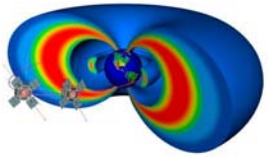

RBSP Radiation Belt Storm Probes

Managing the Impacts of Flight Software Changes on the Ground Software Element (The RBSP Experience)

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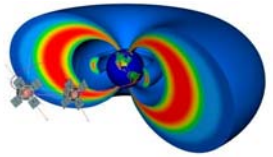
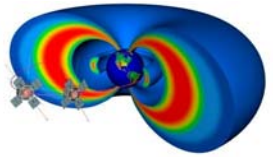
Agenda



- Introduction
- Proper Requirements Management
- Control of Interface Definitions
- Key Engineering Roles
- Architectural Decisions
- Conclusion / Questions

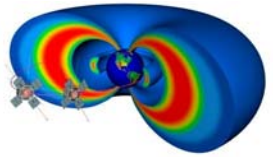
Introduction / Agenda



- **RBSP is a NASA mission to study near-Earth space radiation.**
- **The mission consists of two nearly identical spacecraft.**
- **Each spacecraft hosts 5 instrument suites, with a total of 10 unique science instruments.**

- **This presentation will discuss 4 areas of system engineering that helped RBSP minimize the system wide impact of software changes.**
  - Requirements Management
  - Interface Definitions
  - Key Engineering Staff
  - Architectural Decisions

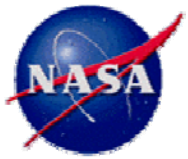
Requirements Management (Know Your System)



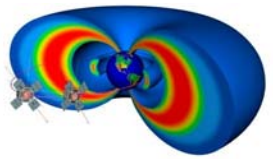
- **What is your system?**
  - End-To-End Mission? Observatory? Spacecraft? Flight Software (FSW)? Ground System? Ground Software (GSW)?
  - How do your requirements fit with everyone elses?

- **How are your requirements documented?**
  - Requirements Flow Down
  - Traceability
  - Verification

- **How are changes to these requirements managed?**
  - Documented Change Requests
  - Change Control Board (CCB)

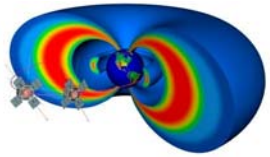


The RBSP System



- **Two Spacecraft**
  - 1 Mission Operations Center (MOC)
  - 2 Prime Strings of Workstations (RBSP-A and RBSP-B)
  - Plus Backup systems
- **Five Instrument Suites per Spacecraft**
  - 5 Science Operations Centers (SOC)s
- **Both Flight Software (FSW) and Ground Software (GSW) Requirements and Test Cases are Documented in Telelogic DOORS.**
  - Provides traceability of flow down and verification
- **Requirements changes were tracked in Atlassian's JIRA Tool**
- **Changes to baseline document are approved by a software CCB**
- **56 FSW requirements issues addressed in 5 document revisions**

Interface Definitions
(Know Your Interfaces)

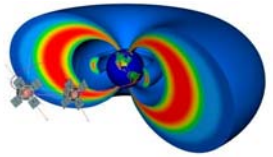


- **What other systems are coupled to (or impact) your system?**
  - How can a change in someone else's requirements impact you?
  - How can a change in your requirements impact someone else?

- **How are these interfaces documented?**
- **You need to be able to see the forest as well as the trees**
  - Identify areas of coupling between systems
  - Document these areas of coupling as clearly as possible with words, diagrams and tables

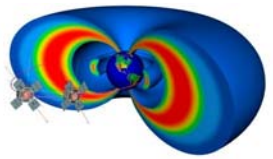
- **How are interface changes managed?**

RBSP GSW / FSW Interface



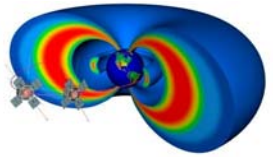
- **Documented in a Ground Software (GSW) to Flight Software (FSW) Interface Control Document (ICD)**
- **Documents RBSP's use of:**
  - CCSDS Uplink Command Formats
  - CCSDS Downlink Telemetry Formats
  - CCSDS File Delivery Protocol (CFDP) for playback of recorded data
  - Onboard Memory Management (Including objects)
  - Events and Command Status Formats
  - Instrument Time-tagged Command Buffers
- **Changes are tracked in JIRA and approved by CCB**
- **45 ICD issues addressed in 6 document revisions**

Key Engineering Staff (Know Your Roles)



- **Who is Responsible for the Various Aspects of the Software, and at What Level?**
- **Who Owns the Data Formats?**
- **Who Defines the Interface Protocols?**
- **How are These Roles Documented?**

