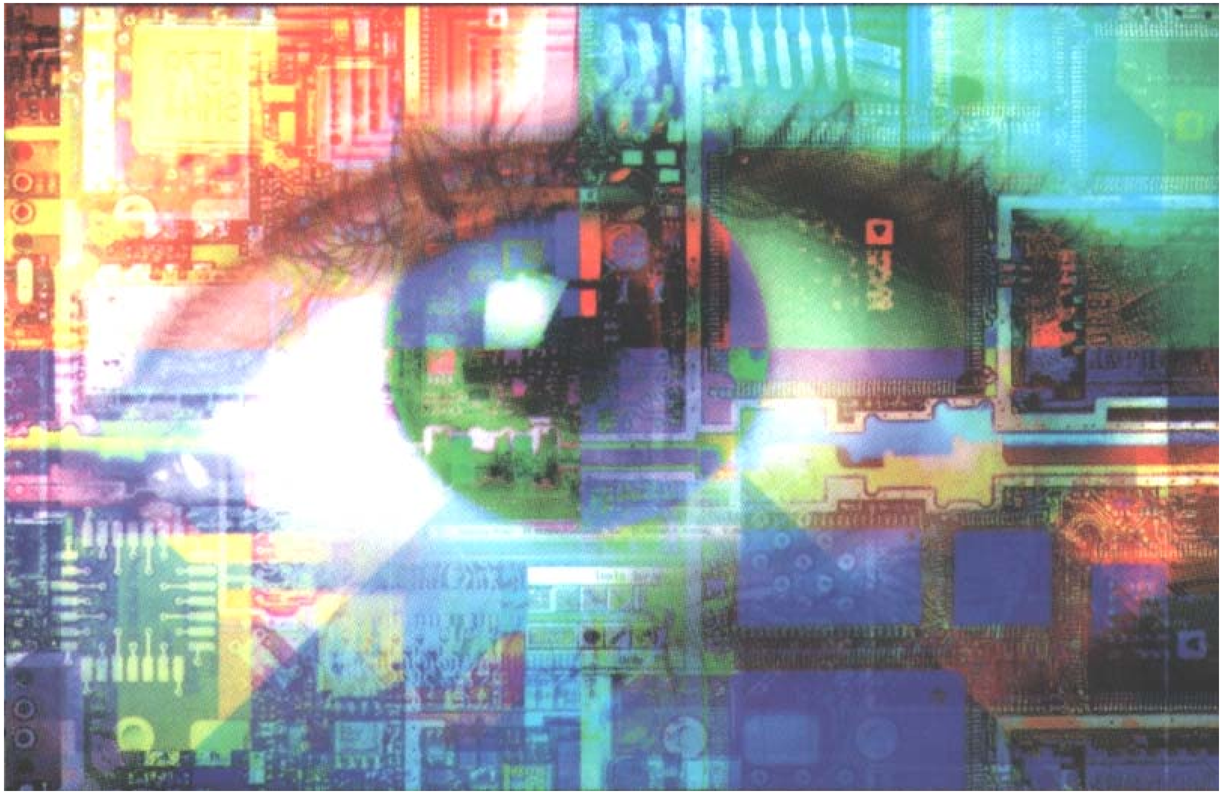
# IPC Annual Meeting



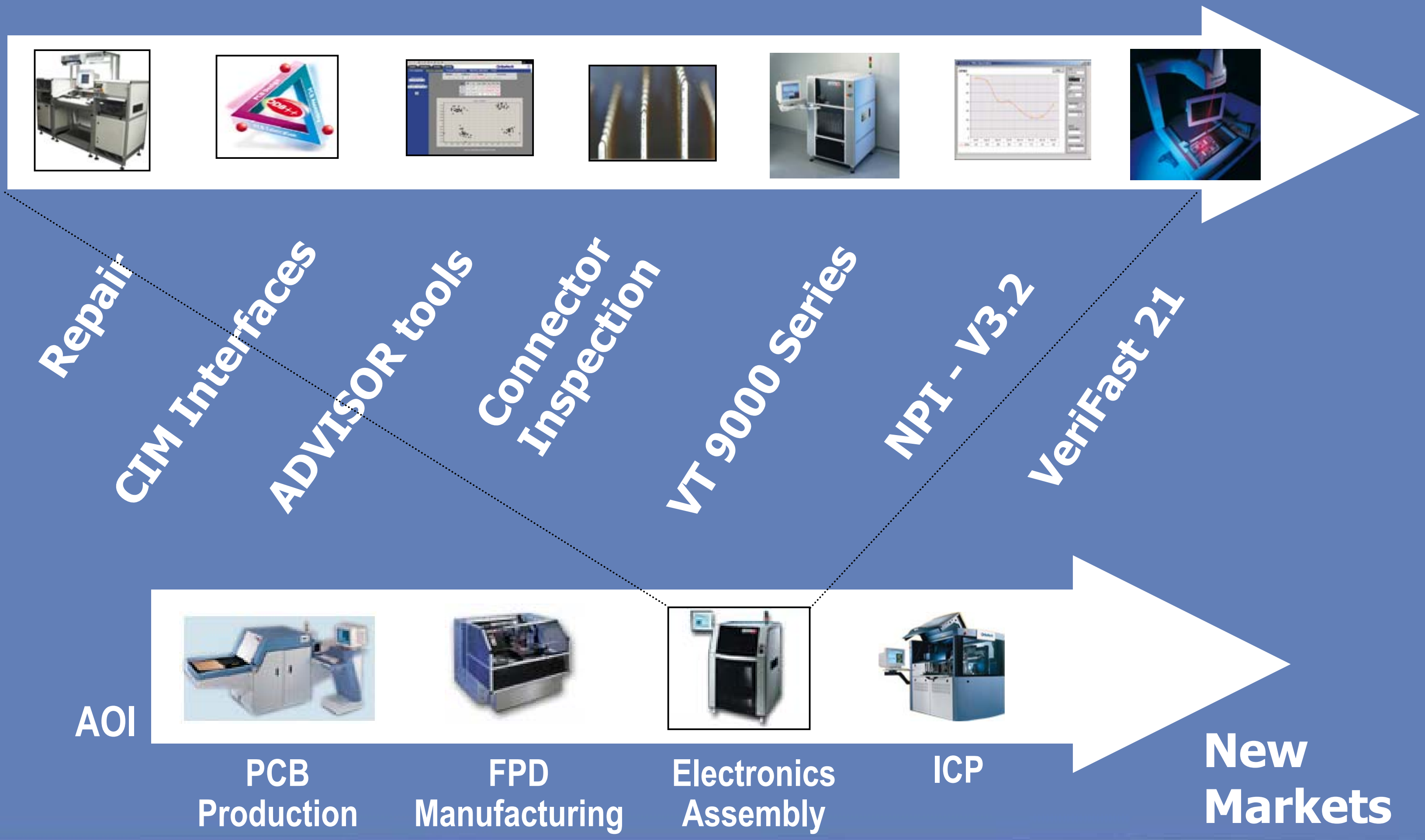
# AOI for NPI and Process Control

Confidential

**Electronics Assembly Solutions**

Orbotech®

# Assembly AOI Solutions



Repair

CIM Interfaces

ADVISOR tools

Connector Inspection

VT 9000 Series

NPI - V3.2

VeriFast 21

AOI

PCB Production

FPD Manufacturing

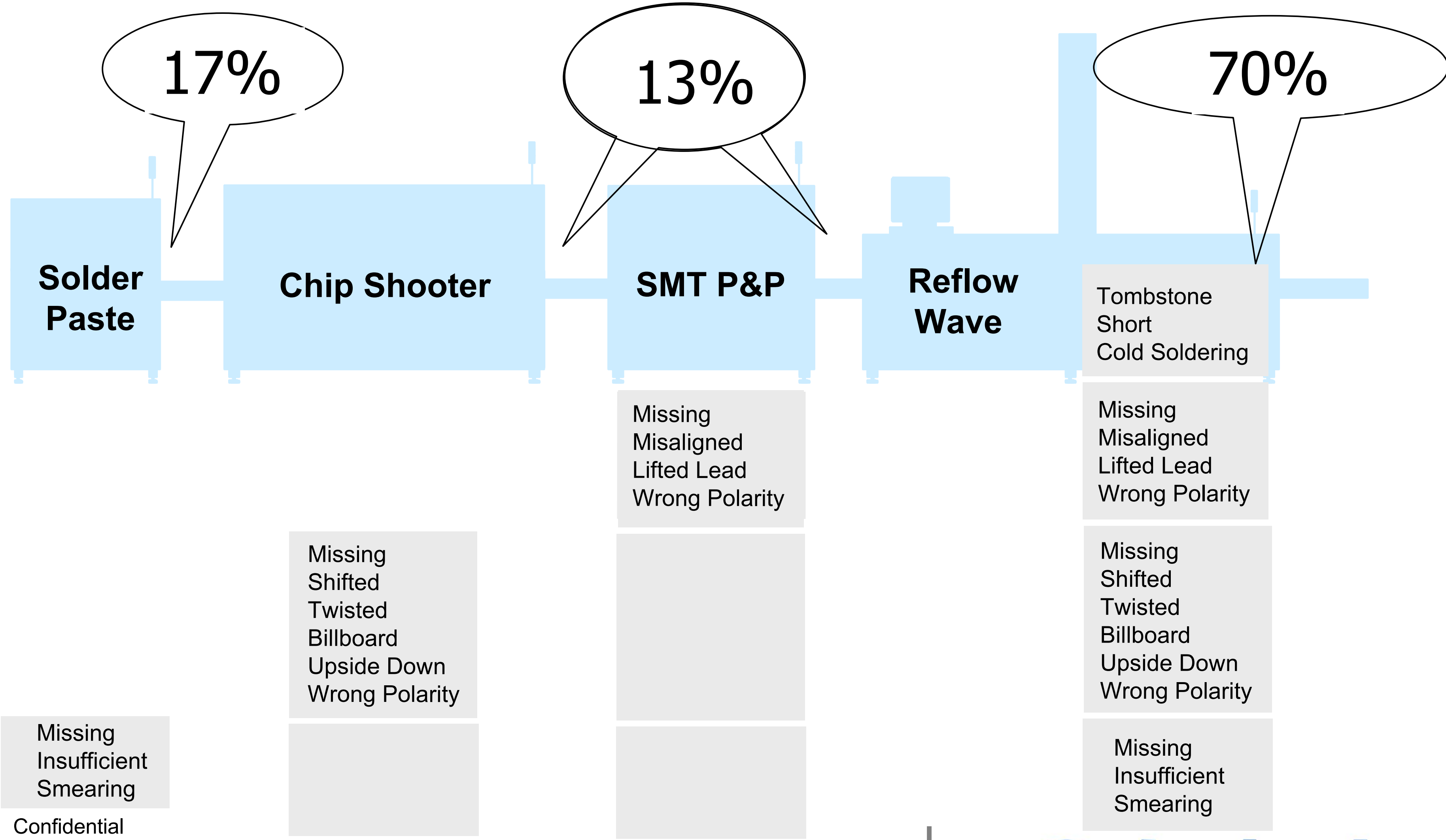
Electronics Assembly

ICP

**New Markets**

Orbotech

# Where to Implement AOI?



17%

13%

70%

**Solder Paste**

**Chip Shooter**

**SMT P&P**

**Reflow Wave**

Tombstone
Short
Cold Soldering

Missing
Insufficient
Smearing

Missing
Shifted
Twisted
Billboard
Upside Down
Wrong Polarity

Missing
Misaligned
Lifted Lead
Wrong Polarity

Missing
Misaligned
Lifted Lead
Wrong Polarity

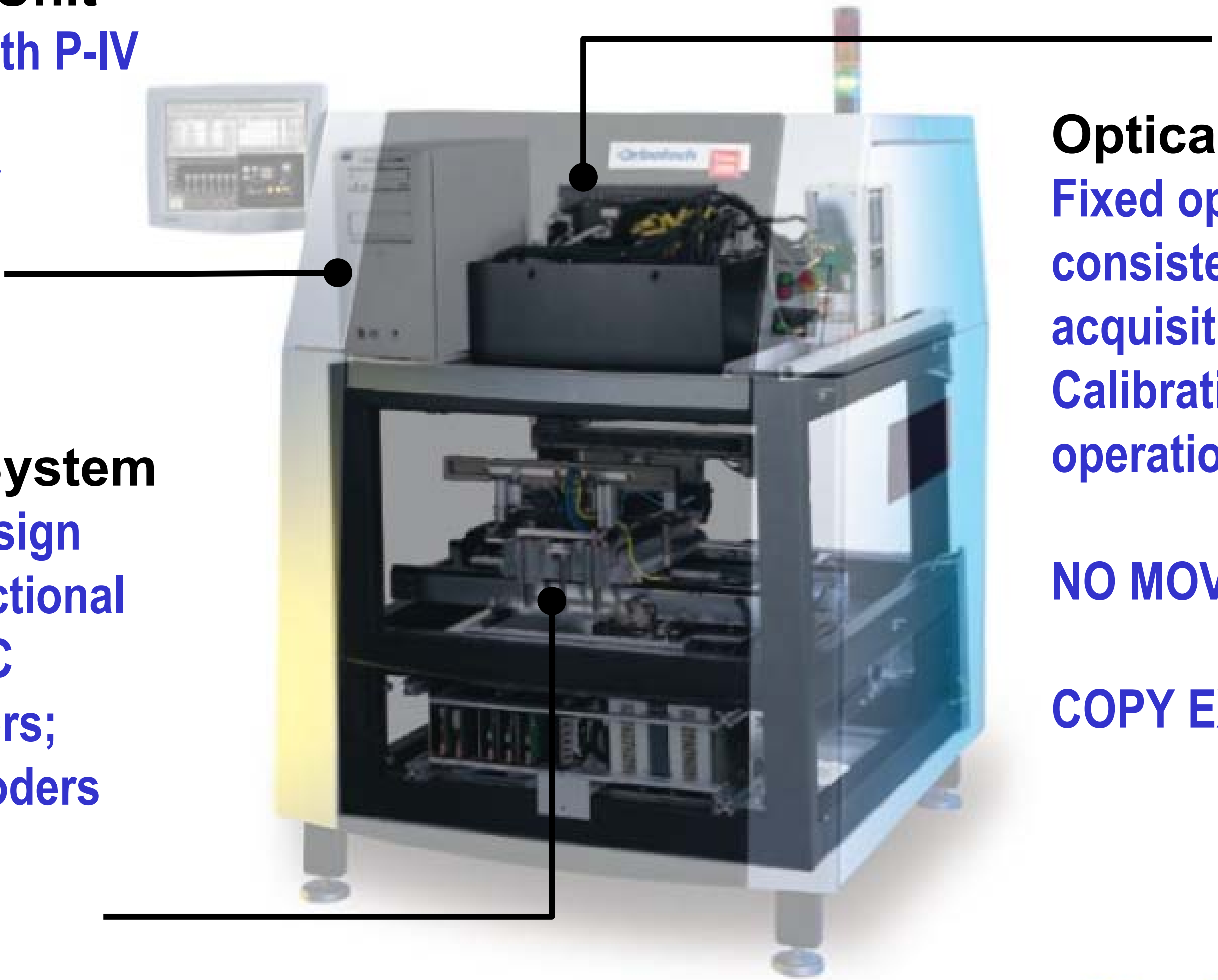
Missing
Shifted
Twisted
Billboard
Upside Down
