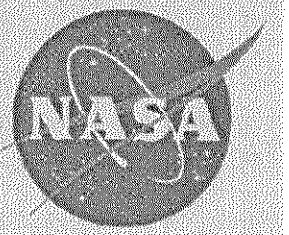
NASA Electronic Parts and Packaging Program
(NEPP) Electronic Parts Technology Workshop
(NEPP ETW) 2011

National Aeronautics
and Space Administration



When is Qualification Not Qualification?

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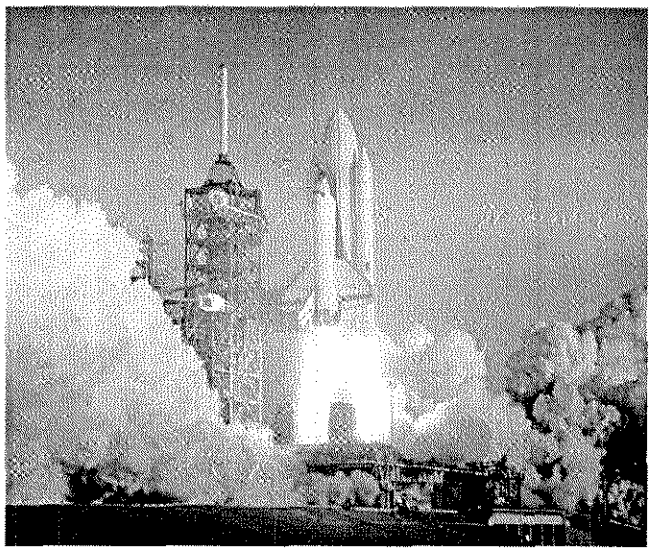
Dictionary



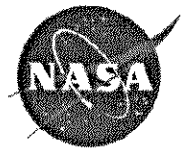
The 2 most relevant definitions:

Qualification:

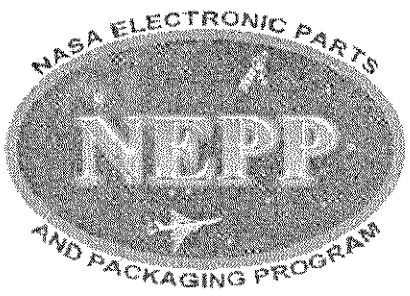
1. A condition or standard that must be complied with
2. A restriction in meaning or application : a limiting modification

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 SCDs 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**

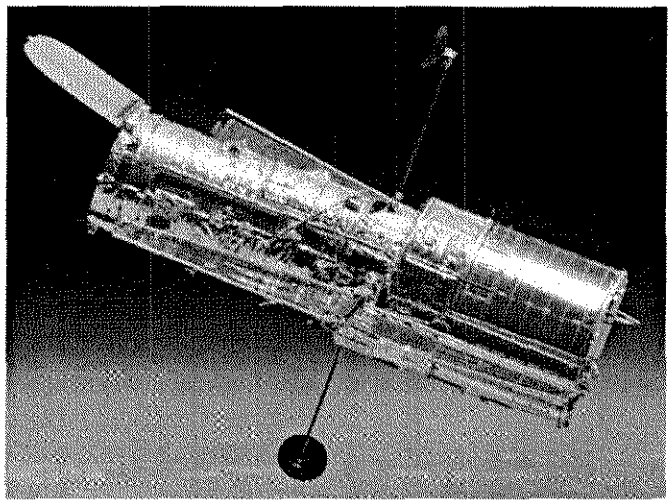
Why is Qualification Important?

