



# Electronic Systems Quality and Reliability

Approach, considerations and execution

MASER Engineering BV

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TECHNIEKHUYS  
VELDHOVEN

***PLOT CONFERENTIE***  
***TOMORROW'S RELIABILITY***



MASER Engineering, founded in 1993, is an independent engineering service company operating in the semiconductor and electronic systems industry.

Reliability Test and Failure Analysis services are offered to a wide range of customers that are active as Fabless Semiconductor or Integrated Device Manufacturers (IDM), automotive/industrial electronics supplier or in Aerospace and Space applications.

# Topics

- Questions about system quality and reliability
- System customer reliability approach
- MASER system reliability approach
- Semiconductor reliability
- System level tests
- Accelerated testing phases
- Typical system development/lifetime flow
- MASER approach
- Case studies



# Questions about system quality and reliability

Questions from customer

- Lifetime of my electronic system?
- Tests needed to perform?
- Mission profile?
- FMEA?
- MTBF?
- Is HALT a lifetime test?
- Can HALT replace the environmental tests?
- What do I need to test to release a second source?
- Do I need to perform reliability monitoring?

# Questions about system quality and reliability

MASER: questions to customer

- Experience with previous types?
- Current field return rate (PPM)?
- Type of components used?
- Application conditions?
- Mission profile?
- Positioning of system (high quality)?
- Special customer requirements (automotive/aerospace)?
- Financial budget?
- Production volume?

# System customer reliability approach

- Customer driven approach
- Extremely high cost in case of quality issue / belt stop or automotive / life critical / medical
- End customers define in a spec the required tests e.g.:
  - Automotive: Volkswagen
  - Industrial: ASML
  - Space: NASA/ESA
- Market area's require specific tests
  - HALT test by automotive and (aero)space
  - UN transportation specification for e.g. Litium batteries
- Components
  - Use qualified components (JEDEC / AEC-Q100)
  - Lifetime data available (HTOL  $T_j \geq 125^\circ\text{C}$  for 1000 hrs)
  - System lifetime can be calculated using the component semiconductor reliability data (HTOL/TC/BLR TC)
  - Typical semiconductors lifetime of ~10 years and for automotive up to ~ 20 year
- Component supply
  - Prevent using broker parts

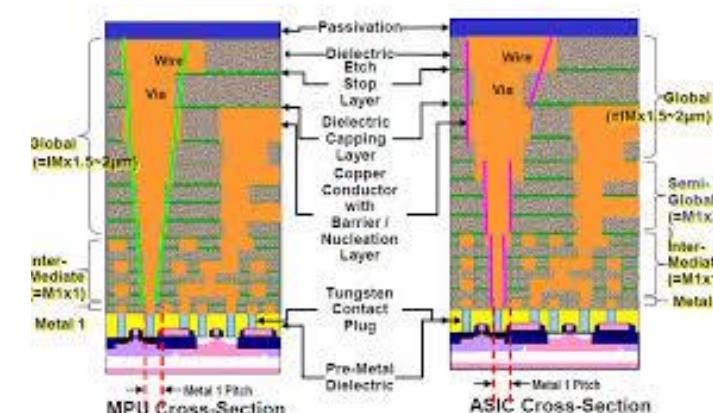
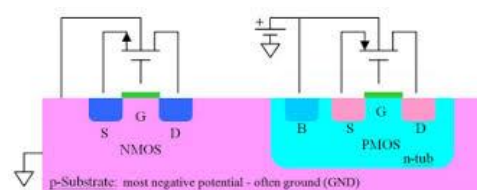
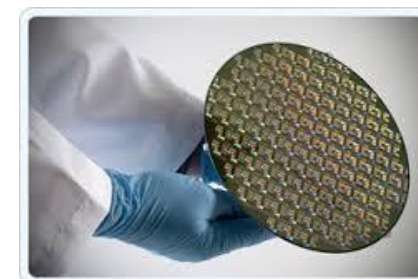
# MASER system reliability approach

- Collect and discuss customer input
- FMEA for new design, new assembly, new PCB manufacturing
- Include all lessons learned in production and from field returns
- Define mission profile in cooperation with customer
- Derate use conditions to test conditions
- Compose qualification plan in cooperation with customer
- Execute qualification plan
- Production