Wrong Polarity

Missing
Insufficient
Smearing

# AOI for High-Mix

- Solder Joint defect detection and coverage (3D)
- Low false calls
- Easy to program
- Cost effective for NPI environment
- Process capability analysis
- Integrated repair and SPC solutions
- Ease of transfer to volume (Copy Exact)

# System Overview – Assembly AOI



**Control Unit**

IBM PC with P-IV Pentium processor

**Motion System**

Robust design

X-Y-Z directional motion; DC servomotors; linear encoders

**Optical Head**

Fixed optical head for consistent picture acquisition. Calibration-free operation

NO MOVING PARTS

COPY EXACT

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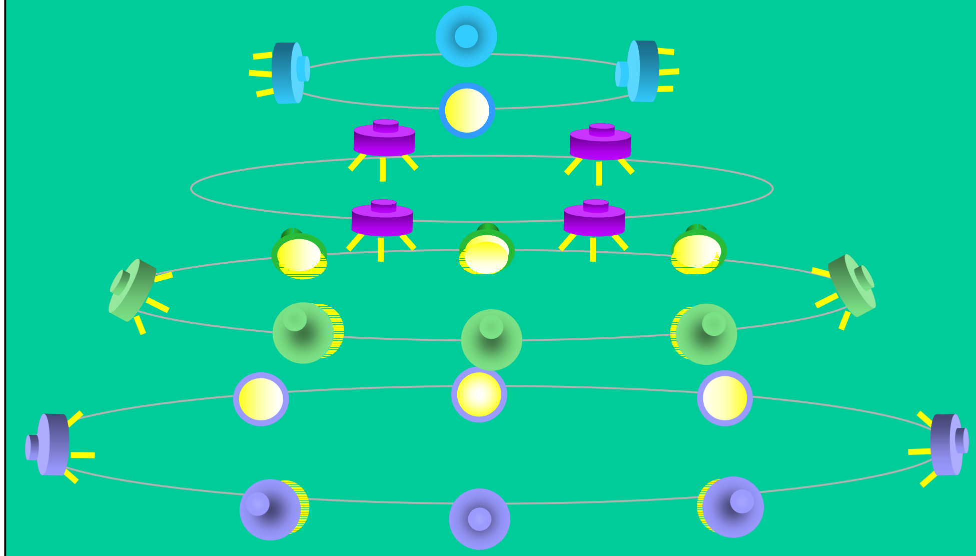
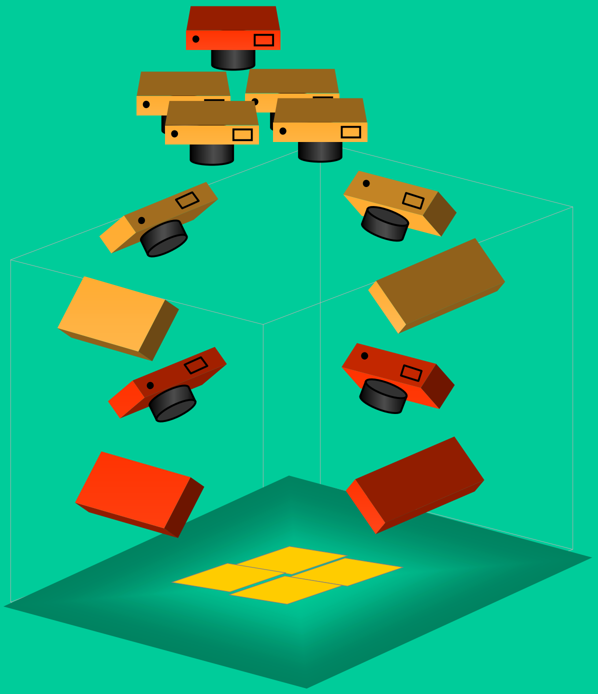
# Imaging Technology

## Lighting



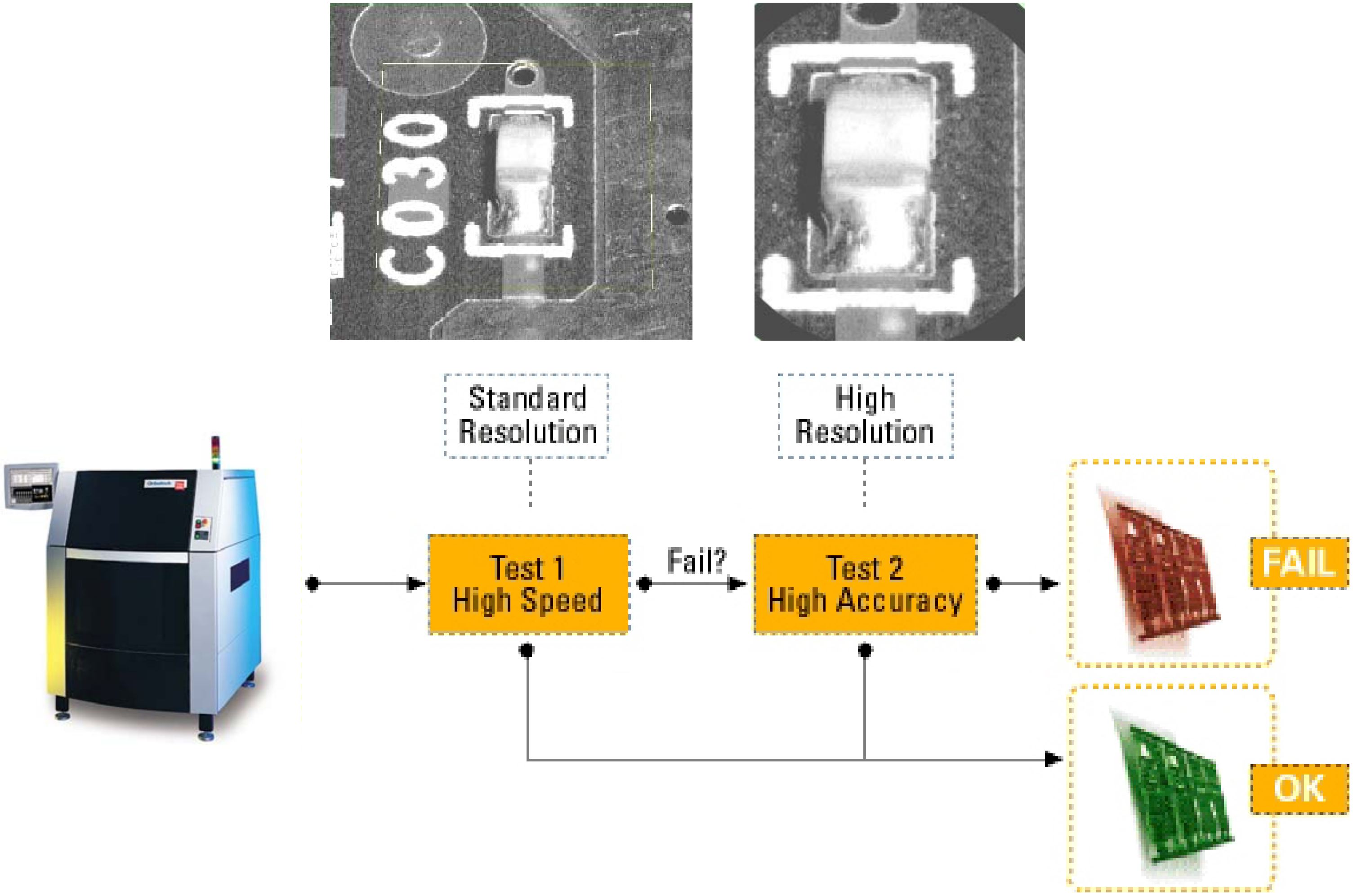
**18 diffuse & direct lighting directions**

