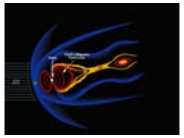
Magnetospheric MultiScale Mission

SpaceWire Implementation

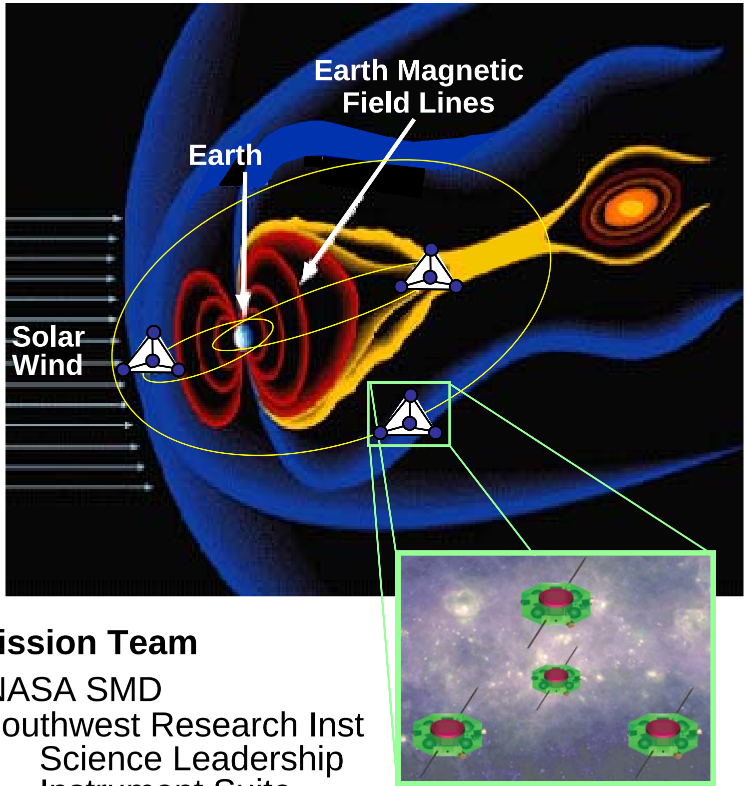
George L. Jackson, MMS Spacecraft Avionics Lead
David Raphael, MMS C&DH Lead
Glenn Rakow, NASA SpaceWire Representative

SpaceWire Working Group
Noordwijk, Netherlands
January 17-18, 2007



MMS Mission Overview

Magnetospheric Multiscale Mission (MMS)

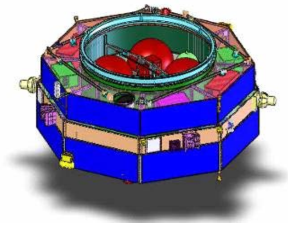


Science Objectives

Discover the fundamental plasma physics process of reconnection in the Earth's magnetosphere

- Temporal scales of milliseconds to seconds
- Spatial scales of 10s to 100s of km

Mission Description



- 4 identical satellites
- Formation flying in a tetrahedron
- 2 year operational mission

Orbits

Elliptical Earth orbits in 2 phases

- Phase 1 day side of magnetic field 1.2 R_E by 12 R_E
- Phase 2 night side of magnetic field 1.2 R_E by 25 R_E

Significant formation flying and orbit adjust requirements

Instruments

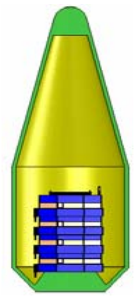
Identical *in situ* instruments on each satellite measure

- Electric and magnetic fields
- Fast plasma
- Energetic particles
- Hot plasma composition

Spacecraft

- Spin stabilized at 3 RPM
- Intersatellite ranging system

Launch vehicle



4 satellites launched together in one Evolved Expendable Launch Vehicle (EELV)

