When is Qualification Not Qualification?

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Dictionary

The 2 most relevant definitions:

Qualification:

1. A condition or standard that must be complied with
2. A restriction in meaning or application: a limiting modification

http://www.merriam-webster.com/dictionary/qualification
Space Qualification

• Qualification is considered essential for most spaceborne electronic parts
• But what constitutes qualification?
• Ideally, qualification is a process that assures parts meet minimum mission requirements
• NASA’s qualification requirements vary widely
  – Minimum: it said “space qualified” in the catalog
  – Maximum: long and costly, multi-discipline evaluation and testing, of the part, the packaging and the radiation effects, based on a “recipe”
  – Different approaches used across NASA, influenced by traditional roles and changes to reflect new realities
• MIL specification “Class S” probably comes closest to being the universally usable, space part
  – European Space Agency (ESA) and Japanese Aerospace Exploration Agency (JAXA) qualified parts essentially equivalent
  – TOR compliant SCMs may be superior for military space applications
NEPP’s Role

- **NEPP DOES NOT Qualify Electronic Parts**
- **NEPP Evaluates Electronic Parts Technologies**
  - To identify strengths and weaknesses
  - To identify gaps in available test and inspection methods needed for the technology
  - To modify or develop tests and inspections to fill the gaps
  - To provide guidance for appropriate tests and inspections to select from and use for qualification for different mission needs
Why is Qualification Important?

• Increases probability of success
• Provides a known design margin to worst case application conditions
• Establishes a formal process so lessons can be understood, learned and tracked
• Parts that fail to meet qualification requirements can be fixed or mitigated before being installed in hardware, thus avoiding expensive rework
• Provides data to support specification changes
• Provides a benchmark for part performance

Qualification DOES NOT GUARANTEE all lots will meet the requirements for ever and ever
Qualification Objectives

• Ensure parts are suitable for the intended use
• Find the limiting weaknesses
• Test like we fly?
  – Not so much at part level, significant margins employed to force out failures
• Cover the maximum range of the key stresses seen in the system’s applications + margin
  – The MIL system’s ranges of temperature, vibration, shock etc. do this very well for most space applications
Space Challenges for Electronic Parts

- **Vacuum:**
  - Outgassing, offgassing, property deterioration, “oil canning”
- **Microgravity:**
  - Foreign Object Debris (FOD) a threat from the system or to the system
- **Shock and vibration**
  - During launch, deployments and operation
- **Thermal cycling**
  - Usually small range, with a high number of cycles in Low Earth Orbit (LEO)
- **Thermal management**
  - Only conduction and radiation transfer heat
- **Low volume assembly for specialty parts**
  - Limited automation, lots of rework
- **Long life**
  - Costs for space are high, make the most of the investment
    - Absolute necessity for some applications
- **Novel hardware**
  - Lots of “one offs” and unusual configurations
# Summary of Environment Hazards for Electronic Parts in NASA Missions

<table>
<thead>
<tr>
<th>Missions</th>
<th>Plasma (charging)</th>
<th>Trapped Protons</th>
<th>Trapped Electrons</th>
<th>Solar Particles</th>
<th>Cosmic Rays</th>
<th>Human Presence</th>
<th>Long Lifetime (&gt;10 years)</th>
<th>Nuclear Exposure</th>
<th>Repeated Launch</th>
<th>Extreme Temperatures</th>
<th>Planetary Contaminants (Dust, etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO</td>
<td>Yes</td>
<td>No</td>
<td>Severe</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>LEO (low-incl)</td>
<td>No</td>
<td>Yes</td>
<td>Moderate</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Not usual</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>LEO Polar</td>
<td>No</td>
<td>Yes</td>
<td>Moderate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Not usual</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Shuttle</td>
<td>No</td>
<td>Yes</td>
<td>Moderate</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Rocket Motors</td>
<td>No</td>
</tr>
<tr>
<td>ISS</td>
<td>No</td>
<td>Yes</td>
<td>Moderate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Interplanetary</td>
<td>During phasing orbits</td>
<td>During phasing orbits</td>
<td>During phasing orbits</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
</tr>
<tr>
<td>Exploration - CEV</td>
<td>Phasing orbits</td>
<td>During phasing orbits</td>
<td>During phasing orbits</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Rocket Motors</td>
<td>No</td>
</tr>
<tr>
<td>Exploration – Lunar, Mars</td>
<td>Phasing orbits</td>
<td>During phasing orbits</td>
<td>During phasing orbits</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Maybe</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Expendable Launcher</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>No</td>
<td>Yes</td>
<td>Maybe</td>
</tr>
<tr>
<td>Manned Launcher</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Maybe</td>
<td>No</td>
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</table>
# The Space Environment