# Semiconductor reliability: Wafer

- Industry accepted specifications
  - JEDEC JESD47G
  - AEC-Q100
  - MIL-STD-883
- Models
  - Arrhenius: accelerated life time testing of silicon
  - Coffin Manson: TC testing of component and board level solderjoint
- Wafer FAB process qualification tests
  - Hot Carrier Injection (HCI)
  - ElectroMigration (EM) 200/225/250°C
  - Negative bias Temperature Instability (NBTI)
  - Time Dependent Dielectric Breakdown (TDDB)



# Semiconductor reliability: Product

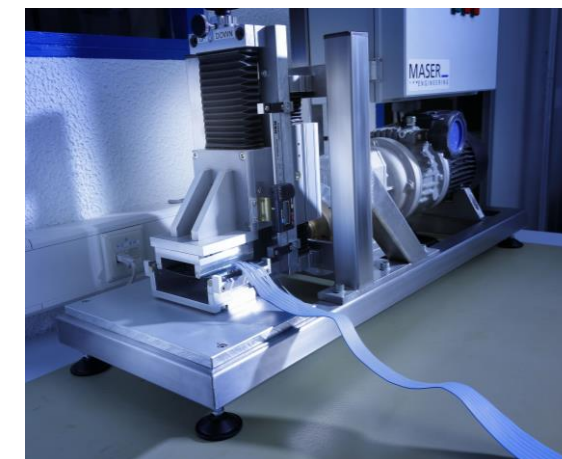
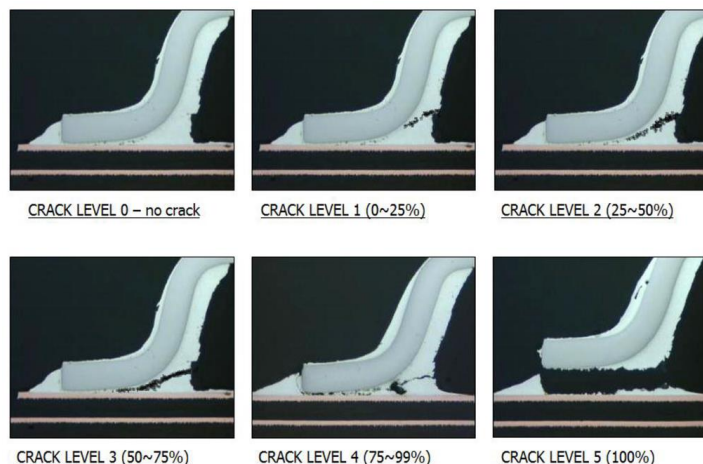
- Product qualification
  - 3x77: High Temperature Operating Life (HTOL)  $T_j \geq 125^\circ\text{C}$  for 1000hrs (extended 2000/3000hrs)
  - ESD (HBM/CDM) and Latch-Up
- Package qualification
  - Moisture Sensitivity Level Assessment (MSLA)
  - MSL preconditioning prior to TC/HAST/UHST/THB/PTC
  - 3 x 25/77 Temperature Cycling (TC) test  $-65/+150^\circ\text{C}$  for 500 cycles
  - 3 x 25/77 Highly Accelerated Stress Test (HAST) test biased @  $110^\circ\text{C}/85\%\text{RH}$  for 264 hrs (or THB)
  - 3 x 25/77 Unbiased Highly Accelerated Stress Test (UHST) test unbiased @  $110^\circ\text{C}/85\%\text{RH}$  for 264 hrs
  - 3 x 25/77 High Temperature Storage Life (HTS) test  $T_a = +150^\circ\text{C}$  for 1000 hrs
  - 1 x 45 Power Temperature Cycling (PTC) test  $-40/+125^\circ\text{C}$  for 1000 cycles biased (5 min on/off)
- Mechanical
  - Package DROP, shock (MS), vibration (VVF) and constant acceleration (CA)
  - Solderability (SD), wirepull/shear (WBP/BS) and solderball shear (SBS)
  - Gross/Fine leak (GFL) (Hermetic packaging)