## Cameras



**5 Angles, 2 resolutions**

# AutoVerify



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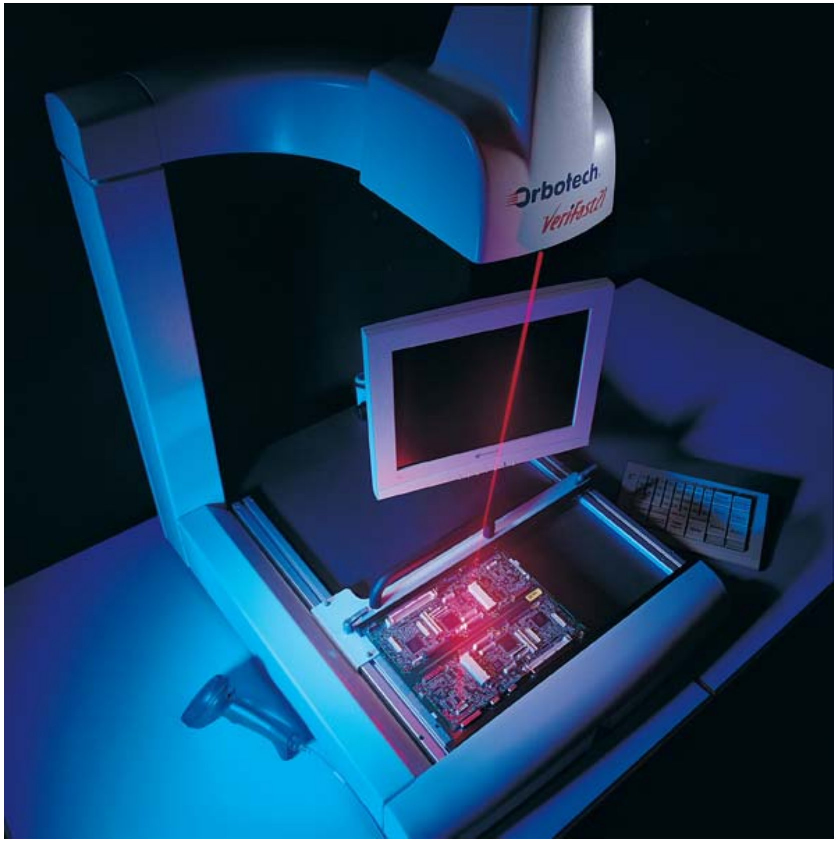
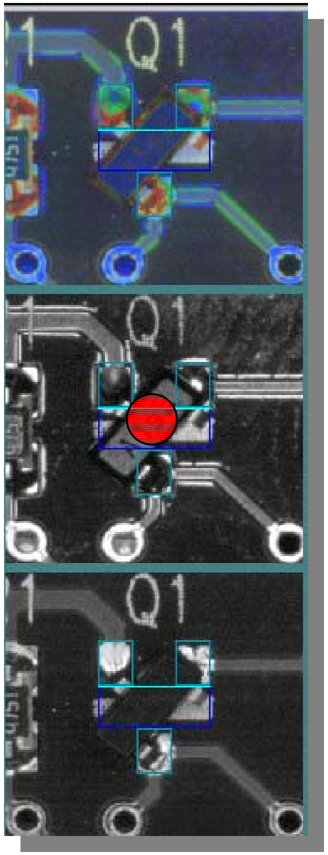
# Rework Station



- Rapid defect verification and repair
- Ergonomic design
- Cost effective configuration
- Supports multiple AOI systems
- Colour Defect images



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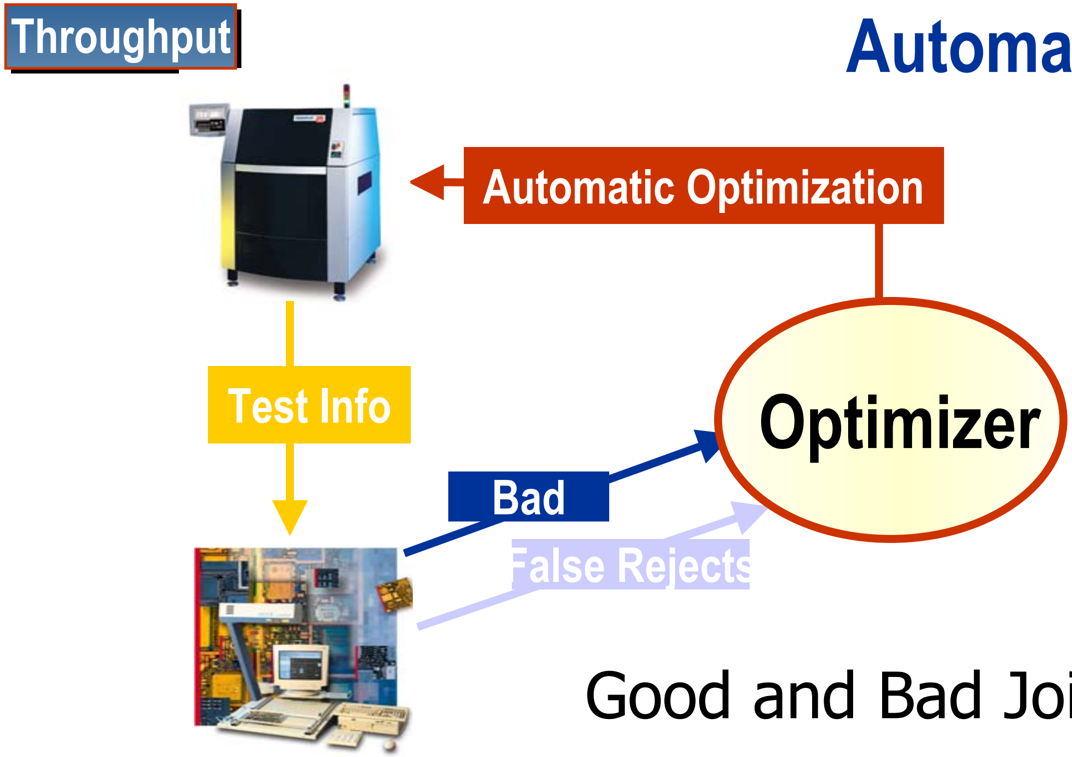
# Self Learning Approach

## Automatic Optimization Software



Throughput

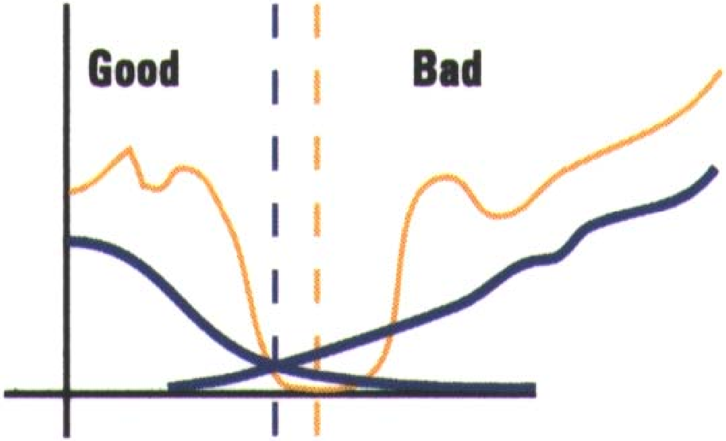
Automatic Optimization

Test Info

Optimizer

Bad

False Rejects



Good and Bad Joint data collection

Provides real-time closed loop feedback to AOI

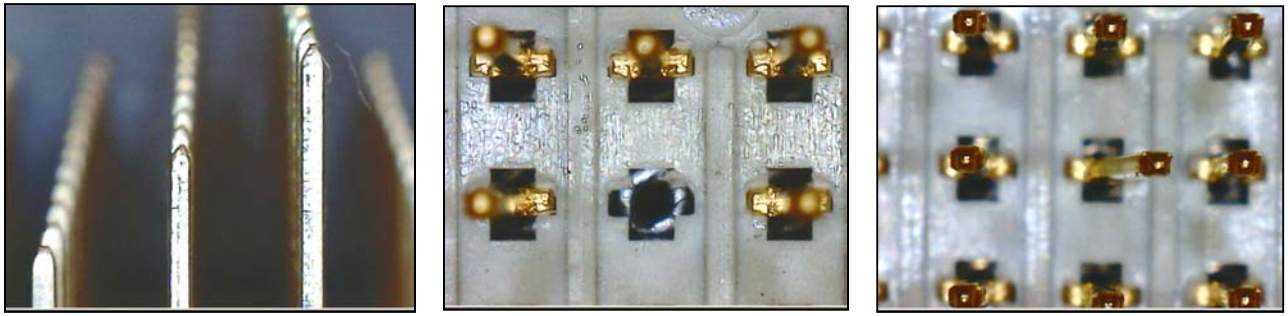
Component and Defect Database

# Connector inspection (Press Fit & Backplanes)

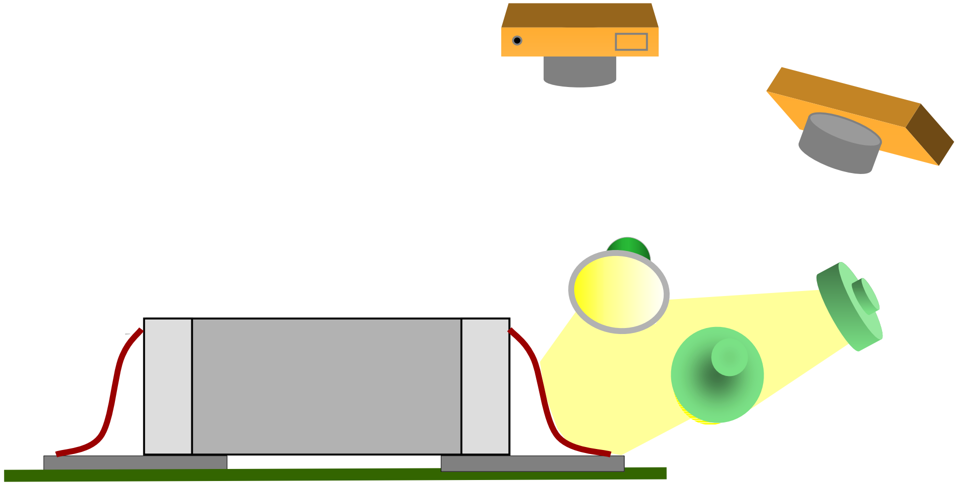
Simultaneous connector pin and SMD component inspection

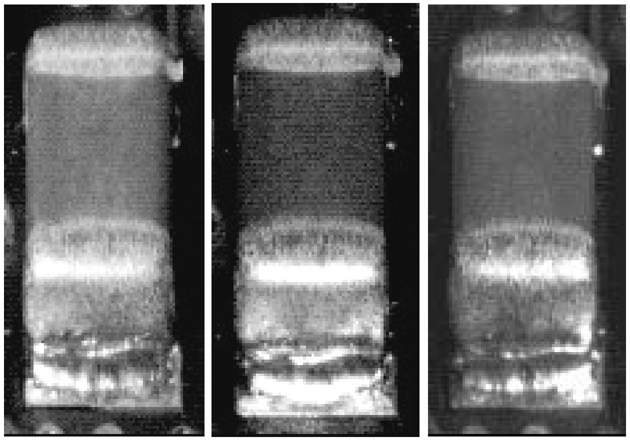
3D imaging technology provides pin height measurement

Large board format capability



# Solder Joint - Shape & Volume

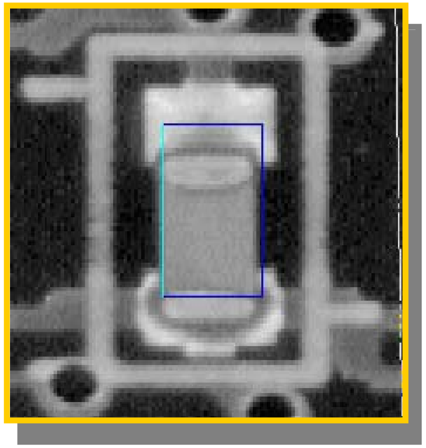




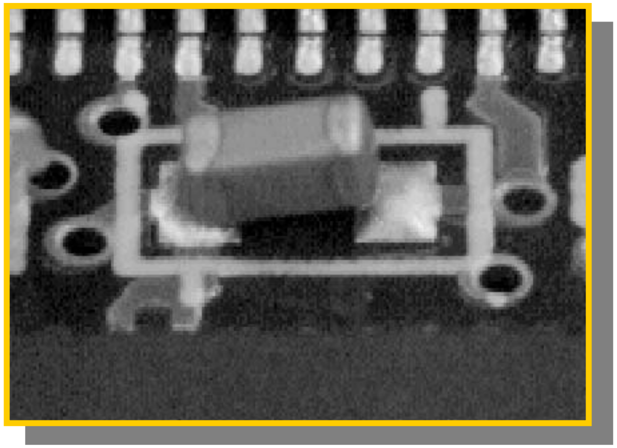
**Inspection algorithms run through features extracted from solder joint using angled and top view cameras and different light combinations.**

