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ENGINEERING

MANUFACTURING

DISTRIBUTION

INTEGRATION

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PCB Assembly Testing & Best Practices

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Presented by Eric Rossi Engineering Manager
& Members of the EMAC Engineering Team

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Seminar Overview

This seminar will cover the best practices to producing an Assembled Board that can be tested as well construction of Test-Sets for testing of PCBAs. The seminar will start by discussing the various ways an Assembled Board can be tested (AOI, ICT & FCT) and then delve deeper into Functional Circuit Testing and Design For Test (DFT). Further instruction will cover Constructing Test-Sets, Test Software and Test Data Logging and Reporting. Time will be set aside for Q&A after the presentation.

EMAC, Inc Overview

- **Sale of Off-The Shelf SBCs, SOMs, PPCs, Servers**

- **Engineering Services both Software & Hardware, including Design of Test-Sets**

- **Integration Services (Box Builds, Wiring Panels, etc.)**

- **Manufacturer of Electronic Assemblies**

- **EMAC Contract Manufacturing (CM)**
  - **What makes us different**
    - **We are an Engineering company that does Manufacturing**
    - **Closed Loop Process**
    - **We feed design issue back to the Client for them to fix or EMAC can perform the changes**
    - **As an Engineering Company we can make Smart recommendations on Part & Design for Manufacturing Issues**
    - **We are very good with Complex boards**
    - **We have designed a number of Custom Tools to assure High Quality & Customer Satisfaction**

Types of Testing (assuming a known good design)

- **Automated Optical Inspection (AOI)**
- **In Circuit Testing (ICT)**
- **Automated X-Ray Testing (AXT)**
- **Boundary Scan Testing (BCT)**
- **Functional Circuit Testing (FCT)**

These five types of Tests can be used independently, but usually in conjunction with one another depending on the tolerance of failure for the product (life support vs home climate control).

- **Automated Optical Inspection (AOI)**
  - **Inspects many of the same things that ICT checks for**
    - **Shorts between component leads & traces**
    - **Solder bridges**
    - **Component top markings**
    - **Soldering & process issues**
    - **Correct location/setting of switches or jumpers**
    - **Presence or absence of or wrong Components**
    - **Misoriented Components**
  - **Cannot detect wrong values without markings**
  - **Very dependent on operator & programming**

- **In Circuit Testing (ICT; Custom Test Head)**
  - **ICT mainly tests the performance of selected parts**
  - **ICT is a somewhat Universal Tester with a Custom Head & Test Criteria**
  - **Advantages:**
    - **Can detect up to 99% of manufacturing Defects**
    - **Very fast Testing (good for high volume)**
    - **Does not requiring powering the whole board**
  - **Disadvantages:**
    - **Can be Expensive + Custom Test Head**
    - **Limited access to test points on dense PCBs**
    - **The Test Head & programs may need to be redesigned for each new board revision**

Big Iron ICT

Small Iron ICT

Flying Probe ICT
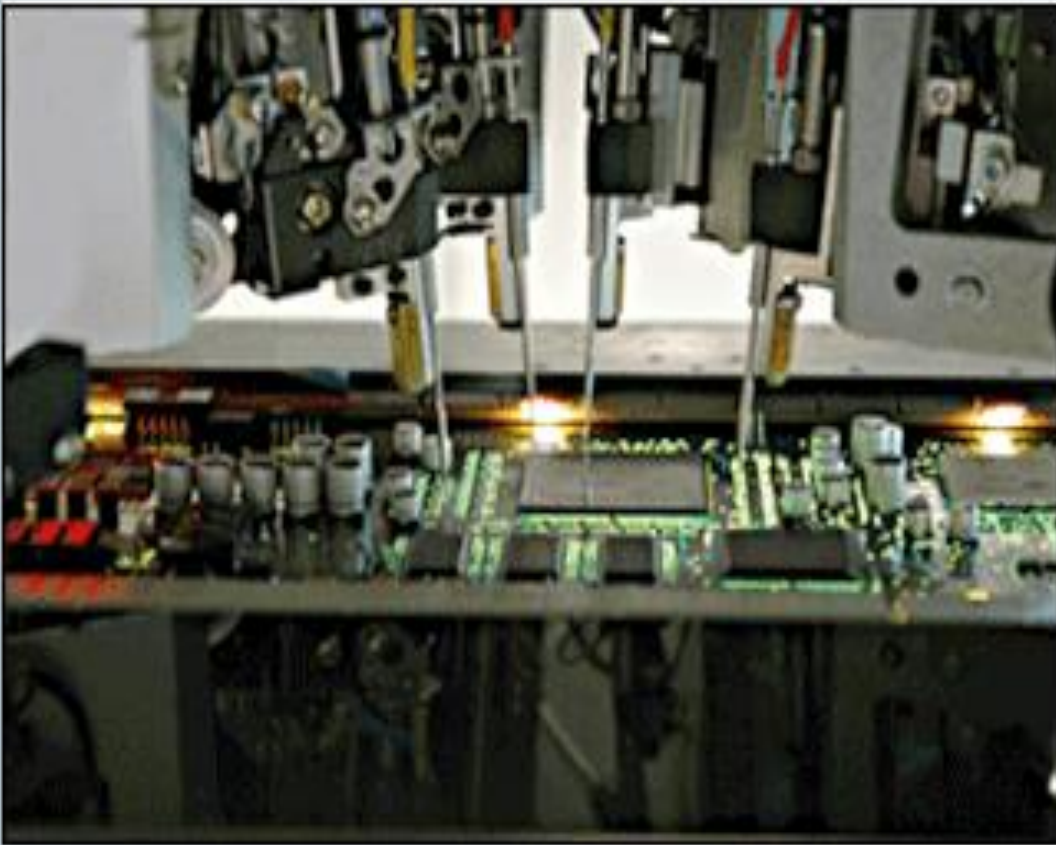
- **Functional Circuit Testing (FCT)**
  - **FCT is a Custom Tester specific to the UUT**
  - **Requires good planning & known quantity needs**
  - **Can be used in Lot Sampling (Statistical) scenario**
  - **Advantages:**
    - **Best overall test (assures customer satisfaction)**
    - **Can be less expensive depending on FCT design**
    - **Less complex than other Testing methods**
  - **Disadvantages:**
    - **Can be Time consuming especially when paired with Programming**
    - **Can add greatly to production test time & cost**
   - **Less accurate in finding all faults**

- **FCT Test-Set HW Considerations**
    - **Types of FCTs (From Simple to In-Line Hands Free)**
        - **Manual Testing (Cables & Jigs)**
            - **Disadvantages**
                - **Slow Test Time / Higher Test Cost**
                - **Can Require a Significant amount of maintenance over time**
            - **Advantages**
                - **Inexpensive Construction**
                - **Relatively Short Lead Time**
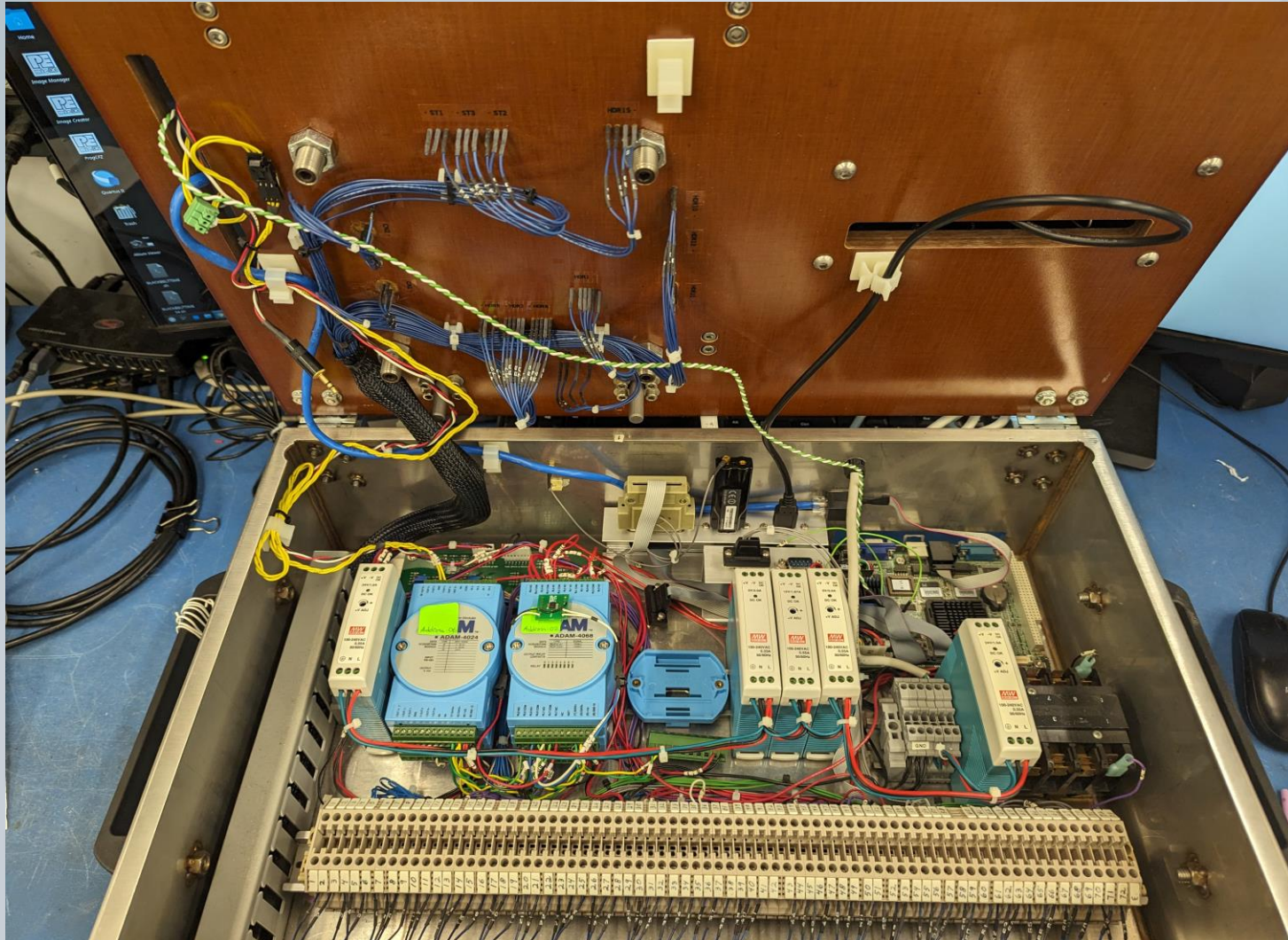
FCT Test-Set HW Considerations (Continued)

