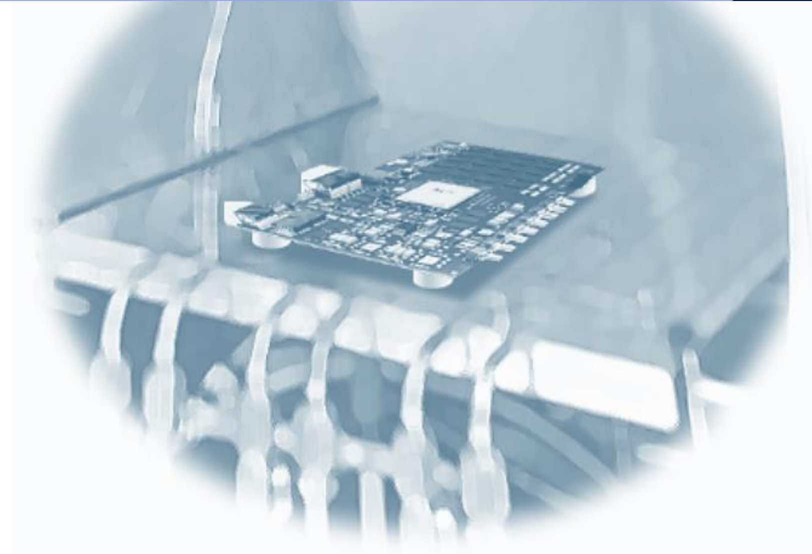
#4000134677/21/NL/FE

DSi Aerospace



ALTER TECHNOLOGY

SPACE SYSTEMS

ATCOS GSTP Study: Alternative Test Methods for COTS – Test Results

We. Create. Space.

Presentation Overview

- Study goal
- Consortium
- Test overview
- Test results
- Conclusion

Study goal

- Compare component level testing with board level testing in order to understand if and how component level testing can be reduced and transferred to board level testing
- Identify suited acceleration means (HALT, HASS) for board level testing to optimize test effort

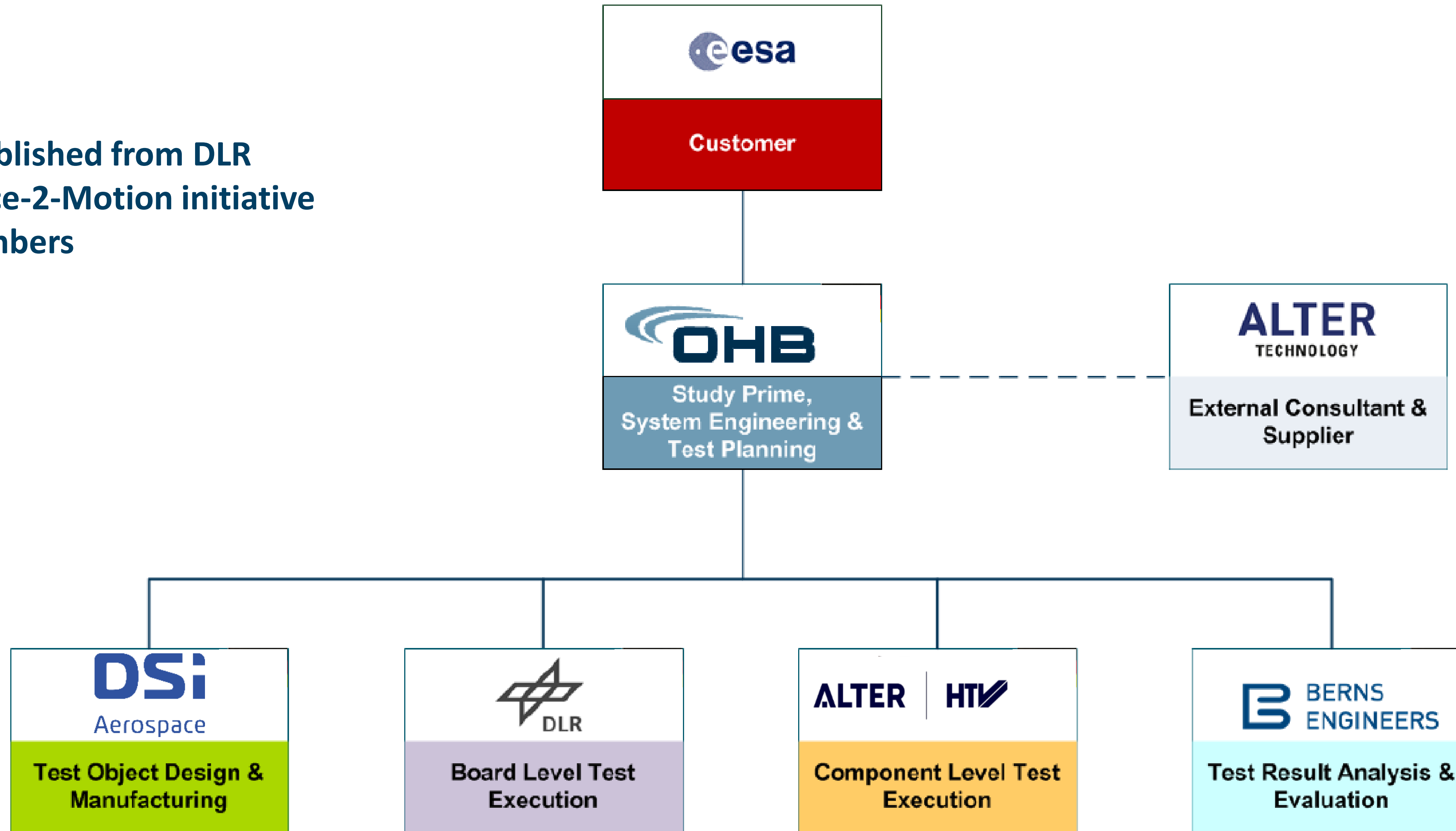
HALT – Highly Accelerated Life Test
HASS – Highly Accelerated Stress Screening

Notes:

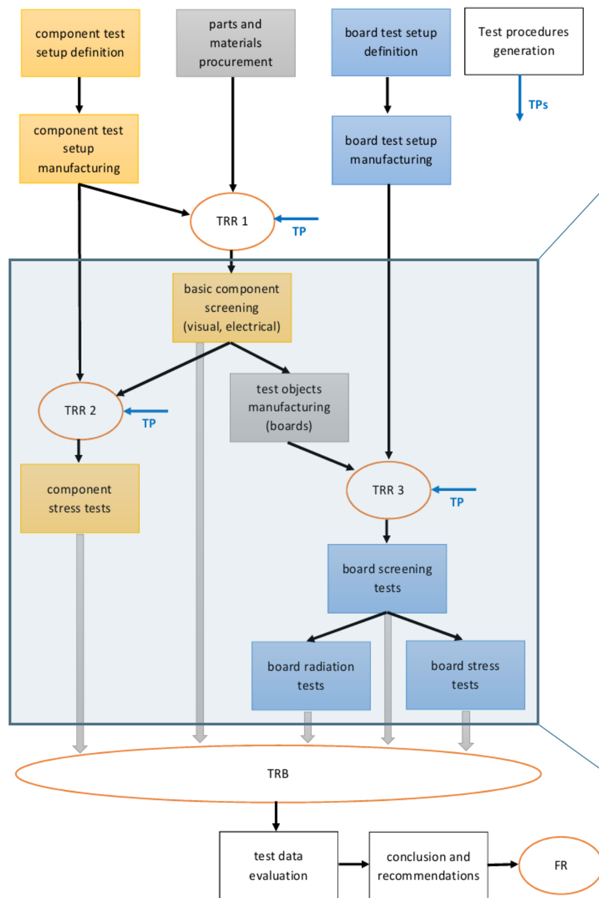
- Study considers qualification testing aspects (flight representative hardware) and screening testing aspects (flight hardware)
- Study is based on existing hardware (board from DSI)

