The Influence of Free Space Environment in the Mission Life Cycle

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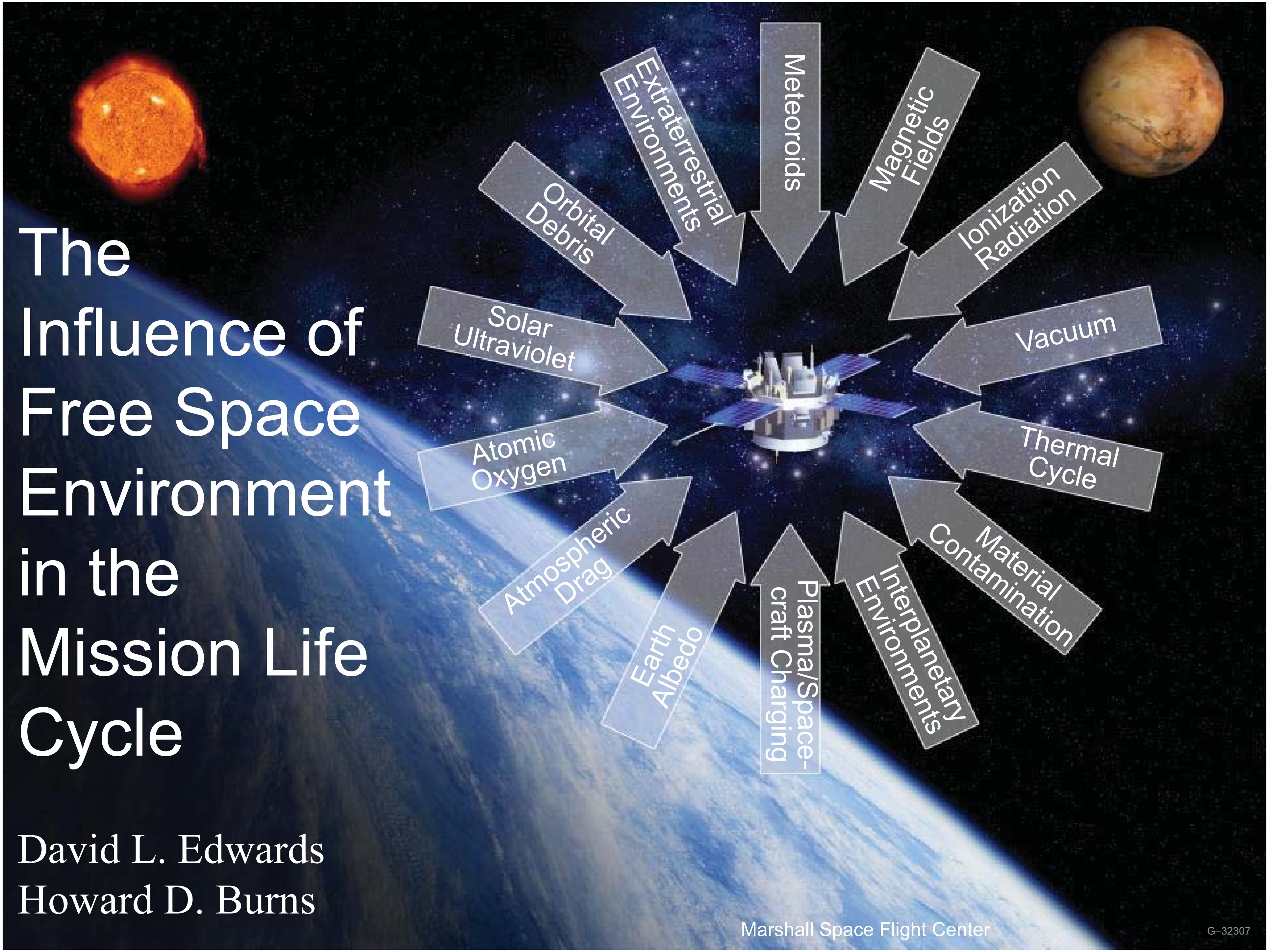
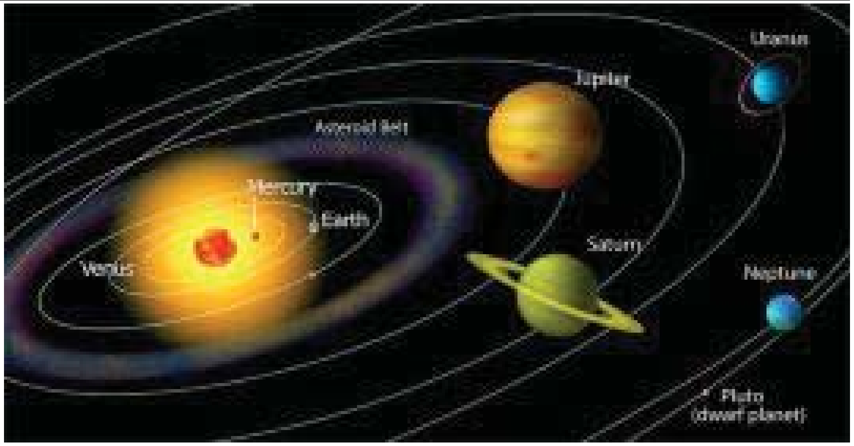