- Manual Example:
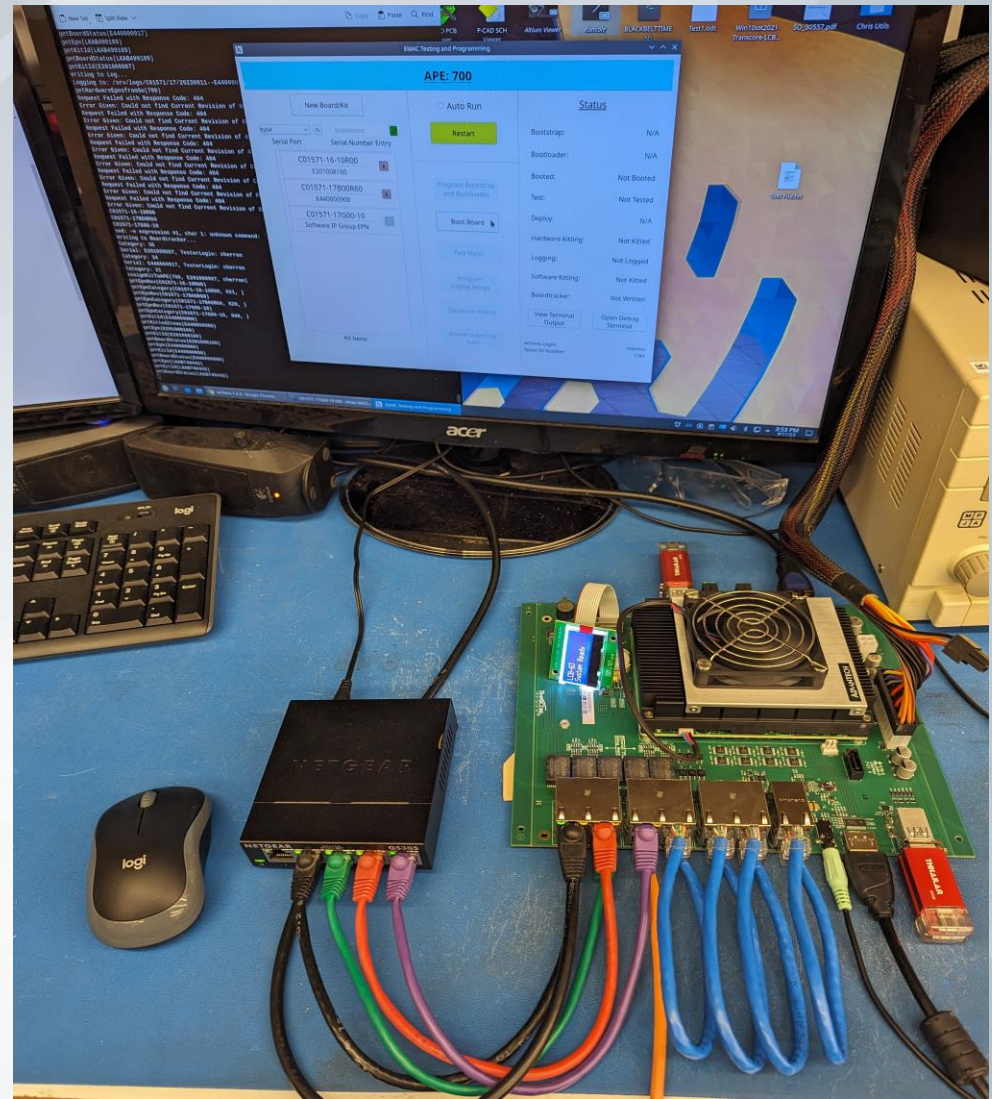
- **FCT Test-Set HW Considerations (Continued)**
  - **Semi-Automatic Test-Set (Bed of Nails)**
  - **Disadvantages**
    - **Can be Complex**
    - **More Expensive than Manual**
    - **Longer Lead Time**
    - **Can still involve connecting some cables**
  - **Advantages:**
    - **If constructed correctly it should be Reliable**
    - **If constructed correctly it should be Robust**
    - **Generally much Faster than Manual**
    - **Less Tester Fatigue (especially with Pneumatic Fixture Clamp)**

Semi-Automatic Test-Set
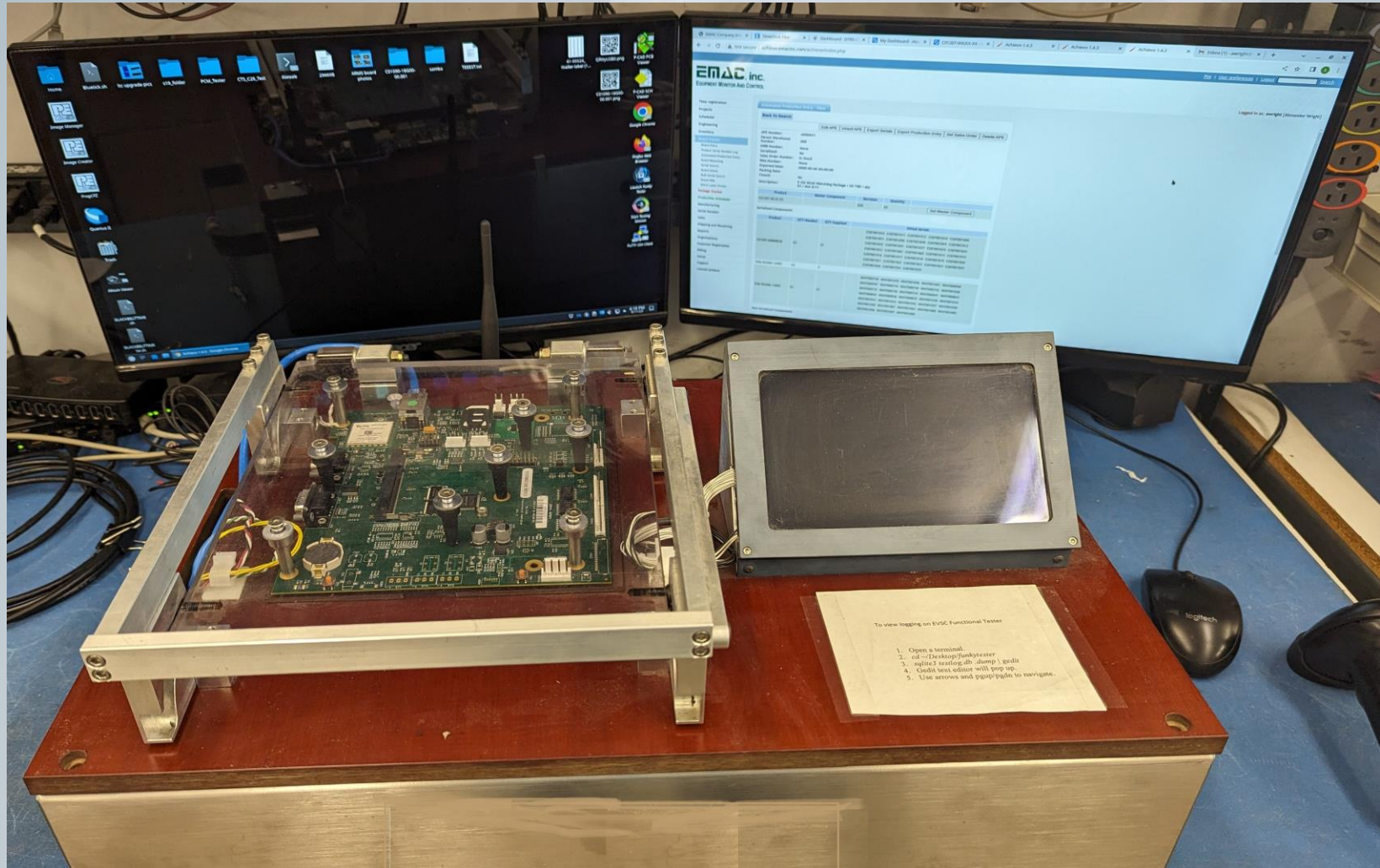
Semi-Automatic Test-Set (Inside View)