# Semiconductor reliability: Board

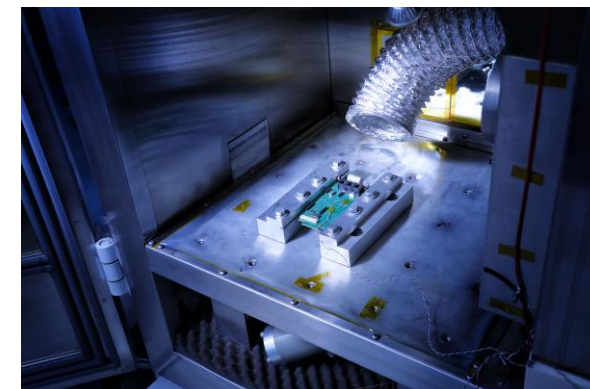
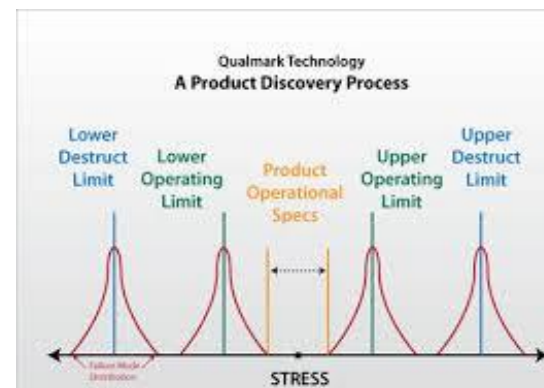
- Board Level Reliability

- Performed on package technology level with daisy chain devices
- BLR TC test: characterise solderjoint reliability 1 cph – 10k/min ramp - -40/+125°C for 1000 cycles
- BLR Drop test to characterise solderjoint reliability 1000 drops
- BLR Bending test to characterise solderjoint 250K bends
- Daisy chain devices for continues resistance monitoring / glitch detection
- Results plotted in weibull plot



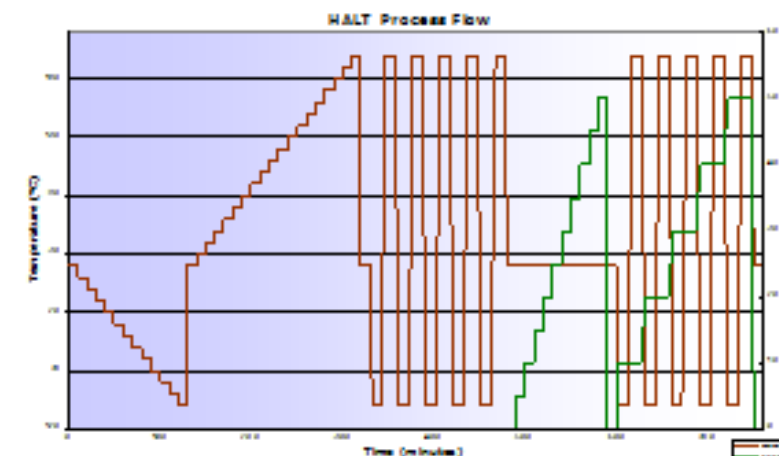
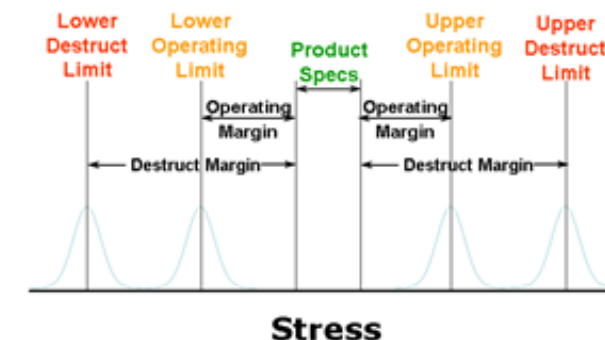
# System level tests

- HALT test
- IPC-A-610 inspection
- Environmental tests (validation)
- Mechanical tests
- Complete unit including external influences