Consortium

Established from DLR Space-2-Motion initiative members



Test Plans



basic component screening (visual, electrical)

TRR 2

TP

test objects manufacturing (boards)

component stress tests

TRR 3

TP

board screening tests

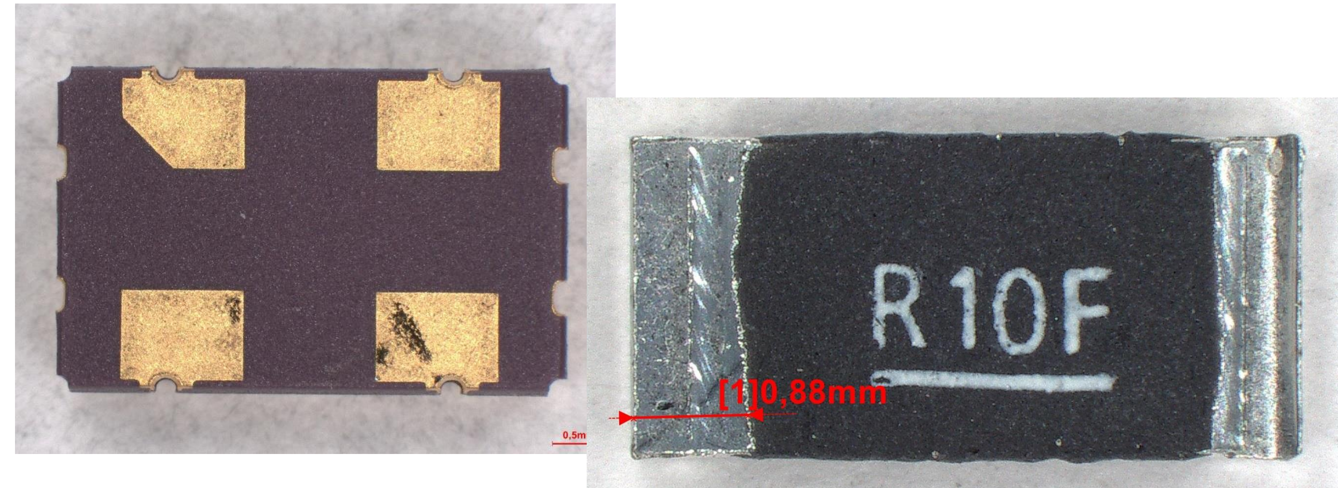
board radiation tests

board stress tests

Component Level Screening

- **30 component types tested, 1116 components total**
  7 ICs, 1 hybrid, 3 oscillators, 7 discretes, 1 inductor, 6 capacitors, 4 resistors, 1 connector

- **Results of visual inspection:**
  - 1 shipment completely rejected → inadequate packaging (by distributor -> ESD+damage)
  - 17 component types 100% pass, 13 component types with some fails
  - 63 of 1116 components failed → but still being used for board manufacturing
    - Foreign particles and contamination
    - Scratches
    - Corrosion on test points or pins
    - Exposed base material of pins
    - Package discolorations
    - Deviation from specifications
    - Bent pins



Component Level Screening

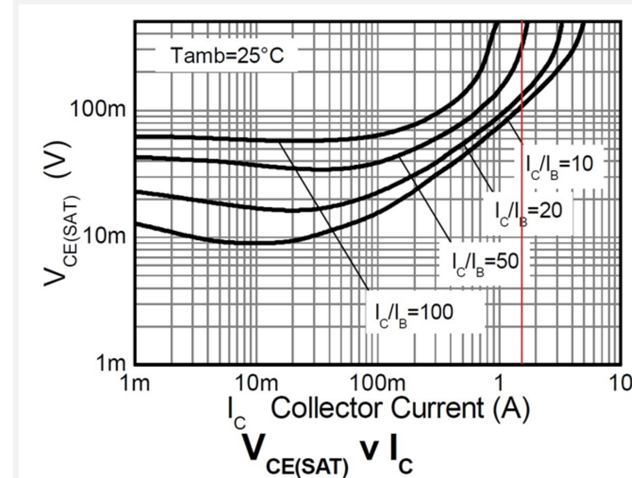
- **Results of electrical testing:**
  - No failures found
  - Found error in one transistor data sheet: VCE(sat)(max) listed as 200 mV in one place, 300 mV in another

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Characteristic	Symbol	Min	Typ	Max	Unit	Test Condition
Collector-Emitter Saturation Voltage (Note 9)	$V_{CE(sat)}$	- - - -	15 45 145 160	20 60 185 200	mV	I_C = 0.1A, I_B = 10mA I_C = 0.5A, I_B = 50mA I_C = 1A, I_B = 20mA I_C = 1.5A, I_B = 20mA

All parts are fail at the last VCE(sat) parameter, for which a maximum of 200 mV, measured with IC = 1.5 A, IB = 20 mA, IC/IB=75, is given in the "Electrical Characteristics" table in the data sheet.

However, according to the "Typical Electrical Characteristic Diagram" in the data sheet, a typical value much higher than 200 mV is given. (See below, test condition IC= 1.5 A is marked in red). The typical value for IC/IB=75 should be higher than 300 mV.

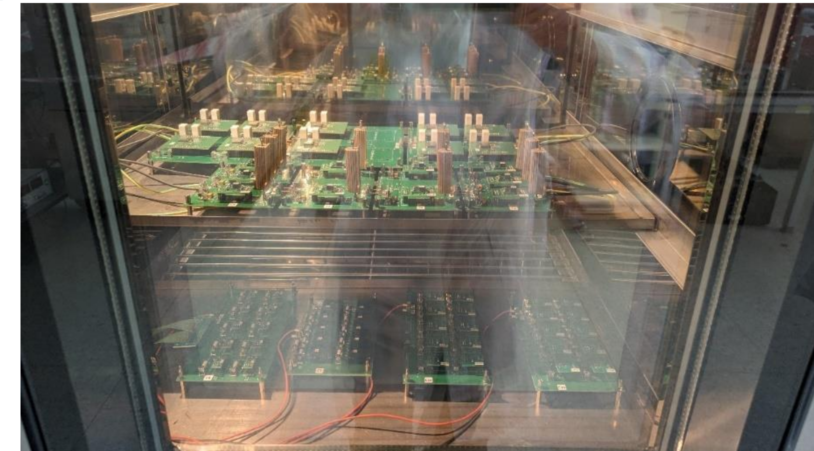


Measured values of VCE(sat) at these conditions vary between 0.692 and 1.373 V, which is a typical, in-conspicuous range of values.

We suspect the limit of 200 mV is erroneous.