Mission Status

- Currently in Phase A
- Launch in 2013

Mission Team

NASA SMD

Southwest Research Inst

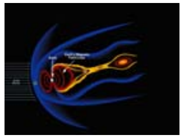
- Science Leadership
- Instrument Suite
- Science Operations Center

NASA GSFC

- Project Management
- Mission System Engineering
- Spacecraft
- Mission Operations Center

NASA KSC

- Launch services

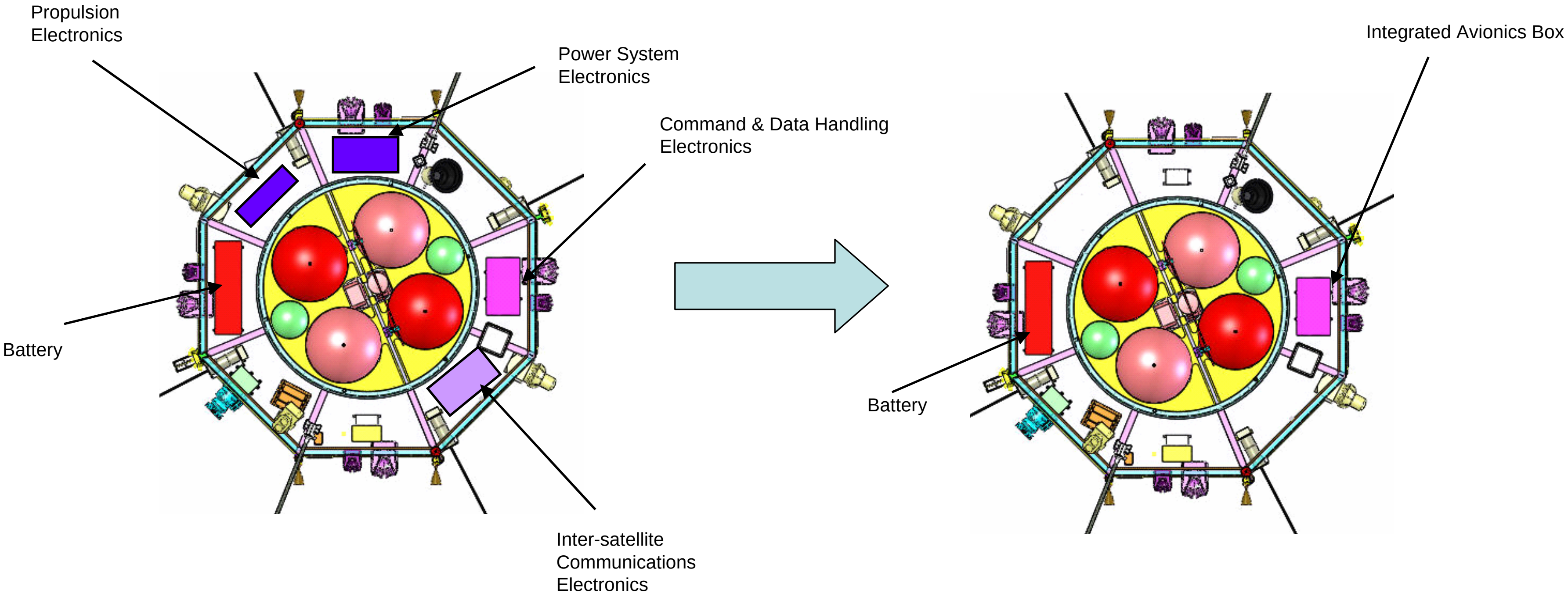


MMS Spacecraft Avionics

Magnetospheric Multiscale Mission (MMS)

- **Traditional spacecraft avionics systems use separate electronics boxes for each function.**