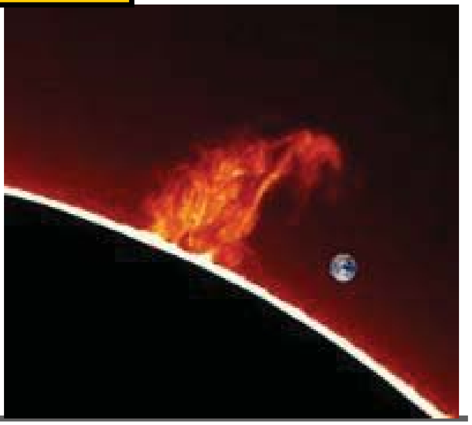
Space Environment Model Use in Mission Life Cycle

- Mission Concept
- Preliminary Design
- Design & Fabrication
- Assembly, Integration Test, and Launch
- Operations
- Closeout
- Anomaly Resolution Lessons Learned



Space Climate
Minimize Risk

Space Weather
Manage Residual Risk

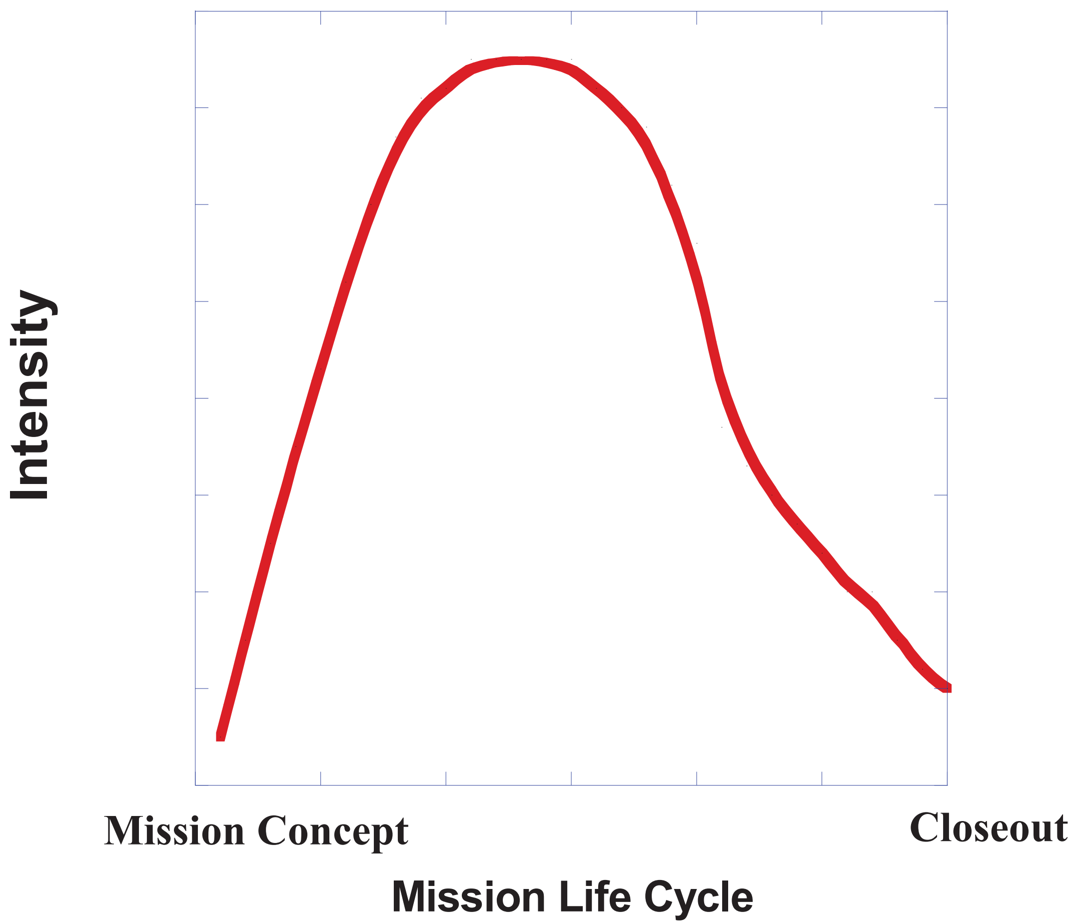


Space Environment ‘ Trades’ that must be balanced

- **Free Space Environments have significant influence on the design, development, and operation of aerospace systems.**
- **Figures of Merit (FOMs) and weighting factors.**
- **FOMs that must be balanced include:**
    - Mission objectives and concept
    - Performance
    - Schedule
    - Programmatic and Technical risk
    - Cost
    - Mass
    - Legal and Regulatory
    - Natural environments
    - Induced environments

- **For aerospace applications, it is very important to understand the statistics, including uncertainties and variability, of each environment.**

Level of Effort over the Mission Life Cycle



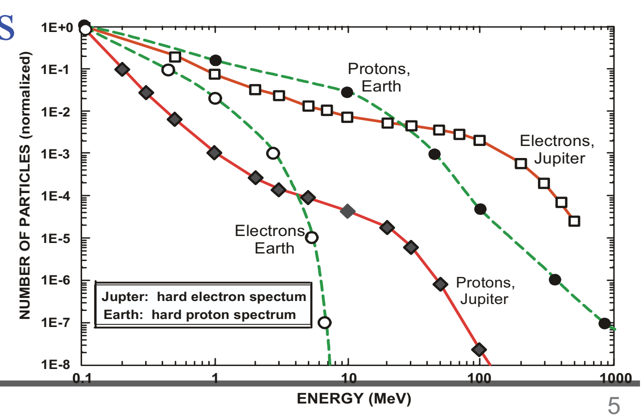
Spacecraft Engineer tasks within the Mission Life Cycle

1. Define the environment
2. Anticipate potential environment – spacecraft interactions that could be of concern
3. Identify candidate materials
4. Identify engineering performance failure limits
5. Identify potential mitigation strategies for adverse interactions
6. Test materials and verify functionality in an emulated space environment
7. Gather and analyze inflight data
