The Evolution of the PCBA Electronics Manufacturing Processes and the Future of Innovation

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The Evolution of the Electronics Industry

Transistor by transistor, smaller components, new devices and the change to the SMD technologies, the electronics industry is literally changing the world and right now there are more than one billion transistors for each person on the planet. With these new innovations, it’s no surprise that the electronics industry outspends all other industries in research and development.

Despite an impressive track record of pioneering technology, however, today’s electronics industry is itself in a state of disruption. Product life cycles are compressing, emphasizing the need to create innovative products and services faster and cheaper than ever before.
The Evolution of the Electronics Industry

Competitive pressures are at an all-time high, with aggressive new entrants and a continuing need to contain operational costs. And though profit margins for some electronics segments, including network equipment and medical devices, remain relatively high, most others are under heavy margin pressure.

Together, these trends are driving electronics companies to find new growth opportunities and new ways for lean manufacturing processes. CEOs realize that innovative products and services are only successful when those products and services deliver on customer needs.
The Evolution of the Electronics Industry
The Evolution of the Electronics Industry
The Evolution of the Manufacturing Process

Electronic Assembly Process Requirements:

• **PCBA Design**
  - Mother Panel type, size and Panelize (1-up, 2-up... n-up)
  - Type of Components (SMT, Through Hole)
  - Physical Layout (Components Population and % per side)
  - Tooling (SMD Stencils, work-holders, jigs, fixtures, assembly stations, etc)
  - Materials (solder paste, solder, flux, conformal coating, etc)
  - Specific Manufacturing Design Rules

• **Assembly Requirements**
  - Equipment and assembly stations
  - Processes (SMT, Hand Insertion, Soldering, Testing, Programing and Assembly)
  - Sequence (Process Flow Chart)
  - Specific Customer Requirements (100% X-Ray, Conformal Coating, 3D SPI and AOI (2D or 3D), Laser Marking, Traceability, etc.)
Surface Mount Assembly Board Types

Type I
- Exclusive SMT
- Single or double-sided mounting

Type IIA
- Mixed Technology
- Topside: SMT and PTH components
- Bottom side: simple SMC only

Type IIB
- Mixed Technology
- Any SMC top or Bottom
- PTH top or top/bottom

Type III
- Underside Attachment
- PTH Top Side
- Simple SMC Bottom Side
Traditional Electronics Manufacturing process

- Mixed Brands/Technologies
- SMT Lines (Single or Dual)

Analysis and Rework

Testing

Singulation

Visual Insp.

Packaging

Market Place
Traditional Electronics Manufacturing process

- SMT single lines (Single or Dual Lanes)
- Hand or Automatic Insertion for thru hole components
- Wave, Selective and or Manual Soldering process
- One station for Analysis and Rework
- Standalone Testing
- Several Visual Inspection (operator dependent)
- In some cases PCBA Final Assembly Cells
- Mixed Brands/Technologies
Traditional Electronics Manufacturing process

- Excessive material and transportation between each process
- High Energy Consumption
- High Labor Costs
- Quality Inspection mostly Operator dependent
- Excessive PCB handling and SCRAP (damaged components)
- Low Speed, Low FTT and Low defects detection
- High Operational and Manufacturing Costs
KPI’s
Key Performance Indicators
Key Performance Indicators

A performance indicator or key performance indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organization or of a particular activity in which it engages. Often success is simply the repeated, periodic achievement of some levels of operational goal and sometimes success is defined in terms of making progress toward strategic goals. Accordingly, choosing the right KPIs relies upon a good understanding of what is important to the organization. These assessments often lead to the identification of potential improvements, so performance indicators are routinely associated with 'performance improvement' initiatives.
Key Performance Indicators

• BTS (Build to Schedule)

Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. It is an important tool for manufacturing, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, what quantity, mix and sequence, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs.
Key Performance Indicators

- WIP (Work in Process)

In-process inventory (good parts or rework) are partially finished goods waiting for completion and eventual sale or the value of these items. These items are either just being fabricated or waiting for further processing in a queue or a buffer storage.

