Environmental Verification Standards for Space Hardware

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Topics

- **Background**
  - **-JPL Design Principles**
  - **-JPL Flight Project Practices**
- **Environmental Design and Verification**
- **Environmental Program Flow**
- **Environmental Verification Summary**
- **Environmental Design and Test Margins**
- **Summary**

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JPL Environmental Testing Standards

• **Design Principles**
  - •Capture institutional standards for designing, verifying, validating, and operating flight systems

•**Flight Project Practices**
  - •Establish standards of uniformity, where standardization is judged to have significant benefit
  - •Capture approaches and methods important to sponsors
  - •Incorporate lessons learned that were key to past successes, and where deviations created significant problems
  - •Require management review and approval to waive

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JPL Environmental Testing Standards (Cont.)

•**Flight Project Practices (Cont.)**
  - •6.13 Design and Verification for Environmental Compatibility
    - •Flight hardware designed and verified to be fully compatible with all anticipated environments.
    - •System level environmental test program: modal, static, random vibration, acoustic, thermal, EMI/EMC and pyroshock
    - •Assembly/subsystem level environmental test program: random vibration, acoustic, thermal pyroshock, EMC, and atmospheric

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JPL Environmental Testing Standards (Cont.)

Flight Project Practices (Cont.)

- 6.13 Design and Verification for Environmental Compatibility (Cont.)
  - Test Authorization: project approved and certified
  - Test Execution: approved procedures
    qualification and flight acceptance testing
    - Protoflight testing all flight articles
    - Qualification testing one flight unit followed by flight acceptance testing all other flight units
  - Test Configuration
    - All hardware environmentally tested before system level environmental tests
    - System level environmental tests include full complement of flight hardware

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JPL Environmental Testing Standards (Cont.)

Flight Project Practices (Cont.)

- 6.13 Design and Verification for Environmental Compatibility (Cont.)
  - Post-Test Documentation: Test results documented including exceptions
  - Test Certification-Review of test objectives and requirements satisfied by project

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JPL Environmental Testing Standards (Cont.)

Flight Project Practices (Cont.)

- •6.13 Design and Verification for Environmental Compatibility (Cont.)
  - •Document Standards (ie implement this Flight Project Practice)
    - **•Spacecraft System Dynamic and Static Testing**
    - **•System Thermal Testing**
    - **•Assembly and Subsystem Level Environmental Verification**

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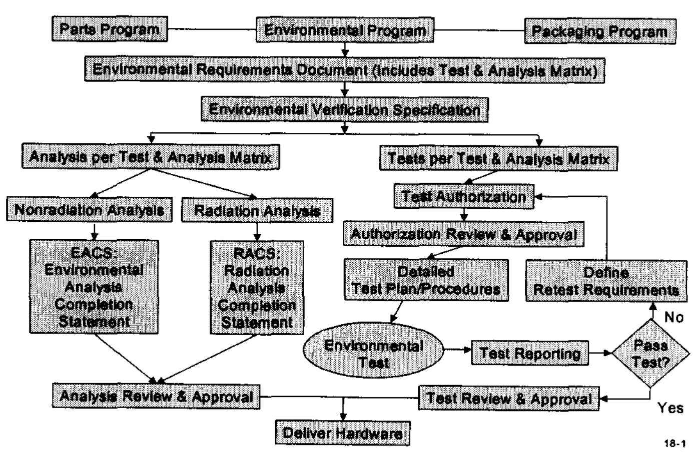
Typical Environmental Program Flow



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Typical Environmental Verification Summary

Environment	Assembly	Spacecraft
Dynamics	T	T
Thermal	T	T
Electromagnetic Compatibility	T	T
Magnetics	T	A
Electrostatic Discharge	A	—
Radiation	A	—
Solid Particles	A	A
Atomic Oxygen	A	—

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TYPICAL TEST REQUIREMENTS AND MARGINS

Test Description	Assembly			Spacecraft / System
	Flight Acceptance	Protoflight	Qualification	Protoflight
Acoustics Amplitude Duration	MEFL 1 min	MEFL + 3dB 1 min	MEFL + 3dB 2 min	MEFL + 3dB 1 min
Random Vibration Amplitude Duration	MEFL 1 min/AXIS	MEFL + 3dB 1 min/AXIS	MEFL + 3dB 2 min/AXIS	MEFL + 3dB 1 min
Pyro Shock	NONE	MEFL + 3dB 1 shock/AXIS	MEFL + 3dB 2 shocks/AXIS	2 firings (dominant shock sources) 1 firing (other sources)

MEFL: Maximum Expected Flight Level

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TYPICAL TEST REQUIREMENTS AND MARGINS (CONT.)