# Full 3D Inspection

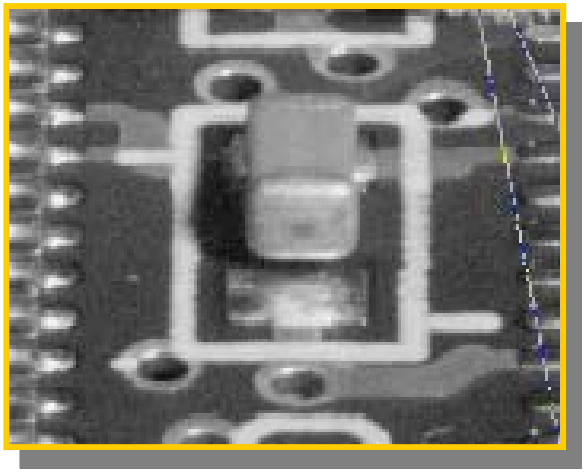
Top Camera



Side Camera



Side Camera



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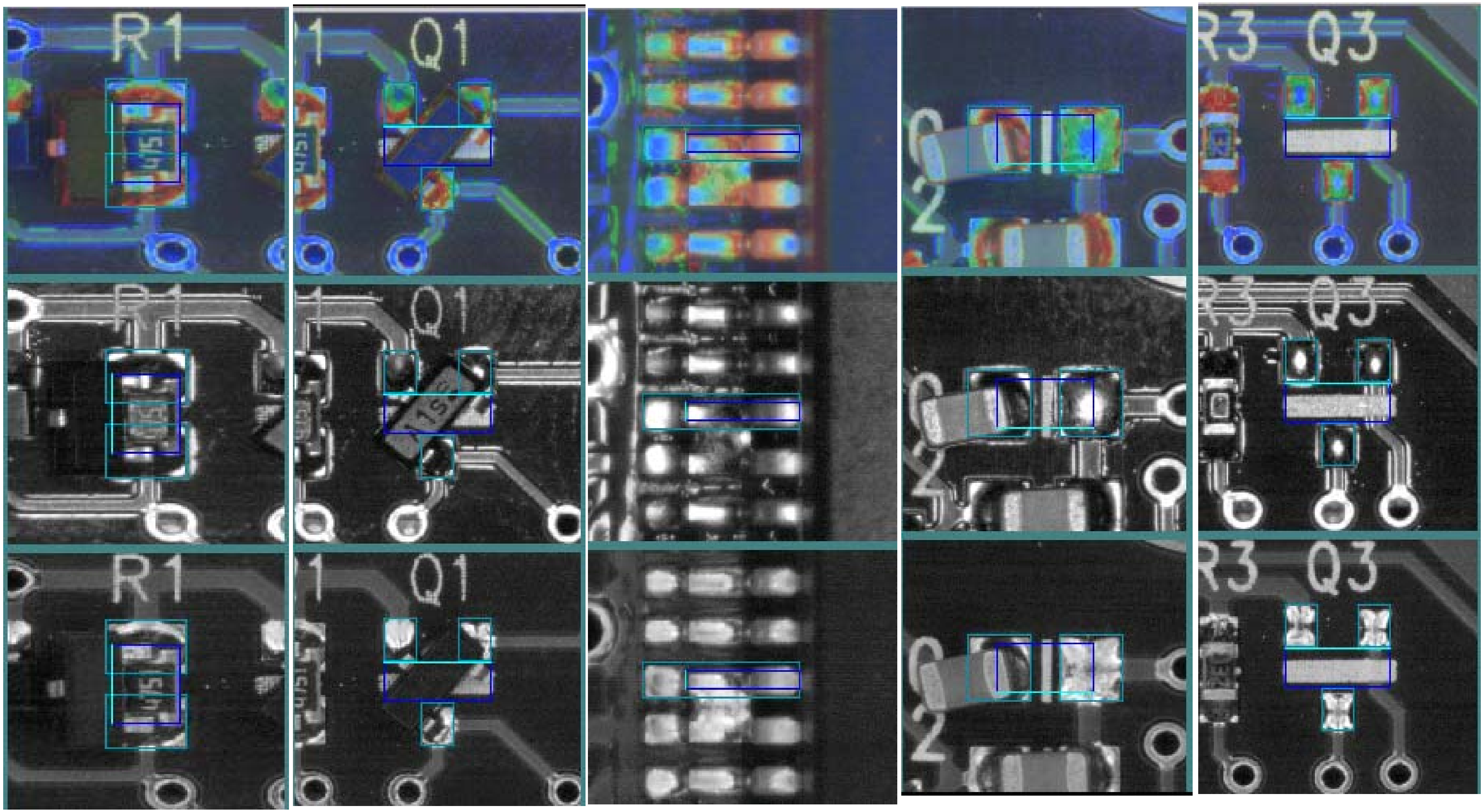
# Defect Images



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# Production Environments

- **High Mix/Low Volume**
- **NPI Center**

**NPI Inspection Method**

- **Quick and easy program set-up**
- **High detection from 1st board**
- **Easy to follow method for efficient fine-tuning**
- **Reduces operator training requirement**

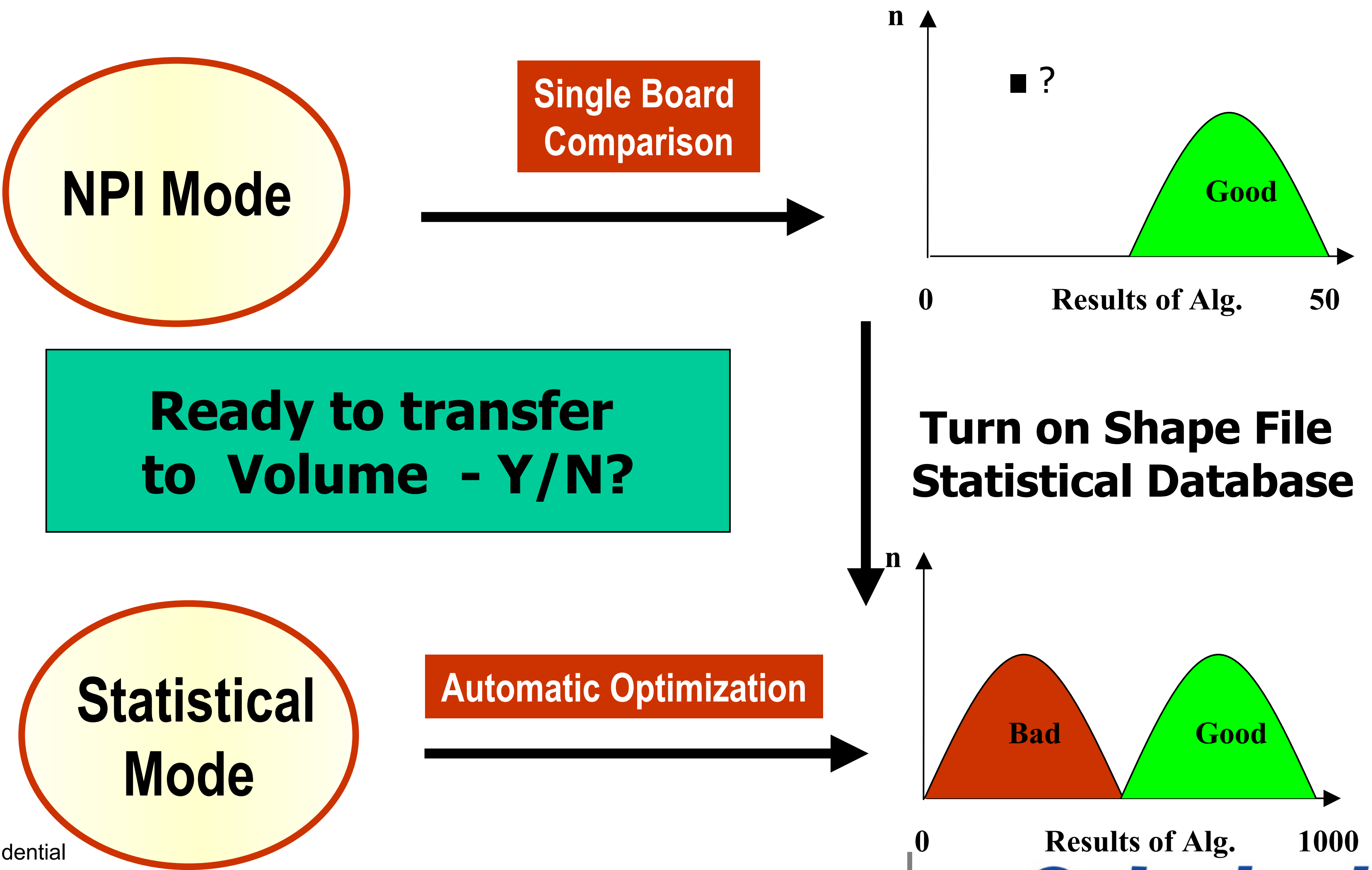
**Seamless transfer to volume production**

- **High Volume/Low Mix**
- **Production**

**Statistical Modelling**

- **Records process variance**
- **Distinguishes between acceptable and unacceptable solder joint characteristics**
- **Maintains detection levels via automated feedback loop from repair station**

# Combining NPI and Volume Capabilities



**NPI Mode**

**Single Board Comparison**

**Ready to transfer to Volume - Y/N?**

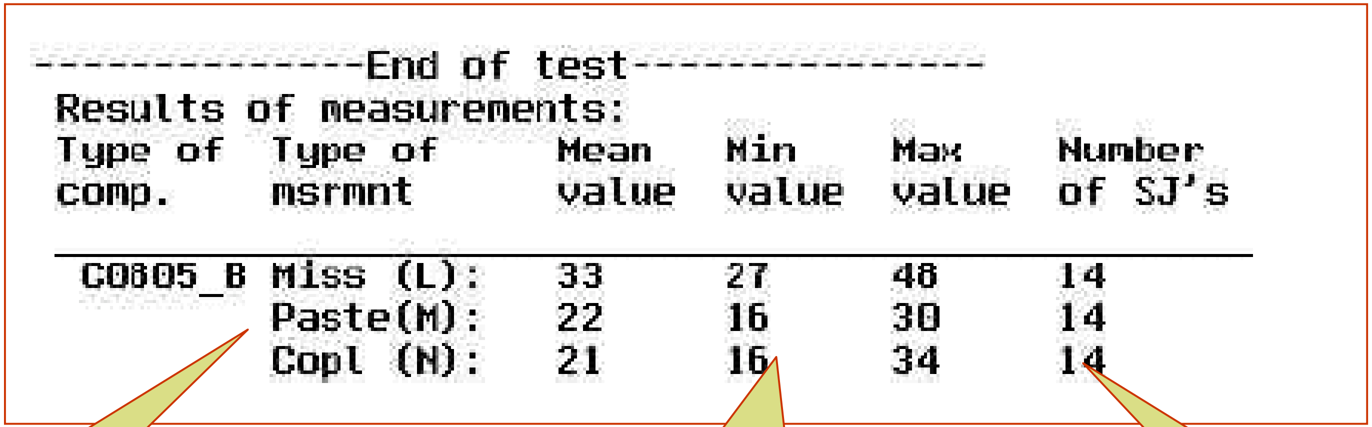
**Turn on Shape File Statistical Database**

**Statistical Mode**

**Automatic Optimization**

# Determining Thresholds

**The system determines the threshold factors for solder joints automatically, and produces a summary for the operator:**



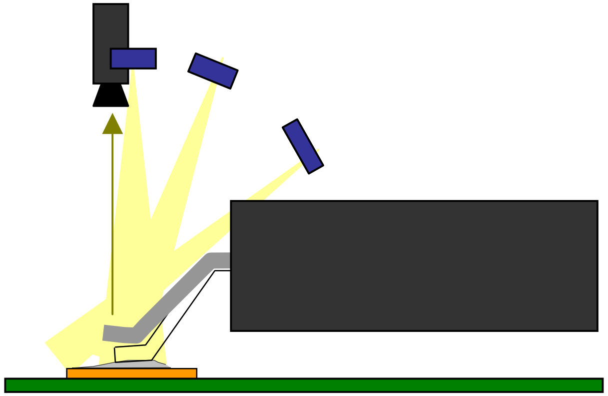
```
---------------End of test----------------
 Results of measurements:
 Type of   Type of      Mean    Min     Max     Number
 comp.     msrmnt       value   value   value   of SJ's

  C0805_B  Miss (L):    33      27      48      14
           Paste(M):    22      16      30      14
           Copl (N):    21      16      34      14
```

**Component and inspectiontest**

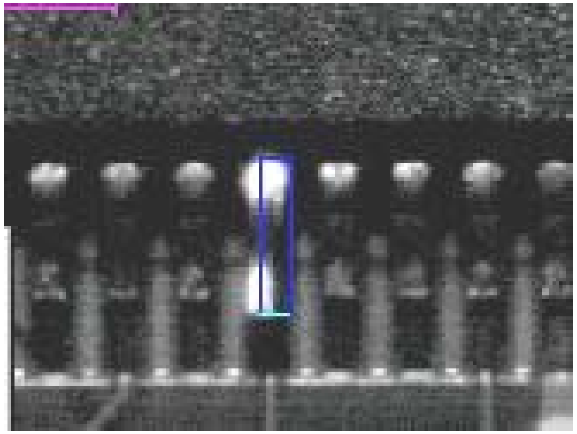
**Upper and lower thresholds and mean values**