- **FCT Test-Set HW Considerations (Continued)**
  - **Fully-Automatic Test-Set (In-Line)**
  - **Disadvantages**
    - **Can be Very Complex**
    - **Much more Expensive than Semi-Automatic**
    - **Much Longer Lead Time**
    - **Can require a lot of Space**
  - **Advantages:**
    - **Essentially Hands Free**
    - **Highly Reliable & Robust**
    - **Generally Faster than Semi-Automatic**
    - **Real Time Data Analysis (Failure Trend Notification)**

Fully-Automatic Test-Set (In-Line)

- **FCT Test-Set HW Considerations (Continued)**
    - **Other Considerations**
        - **Component Height**
        - **Fiducials & Locating Holes**
        - **Simulating Loads & Sensors (Temp)**
        - **Shutting Off UUT Power while keeping the Test-Set Powered**
        - **Physical Test vs. Point Test (for a push button, press the button or just test the input)**
        - **RTC & Backup Battery Testing**
        - **Conformal Coating (leave Test Points uncoated)**
        - **Multi-Board Testing (mother/daughter)**
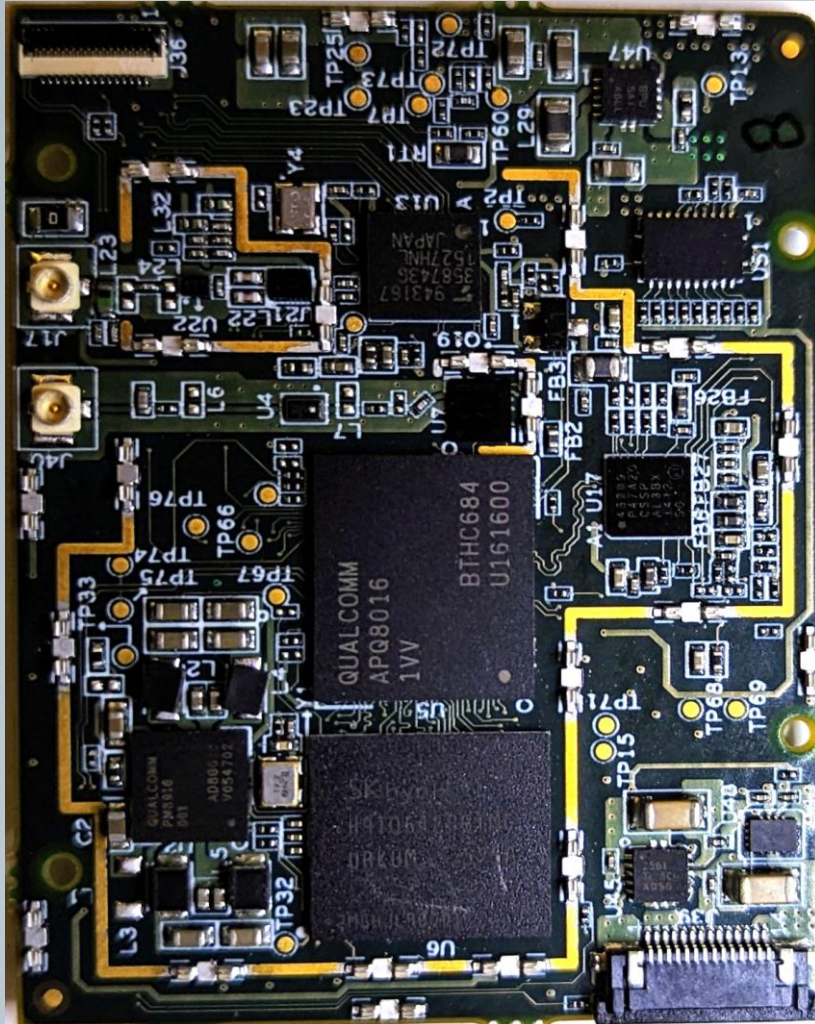   - **Testing Board Arrays**

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- # Design For Test
  - ## Test Targets:
    - **Test Pad; Via (untented; best if solder filled)**
    - **TH Pin (known length)**
    - **Turrets/Loops/Lugs; (no SMT leads)**
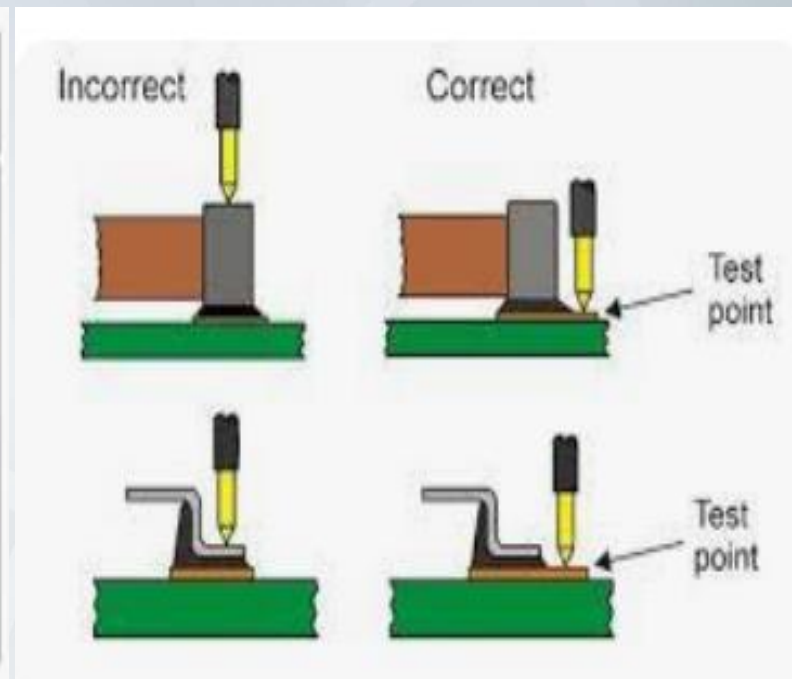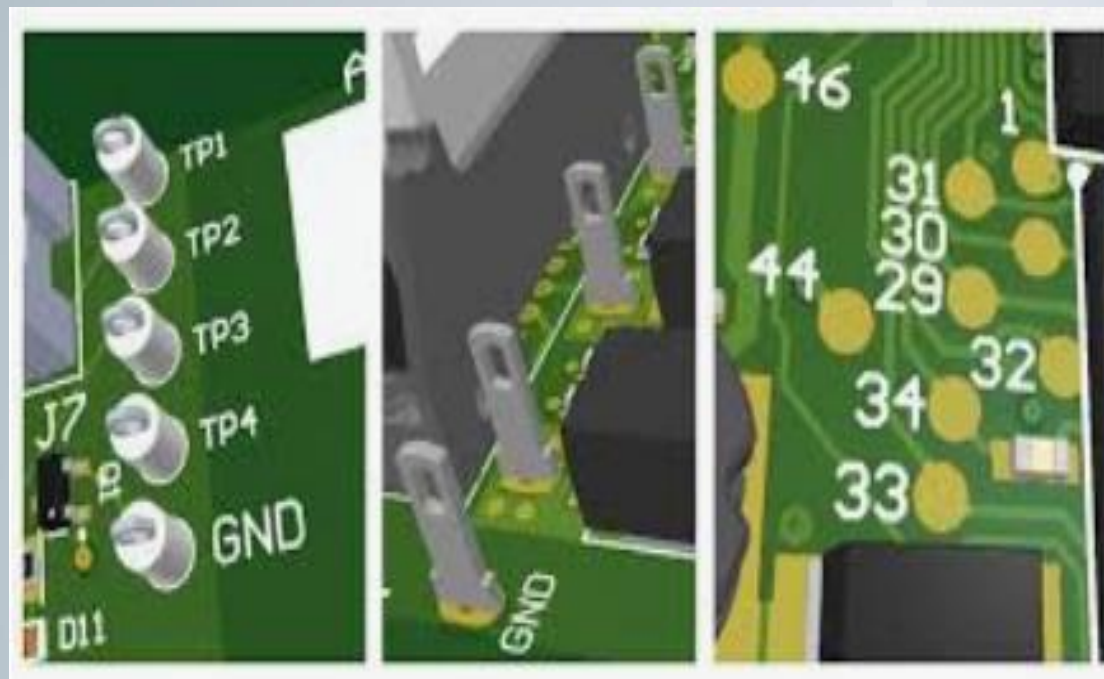
Actual PCB with Test Points Top & Bottom
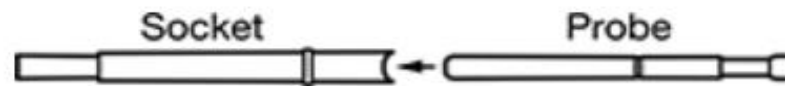
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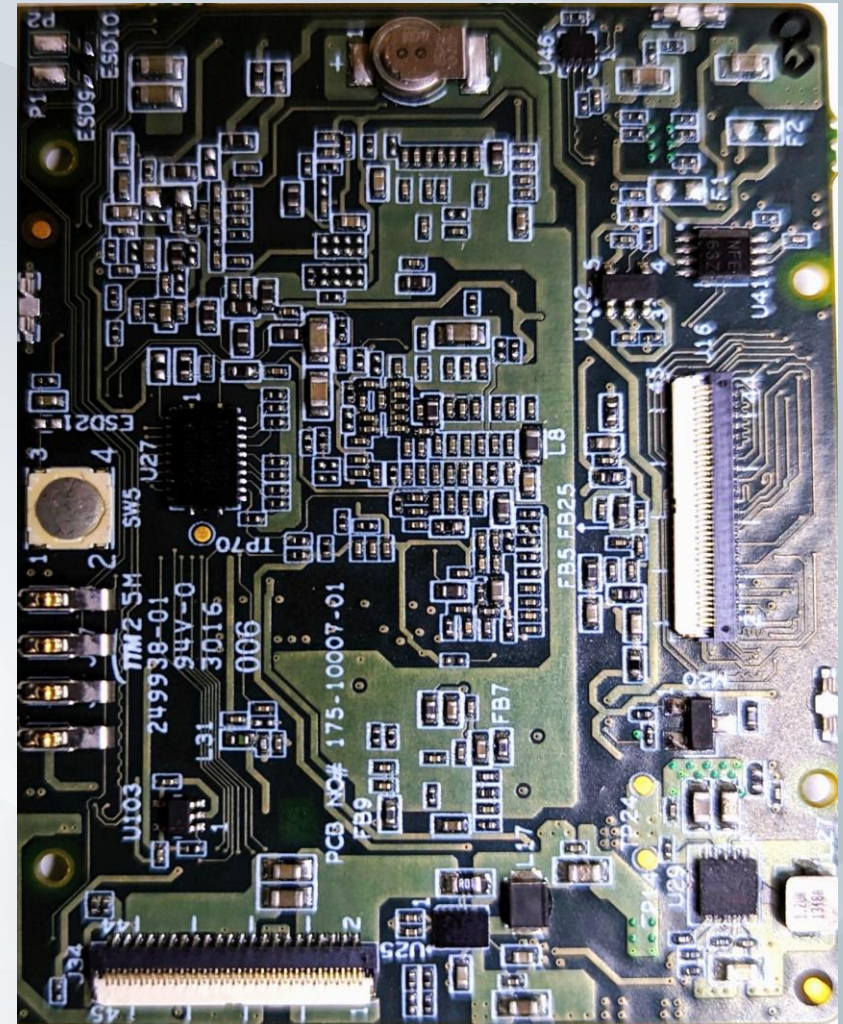
- **Design For Test (Continued)**
  - **Test Probe Types: (Pogo Pins) Round, Cup, Flat, Waffle, Crown, Spear, Chisel**