Test Description	Assembly			Spacecraft System
	Flight Acceptance	Protoflight	Qualification	Protoflight
Temperature	Allow Flt + 5°C Cycles: 1-10 depending on mission cycles. Electronics Dwell: 60 hr. hot / 8 hr. cold Mechanisms Dwell: 24 hr. hot / 24 hr. cold	-35 to 75°C or Allow Flt +20 & -15°C Cycles: 1-10 depending on mission cycles. Electronics Dwell: 144 hr. hot / 24 hr. cold Mechanisms Dwell: 24 hr. hot / 24 hr. cold	-35 to 75°C or Allow Flt +20 & - 15°C Cycles: 1-10 depending on mission cycles. Electronics Dwell: 144 hr. hot / 24 hr. cold Mechanisms Dwell: 24 hr. hot / 24 hr. cold	Temp. within Allowable Flt & not to exceed assembly PF. Dwell time and Number of Thermal Cycles are Mission Dependent
Pressure Profile	None	1.5 X MAX dP/dt	1.5 X MAX dP/dt	Facility Limited
EMC RF Susceptibility Emissions	None (grounding/ isolation only)	MEFL + 6 dB Freq. Dependent Margin > 60 dB	MEFL + 6 dB Freq. Dependent Margin > 60 dB	MEFL + 6 dB Freq. Dependent Margin > 60 dB
EMC Radiated Emissions	None (grounding/ isolation only)	MEFL - 6 dB Freq. Dependent	MEFL - 6 dB Freq. Dependent	MEFL - 6 dB Freq. Dependent

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Thermal Margins Comparisons

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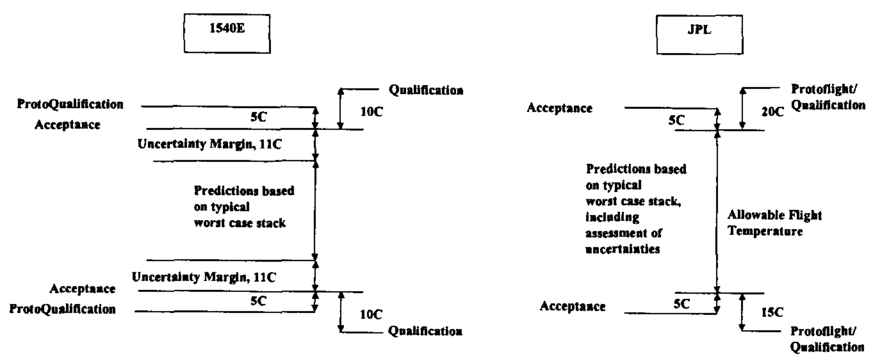

Besides more conservative overall margin for JPL, there is another significant difference. The JPL approach requires the assessment of uncertainties in the definition of worst-case thermal scenarios.

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Summary

• Environmental Design and Verification Standards for flight systems have been evolving at JPL and other NASA centers for the last 40 years.

  • JPL documenting in institutional standards imbedded in Flight Project Practices

• System level environmental test program: modal, static, random vibration, acoustic, thermal, EMI/EMC and pyroshock

• Assembly/subsystem level environmental test program: random vibration, acoustic, thermal pyroshock, EMC, and atmospheric

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Backup

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Assure Product Reliability
Hardware Terminology

TERMINOLOGY	JPL	GSFC	EUROPEAN	OTHER TERMS
Piecepart		Part		component, element
			specific item name	
Subassy		Assembly(?) pwr & gyro		component, slice, tray, unit, element, blackbox
Assembly		component, unit, section (testable level)		unit, element, blackbox, instrument
Subsystem		Subsystem, instrument, module, structural assembly		unit, element, blackbox, instrument, system
System		Payload = spacecraft, laboratory, observatory, satellite	spacecraft	spacecraft, instrument, subsystem

Suggestions: s/c system, (engineering+ +payload)
instrument system - single instrument
payload system - group of instruments

Issue: 1) slice, tray, synonomous with subassembly
2) define assembly levels up-front in doc list

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