Optimal production management aims to minimize work in process. Work in process requires storage space, represents bound capital not available for investment and carries an inherent risk of earlier expiration of shelf life of the products and quality hidden issues.
Key Performance Indicators

- FTT (First Time Through) or FTY (First Time Yield)

Also known as throughput yield (TPY), is defined as the number of units coming out of a process divided by the number of units going into that process over a specified period of time. Only good units with no rework or scrap are counted as coming out of an individual process. Also related, "first time yield" (FTY) is simply the number of good units produced divided by the number of total units going into the process. First time yield considers only what went into a process step and what went out, while FPY adds the consideration of rework.
Key Performance Indicators

• OEE (Overall Equipment Effectiveness)

Term coined by Seiichi Nakajima in the 1960s to evaluate how effectively a manufacturing operation is utilized. It is not however an absolute measure and is best used to identify scope for process performance improvement, and how to get the improvement. If for example the cycle time is reduced, the OEE will increase i.e. more product is produced for less resource.

OEE measurement is commonly used as a key performance indicator (KPI) in conjunction with lean manufacturing efforts to provide an indicator of success.
Key Performance Indicators

- R&M (Reliability and Maintainability)

**Reliability** describes the ability of a system or component to function under stated conditions for a specified period of time.

**Maintainability** is the ease with which a equipment can be maintained in order to isolate defects or their cause, correct defects or their cause, prevent unexpected breakdowns, maximize a product's useful life, maximize efficiency, reliability, and safety.

**MTBF** (Mean time between failures): is the predicted elapsed time between inherent failures of a system during operation. MTBF can be calculated as the arithmetic mean (average) time between failures of a system.

**MTTR** (Mean Time To Repair) is a basic measure of the maintainability of repairable items. It represents the average time required to repair a failed component or device.
Key Performance Indicators

• Labor (Direct and Indirect) as % of Revenue

**Direct labor cost** is a part of wage-bill or payroll that can be specifically and consistently assigned to or associated with the manufacture of a product, a particular work order, or provision of a service. Also, we can say it is the cost of the work done by those workers who actually make the product on the production line.

**Indirect Labor cost** are those costs which are not directly related to production. Indirect costs may be either fixed or variable. Indirect costs include administration, personnel and security costs.

**DL/IL Ratio = DL/(Salaries+IL+SC)**
Key Performance Indicators

Wages per hour are lower in Mexico than in China

Wages per hour in the manufacturing sector

Source: Bank of America Merrill Lynch Global Research, INEGI, ILO, Bloomberg
Key Performance Indicators

Labor Costs Main Regions

Mexico currently considered as a Low Cost Country

- Mexico: 40%
- China: 200%
- Europe: 200%
Key Performance Indicators

• Reducing Costs & Increasing Profitability

Total Manufacturing Cost per Unit Excluding Materials: this is a measure of all potentially controllable manufacturing costs that go into the production of a given manufactured unit, item or volume.

Manufacturing Cost as a Percentage of Revenue: a ratio of total manufacturing costs to the overall revenues produced by a manufacturing plant or business unit.

Productivity in Revenue per Employee: this is a measure of how much revenue is generated by a plant, business unit or company, divided by the number of employees.

Energy Cost per Unit: A measure of the cost of energy (electricity, steam, oil, gas, etc.) required to produce a specific unit or volume of production.
PCBA Manufacturing Process Evolution to Continuous Flow
Traditional Manufacturing process

Continuous Flow, Automated and Smart Process
Industry 4.0 or the fourth industrial revolution, is the current trend of automation and data exchange in manufacturing technologies, this creates what has been called a "smart factory". Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services used by participants of the value chain.
Continuous Flow Process

**Continuous Flow** in a manufacturing concept means the link of all the PCBA operations, starting from PWB loading to packaging, in a unique process flow line, reducing WIP, Labor, material Handling and floor space.