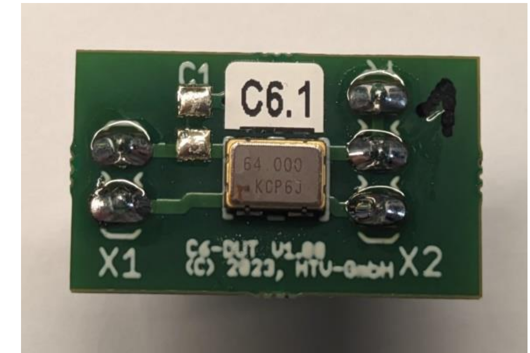
Component Level Stress Tests

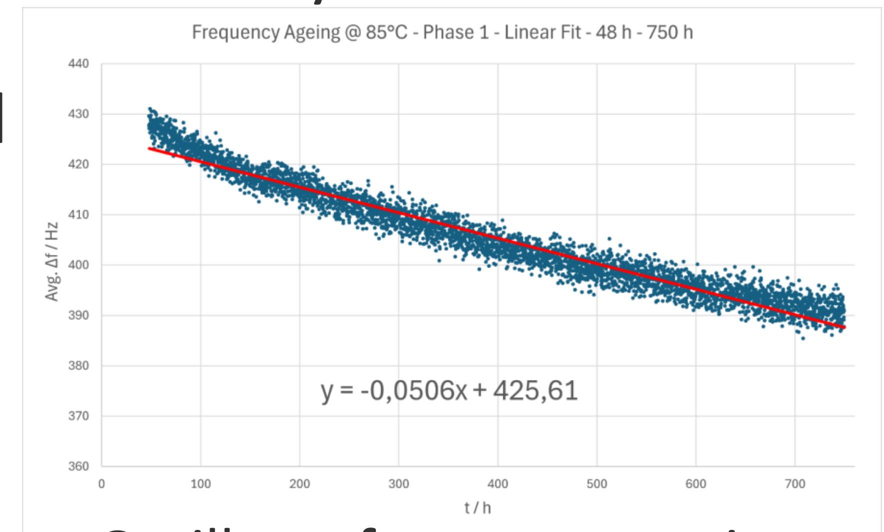
- **15 component types tested, 150 components total**
  3 ICs, 1 module, 1 oscillator, 5 discretes, 1 inductor,
  2 capacitors, 1 resistors, 1 connector
- **Stress test = life test + type specific tests + DPA**
- **Life test usually @ 125°C**
  2 groups 1000h @ 125°C, 1500h @ 85°C
  - Some components have max. operating temperature 85°C
  - Some are self-heating



Component Level Stress Tests

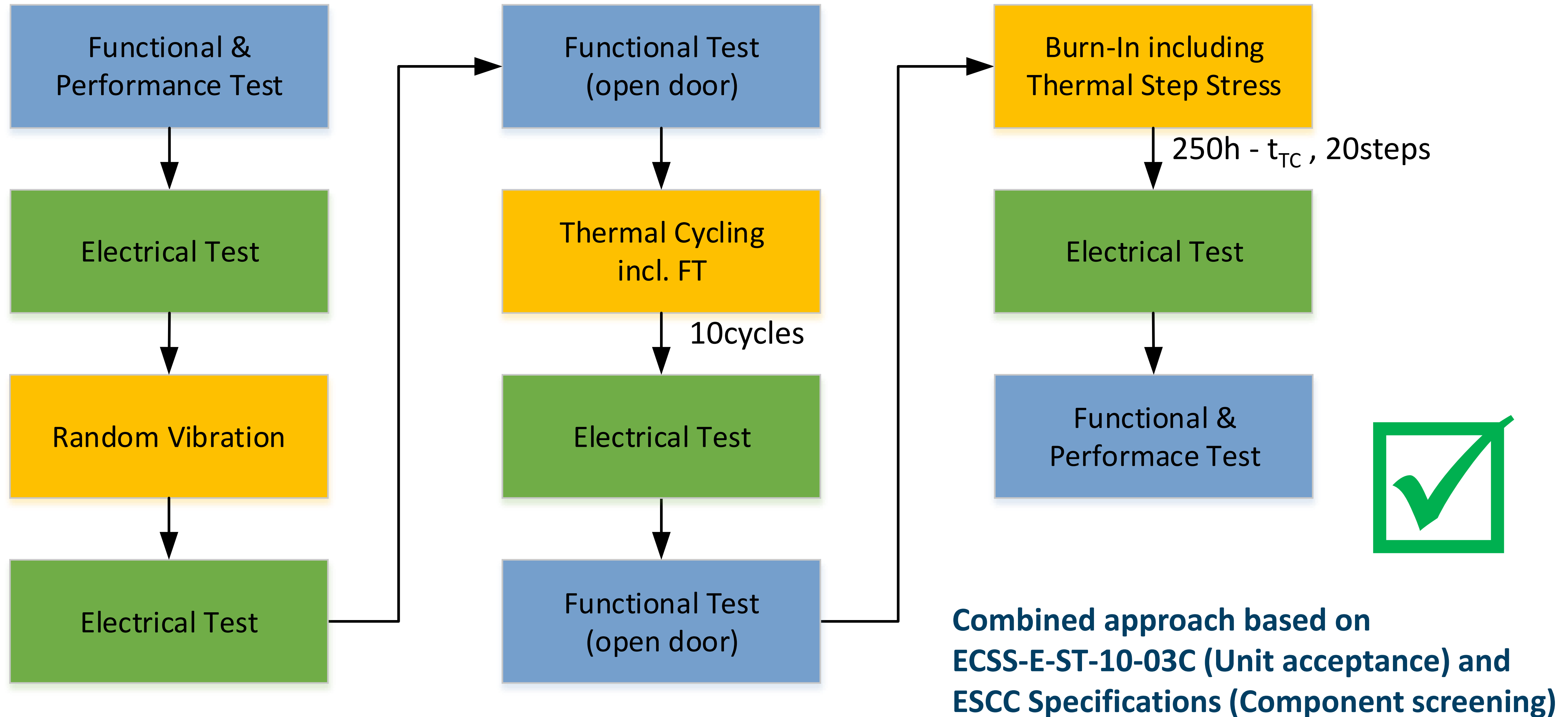
- **Life test results:**
  - No catastrophic failures
  - Sometimes, large tolerance windows listed in data sheets – component performance generally well within range
  - Parametric failure of inductor – inductance increased by ~ 12% during test, exceeds max limit
  - Line regulation of power module not as good as expected from data sheet “typical value”
  - Oscillator (64 MHz, specified as +/- 50 ppm) performed very well
    - <1 ppm change during 1500 h @ 85°C
    - <2 ppm change during shock and vibration





