Technology Workshop for Discovery

Washington, DC

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Entry, Descent and Landing (EDL) Instrumentation

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The Community Announcement Language on EDL Instrumentation

- “Discovery Program investigations involving entry, descent, and landing (EDL) into the atmosphere of a Solar System object (including the Earth) shall include an Engineering Science Activity (ESA), to be funded outside of the cost cap, to obtain diagnostic and technical data about vehicle performance and entry environments. Details of the goals and objectives of this activity will be posted on the Discovery Program Acquisition Website (discovery.larc.nasa.gov) in the Program Library.”

Entry, Descent and Landing (EDL) Instrumentation

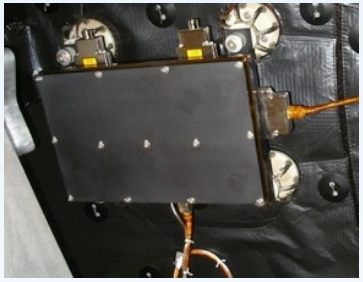
- Goal
  - **To advance knowledge and improve future entry system designs**: NASA desires to collect engineering performance data from planetary entry probes (Earth return capsules, other planets)
  - Past experience tells us that we must ask this question of proposers *up front* to minimize cost and risk of accommodation
- Approach
  - Goals and Objectives document will be provided—what we want you to measure, not how to measure it
  - It is recognized that these are small vehicles: potentially low mass, power, volume, and data availability; not Flagship-class
  - Want proposers to concentrate on “bang-for-the-buck” and minimize any negative impacts to science
  - The funding for implementation will be provided outside the cost cap
  - NASA will provide experts for consultation

Benefits of Instrumenting Entry Systems

- Advance the state of knowledge about these vehicles and their environments
  - Provide feedback on system performance, rather than “pass/fail”
  - Provide forensics
  - Inform future risk postures and margin practices
  - Guide technology investments to support future missions
- Save time and money, on following missions
  - Show where the system does or does not need improvement (especially useful for build-to-print)
  - Allow project to tailor testing for resource savings
- Improve mass fraction and increase science return
  - Targeted margins may save 10’s to 100’s of kg on the spacecraft
  - Greater knowledge -> Improved systems -> Smaller launch vehicles or more payload delivered

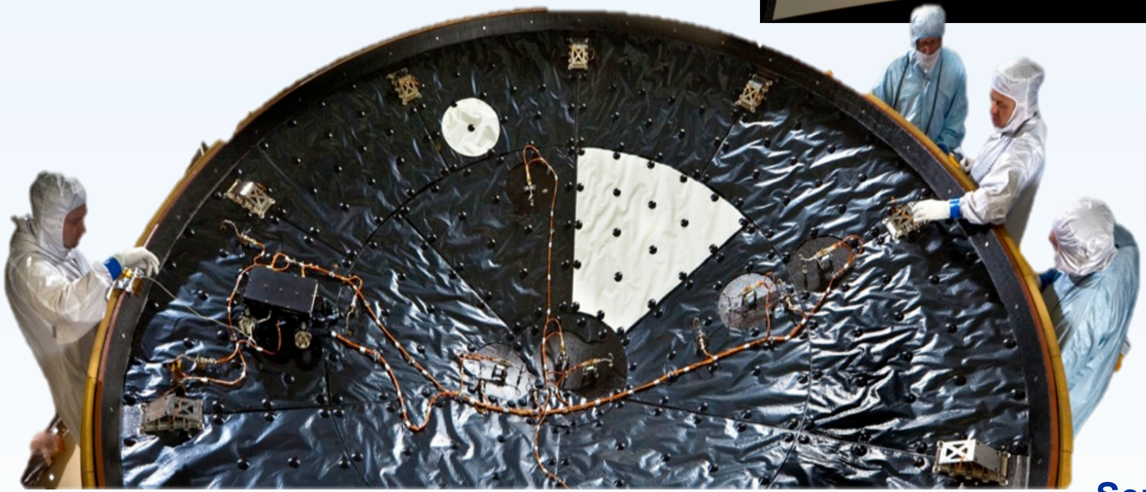
EDL Instrumentation "State-of-the-Art": MEDLI

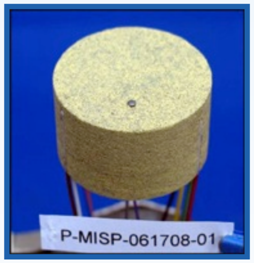
- MEDLI consisted of 7 pressure ports, 7 integrated sensor plugs, with support electronics
- Gathered engineering data during entry and descent for future Mars missions:
  - Aerothermal, aerodynamic, and thermal protection system performance
  - Atmospheric density and winds



Sensor Support Electronics (custom)

Mars Entry Atmospheric Data System (MEADS)





MEDLI Instrumented Sensor Plug (MISP)

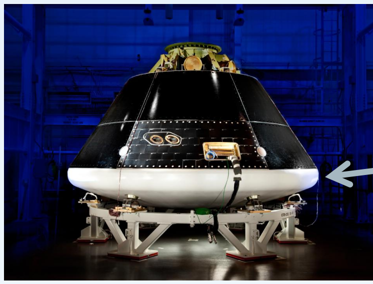
The MEDLI instrumentation made MSL the first extensively instrumented heatshield ever sent to Mars