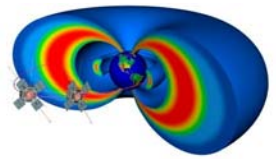
Key Roles on RBSP

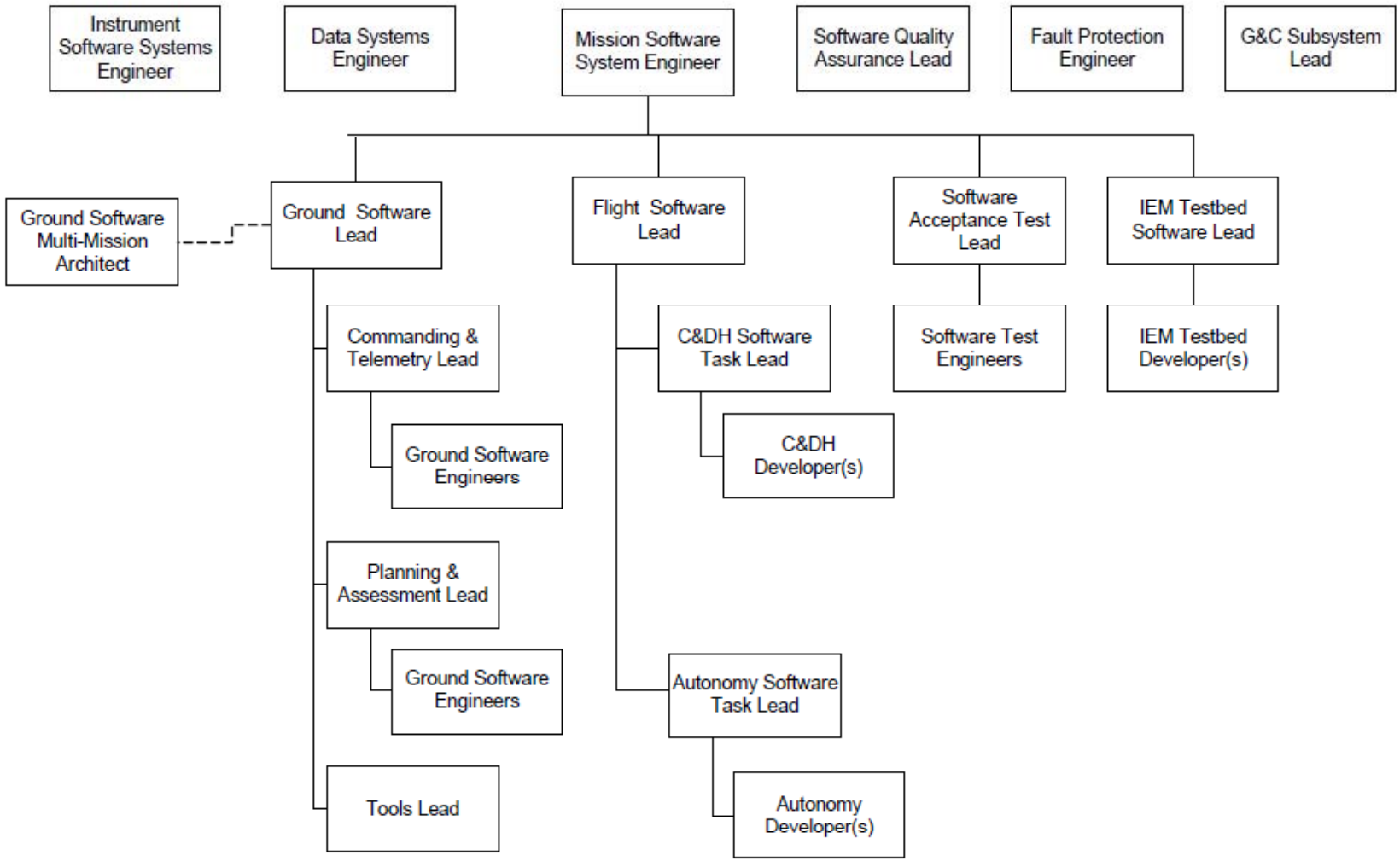


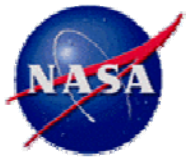
- **Documented in the Software Development and Management Plan (SDMP)**

- **Mission Software Systems Engineer**
  - Responsible for coordinating, planning, and directing the development and test of the RBSP software.
- **Data Systems Engineer**
  - Supports the Systems Engineering team to develop and manage the end to end data flow.
- **Flight Software Lead Engineer**
  - Leads FSW team and is responsible for spacecraft software elements
- **Ground Software Lead Engineer**
  - Leads GSW team and is responsible for ground software elements

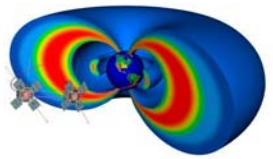
Example Org Chart







Architectural Decisions (Know Your Design)

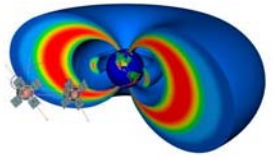


- **Minimize Coupling**
  - Whenever possible work to keep the elements of the system as loosely coupled as possible.
  - Minimize the amount and scope of information one system element needs to know about another.

- **Create Cohesive System Elements**
  - Each system element should be as cohesive as possible, performing just its defined task.

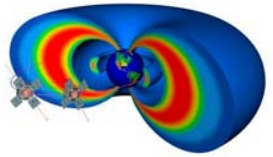
- **DON'T**
  - Cross protocol boundaries
  - Over specify to the point of tying developer's hands

RBSP's System Architecture



- **"Bent Pipe" system for "Decoupled" operations**
- **Instrument teams work directly with their instrument**
- **The spacecraft and ground system are transparent or invisible wherever possible**
- **Instrument commands are not contained within the spacecraft database in the MOC, but are instead maintained at each individual instrument team's SOC**
- **Critical instrument telemetry can be alarmed in MOC**

Conclusion / Questions



- **In order to effectively manage the impacts of changes to the flight requirements or interfaces, everyone needs to:**
  - Know Their System
  - Know Their Interfaces
  - Know Their Roles
  - Know Their Design
- **Questions?**