Oscillator frequency ageing

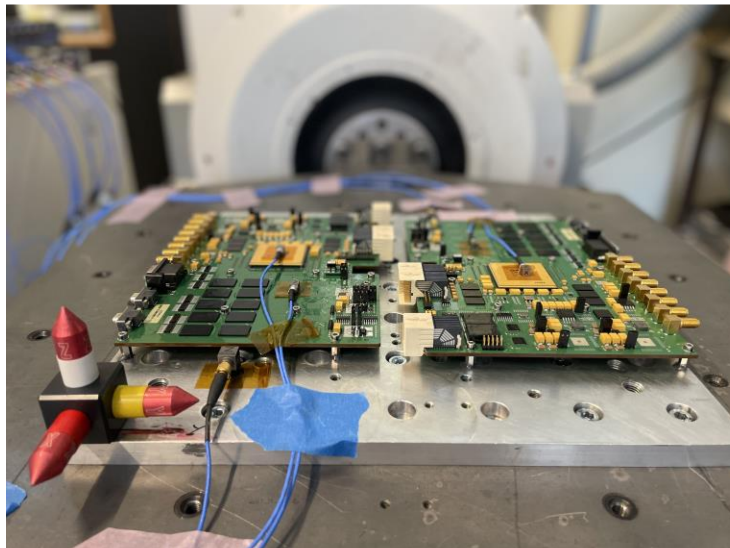
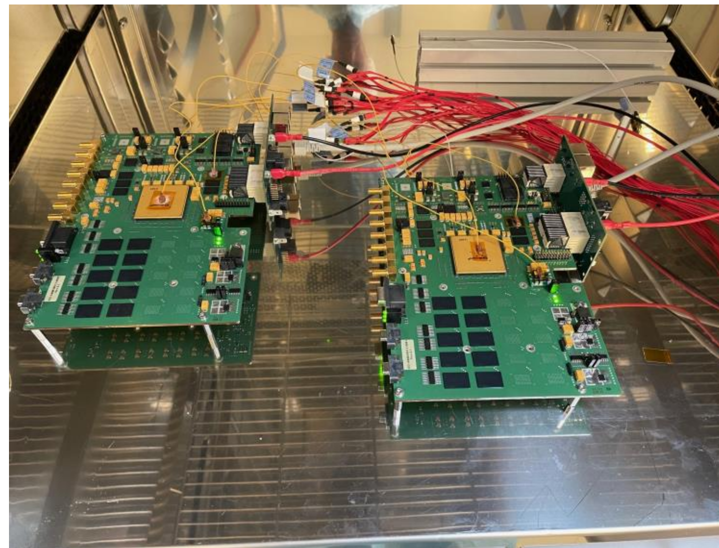
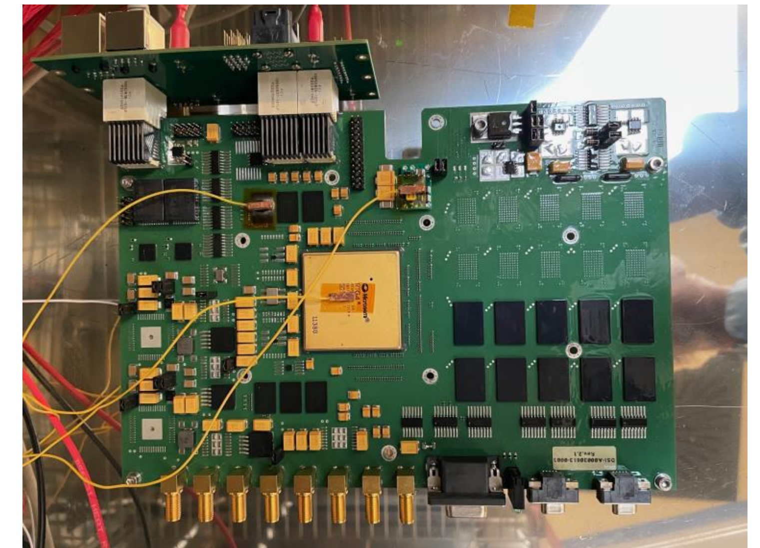
Board Screening Tests



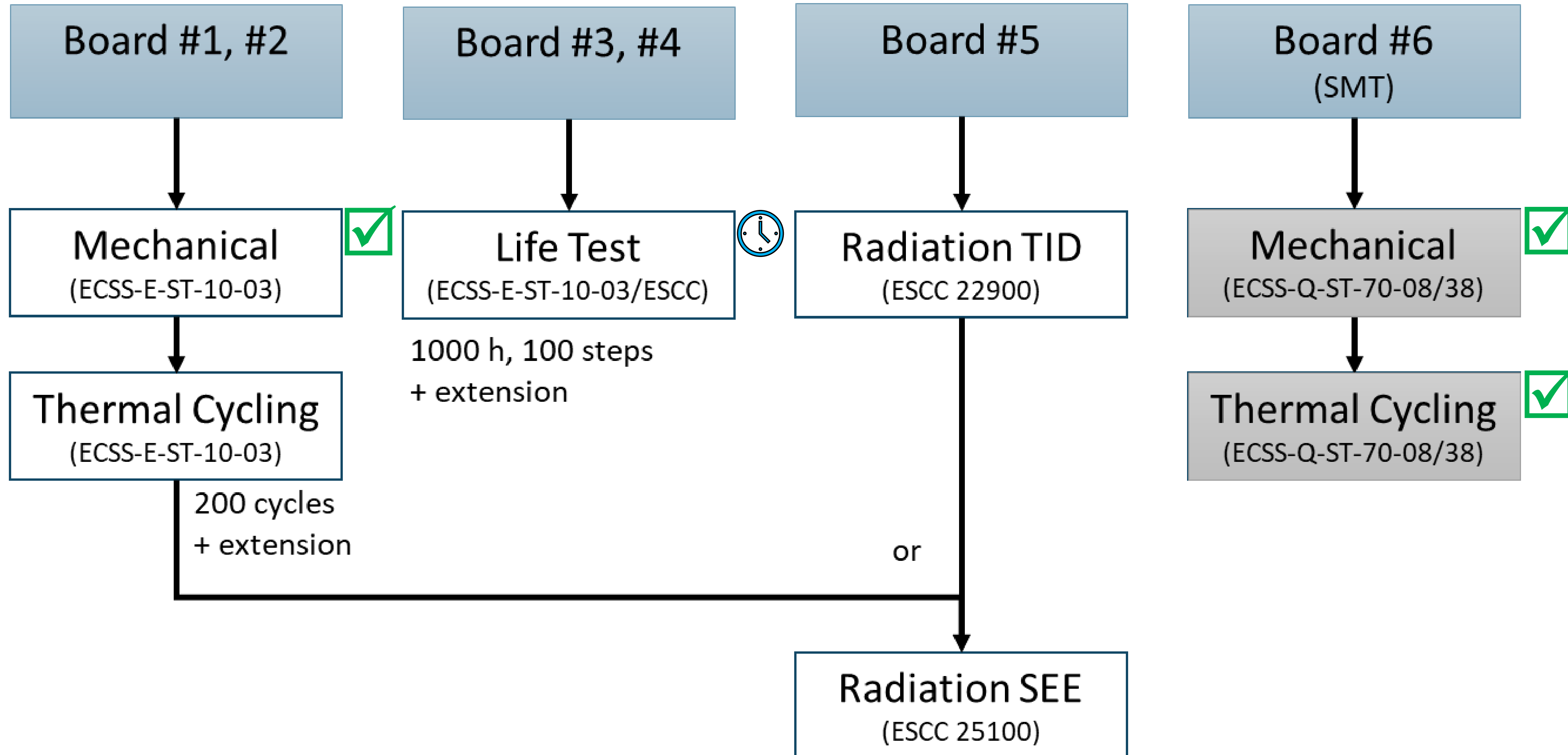
Combined approach based on ECSS-E-ST-10-03C (Unit acceptance) and ESCC Specifications (Component screening)

Board Level Screening Tests

- Screening tests performed on 5 Boards
- Results Visual Inspection: passed
- Results Functional Testing: passed
- Results Electrical Testing: passed