Spring Test Probes

Round | Socket | Probe | 90° Cup

Flat | Waffle | Crown | 30° Spear

  - **Try to keep all Test Points on one side of the board & Distribute Targets evenly across the PCB**

Design For Test (Continued)

- **Test Probe Sizes:** Best .1"; Adequate .075"; Tolerable .050" & .039"

- **Test Target Size:** Best > .035"; Adequate > .028"; Tolerable < .020"

- **Test Target Clearance:** minimum of .018" annular ring that is free of components

- **Test Target Edge Spacing:** Targets should be .125" from board edge

- **Tooling Holes:** Minimum of two 0.125" holes with .2" clearance

- Leave adequate space for Push Rods (Hold Down Posts)

Design For Test (Continued)

- Do not put Test Points under BGAs
- Use multiple Test Points for Power Connections
- Be sure to distribute Test Points across the board to prevent Flex Stress
- Be aware of the total force of all pogo pins (~1 newton per pin)
- Try not to use No-Clean Flux in your manufacturing process if using a Test-Set with Pogo Pins

- **Bed of Nails Test-Set Construction**
  - **Materials:**
    - **Test Probes (Pogo Pins)**
    - **Guide (Tooling) Pins**
    - **Push Rods (Hold Down Posts)**
    - **Probe Plate**
    - **Spring Loaded Stripper (Top) Plate**
    - **Pressure Plate**
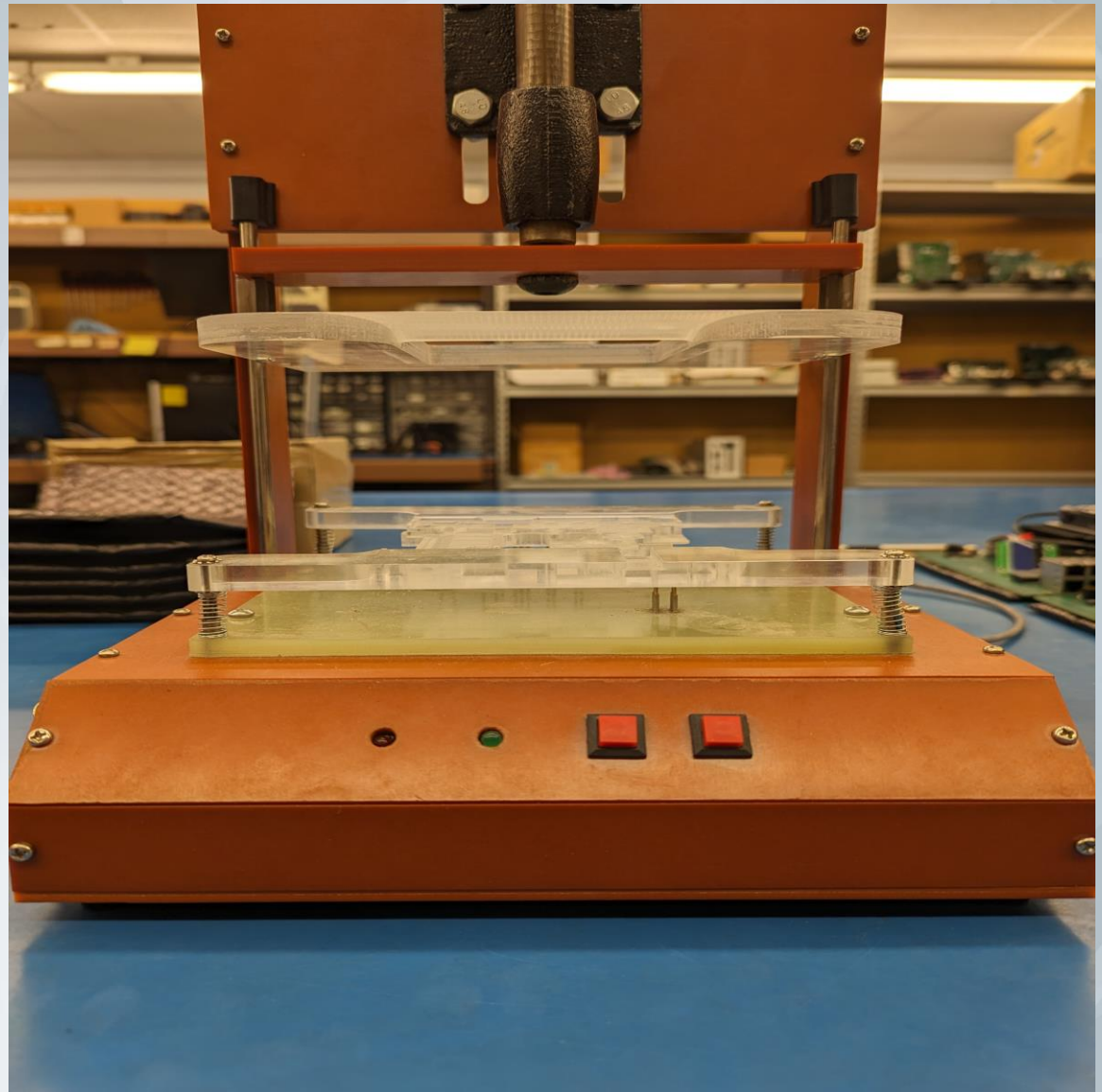   - **Interface (T) Board or Terminal Block (Wireless or Wired)**
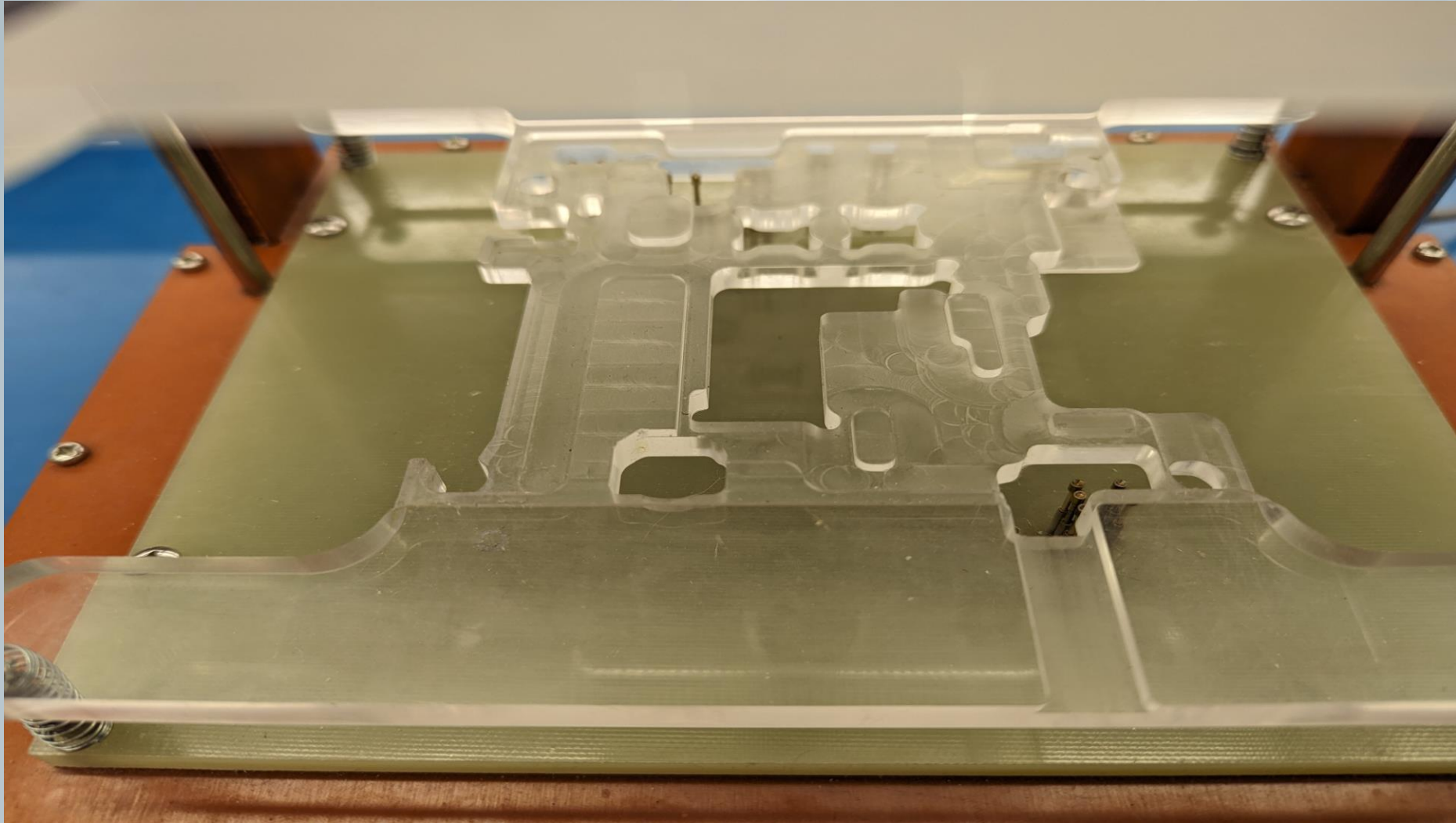
Bed of Nails Test-Fixture
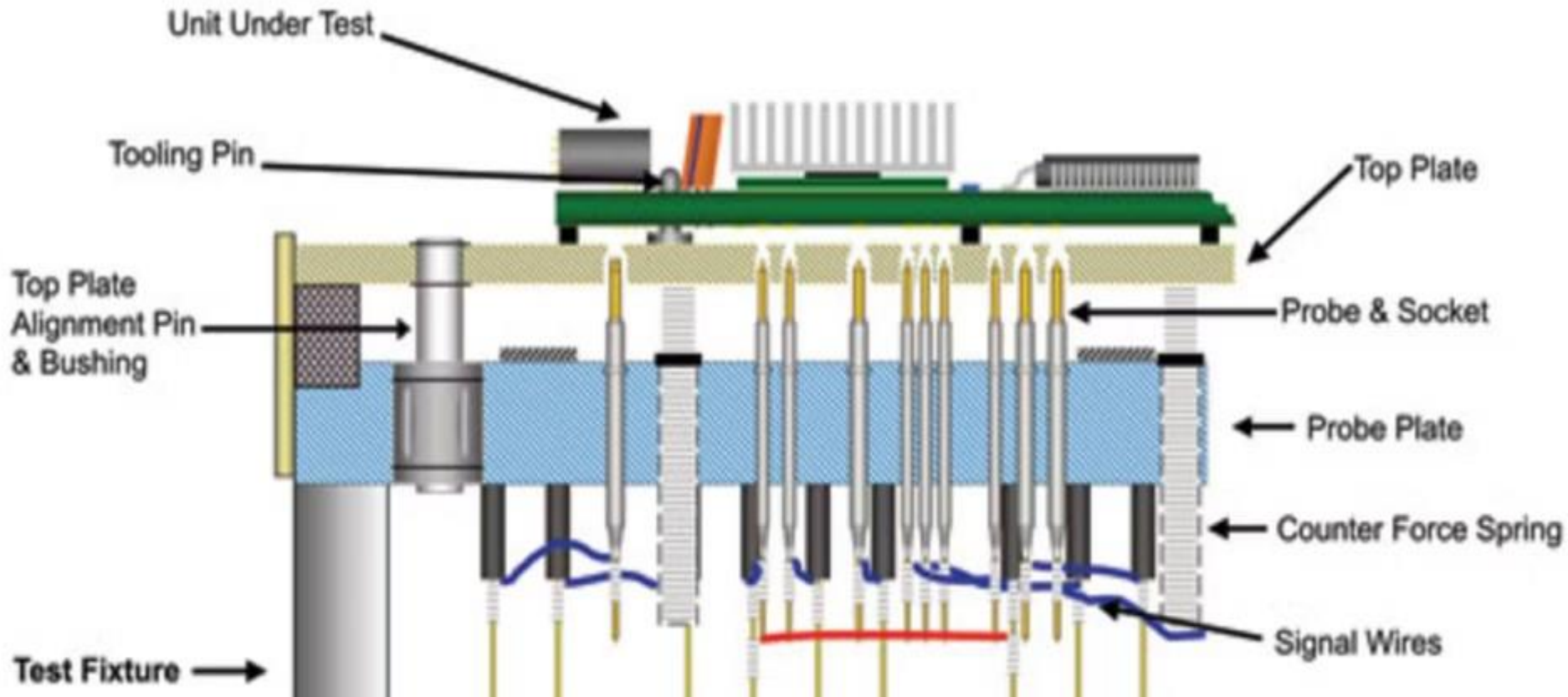
Bed of Nails Test-Fixture

Bed of Nails
Test-Fixture
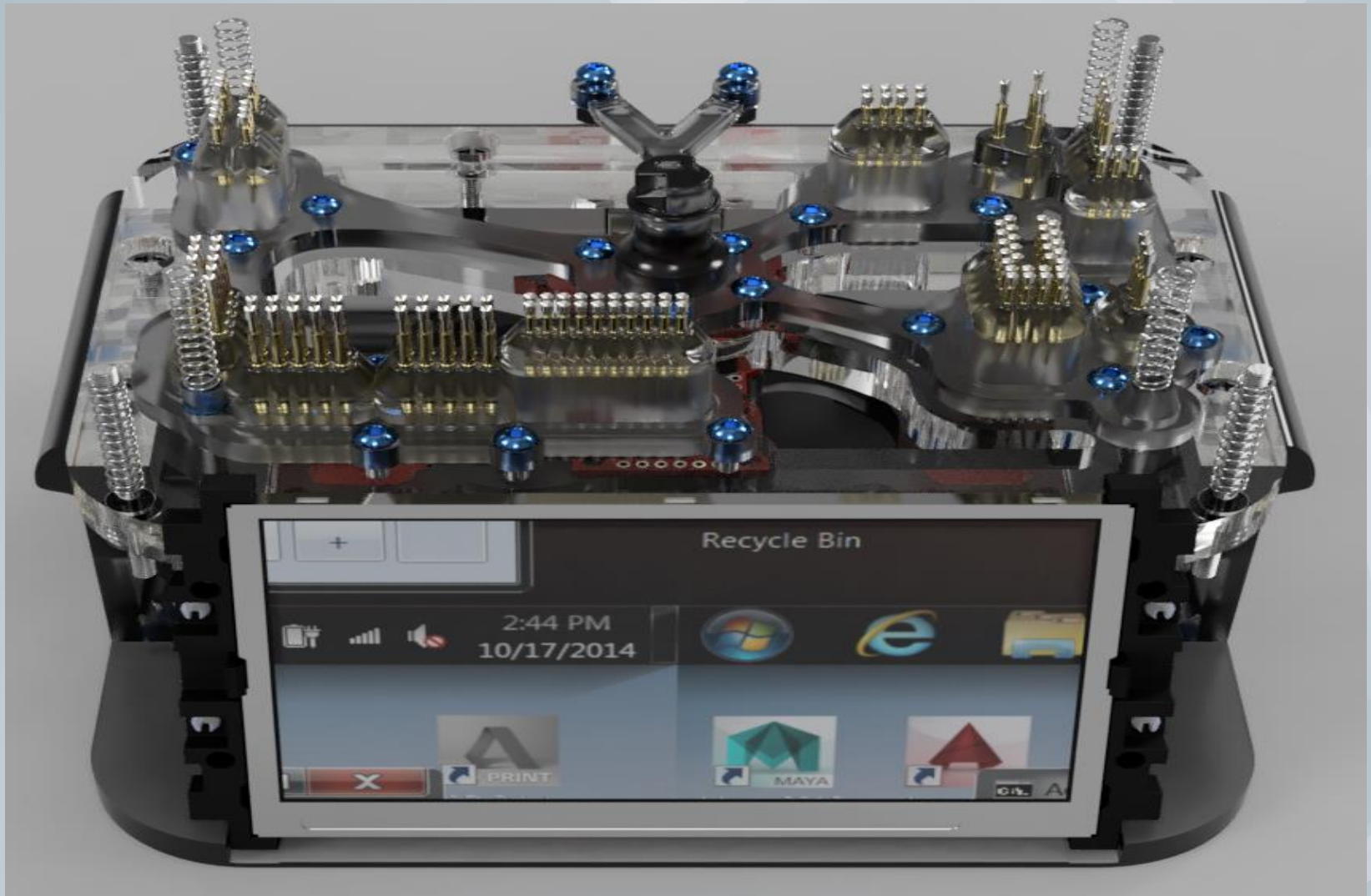
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Bed of Nails Test-Fixture