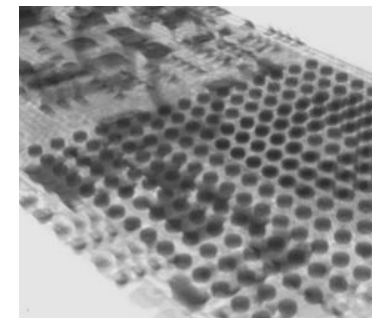
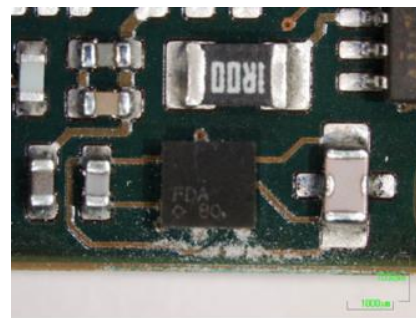
# HALT test

- What is HALT
  - Highly Accelerated Life Test (HALT)
  - To verify robustness of (electronic) system in design phase
  - Combined temperature and vibration test and Stress product outside specification
- Goal
  - Determination of operating and destruct limits
- HALT test procedure
  - Temperature step stress and Temperature cycles (5)
  - Vibration step test
  - Combined temperature and vibration test @ tested limits
- QualMark OVS 1.5 HP
  - Table size: 450 x 450 x 400 mm with liquid Nitrogen cooling
  - Temperature range -100°C to +200°C, ramp rate up to 60 K/min
  - Excites six axes, 3 linear and 3 rotational up to 45 Grms / 2 Hz to 10 kHz random broadband
- Cases
  - Broken connector/capacitor/wrong Resistor



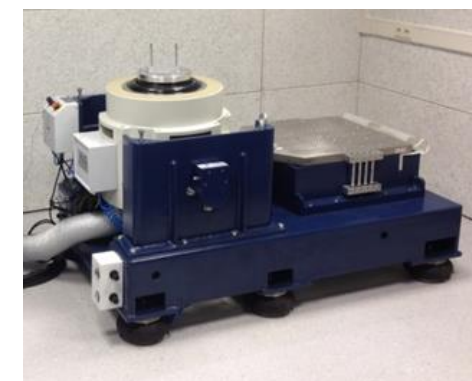
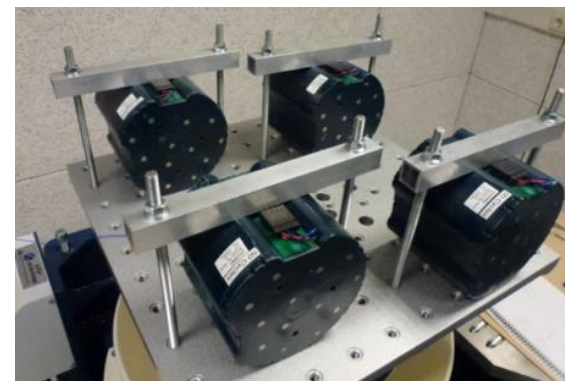
# IPC-A-610 PCB/PCBA inspection

- IPC-A-600/610 PCB/PCBA inspection
  - IPC-A-610, Acceptability of Electronic Assemblies is the most widely used standard published by the IPC
  - IPC-A-600 – Acceptability of Printed Boards is an inspection criterion, setting the level of acceptance criteria for each class of product
- INSPECTION CLASSIFICATION
  - Class 1 – General Electronic Products
  - Class 2 – Dedicated Service Electronic Products
  - Class 3 – High Performance/Harsh Environment Electronic Products
- ANALYSIS TECHNIQUES
  - Non destructive
    - Optical inspection
    - X-ray inspection
    - Delamination of packages
  - Destructive
    - Cross-sectioning
    - Optical and SEM inspection
    - SEM-EDX analysis



# Mechanical tests

- In house tool shop
  - Fast turn around time for design and manufacturing of fixtures
- Shock
  - Lansmont M23 Shock tester
  - Shock level: Max 10000 G
  - Pulse shape: Half Sine / Trapezium
- Vibration
  - Electro Dynamic Shaker (ETS Solutions M124/GT600M)
  - Wide range of tests possible (sine/random)
  - Specification
    - Frequency range: DC – 4000Hz
    - Sine acceleration: 100g
    - Sine force: 10.000N/1.000kgf
    - Displacement: 51mm



# Environmental tests

- Climate
  - Several ESPEC Climate Test systems available
  - Temperature range: -40°C / +150 °C
  - Humidity range: +40%/+95% R.H.
  - According to IEC/MIL standards
  - Real-time monitoring of conditions
  - ISO17025 accreditation for several tests
- Temperature cycling/shock
  - Several ESPEC Temperature Cycling Test systems available
  - Temperature range: -70°C / +300 °C
  - 1 and 2 chamber system
  - According to IEC/MIL standards
  - Real-time monitoring of conditions
  - ISO17025 accreditation for several tests