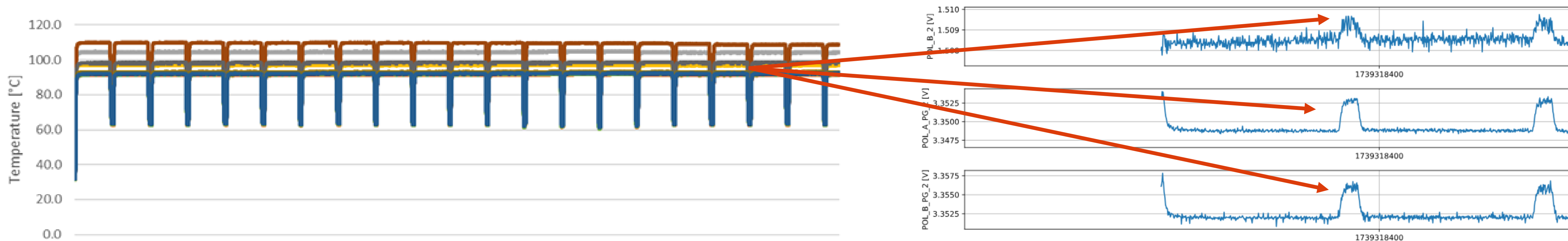




Test Plans – Board Stress Tests



Board Level Stress Tests - ongoing

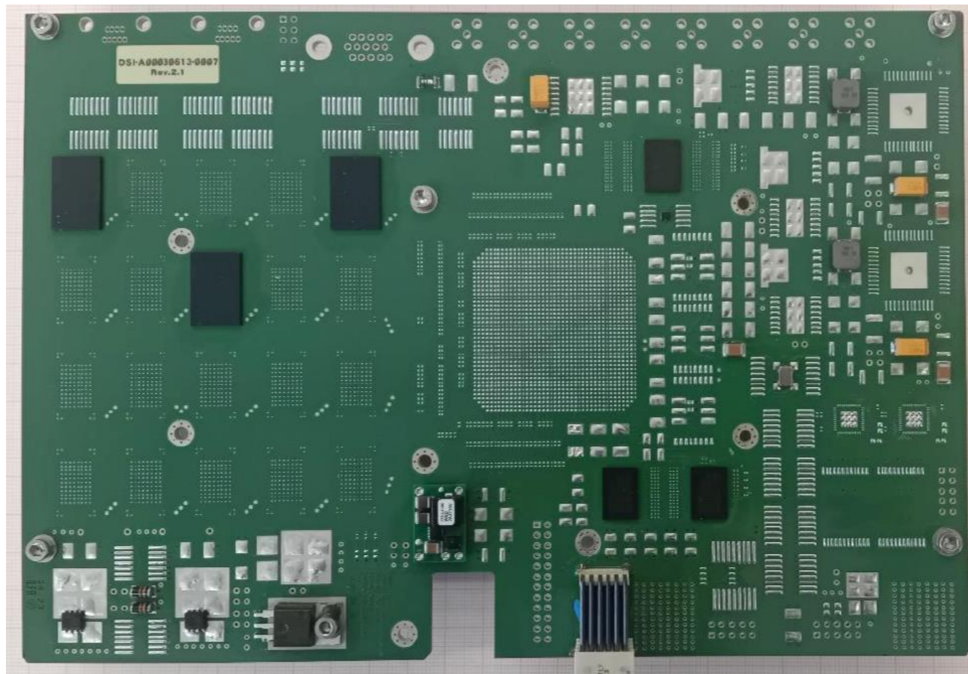
- Mechanical tests performed on Board 1 and Board 2 (passed)
- Life test almost completed on Board 3 and Board 4 (~800h)
  - All functions still regular
  - No significant drift in monitored electrical parameters

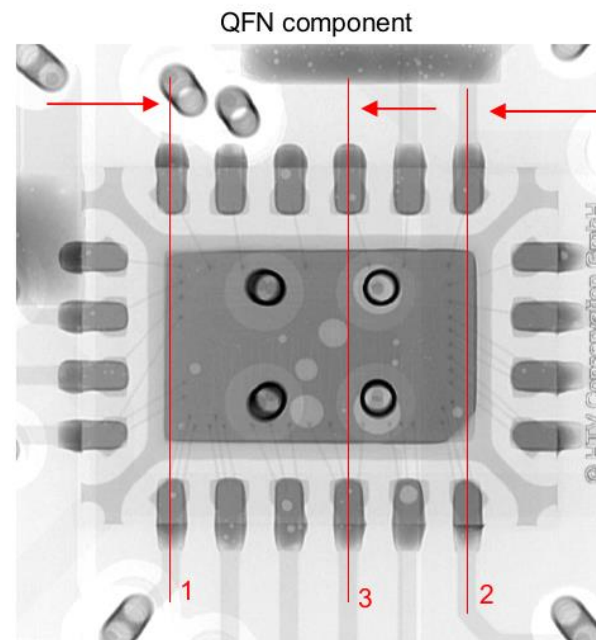


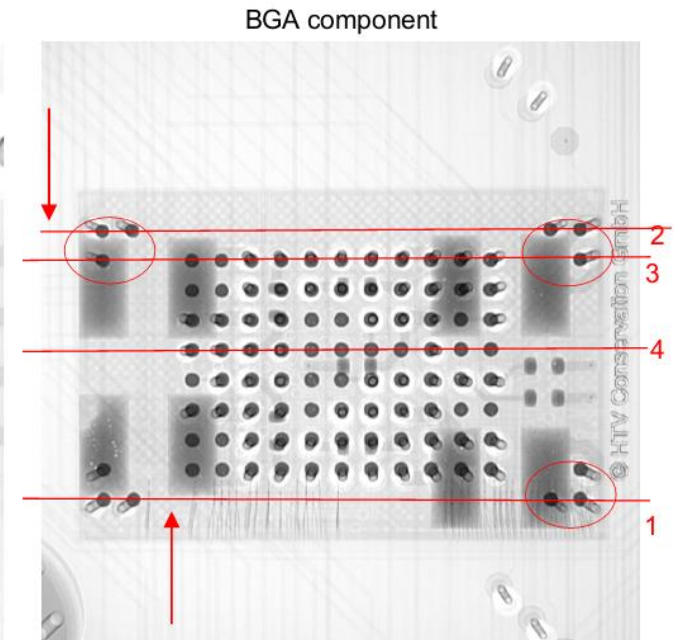
In-Situ parameter measurements

Board Level Stress Tests - ongoing

- Mounting Verification on passive board (16 component types)
  - Environmental Testing completed → no obvious damages
  - Microsectioning ongoing







Conclusion

- **No severe issues during component level testing**
- **Screening without failure on all 5 boards**
- **Board stress tests ongoing**
  - Mechanical Tests successful
  - Life Test at 800h out of 1000h (+extension) – so far fully functional
- **Mounting verification testing completed, microsectioning ongoing**
- **Comparison between component level results and board level results ongoing**