- **Bed of Nails Test-Set Construction (continued)**
    - **Considerations:**
        - **Clam Shell or Straight Z-Axis Pressure Plate**
        - **Manual, Pneumatic or Vacuum Press Actuation**
        - **Wired or Translator (T) Board**
        - **Cable/Plug Access**
        - **Interface Circuitry**
        - **Test Computer UI (internal or external)**
        - **Bar Code Scanner**
        - **ESD Protection & Safety Considerations**
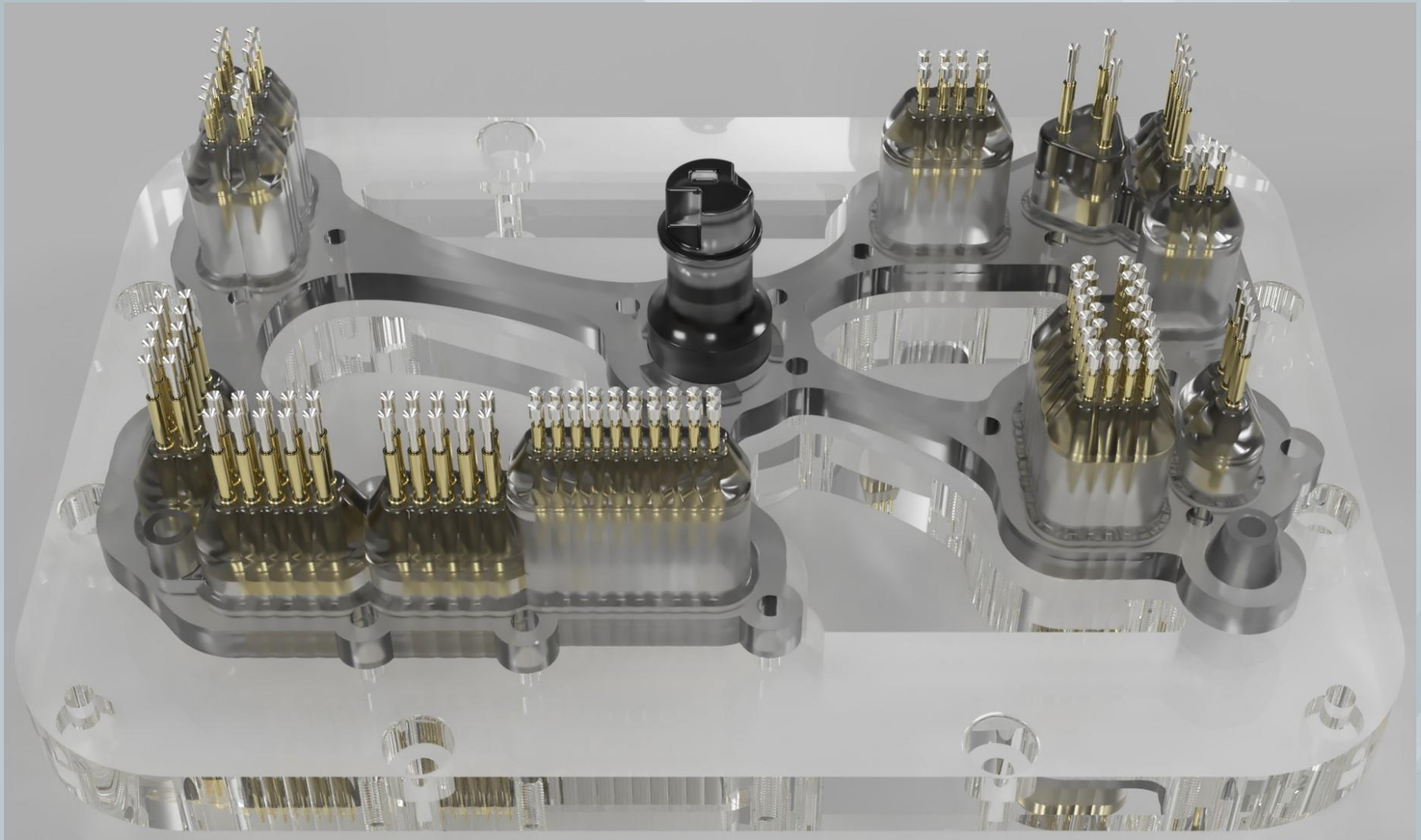   - **Conventional or 3D Print**

3D Printed Tester

3D Printed Test-Fixture

- **Bed of Nails Test-Set Construction** (continued)
  - **Design for Maintenance & Repair:**
    - **Provide a Dust Cover of some sort**
    - **Clean & Replacing Pogo Pins**
    - **Easy Access to Fuses, Wiring & Circuitry**
    - **Easy Socket Change Out**
    - **Limiting Cables that require plugging & unplugging**
    - **Scheduled Maintenance & Calibration (swap out Pogo Pins & Cables)**
    - **Keep Spare Parts On-Hand**

- **FCT Test-Set Software**
    - **Considerations**
        - **Running the Test SW on the UUT**
        - **Running the Test on Computer**
        - **Using the Test-Set for Repair as well as Testing**
    - **Data Logging & Reporting**
        - **Serial#**
        - **Time, Date, Duration & Tester**
        - **Pass/Fail Status & What Failed**
        - **Measurements of Key Test Points a (Voltage, Current, Frequency, etc.)**
   - **Board Tracker (EMAC's Logging DB)**

