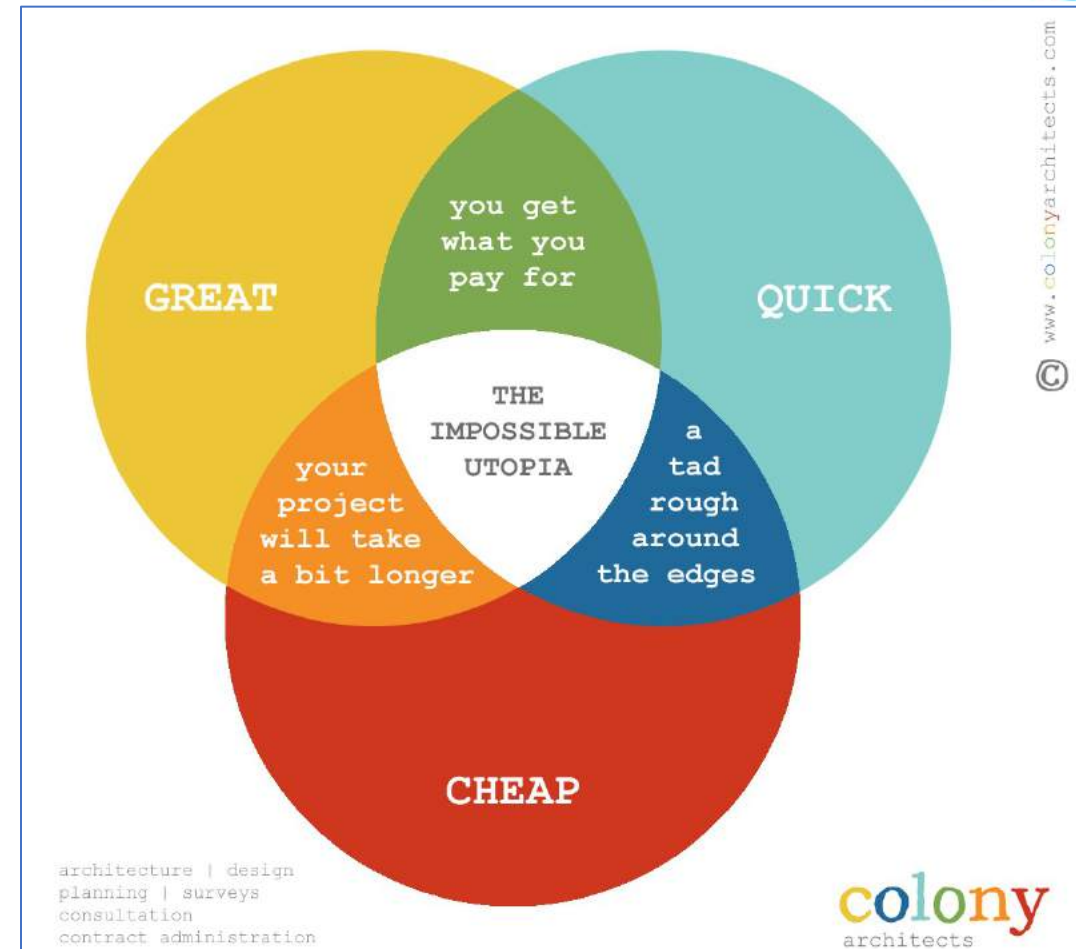4. Smart Quality Control

Quality at Design
1. DFMEA
2. PFMEA
3. 5M
4. QIS
5. Six Step QA testing
6. Six Success Factors

With Smart Quality System Implemented:
1. Production Efficiency with more than 70% improvement
2. Defect Rate with more than 94.4% reduction

Last but not least......

Thank you !

My Contact: fung_vincent88@hotmail.com

Vincent WC Fung