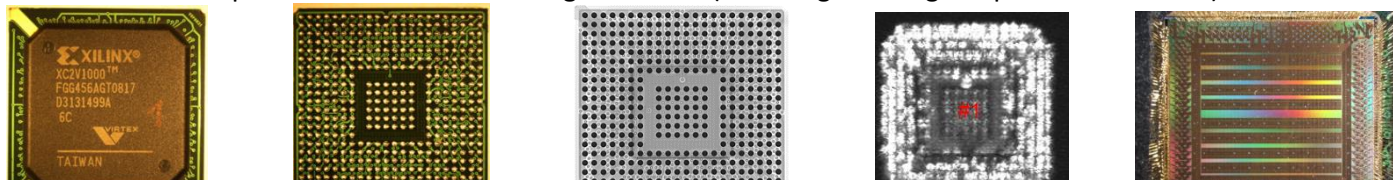
# Enclosure (housing) tests

- Dust test:
  - IP5X (dust protected) / IP6X (dust tight)
  - Talcum powder, BS 1701 or Arizona dust
  - IEC60529, MIL-STD-810 method 510.4
- Water tightness:
  - IPX1 – IPX8
  - Protected against vertically falling water drops. spraying water and splashing water
  - Protected against (powerful) water jets and the effects of temporary/ continuous immersion in water
- Corrosion test:
  - Salt mist/fog
  - Test condition: 5% NaCl, +35°C
  - IEC68-2-11, MIL-STD-810 method 509.4
- Solar Radiation test:
  - Irradiance 1000+/- 100W/m<sup>2</sup> at 280-3000nm
  - Light source = metal halogenide
  - MIL-STD-810, method 505.4, DIN75220 or IEC 60068-2-5



# Broker screening

- Performed to check quality of device and whether the device is indeed the device which is marked on the package
- Results: remarked, no chip, other device in, only few devices in reel.
- Incoming quality screening (procedure based on 10 samples)
  - External Visual Inspection: all 10 samples
  - 2D High resolution X-ray inspection: all 10 samples
  - SAM inspection: all 10 samples
  - Decapsulation: 5 samples
  - Internal Visual Inspection: 5 samples
  - Wire pull test / Wire Ball Shear : 5 samples
  - Project control and reporting in pdf
  - The random sample size is based on a homogeneous lot (including known good part for reference)