- **FCT Test-Set Software (Continued)**
  - **What to Report**
    - **First Pass Yield**
    - **What Failures are most prevalent**
    - **Average Test Time**
  - **Test/Program Application (TPA)**
    - **TPA - Is a Custom Application written by EMAC to allow the efficient reuse of Test SW and User Interface for Programming & Testing PCBAs**
    - **TPA Application Programming Interface (API)**
      - **Stand Alone use or with Back-End Server**
    - **TPA Demo**
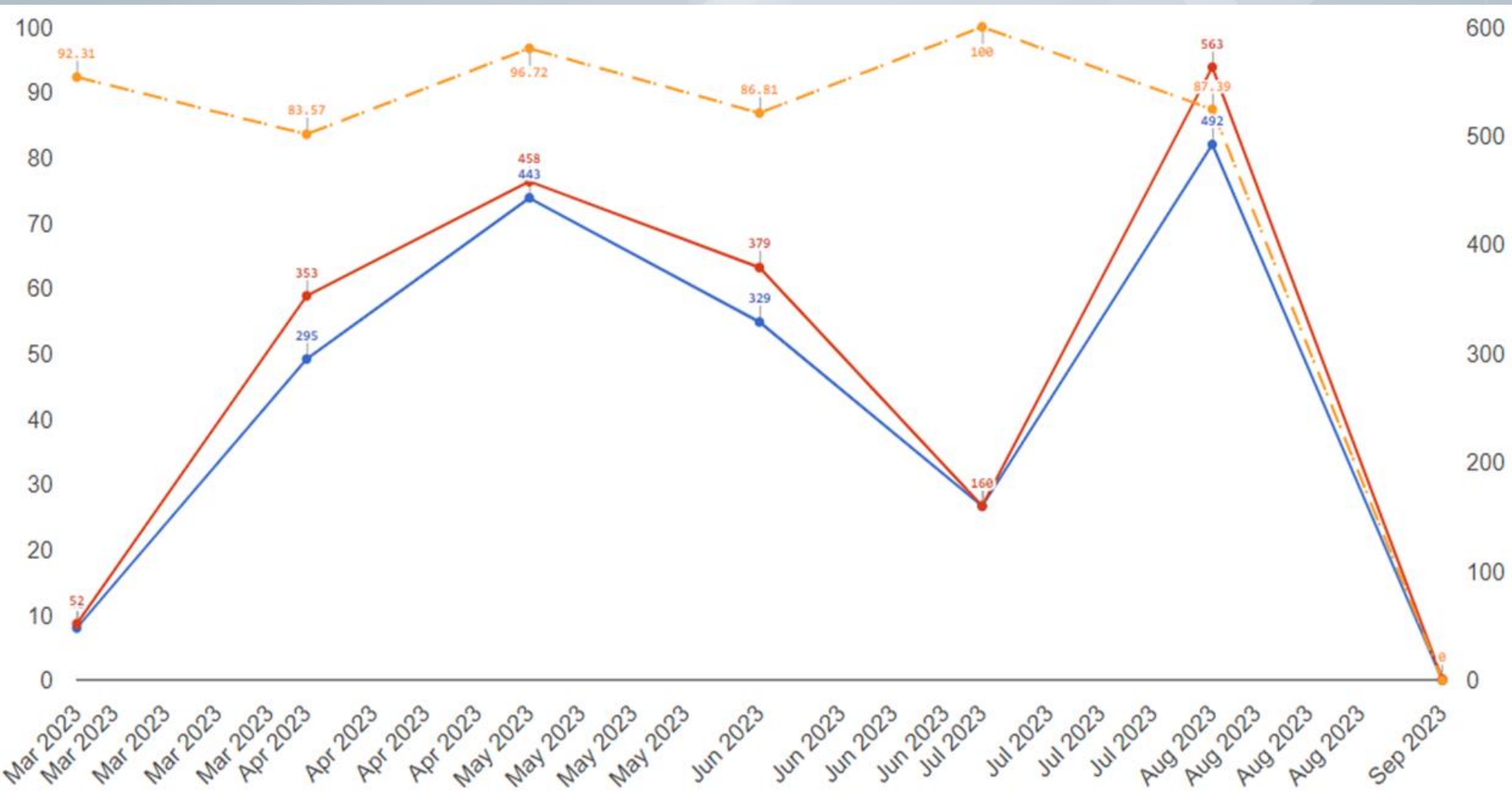
Test Reporting (5 boards 1st Pass Yield)
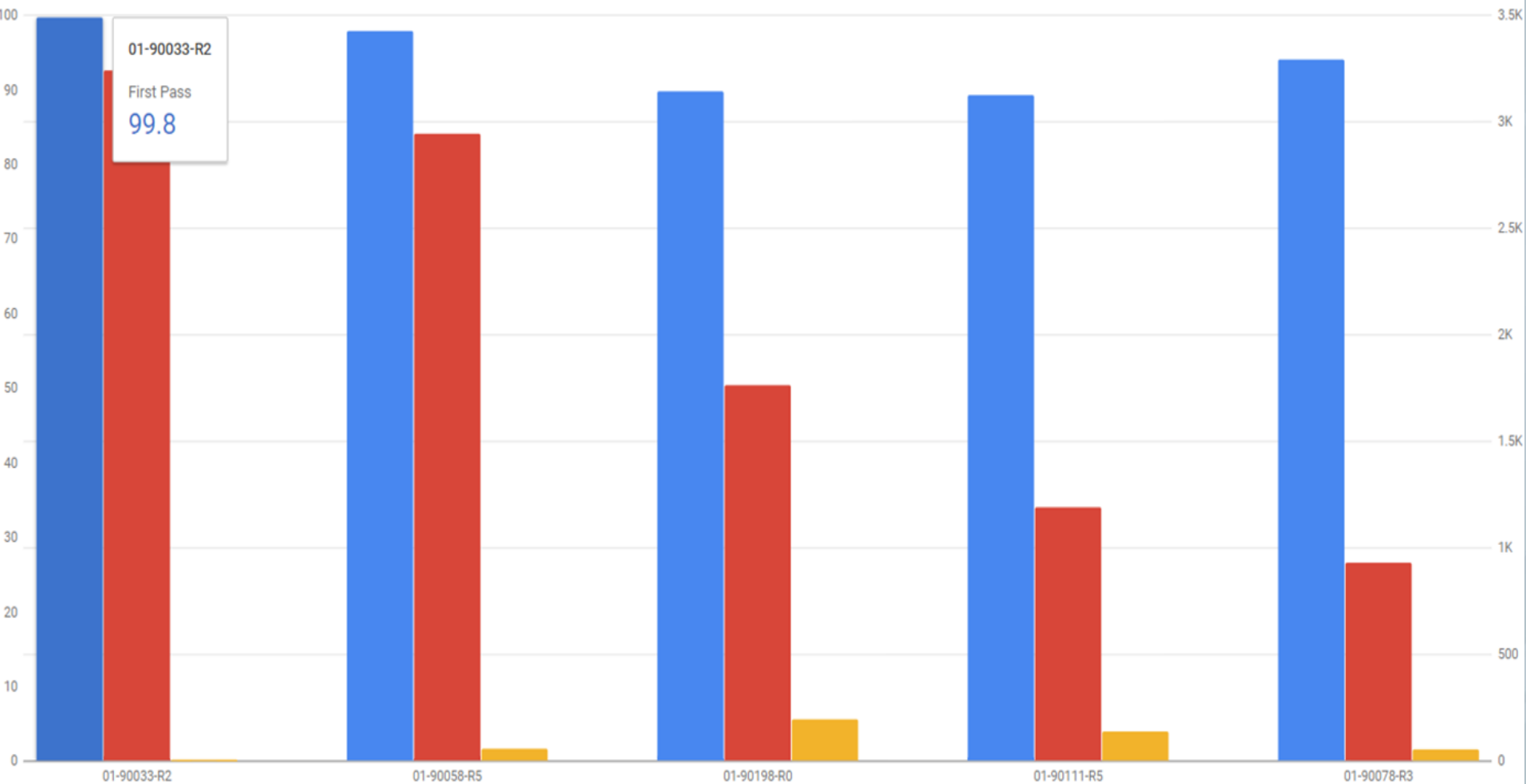
Test Reporting (single board over 4 runs)