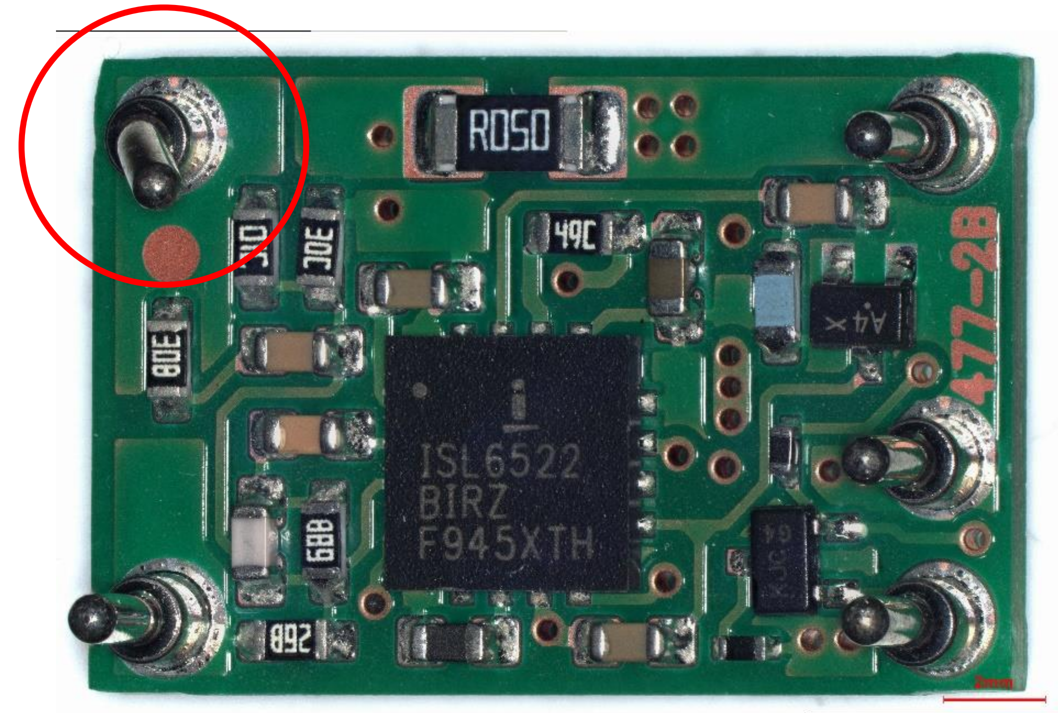
Commercial components selected so far appear to be robust and industrial mounting appears to be reliable, pending

- confirmation from microsectioning
- board level thermal cycle testing
- radiation testing