**No of solder joints analyzed**

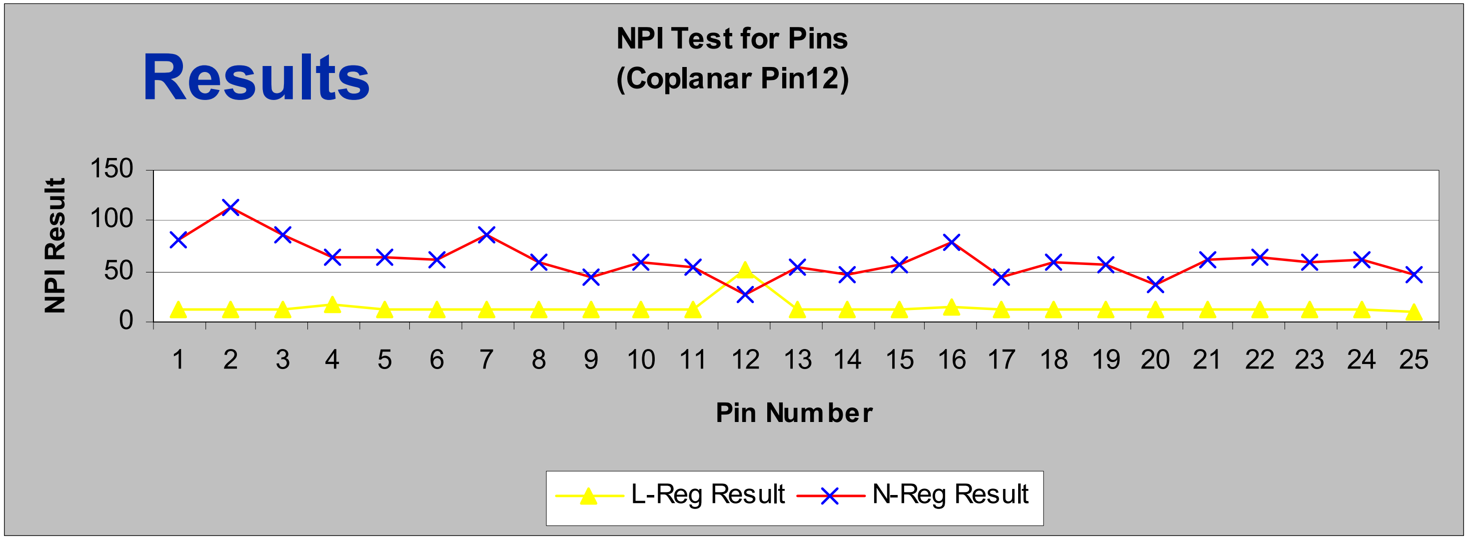
# NPI Mode



## Inspection Method



## Results



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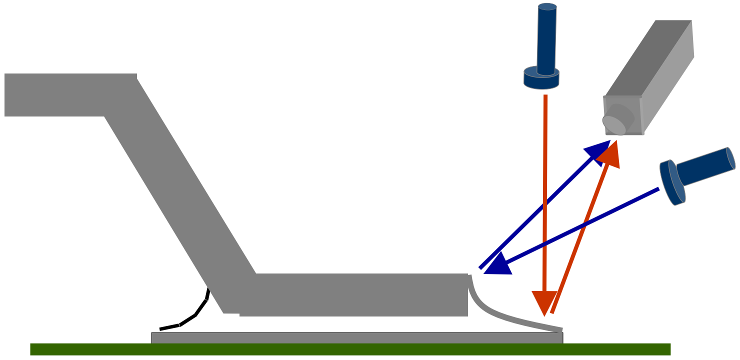
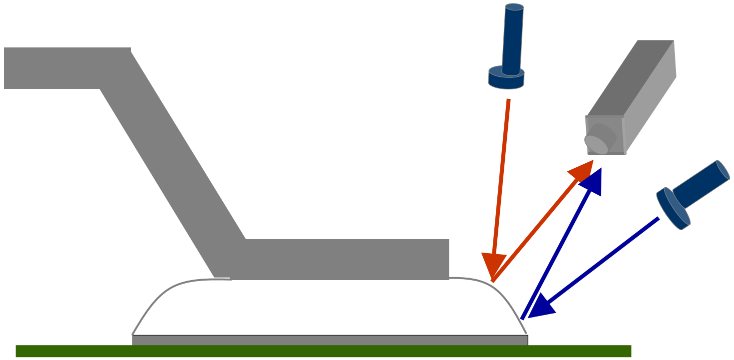
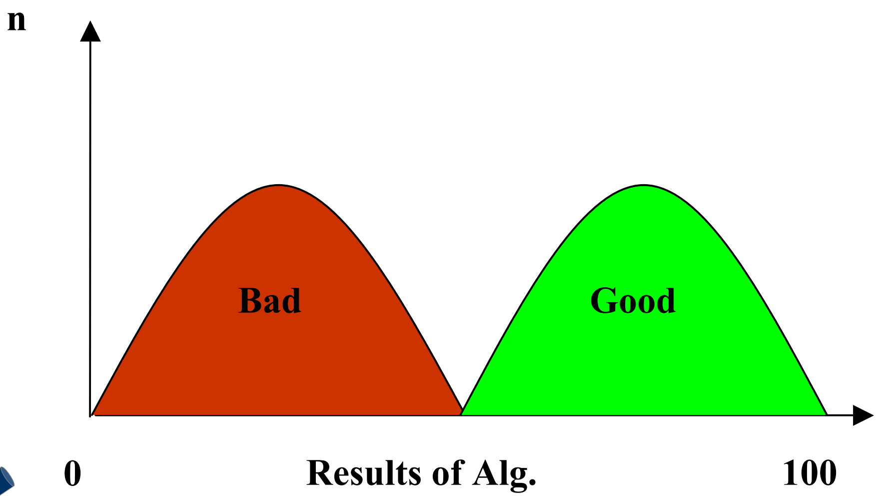
# Statistical Analysis