<table>
<thead>
<tr>
<th></th>
<th>EARTH</th>
<th>LEO</th>
<th>GEO</th>
<th>MOON</th>
<th>MARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orbit</strong></td>
<td>1.0</td>
<td>10⁻³ to 10⁻⁶</td>
<td>10⁻³ to 10⁻⁶</td>
<td>0.165</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Gravity</strong></td>
<td>1.0</td>
<td>10⁻¹³</td>
<td>10⁻¹⁸</td>
<td>10⁻¹¹- 10⁻¹⁵</td>
<td>6X10⁻³ - 1.5X10⁻²</td>
</tr>
<tr>
<td><strong>Atmos. Press</strong></td>
<td>1.0</td>
<td>10⁻¹³</td>
<td>10⁻¹⁸</td>
<td>10⁻¹¹- 10⁻¹⁵</td>
<td>6X10⁻³ - 1.5X10⁻²</td>
</tr>
<tr>
<td><strong>Max Temp. (°C)</strong></td>
<td>65</td>
<td>125</td>
<td>128</td>
<td>111</td>
<td>27</td>
</tr>
<tr>
<td><strong>Min. Temp. (°C)</strong></td>
<td>-96</td>
<td>-65</td>
<td>-196</td>
<td>-171</td>
<td>-143</td>
</tr>
<tr>
<td><strong>Radiation: UV</strong></td>
<td>TID</td>
<td>SEE</td>
<td>SEE</td>
<td>SEE</td>
<td>SEE</td>
</tr>
<tr>
<td><strong>Debris/ Micrometeoroids (Impacts/m²/year)</strong></td>
<td>11 to 26</td>
<td>&lt;LEO</td>
<td>&lt;LEO</td>
<td>.01 to 10⁻⁴</td>
<td>&lt;Moon</td>
</tr>
<tr>
<td><strong>Surface Dust</strong></td>
<td>Minor</td>
<td>N/A</td>
<td>N/A</td>
<td>Major</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>ESD Risk</strong></td>
<td>Medium</td>
<td>High external</td>
<td>High external</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Spacecraft Versus Launch Vehicle

Overstatements with a Grain of Truth:

• Expendable Launch Vehicle (Unmanned)
  – It Only Has to Last 30 Minutes

• National Asset Spacecraft (Hubble, Mars Science Lab)
  – One Strike and You Are OUT
  – Does it Pass the Front Page of the Post Test?

OR

• Science Spacecraft (regular)
  – It Must Meet Minimum Science Requirements (including life)

• Science Spacecraft (high risk or technology demonstrator)
  – We Want It to Work
  – It MUST Do No Harm

AND

• Expendable Launch Vehicle (Manned)
  – It MUST Work and work for days to cover emergencies

These Principles Drive Parts Selection and Qualification
Space Qualified-The Facts

• There is NO SUCH THING AS NASA SPACE QUALIFIED
• JAXA and ESA have Agency-level specifications and therefore do Space Qualify, NASA does not
• NASA qualifies for the mission
  – It is impractical and unaffordable to try to cover all possible worst case conditions a part might see, in order to “Space Qualify” it for all missions
• Please stop using “Space Qualified” without attribution
• It is probably OK to say:
  – JAXA or ESA Space Qualified to Specification XYZ123
• It is OK to say:
  – Qualified to MIL-PRF-38534/38535 Space Level Class K/V
  – Qualified to Aerospace TOR XYZ
• It is also OK to say:
  – Qualified for use by NASA Project ABC
  – Qualified to NASA MSFC Specification 40M38298
• It is NOT OK to just say Space Qualified or NASA Qualified

And Then There Is ...

• **HERITAGE**
  - It has flown before
  - It has been selected for a flight application – has NOT flown

AND

• Qualification by Similarity

Both can be legitimate and acceptable BUT:

• It’s not about the part, it is about the application
  - Is the acceptable risk level the same or higher?
  - Is the operating environment the same or more benign?
  - Is the redundancy the same?
  - Is it being used in the same way?
  - Etcetera?
Future Challenges

• Who knows? BUT it will be:
  – Smaller and lighter
  – More efficient
  – Faster
  – Changing continuously
  – Desirable BUT perhaps not space-worthy
  – And someone always expects it to be more affordable

• And we need to be:
  – Flexible and innovative
  – Open-minded
  – Willing to expand the definition of “part” as integration puts more system levels on a chip or in a package

Business as Usual – JUST EVEN MORE COMPLEX
http://nepp.nasa.gov