Thank you

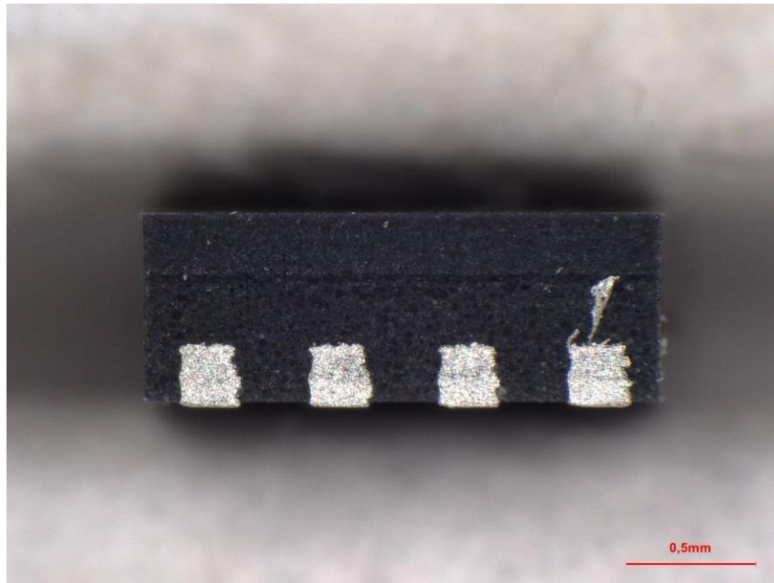
Backup Slides

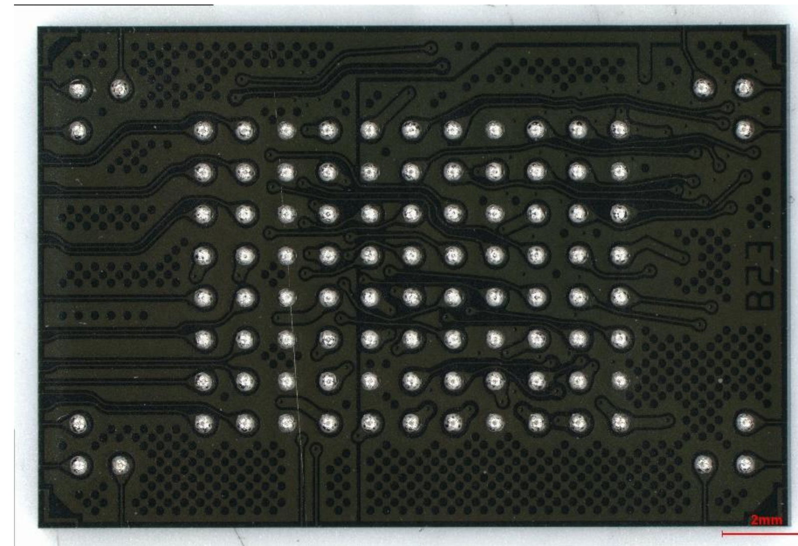
Component Level Screening

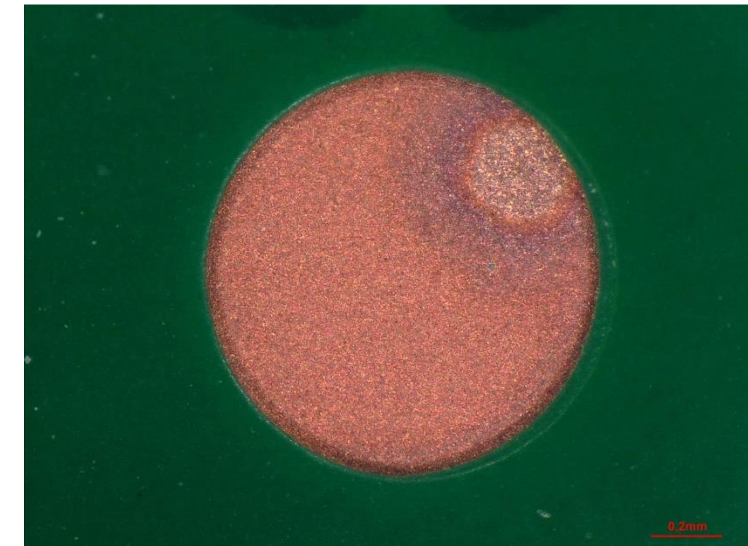


Styrofoam packaging is not ESD safe - and leads to bent pins

Component Level Screening





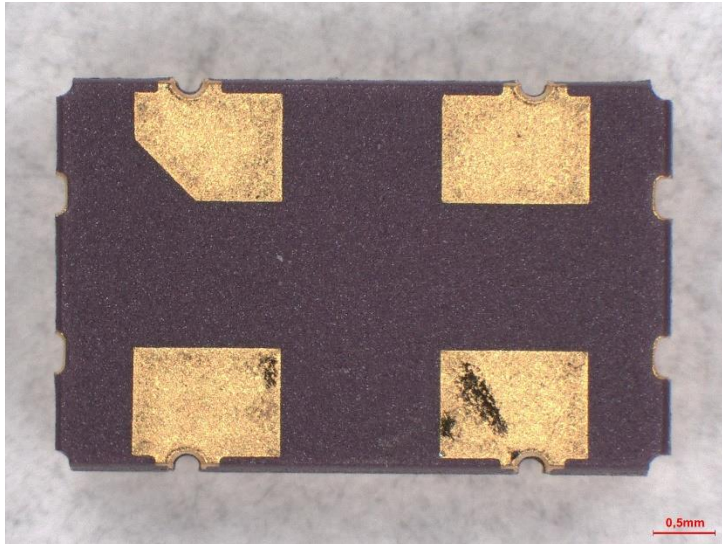


Metallisation particle

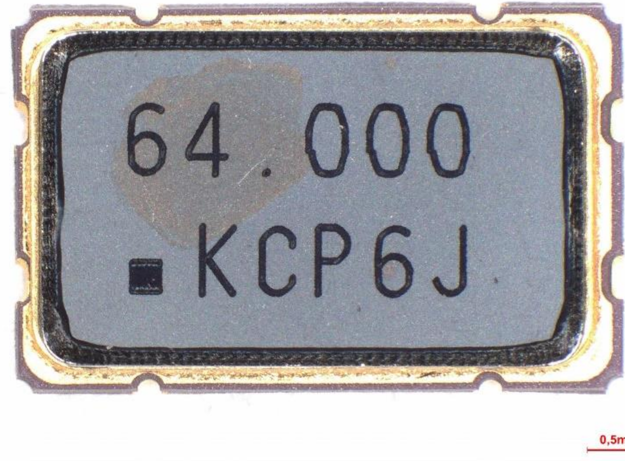
scratch

corrosion

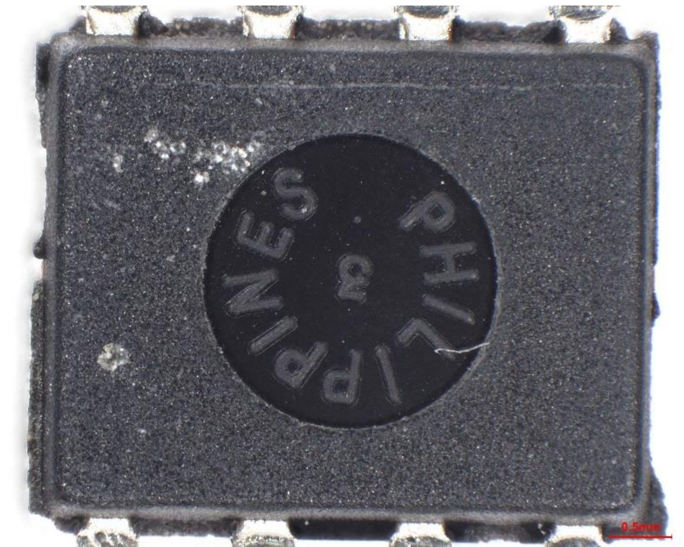
Component Level Screening



contamination

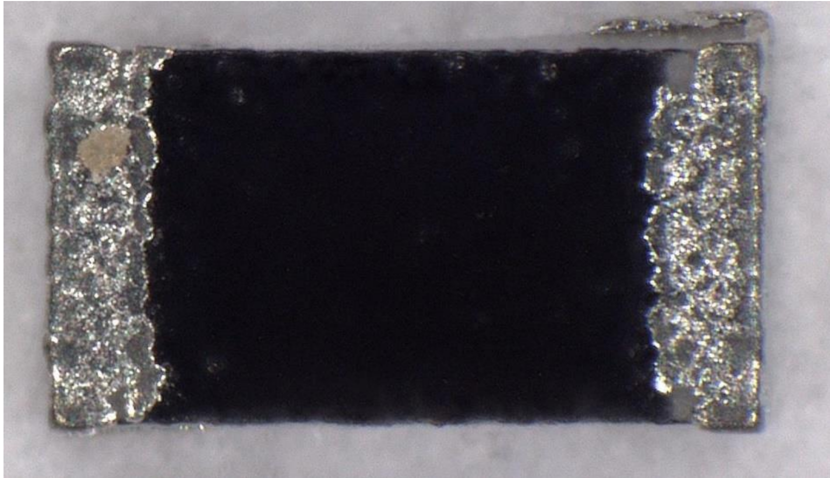


discoloration



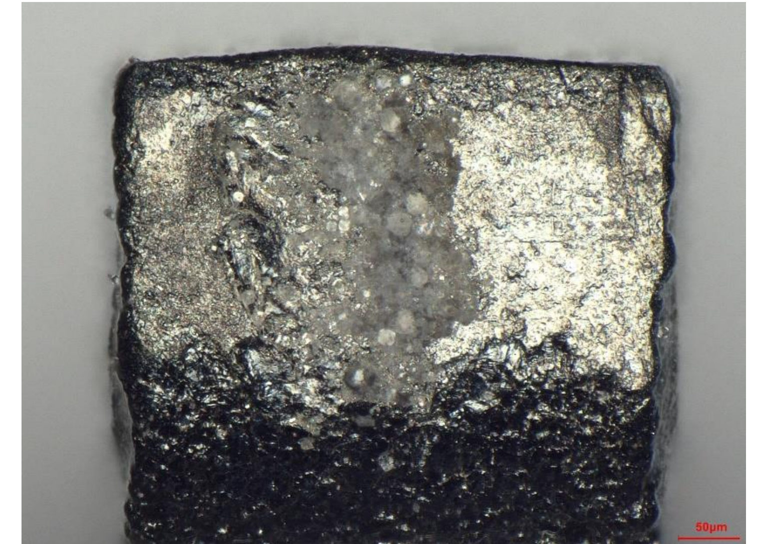
contamination

Component Level Screening



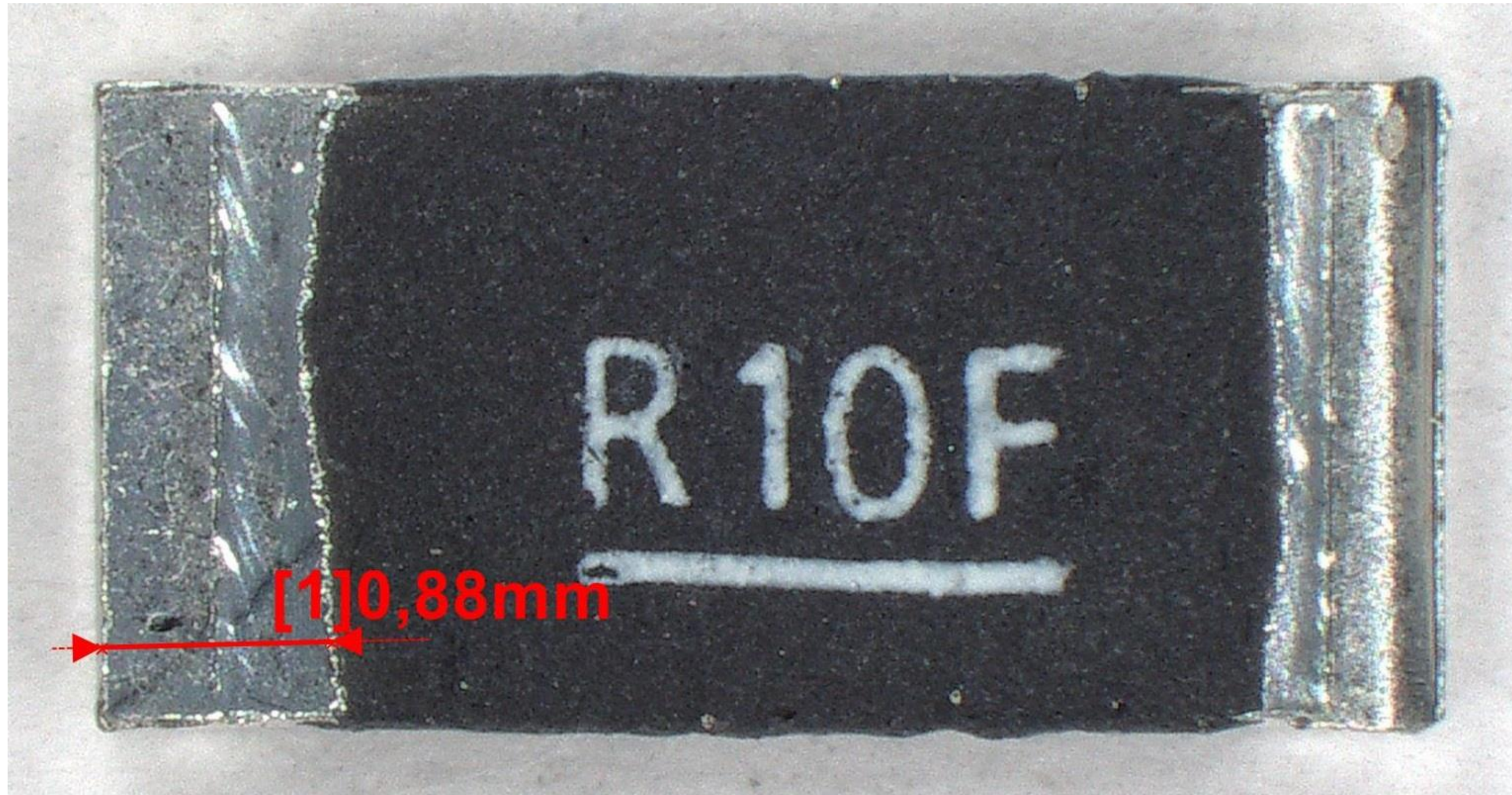
contamination

Bent pin



Corrosion on pin

Component Level Screening