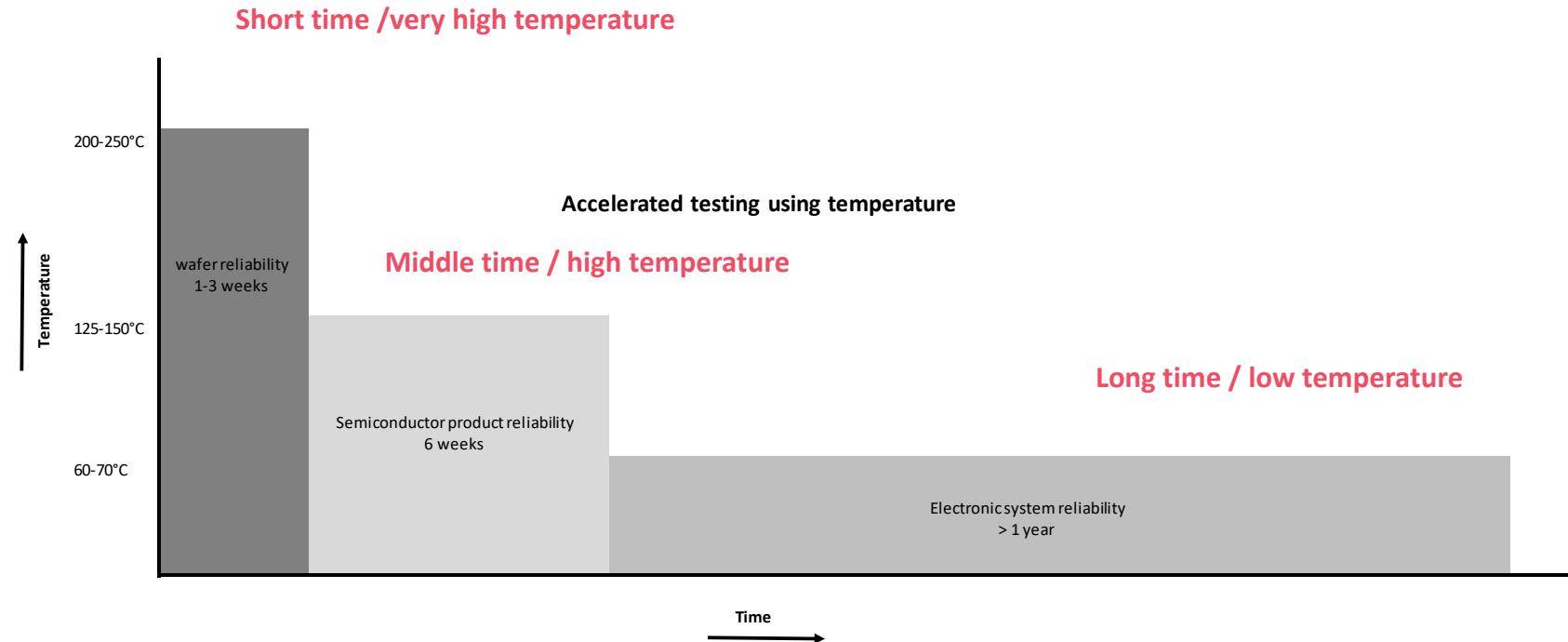


# Typical system test flow

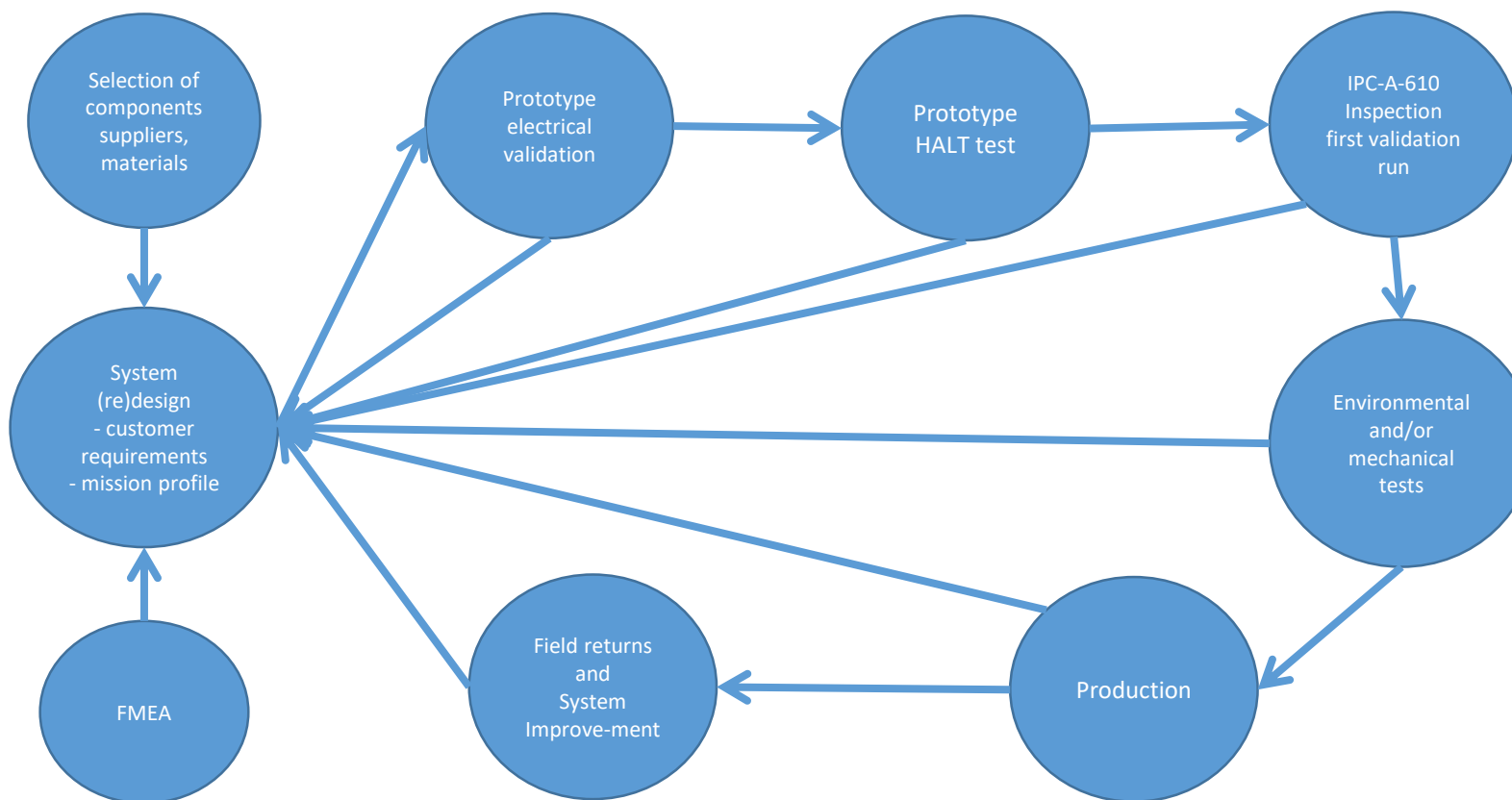
- Use qualified components and released design guidelines
- Design and take experience from field into account
- Start with HALT test (1 week test)
  - 1-2 units: Check robustness of design
- Redesign (in case applicable)
- IPC-A-610 inspection (1-2 weeks)
  - 1-2 units: Confirm expected quality of PCB supplier and PCB assembly house
- Environmental and Mechanical tests (3-4 weeks)
  - Confirm expected quality
  - 1-2 units: Early life Screening
- Other tests (6-8 weeks)
  - 1-2 units: Special application requirements e.g. outdoor
- Production



