Short Course on Space Qualification (Syllabus)

Aim:

Develop a professional course on Space Qualification (compatible with a tertiary education micro-credentialing scheme), targeting professionals such as engineers, physicists but also lawyers and entrepreneurs as many others professional figures in the space industry.

Syllabus

1. **Reliability**

   a. Solder Heat Resistance Test (SHRT)
   b. Temperature Cycle
   c. Thermal Shock
   d. Autoclave or Pressure Cooker Test (PCT)
   e. Highly Accelerated Stress Test (HAST)
   f. Burn-in
   g. Temp Humidity Bias (THB) Test
   h. High Temperature Storage (HTS)/ Stabilization Bake
   i. High Temp Op Life (HTOL)
   j. Low Temp Op Life (LTOL)
   k. Vibration tests
   l. Solder Joint reliability tests
   m. Wear out tests (HCI, BTI, TDDB, EM)
   n. Package related failure mechanisms: Bond Lifting, Package Cracking, Corrosion, Tin Whiskers, Solder Joint Failures
   o. PCB solder paste printing, solder reflow
   p. Calculation methodology: MIL-HDBK, FIDES, PISTIS

2. **Radiation**

   Space radiation environments and models (SPE, trapped electrons and protons, GCR)

   Interaction radiation with matter (gamma, ions, neutrons)

   Shielding with application to space radiation

   Radiation effects in microelectronics and their mechanisms
   a. TID – mechanisms and test. Sectorial analysis (FASTRAD, NOVICE)
   b. DD – mechanisms and test
   c. SEE – mechanisms and test. Rate calculations using OMERE and SPENVIS
   d. Board level tests

e. Radiation Hardness Assurance for Traditional and New Space programs

Radiation testing
Radiation facilities (accelerators: protons, heavy ions, synchrotron X-Ray; Co-60 sources for TID, neutrons: reactors and spallation sources)
Dosimetry
Radiation testing methodology (single device, board level, etc)

Optical testing
Laser facility and approach to mimic ions with a laser pulse

Monte Carlo simulations and modeling of space radiation effects

3. **Standards**

a. ECSS Q30 (dependability, FMECA, Availability, Derating of EEE)
b. Q60 (EEE, ASIC&FPGA, Hybrids, Microwave, COTS, re-lifting, radiation)
c. Q70 (PCB qual., procurement, design rules, prep., assembly and mounting of RF cables, manual soldering PCB repair, thermal vacuum, outgassing, high reliability soldering, wire wrapping)
d. Automotive – AECQ100, 101
e. MIL-STD-750, MIL-STD-883
f. NASA – parts selection screening, qualification and derating
g. ESCC specifications (close to 700 specs)

Detailed outline of some aspects of space qualification to be covered :

Radiation Facilities

- Single Event Effects testing methods and facilities
  - General introduction to Single Event Effects (SEE) testing
  - SEE testing methods and guidelines for:
    - Atmospheric neutrons
    - Trapped protons
    - Galactic Cosmic Ray ions
  - European accelerator infrastructure for SEE testing, and related RADNEXT network
    - Spallation neutrons
    - High-energy protons
    - Heavy ions
  - Challenges ahead: testing beyond standards

The talk would incorporate both the methodology and facility aspects.

EEE reliability and qualification for Space.

- Introduction
- Overview of the EEE components in the space business
- The procurement of EEE parts for space
- The baselines normative systems: ESCC, MIL
    - Generic specifications
    - Detail specifications
    - Tests and test methods
    - Quality levels
    - Part Identification Number
    - QPL & QML
    - Evolution of the normative systems
- Commercial Space: AEC as an alternative normative system
- Key takeaways

Radiation Hardness Assurance (RHA) for Space Industry (Industrial RHA process)

Introduction
Some parameters of influence on the RHA process

- What is RHA?
- Customer & Program nature

Radiation environment definition and potential impacts on RHA process
Key parameters in the RHA process: TID/DD

- Basics about TID and DD
- Modelling activities
- Test activities
- Device traceability
- Link with Worst Case Analysis
- Margin policy
- Normative systems

Key parameters in the RHA process: SEE

- Basics about SEE
- Test activities
- Device traceability
- SEE rate calculation
- Link with design tolerance (equipment, system)
- Normative systems

Conclusion

TID (level2) (this shall include all or part of ASTM F1892, MIL-STD-88sF of ESCC Basic Standard 22900 as applicable to each facility

Radiation Facilities: ESA standards for Single Event Effects (ESCC 25100) and Displacement Damage (ESCC 22500),

Australian capabilities in radiation and non-radiation testing.