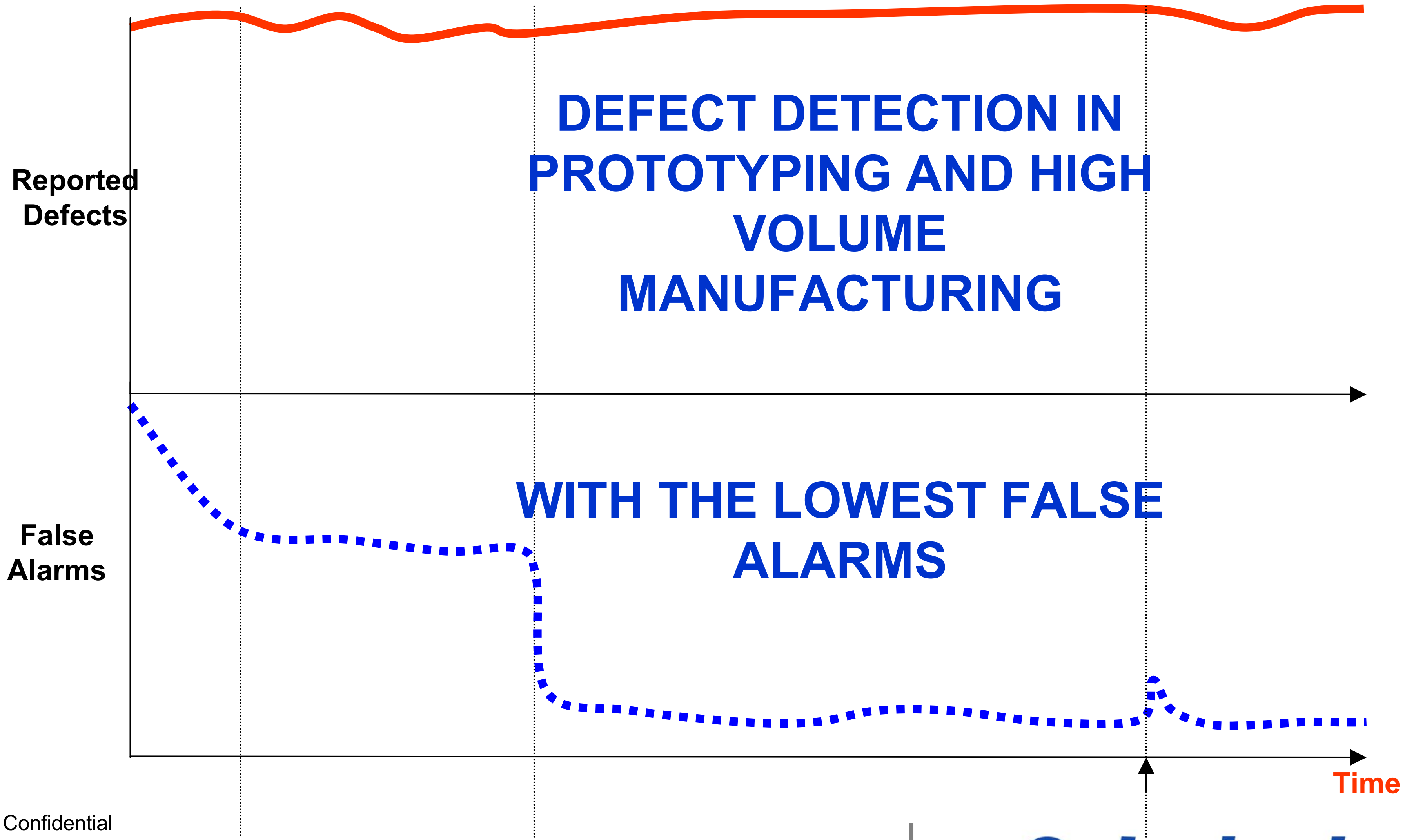
**Result (Good) = 80**



**Result (Bad) = 20**



# NPI and Statistical Modeling



DEFECT DETECTION IN PROTOTYPING AND HIGH VOLUME MANUFACTURING

WITH THE LOWEST FALSE ALARMS

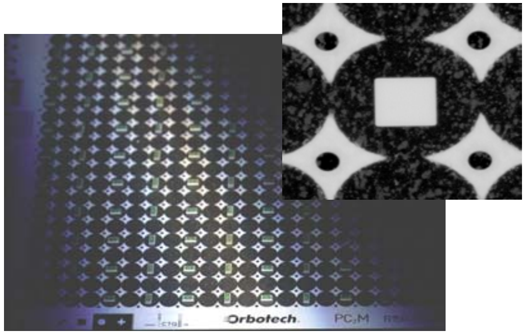
# Process Control

**Paste Printer** → **Chip Shooters** → **Pick & Place System** → **Reflow Oven**

**Post Paste Print AOI**

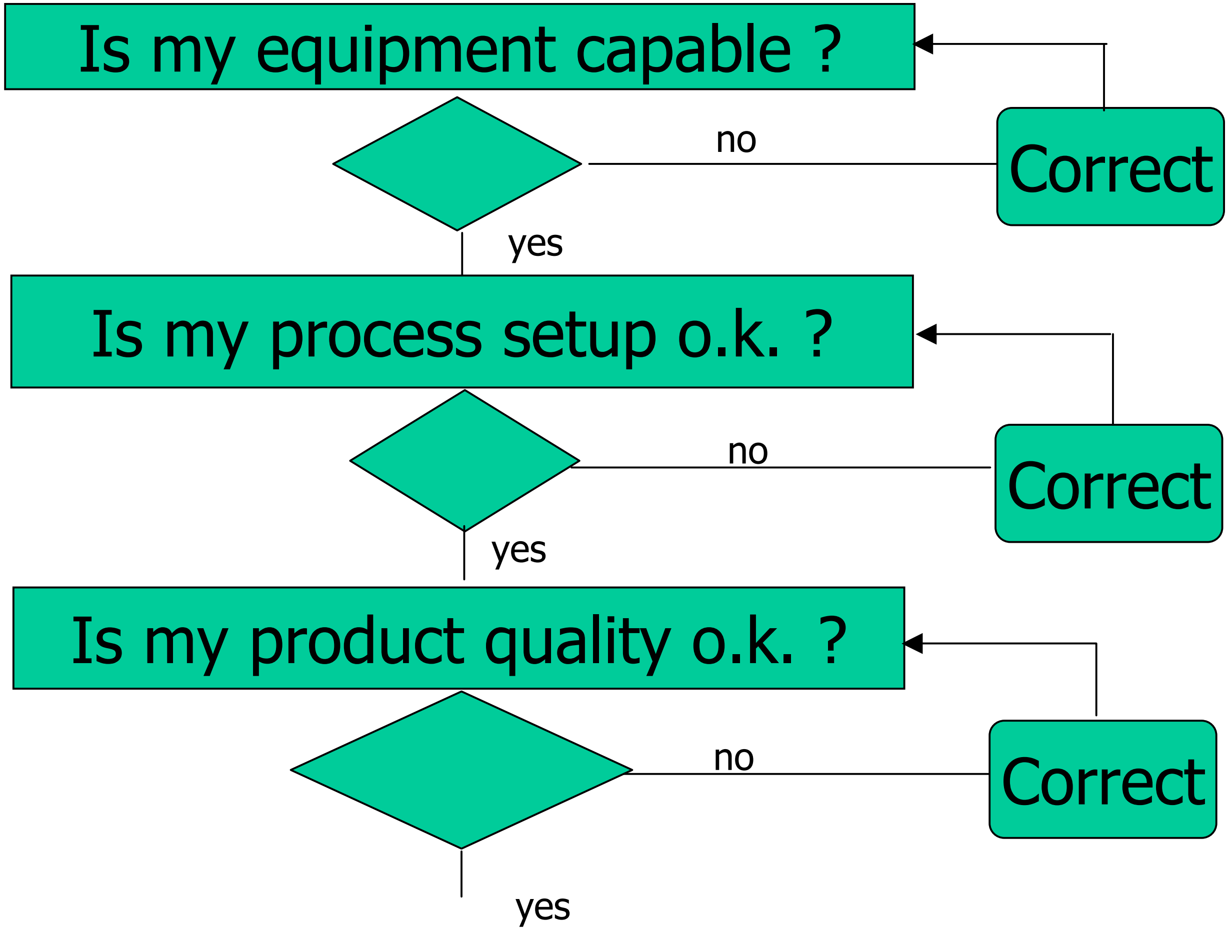
**IPC 9850 or PC$^2$M**

**Process & Equipment Cpk Analysis**



**Post Solder AOI**

# Line Optimization !



Pre-Process Assessment

In-Process Monitoring

Post-Process Analysis

Is my equipment capable ?

no

Correct

yes

Is my process setup o.k. ?

no

Correct

yes

Is my product quality o.k. ?

no

Correct

yes

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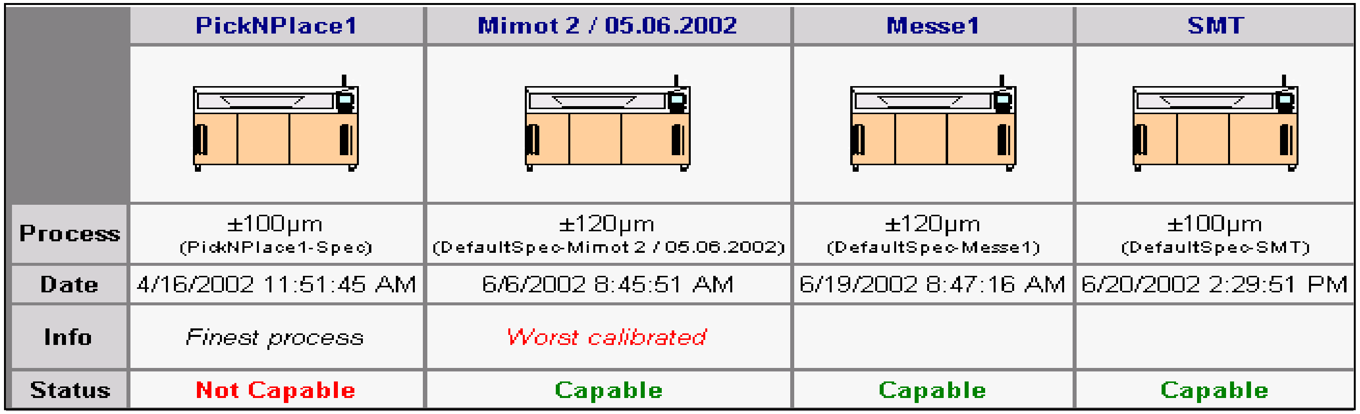
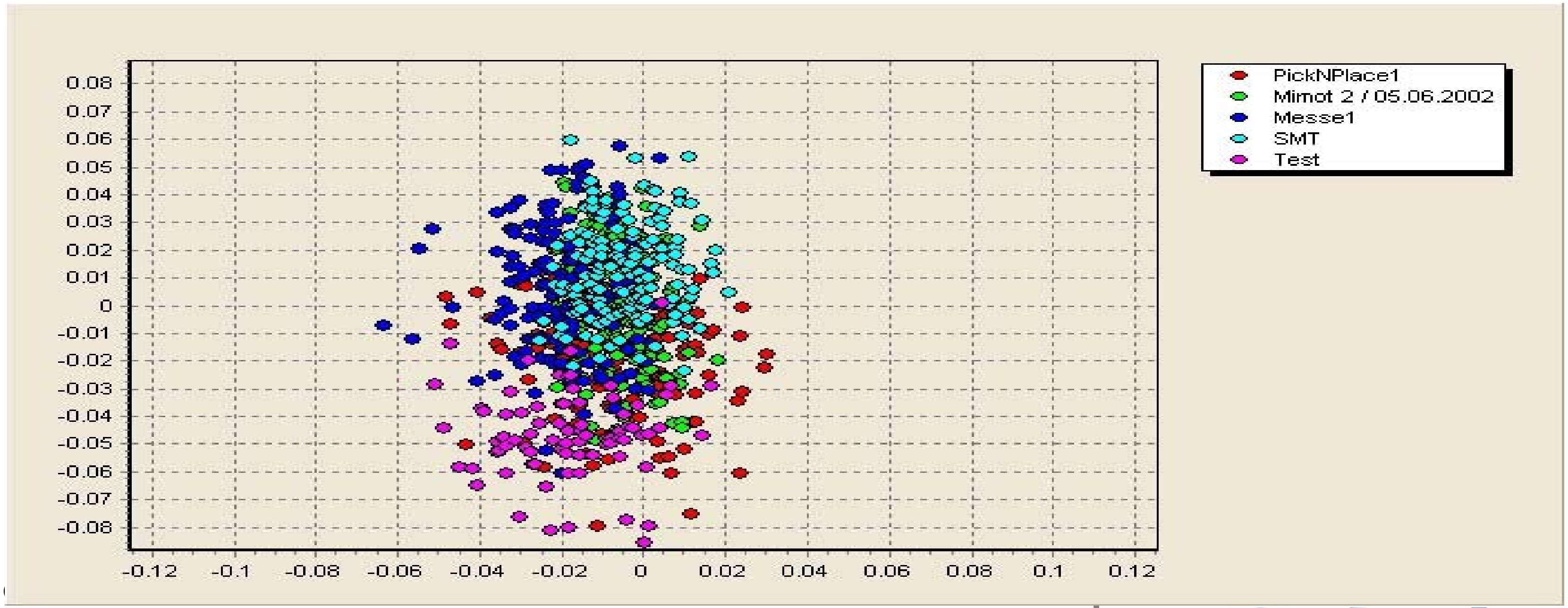
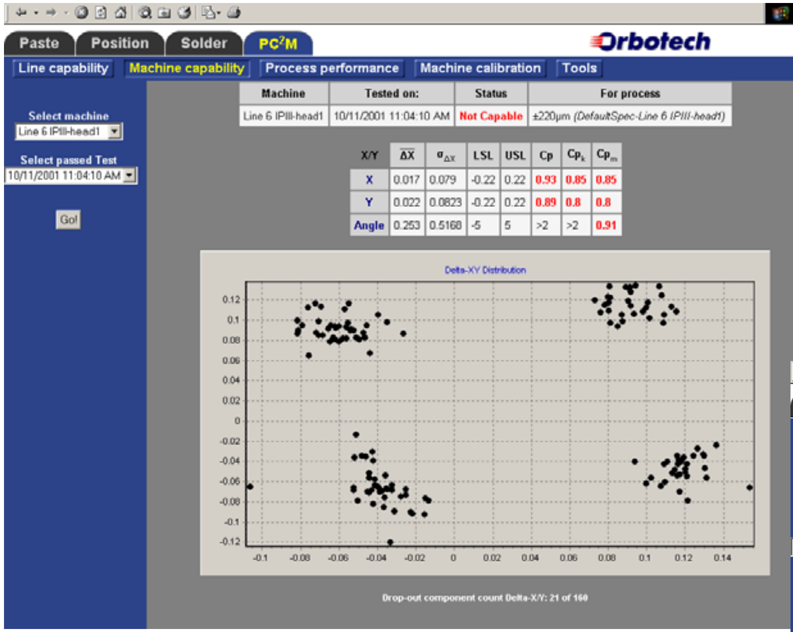
# Line ADVISOR (Cpk)



| | PickNPlace1 | Mimot 2 / 05.06.2002 | Messe1 | SMT |
|---|---|---|---|---|
| **Process** | ±100µm<br>(PickNPlace1-Spec) | ±120µm<br>(DefaultSpec-Mimot 2 / 05.06.2002) | ±120µm<br>(DefaultSpec-Messe1) | ±100µm<br>(DefaultSpec-SMT) |
| **Date** | 4/16/2002 11:51:45 AM | 6/6/2002 8:45:51 AM | 6/19/2002 8:47:16 AM | 6/20/2002 2:29:51 PM |
| **Info** | *Finest process* | *Worst calibrated* | | |
| **Status** | **Not Capable** | **Capable** | **Capable** | **Capable** |



# Accurate Placement  Capability



Select machine: Line 6 IPIII-head1

Select passed Test: 10/11/2001 11:04:10 AM

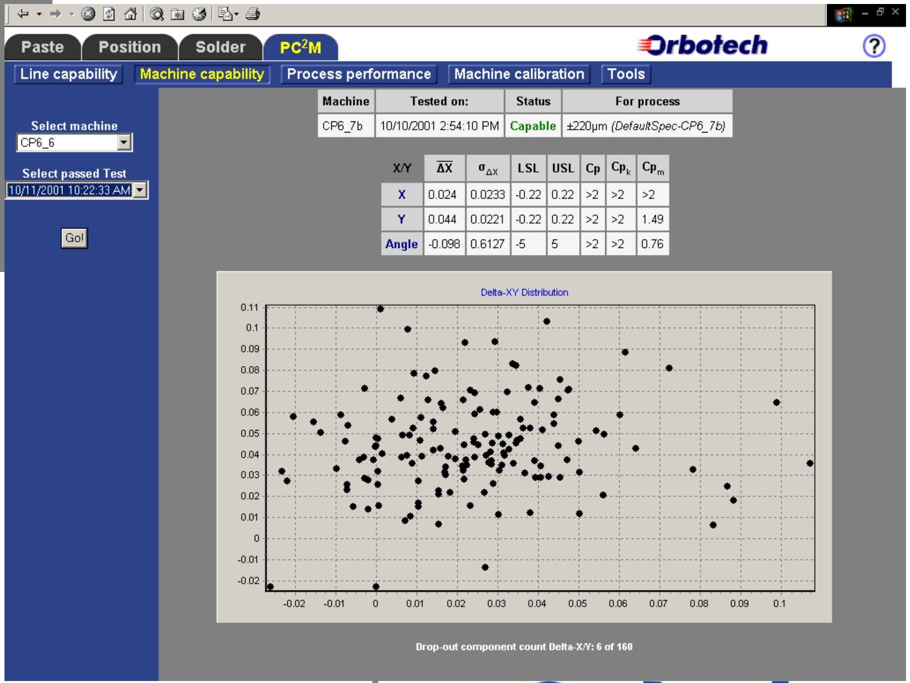
| Machine | Tested on: | Status | For process |
|---|---|---|---|
| Line 6 IPIII-head1 | 10/11/2001 11:04:10 AM | **Not Capable** | ±220µm *(DefaultSpec-Line 6 IPIII-head1)* |

| X/Y | $\overline{\Delta X}$ | $\sigma_{\Delta X}$ | LSL | USL | Cp | $Cp_k$ | $Cp_m$ |
|---|---|---|---|---|---|---|---|
| **X** | 0.017 | 0.079 | -0.22 | 0.22 | **0.93** | **0.85** | **0.85** |
| **Y** | 0.022 | 0.0823 | -0.22 | 0.22 | **0.89** | **0.8** | **0.8** |
| **Angle** | 0.253 | 0.5168 | -5 | 5 | >2 | >2 | **0.91** |