- 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

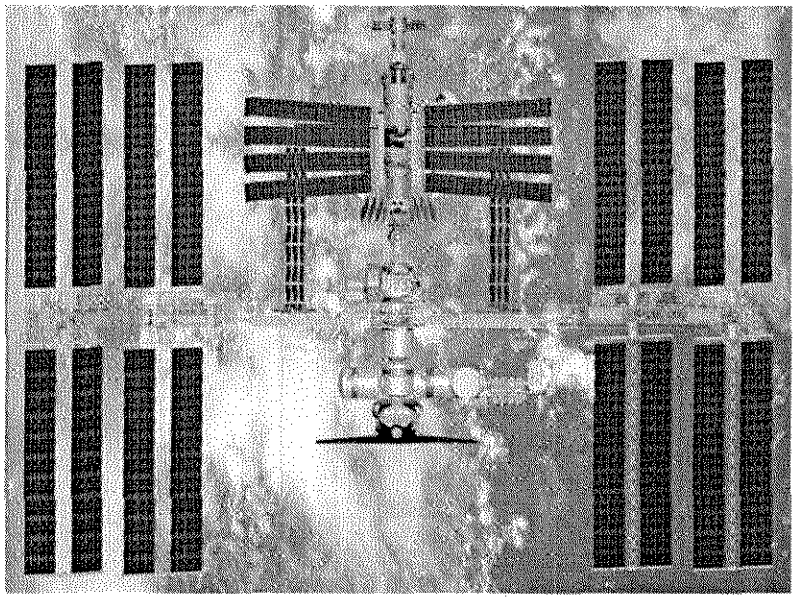
Qualification Objectives

- 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 <u>most</u> 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 cycl**ing
  - 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



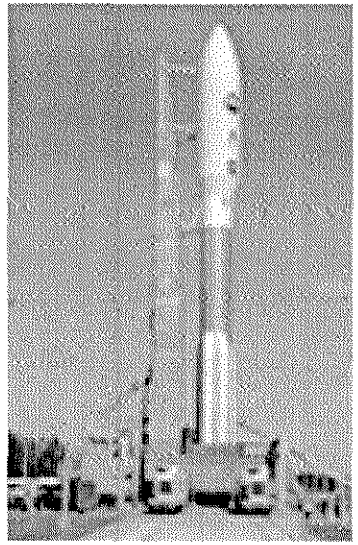
Summary of Environment Hazards for Electronic Parts in NASA Missions

	Plasma (charging)	Trapped Protons	Trapped Electrons	Solar Particles	Cosmic Rays	Human Presence	Long Lifetime (>10 years)	Nuclear Exposure	Repeated Launch	Extreme Temperatures	Planetary Contaminants (Dust, etc)
GEO	Yes	No	Severe	Yes	Yes	No	Yes	No	No	No	No
LEO (low-incl)	No	Yes	Moderate	No	No	No	Not usual	No	No	No	No
LEO Polar	No	Yes	Moderate	Yes	Yes	No	Not usual	No	No	No	No
Shuttle	No	Yes	Moderate	No	No	Yes	Yes	No	Yes	Rocket Motors	No
ISS	No	Yes	Moderate	Yes - partial	Minimal	Yes	Yes	No	No	No	No
Interplanetary	During phasing orbits	During phasing orbits	During phasing orbits	Yes	Yes	No	Yes	Maybe	No	Yes	Maybe
Exploration - CEV	Phasing orbits	During phasing orbits	During phasing orbits	Yes	Yes	Yes	Yes	No	Yes	Rocket Motors	No
Exploration – Lunar, Mars	Phasing orbits	During phasing orbits	During phasing orbits	Yes	Yes	Yes	Yes	Maybe	No	Yes	Yes
Expendable Launcher	No	No	No	Maybe	Maybe	No	No	Maybe	No	Maybe	No
Manned Launcher	No	No	No	Maybe	Maybe	Yes	No	No	Maybe	No	No

The Space Environment

	EARTH	LEO	GEO	MOON	MARS
Orbit					
Gravity	1.0	10^{-3} to 10^{-6}	10^{-3} to 10^{-6}	0.165	0.38
Atmos. Press (Atmospheres)	1.0	10^{-13}	10^{-18}	10^{-11}- 10^{-15}	$6X10^{-3}$ – $1.5X10^{-2}$
Max Temp. (°C)	65	125	128	111	27
Min. Temp. (°C)	-96	-65	-196	-171	-143
Radiation: UV					
TID					
SEE					
Debris/ Micrometeoroids (Impacts/m^2/year)		11 to 26	<LEO	.01 to 10^{-4}	<Moon
Surface Dust	Minor	N/A	N/A	Major	Moderate
ESD Risk	Medium	High external	High external	High	High

Spacecraft Versus Launch Vehicle

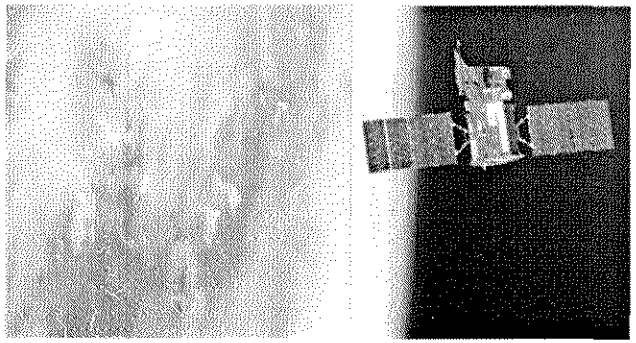


Overstatements with a Grain of Truth:

- 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**

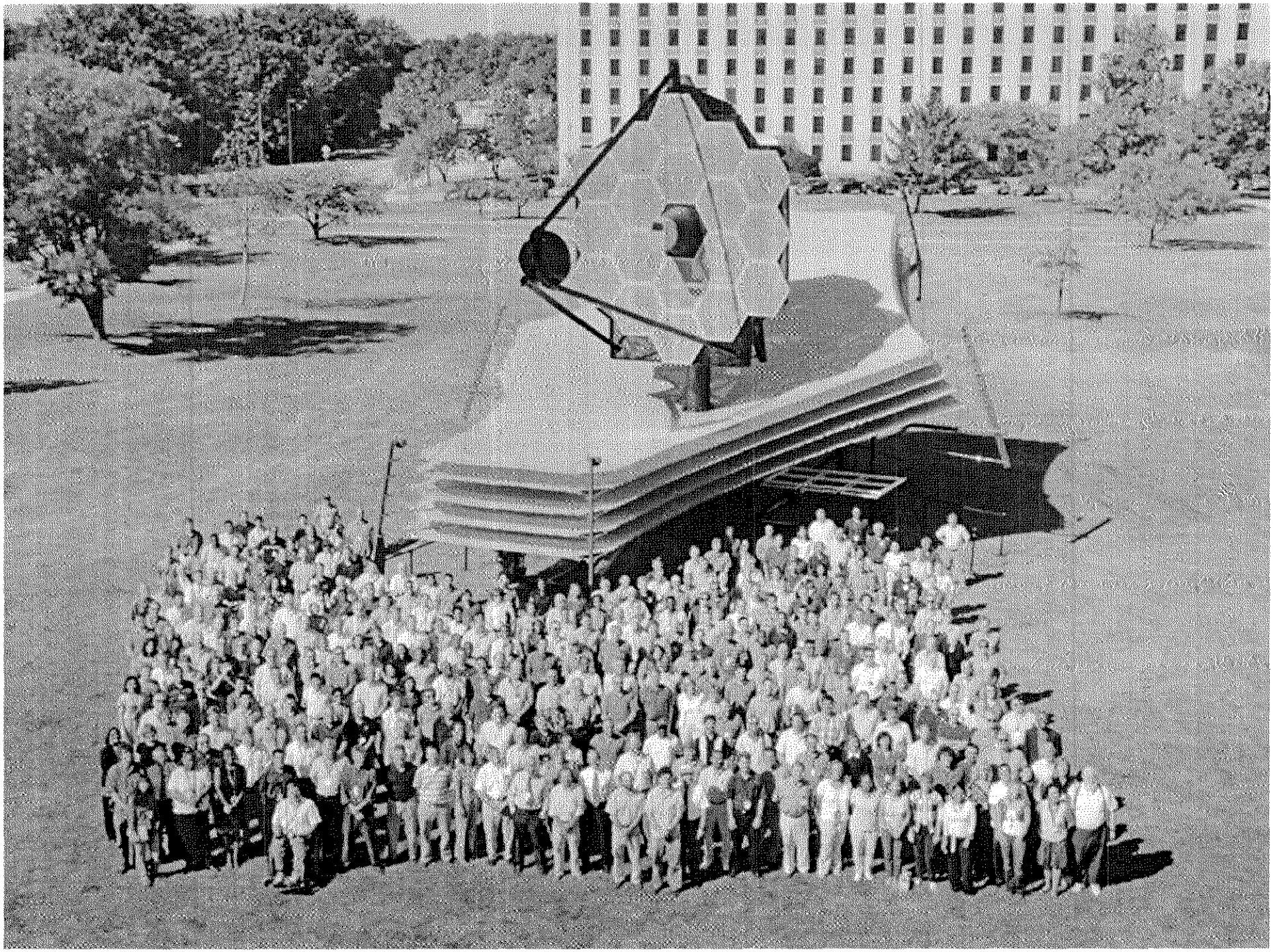
Both can be legitimate and acceptable BUT:

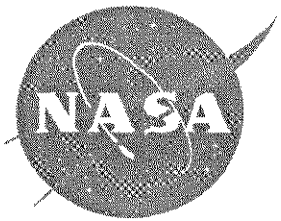
- **It's not about the part, it is about the application**
  - Is the acceptable risk level the same or higher?
  - Is the operating environment the same or more benign?
  - Is the redundancy the same?
  - Is it being used in the same way?
  - Etcetera?

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





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