EMAC Testing Stats for 01-90033-r2 on Date: 2022-09-18 to 2023-09-18 Total Boards Processed: 3251
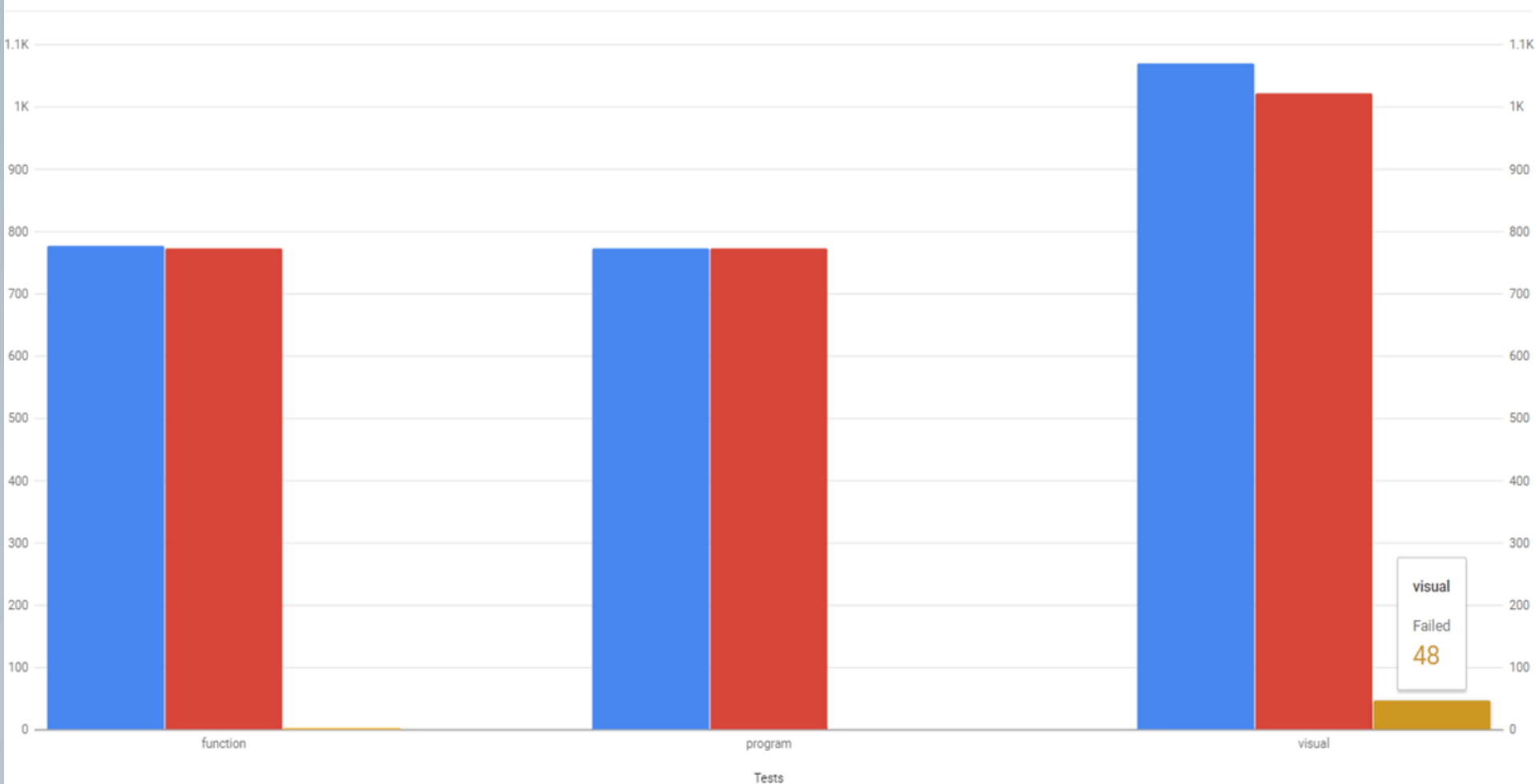Total Pass Percent: 99.78
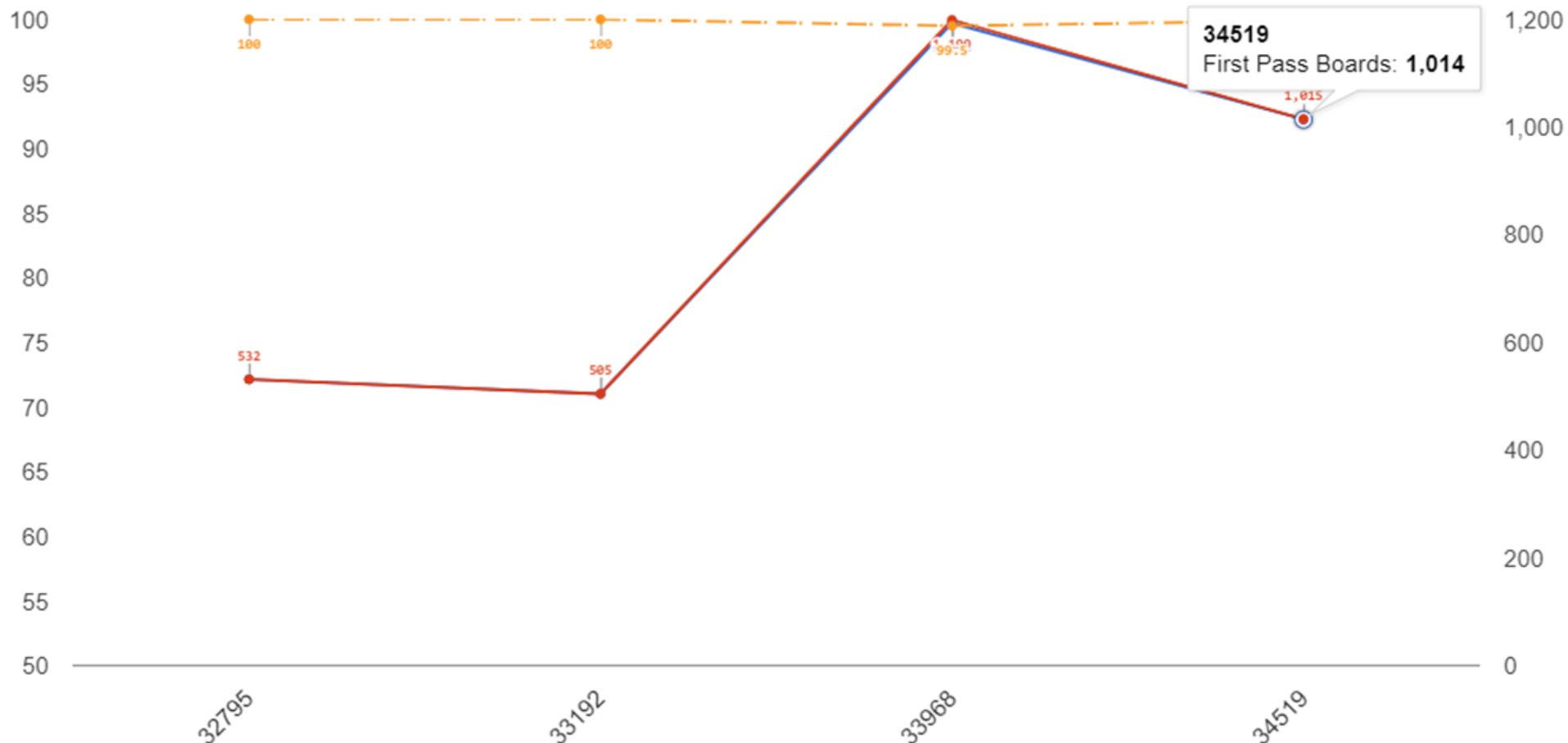
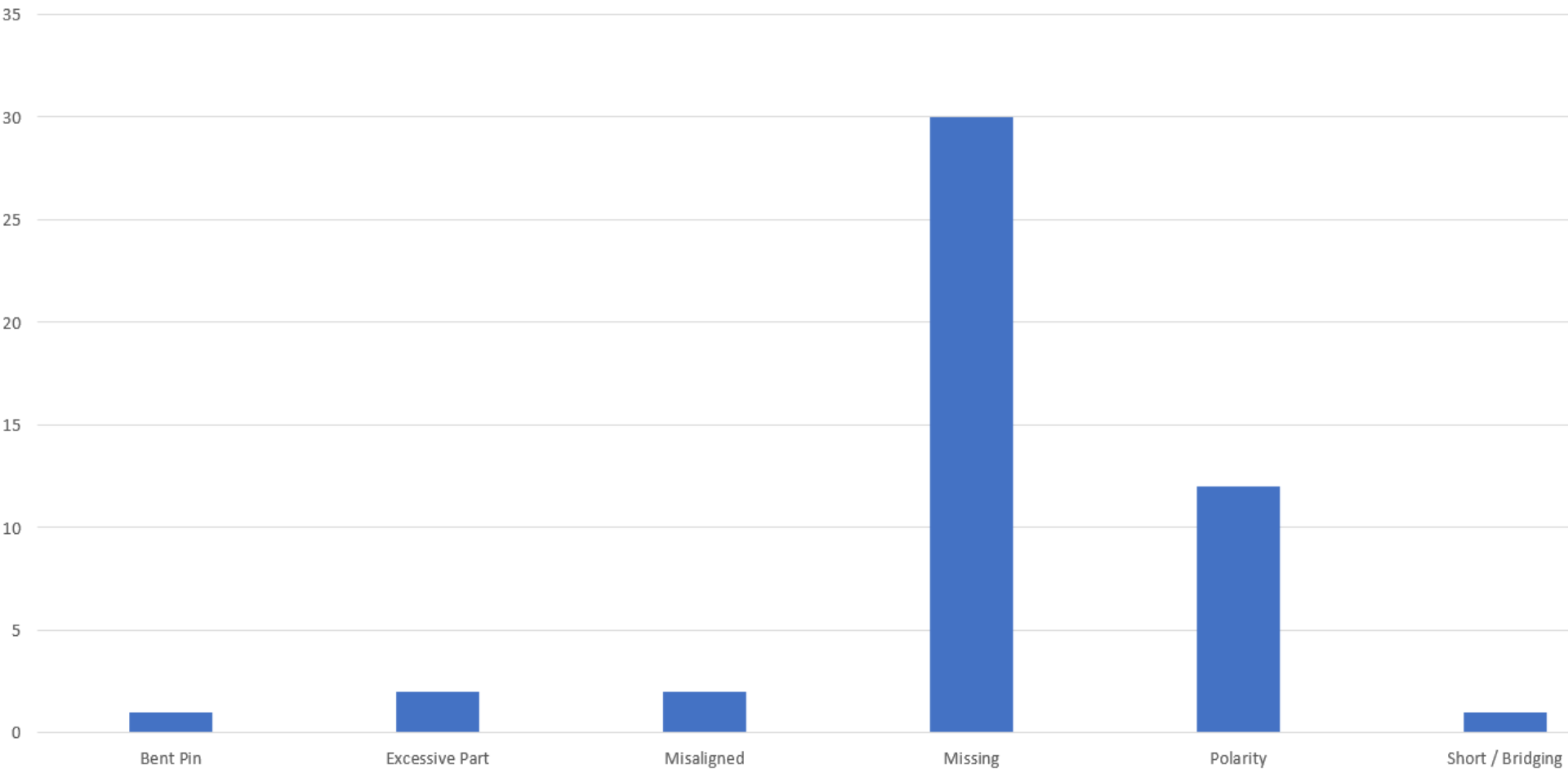# Test Reporting (single board over 6 months)

Test Reporting (breakdown of Issue Categories)

IHRR 35042 for Date Range: 2022-09-18 to 2023-09-18

visual
Failed
48

Test Reporting (breakdown of actual issues)

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