Drop-out component count Delta-X/Y: 21 of 160

**Before Calibration**

**After Calibration**



Select machine: CP6_6

Select passed Test: 10/11/2001 10:22:33 AM

| Machine | Tested on: | Status | For process |
|---|---|---|---|
| CP6_7b | 10/10/2001 2:54:10 PM | **Capable** | ±220µm *(DefaultSpec-CP6_7b)* |

| X/Y | $\overline{\Delta X}$ | $\sigma_{\Delta X}$ | LSL | USL | Cp | $Cp_k$ | $Cp_m$ |
|---|---|---|---|---|---|---|---|
| **X** | 0.024 | 0.0233 | -0.22 | 0.22 | >2 | >2 | >2 |
| **Y** | 0.044 | 0.0221 | -0.22 | 0.22 | >2 | >2 | 1.49 |
| **Angle** | -0.098 | 0.6127 | -5 | 5 | >2 | >2 | 0.76 |

Drop-out component count Delta-X/Y: 6 of 160

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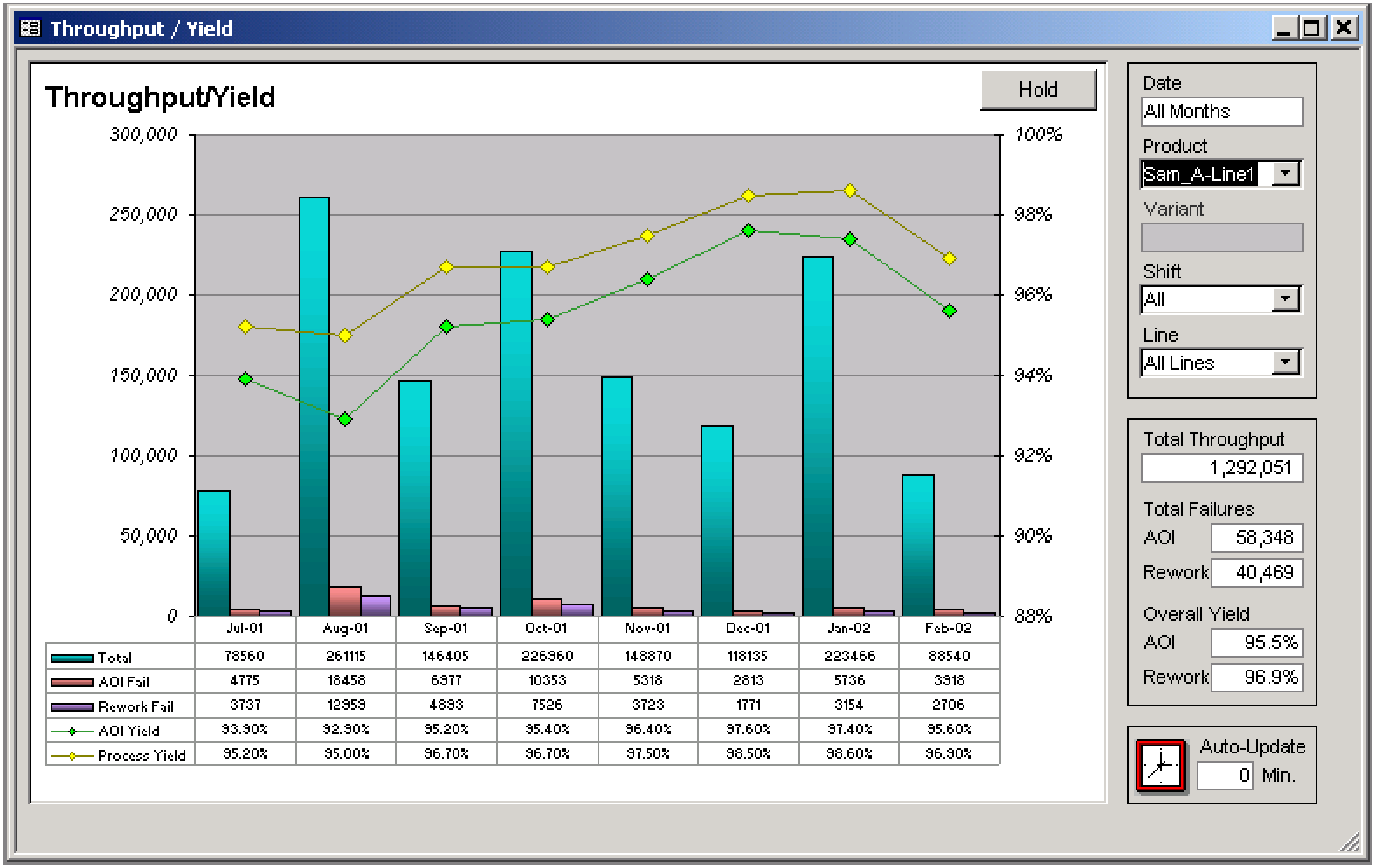
# Yield ADVISOR



**Throughput/Yield**

| | Jul-01 | Aug-01 | Sep-01 | Oct-01 | Nov-01 | Dec-01 | Jan-02 | Feb-02 |
|---|---|---|---|---|---|---|---|---|
| Total | 78560 | 261115 | 146405 | 226960 | 148870 | 118135 | 223466 | 88540 |
| AOI Fail | 4775 | 18458 | 6977 | 10353 | 5318 | 2813 | 5736 | 3918 |
| Rework Fail | 3737 | 12959 | 4893 | 7526 | 3723 | 1771 | 3154 | 2706 |
| AOI Yield | 93.90% | 92.90% | 95.20% | 95.40% | 96.40% | 97.60% | 97.40% | 95.60% |
| Process Yield | 95.20% | 95.00% | 96.70% | 96.70% | 97.50% | 98.50% | 98.60% | 96.90% |

Date: All Months
Product: Sam_A-Line1
Variant:
Shift: All
Line: All Lines

Total Throughput: 1,292,051

Total Failures
AOI: 58,348
Rework: 40,469

Overall Yield
AOI: 95.5%
Rework: 96.9%

Auto-Update: 0 Min.

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# Pareto Analysis

**Reported Defects**

|  | (unknown) | coplanarity | fiducial | horizontal tolerance | missing | polarity | position | solder shape | solder volume | tombstone | twist | vertical tolerance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 🟥 Genuine | 132 | 2390 | 70 | 105 | 215 | 1 | 563 | 77 | 1039 | 44 | 5 | 49 |
| 🟩 False Alarm | 1 | 511 | 20 | 1 | 4 | 0 | 6 | 8 | 222 | 1 | 1 | 7 |

Date: 07/01

Product: Sam_A-Line1

Variant:

Shift: All

Line: All Lines

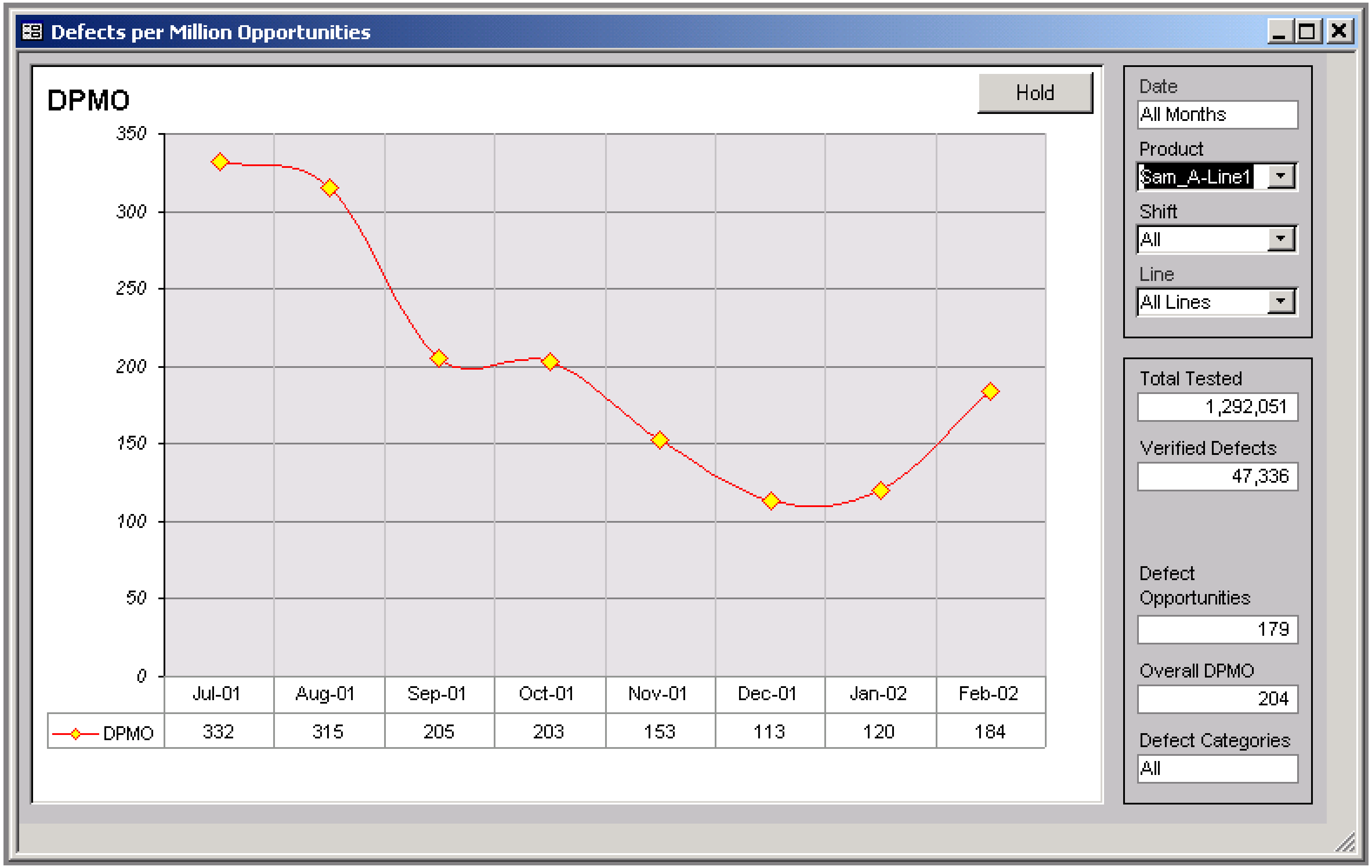
Total Defects

|  |  |
|---|---|
| False Alar | 782 |
| Genuine | 4690 |
| Total | 5472 |

View Top Defects

|  |  |
|---|---|
| coplanarit | 290 |
| fiducial | 90 |
| horizontal | 106 |
| missing | 219 |
| polarity | 1 |
| position | 569 |
| solder sha | 85 |
| solder vol | 126 |

# Yield Improvement



|  | Jul-01 | Aug-01 | Sep-01 | Oct-01 | Nov-01 | Dec-01 | Jan-02 | Feb-02 |
|---|---|---|---|---|---|---|---|---|
| DPMO | 332 | 315 | 205 | 203 | 153 | 113 | 120 | 184 |