Cap metallization exceeds data sheet limit - Tmax=0.762 mm

Test Plans – HASS aspect – burn-in with thermal step stress

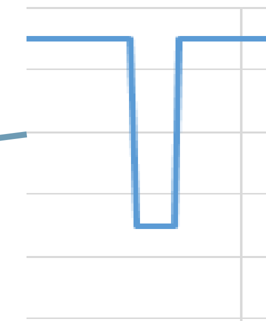
Burn-In (with step stress)

Temperature [°C]

90
80
70
60
50
40
30
20
10
0

0 1000 2000 3000 4000 5000 6000 ~14000

test time prediction [minutes]



Test Plans – HALT aspects – Life Test with thermal step stress

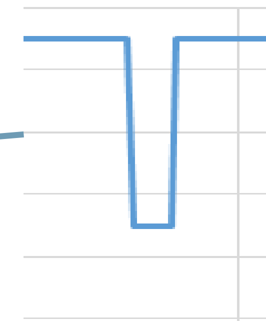
Life Test (with step stress)

Temperature [°C]

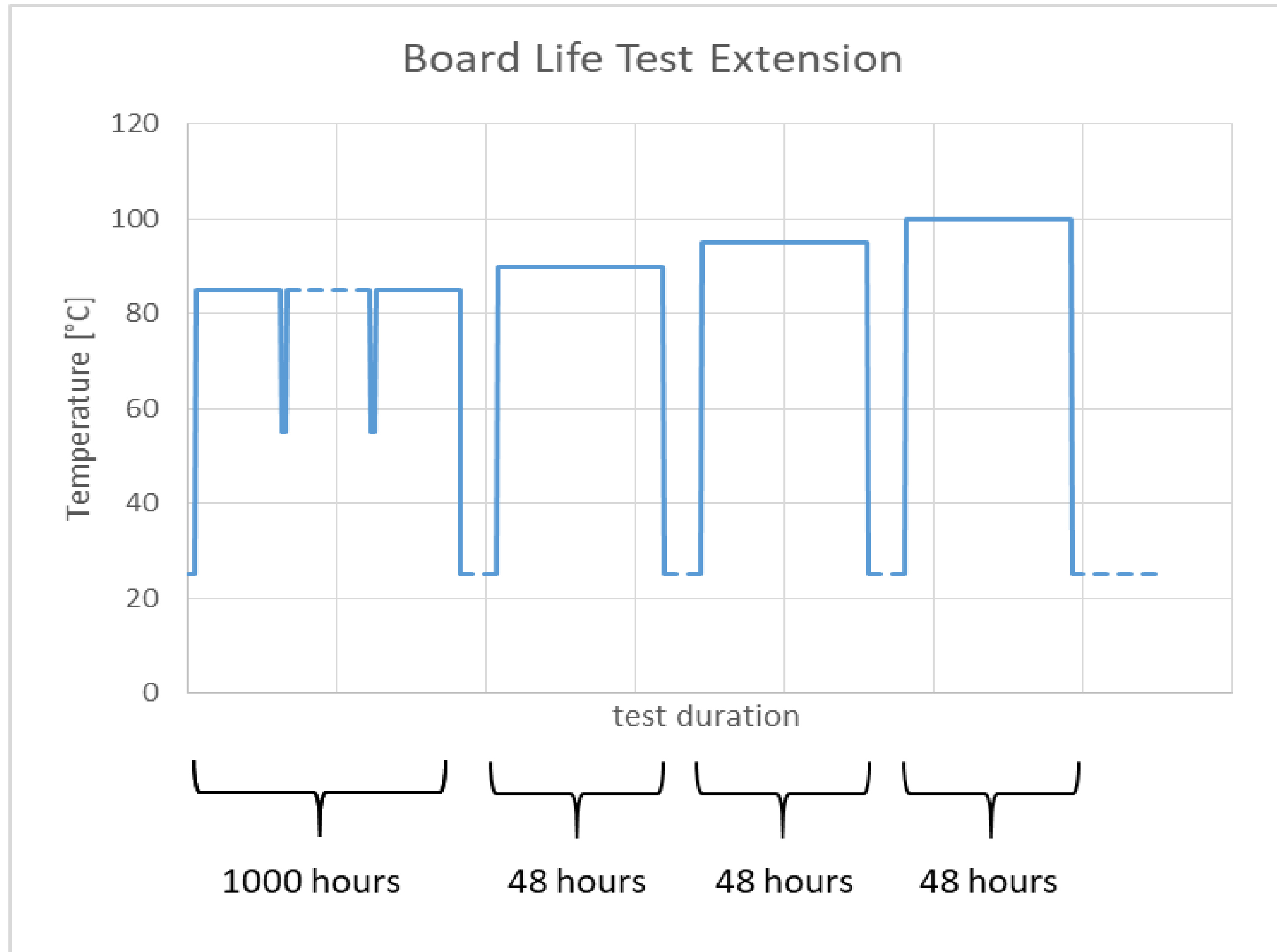
90
80
70
60
50
40
30
20
10
0

0 1000 2000 3000 4000 5000 ~60000

test time prediction [minutes]



Test Plans – HALT aspects – Life Test with temperature increase



Test Plans – HALT aspects – Thermal Cycle Test with temperature increase