# Accelerated testing phases



# Typical system development/lifetime flow



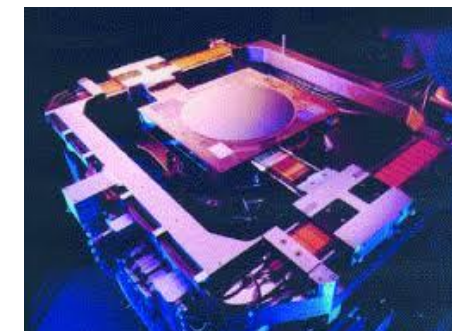
# Case 1: Mobile defibrillator

- Medical
- Use profile: life critical and used in cars/helicopter
- FMEA and experience in the field
- Component selection: be sure about dual source of components and use known suppliers
- Operational time: limited
- HALT test
- System validation tests:
  - Operational validation test 96 hrs @ Tmax and Tmin
  - TC testing 100 cycles
  - Cyclic damp heat test for 240 hrs @ 40°C/95%RH
- Special attention on the following tests:
  - Drop testing of unit (mobile device)
  - Vibration testing (unit in car or helicopter)



## Case 2: Electronics in wafer stage

- Industrial
- Use profile: temperature controlled and uptime critical; but relatively easy to replace (limited numbers sold)
- FMEA and experience in the field
- Component selection: be sure about dual source of components and use known suppliers
- Operational time: very long
- HALT test
- System validation tests:
  - According to ASML GID specification
  - Operational validation test 96 hrs @ T<sub>max</sub> and T<sub>min</sub>
  - TC testing: not applicable
  - Cyclic damp heat test: not applicable
- Special attention on the following tests:
  - Vibration and bump testing (movement in stage)



# Case 3: LED Headlight in car

- Automotive
- Use profile: very high volume, long lifetime, high temperature swing and huge image damage in case of field returns
- FMEA and experience in the field
- Component selection: AEC-Q100 qualified components
- Operational time: very long 10-20 years
- HALT test
- System validation tests:
  - Full validation according to e.g. VW specification
- Special attention on the following tests:
  - Vibration and shock testing
  - Chemical / Sulfur corrosion
  - Solar radiation



# Summary

- Customer requirements
- Application conditions
- System development experience
- Reliability experience
- Continues cycle





# Contact details

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# New Contact



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Questions?

Thank you all