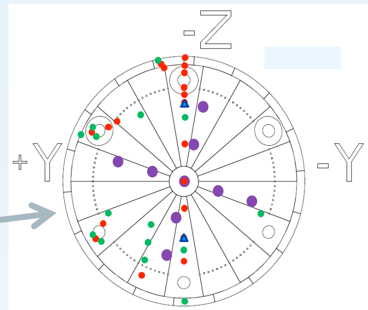
FLAGSHIP-class

EDL Instrumentation SOA 2: EFT-1 Heat Shield

Orion Crew Capsule

- 19 In-Depth TC Thermal Plugs
- 15 Surface TC Thermal Plugs
- 2 Radiometers
- 9 Pressure Ports





Objectives:

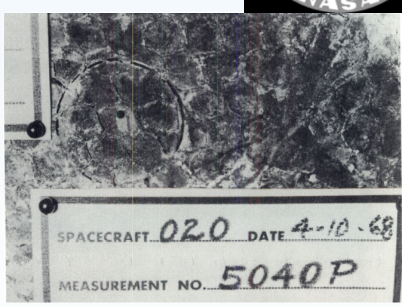
- Deliver flight hardware to measure heat shield response during EFT-1 reentry.
- Data required to validate multiple Flight Test Objectives supporting: human rating, aerodynamic database, heat shield performance

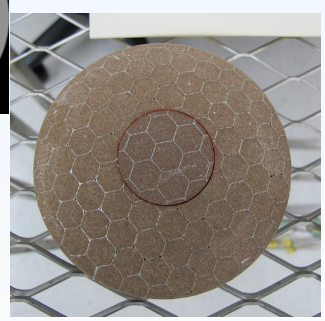
Program:

- Teaming: JSC Crew Service Module Office overall lead
- ARC PM Lead, thermal plugs, radiometer, systems engineering
- LaRC Pressure system design & certification
- JPL Systems engineering & mechanical design
- PM: Ed.Martinez@NASA.gov

Instrumented Thermal Plugs

Avcoat for Orion

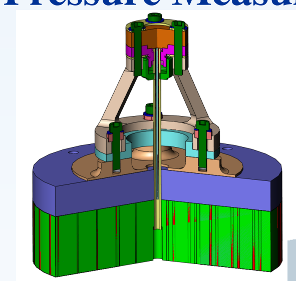




Avcoat TC plugs were flown during the Apollo program

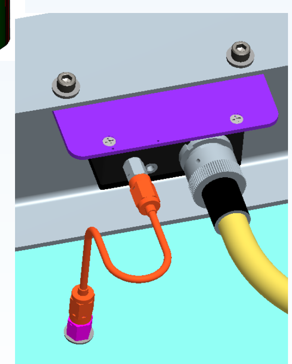
Flight: Fall, 2014

Pressure Measurement & Radiometers



Radiometer

New development and implementation



Pressure

Honeywell PPT

Technical Objectives from the G&O Document

Technical Objectives	Measurement	Accuracy
Thermal Protection		
Reduced TPS and vehicle mass, reduce sub-system risk for future missions	In-Depth Temperatures, as a function of time at multiple locations	±1%
	Recession in Flight (multiple locations)	1 mm
	Final Recession (if recovered)	1 mm
	Heat Flux	5%
Demonstrate adequate bonding and bondline integrity	TPS-to-structure bondline visualization (before and after flight)	±X mm
Atmosphere, Aerodynamics, and Flight Dynamics		
Reconstruct EDL including in-situ winds and atmospheric density. Increase landing accuracy.	Inertial Rates (IMU)	
	Surface Pressure	
	Time Dependent Mass Propserties (fuel burn, etc.)	
Determine vehicle attitude	Roll, pitch, and yaw	±X°
Atmospheric Decelerator		
Enhance system capability (heavier payloads, higher altitudes, etc.), reduce mass, increase reliability and performance for future missions	Deployment angle	±X%
	Deflections/Area oscillations	
	Inflation Pressure & Loads	
	Total drag, as a function of time	
Vehicle Structure		
Reduce mass, increase reliability and performance for future missions	Entry Loads	±X%
	Landing Loads	

Planned AO Library Content

- Goals and Objectives Document: Outline
  - Background and Motivation
  - Goals of the Engineering Science Activity
  - Technical Objectives of the Engineering Science Activity (table, next pg)
  - Data not considered part of the Engineering Science Activity
  - Examples of Implementation
  - TRL Requirements of Data Collection Methods
  - Prioritization of Technical Objectives
  - Data Transfer and Archiving
  - Proposal Requirements for Describing the Engineering Science Activity
- Other documents
  - MEDLI hardware description AIAA paper
  - MISP (thermal plug) and MEADS (pressure port) relevant papers
  - Other documents that may describe the SOA or novel approaches for achieving some of the objectives

Point of Contact

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