8. Investigate and document all possible anomalies
9. Dispose of spacecraft appropriately to not contribute to orbital debris environment.

Mission Concept

- Purpose is to develop feasible concepts for a mission
- As concept matures
  - Baseline mission concept will emerge
  - New technology development identified
  - High level program requirements are established
  - Preliminary schedule and life cycle costs are established

- Define the Environment
  - Available information is collected
  - 1st order Environments Specification Document (ESD) is developed
- Identify potential environment – spacecraft interactions
  - Preliminary concerns are identified based on 1st ESD

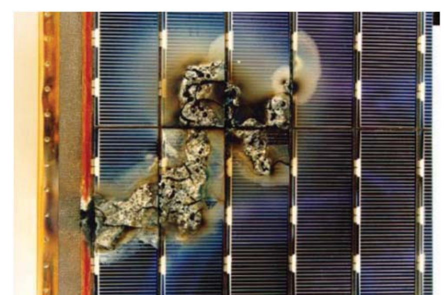


- FOMs are Analyzed against the Mission Concept

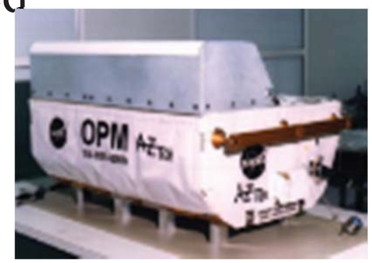
Preliminary Design

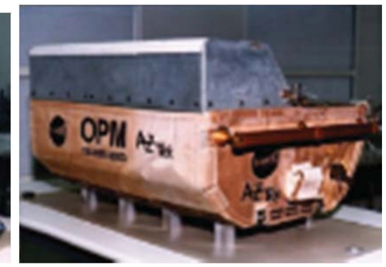
- Initial baseline is established
- Formal flow-down of design specifications from system to sub-system level.
- Schedule and cost estimate are developed
- Planning ground processing requirements and capabilities

- Iterate the environment defn
  - ESD baselined
- Identify potential Environment-spacecraft interactions
  - Risks identified
- Identify candidate materials
- Identify engineering performance failure limits
  - Performance Limits driven by Mission Requirements
  - Design for Demise (End of Mission)
- Identify potential mitigation strategies for adverse interactions
  - Preliminary operational mitigation strategies
- FOMs are Analyzed against the Preliminary design