There are several continuous flow designs (single lane or dual lane):
- Straight Line
- U-Shape Line
- O-Shape Line

These manufacturing lines could include SMT, Soldering, PCBA Testing, Conformal Coating, Singulation but also Final Assembly for End Items.
Continuous Flow Principles

- Single piece flow
- Just in Time (balanced times for each operation)
- Kanban (inventory control system)
- Lean Manufacturing
- Single minute exchange of die or Automatic Change Over
- Production Planning and Control
Continuous Flow Straight Line Process Example

Type IIA
- Mixed Technology
- Topside: SMT and PTH components

Type IIB
- Mixed Technology
- Any SMC top or Bottom
- PTH top or bottom

Type III
- Underside Attachment
- PTH Top Side
- Simple SMC Bottom Side
Continuous Flow U-Shape Process Example

**Type I**
- Exclusive SMT
- Single or double-sided mounting

**Type IIA**
- Mixed Technology
- Topside: SMT and PTH components
- Bottom side: simple SMC only

**Type IIB**
- Mixed Technology
- Any SMC top or Bottom
- PTH top or top/bottom

**Type III**
- Underside Attachment
- PTH Top Side
- Simple SMC Bottom Side
Continuous Flow O-Shape Process Example

**Type I**
- Exclusive SMT
- Single or double-sided mounting

**Type IIA**
- Mixed Technology
- Topside: SMT and PTH components
- Bottom side: simple SMC only

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SMT Placers and Reflow Oven must be Dual Lane
PCB Handling equipment for Continuous Flow

- Link Conveyor 600mm
- Link Conveyor 1200mm
- Gate Conveyor
- Turning Conveyor
- Reject Conveyor 600mm
- Inverter / Flipper
- Shuttle Conveyor
- Buffer
Continuous Flow Process Benefits

- Minimum WIP and almost ZERO PCBA handling reducing SCRAP
- Lower Energy Consumption
- Lower Labor Costs
- Quality Inspection mostly Automated
- CERO Failures with Final Assembly, Quality and Customer
- Immediate reaction to any quality issue
- High Speed lines, High FTT and 100% defects detection in line
- High Competitive Operational and Manufacturing Costs
- Significant Floor Space Reduction (>20%)
Requirements for a Continuous Flow Process

- Assure DFMA for any new product or engineering change

- Automate transportation (Link Conveyors, Turning Conveyors, Inverters, Module Gates, FIFO or LIFO Buffers, etc.) with SMEMA and/or any other equipment communication protocol to reduce material handling

- Balanced cycle times in all the manufacturing operations

- Automate material feeding to the production lines

- Aggressive implementation of BKM for the manufacturing process (Soldering, Testing, Singulation, Automatic Inspection and Poka-Yoke’s)

- Robust and full proof either manual or automated assembly stations

- Assure local technical proficiency
Reducing Maintenance Costs

Improving Maintenance Performance:

% PM tasks/Man-hours reduction

% Indirect labor reduction

- Change from Emergency mode to Preventive mode
- Focus in value added PM for new machinery
- Increase Technical Skills
- Reduce spare parts complexity
Benefits of Automation and Innovation in Mexico

- Exceed customer expectations
- Reduce/eliminate material handling (main cause of damaged components)
- Reduce or eliminate Internal and Customer Quality Rejects caused by workmanship errors
- Assure 100% Testing coverage thru all the process
- Eliminate manual stations for Red/Critical assembly operations where operators with high expertise, training and ability are required, and excessive attrition/operator rotation affect the throughput and quality performance of the line
- Increase productivity and improve manufacturing costs by reducing labor even though investment could be higher than labor saving
Automation and Innovation

Difficult Insertion/Assemblies

Labeling/Thru Hole Placement

Parts Assembly and Packaging
Increasing Productivity

>50% improvement

Pieces per Head

Timeline