



JPL

1st International Workshop on
Test Philosophies, Standards, Methods and Quality for Space Systems



Session 1

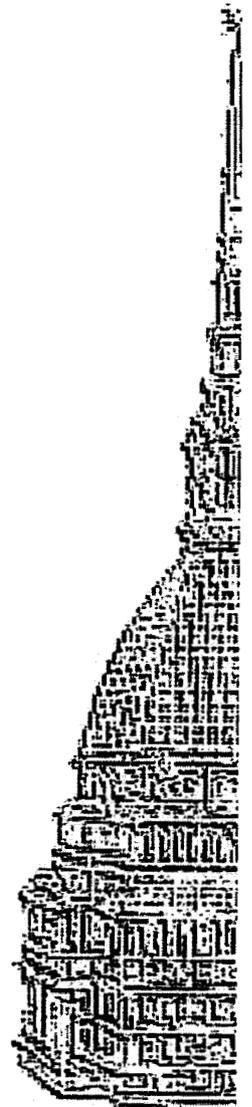
Verification and Testing Standards/Test Quality

Title

**JET PROPULSION LABORATORY
ENVIRONMENTAL TEST STANDARDS
AN OVERVIEW**

A. Hoffman, K. Evans, T. Fisher, J. Forgrave

**Speaker: John Forgrave
Jet Propulsion Laboratory
California Institute of Technology**





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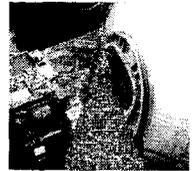
Topics

- **Background**
 - JPL Design Principles**
 - JPL Flight Project Practices**
- **Environmental Design and Verification**
- **Environmental Program Flow**
- **Environmental Verification Summary**
- **Environmental Design and Test Margins**
- **Issues to be Addressed at Workshop**
- **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**

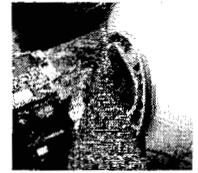
- **Incorporate lessons learned that were key to past successes, and where deviations created significant problems**

- **Require management review and approval to waive**



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JPL Environmental Testing Standards (Cont.)

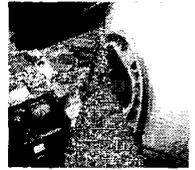
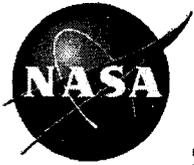
•Flight Project Practices (Cont.)

•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**



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**

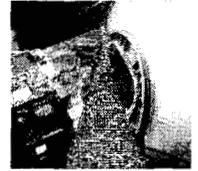
 - All hardware environmentally tested before system level
environmental tests**

 - System level environmental tests include full
complement of flight hardware**



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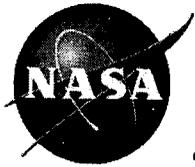
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JPL Environmental Testing Standards (Cont.) Flight Project Practices (Cont.)

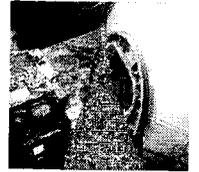
•6.13 Design and Verification for Environmental Compatibility (Cont.)

- 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.)

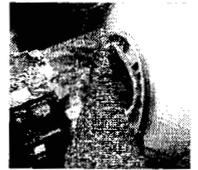
•6.13 Design and Verification for Environmental Compatibility (Cont.)

•Document Standards (ie implement this Flight Project Practice)