- Final Design is complete
- Manufacturing processes are defined and validated
- Hardware is Fabricated



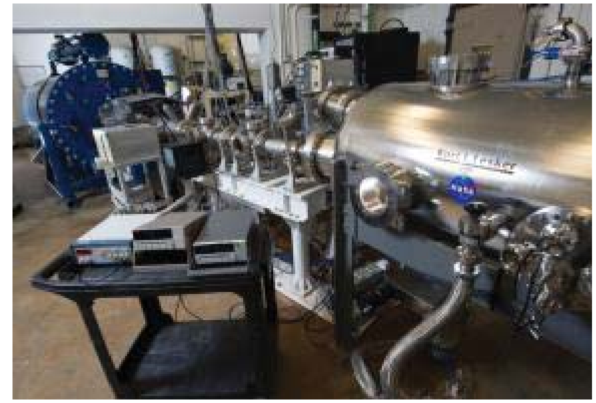


- ESD baselined
- Risks formalized and resolution strategies worked
- Candidate materials selected
- Engineering performance failure limits identified
- Identify potential mitigation strategies for adverse interactions
  - Develop Operational Mitigation Strategies

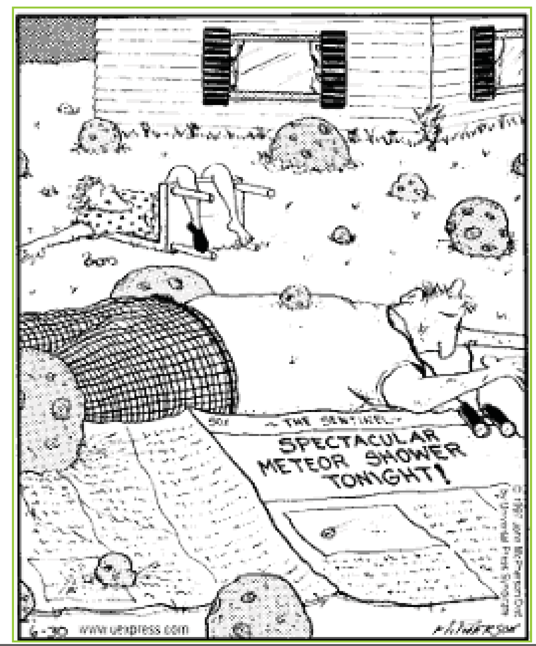
- Test materials and verify functionality in an emulated space environment

- FOMs are Analyzed against the Design

Assembly, Integration, Test, and Launch



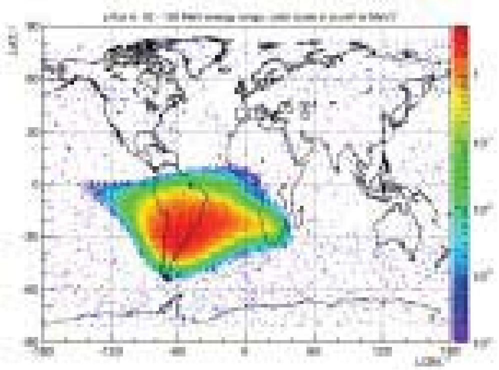
- Assembly and Integration
- Verification and Validation of the Space System
- Functional Testing of the Space System
- Launch
- Test materials and verify functionality in an emulated space environment
  - Materials and sub-system testing should be complete early in the Phase.
- Ground processes facilities monitored for cleanliness
  - Ground Support Equipment, Transportation,.
- Solar Activity Forecast for Day of Launch
- Meteor Shower Forecast
- FOMs are Analyzed against the AIT&L



Operations

- Perform the Mission

- Gather and analyze inflight data to determine alignment of design method with mission performance
  - Analyze and compare Environment Measurements to Models
  - Track performance of engineering surfaces and function
- Implement Operational mitigation strategies for space weather events
- Investigate and document all possible anomalies for future spacecraft design application



Closeout

- Mission complete
- Implement systems decommissioning disposal plans
- Analyze any returned data

- Investigate and document all possible anomalies for future spacecraft design application
  - Assess mission performance to design Reference Mission and document discrepancies and anomalies

- Dispose of spacecraft appropriately to not contribute to orbital debris environment.
  - awareness of space weather events
  - Impact of atmospheric drag
  - Conjunction analysis

Summary

- Space Environment influences all phases of the Mission Life Cycle
- Evaluate the mission design early using an integrated approach
- Require adequate testing of materials and systems
- During flight, evaluate effectiveness of the design methodology and verification of environment models.
- Other
- Other
- Other

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