Date: All Months

Product: Sam_A-Line1

Shift: All

Line: All Lines

Total Tested: 1,292,051

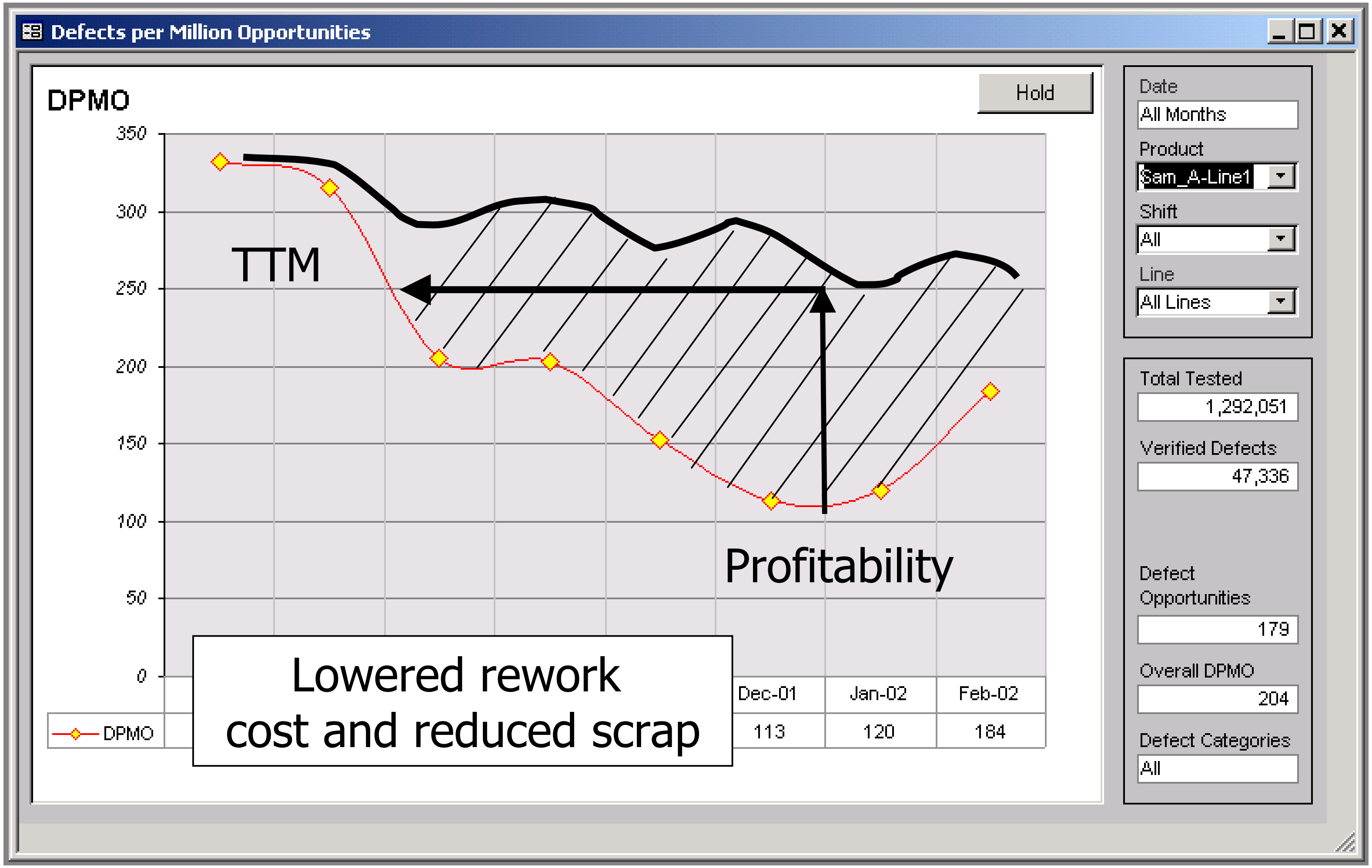
Verified Defects: 47,336

Defect Opportunities: 179

Overall DPMO: 204

Defect Categories: All

# Business Impact



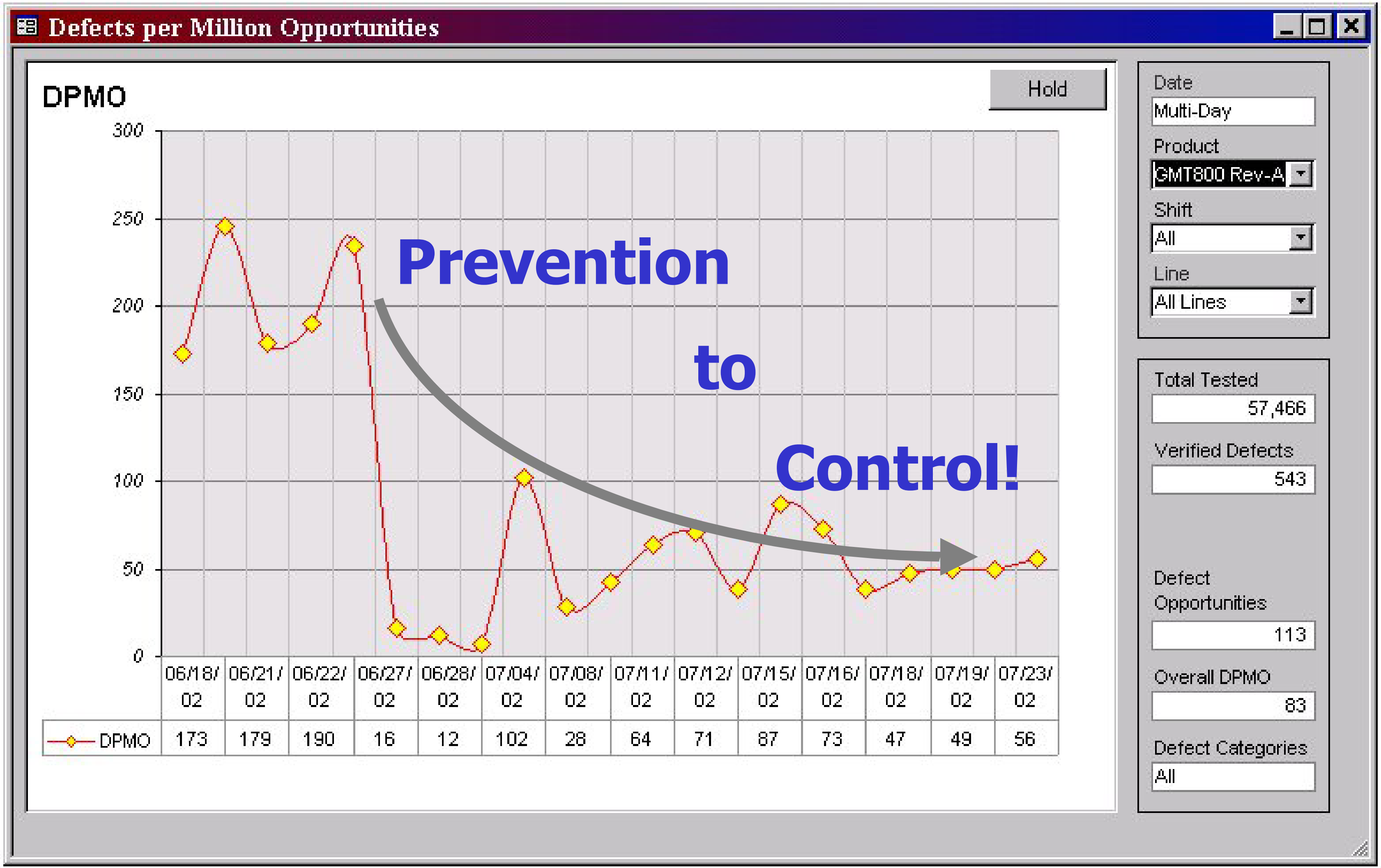
| Dec-01 | Jan-02 | Feb-02 |
|---|---|---|
| 113 | 120 | 184 |

Date: All Months
Product: Sam_A-Line1
Shift: All
Line: All Lines

Total Tested: 1,292,051
Verified Defects: 47,336
Defect Opportunities: 179
Overall DPMO: 204
Defect Categories: All

Lowered rework
cost and reduced scrap

# Prevention and Control !



| | 06/18/02 | 06/21/02 | 06/22/02 | 06/27/02 | 06/28/02 | 07/04/02 | 07/08/02 | 07/11/02 | 07/12/02 | 07/15/02 | 07/16/02 | 07/18/02 | 07/19/02 | 07/23/02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DPMO | 173 | 179 | 190 | 16 | 12 | 102 | 28 | 64 | 71 | 87 | 73 | 47 | 49 | 56 |

Date: Multi-Day
Product: GMT800 Rev-A
Shift: All
Line: All Lines

Total Tested: 57,466
Verified Defects: 543
Defect Opportunities: 113
Overall DPMO: 83
Defect Categories: All

# Production Environments

- High Mix/Low Volume
- NPI Center

**NPI Inspection Method**

- Quick and easy program set-up
- High detection from 1st board
- Easy to follow method for efficient fine-tuning
- Reduces operator training requirement

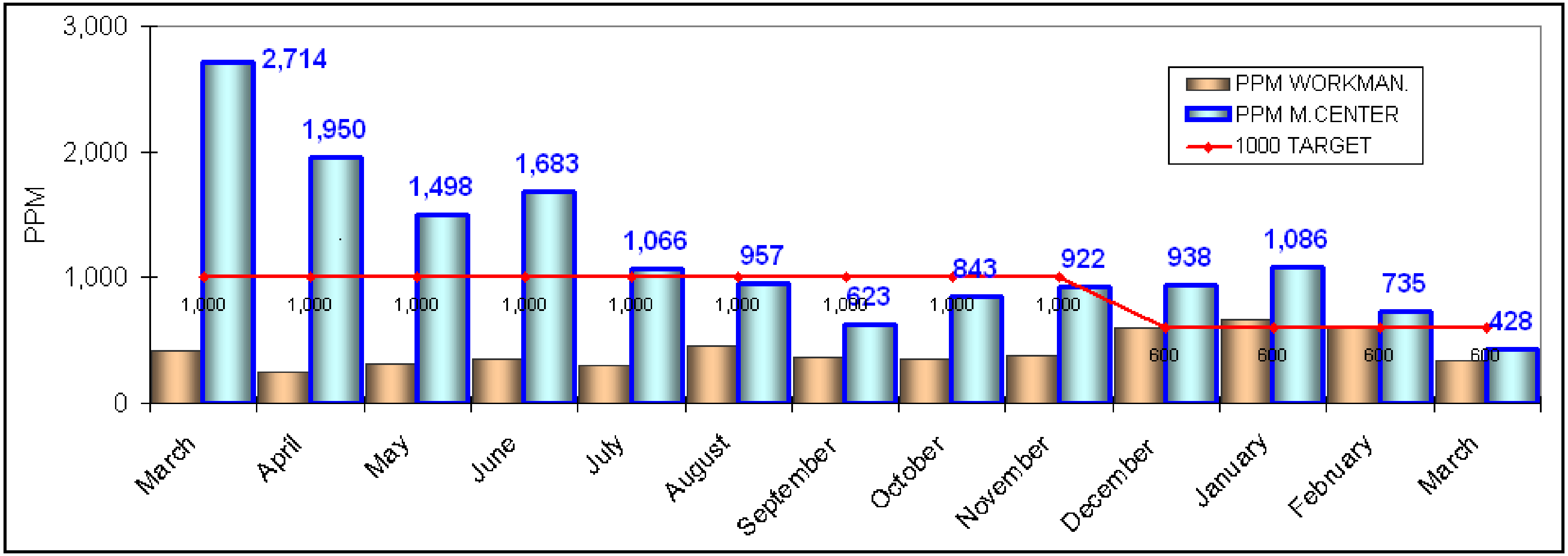
Seamless transfer to volume production

- High Volume/Low Mix
- Production

**Statistical Modelling**

- Records process variance
- Distinguishes between acceptable and unacceptable solder joint characteristics
- Maintains detection levels via automated feedback loop from repair station

# Volume Manufacturing



AOI & ADVISOR Tools applied –
EMS with High-Volume Automotive Product
.....6X DPMO Improvement

# AOI & Process Control….

- Elimination of manual visual inspection
- Increased process yield and decreased rework at ICT & Functional Test
- Lower probability of field returns
- Improved assembly line utilization
- A continuous Closed-Loop improvement mechanism

# ORBOTECH Ltd.

| | |
|---|---|
| Established - | 1981, NASDAQ (ORBK) Since 1984 |
| Products - | AOI, Plotter, LDI & CAM solutions |
| Markets - | PCB, FPD, Assembly, ICP |
| Revenue - | $216 Million 2002, **Profitable 2003** |
| Employees - | 1400 at 30 locations WW |
| Support - | WW direct infrastructure |
| Customers - | Broad mix of OEM and EMS |
| Assembly R&D - | Bad Pyrmont, Germany |
| HQ - | Yavne, Israel, (US - Billerica, MA) |

**Leading Industry-wide AOI supplier!**