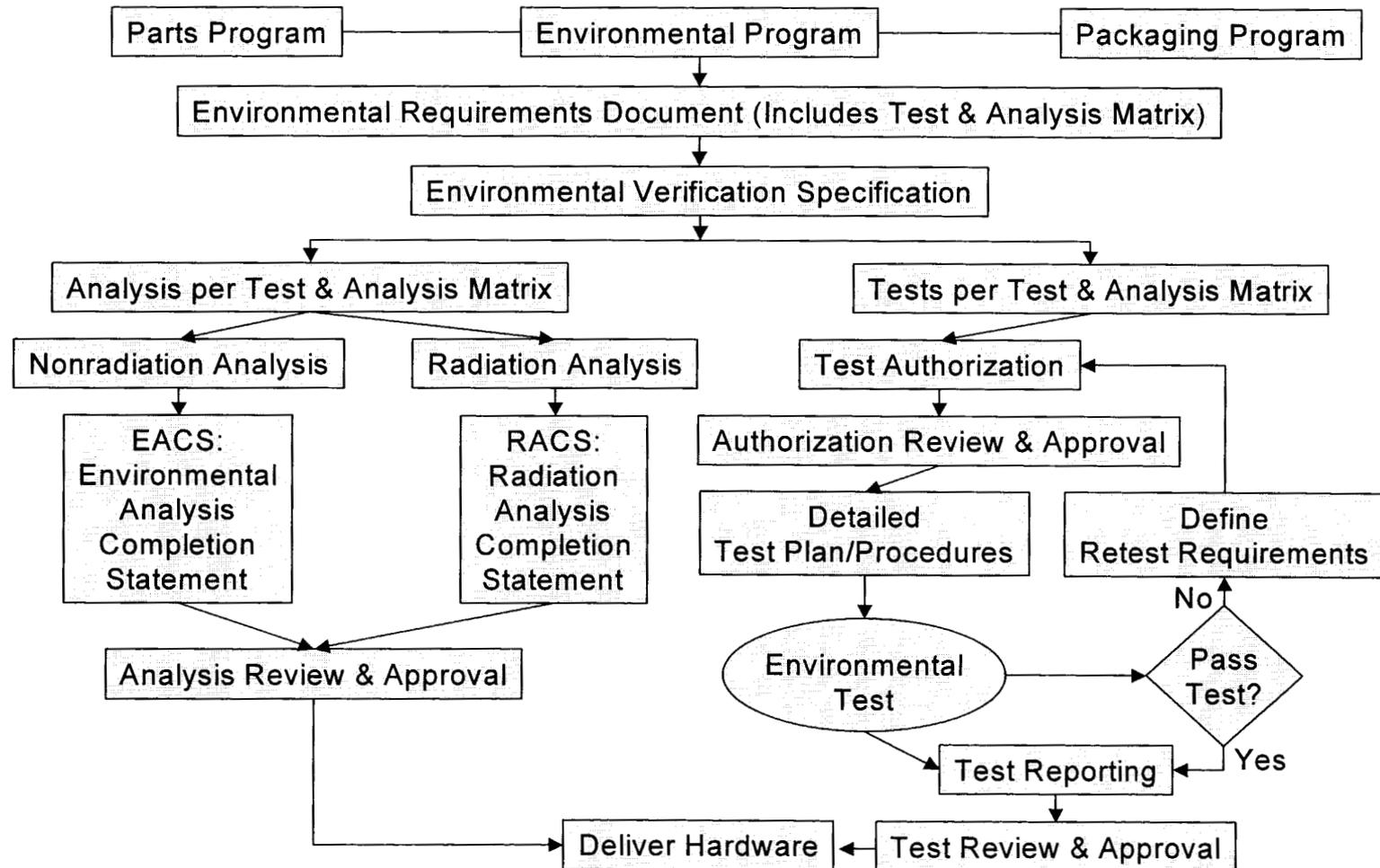
•Spacecraft System Dynamic and Static Testing

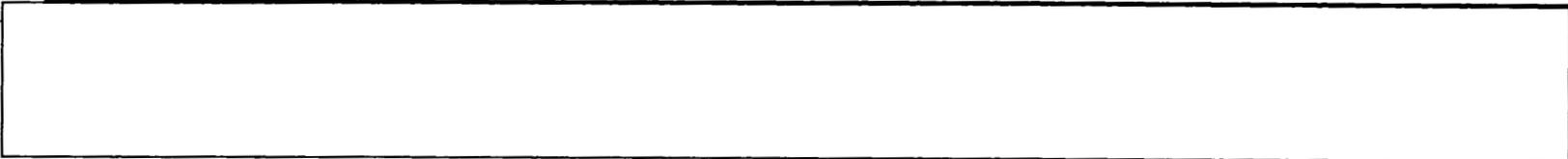
•System Thermal Testing

•Assembly and Subsystem Level Environmental Verification



Typical Environmental Program Flow





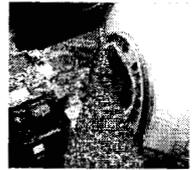
Typical Environmental Verification Summary

Method	Environment	Assembly	Spacecraft
<u>Test (T)</u>	Dynamics	T	T
	Thermal	T	T
	Electromagnetic Compatibility	T	T
	Magnetics	T	A
<u>Analysis (A)</u>	Electrostatic Discharge	A	—
	Radiation	A	—
	Solid Particles	A	A
	Atomic Oxygen	A	—



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	NO TEST
Pyro Shock	NONE	MEFL + 3dB 1 shock/AXIS	MEFL + 3dB 3 shocks/AXIS	1 actual device firings



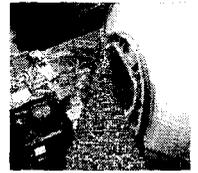
**TYPICAL TEST
 REQUIREMENTS AND MARGINS (CONT.)**

Test Description	Assembly			Spacecraft System
	Flight Acceptance	Protoflight	Qualification	Protoflight
Temperature	Allow Flt + 5°C	-35 to 75°C or Allow Flt +20°C - 15°C	-35 to 75°C or Allow Flt +20°C - 15°C	Within Allowable Flt and not to exceed assembly PF
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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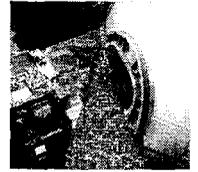


Issues to be Addressed at workshop

- **Terminology**
 - **Hardware Hierarchy**
 - **Environmental Program Definitions**
 - **Qualification**
 - **Flight Acceptance**
 - **Protoflight**
- **Test Margins and Rationale**
- **Post-Test Documentation**
 - **Assembly Level**
 - **Systems Level**
- **Qualification by Similarity**

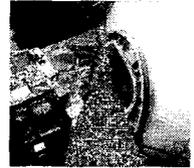


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Summary

- **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**



Assure Product Reliability Hardware Terminology

TERMINOLOGY				
	JPL	GSFC	EUROPEAN	OTHER TERMS
Piecepart		Part		component, element
			specific item name	
Subass'y		Assembly(?) pwr & gyro		component, slice, tray, unit, element, blackbox
Assembly		component, unit, section (testable level)		unit, element, <u>blackbox</u> , 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		