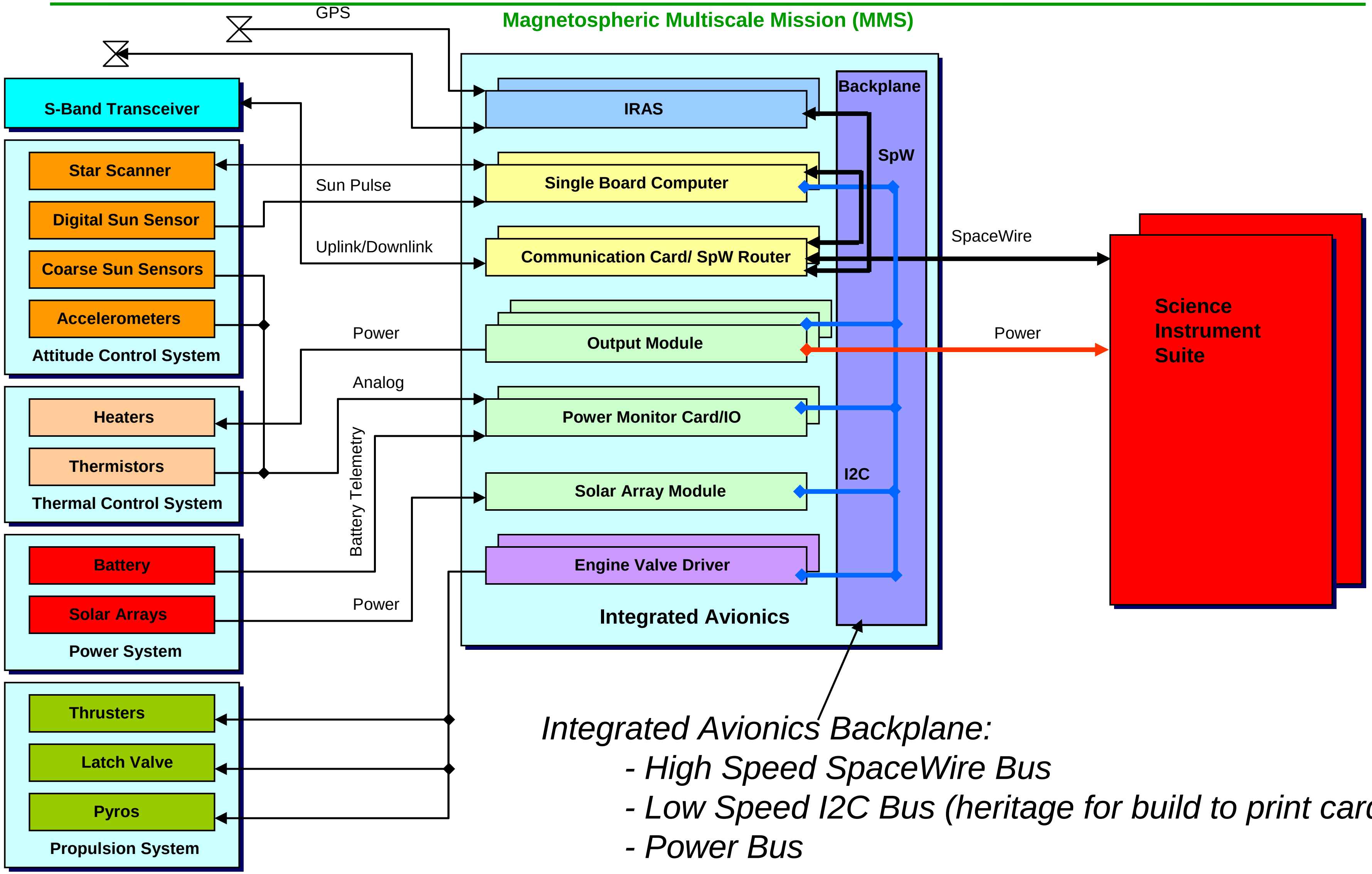
- **MMS has baselined an integrated avionics architecture, in order to save power, mass and reduce integration and test cost.**



Traditional Avionics Approach

MMS Integrated Avionics Approach

Spacecraft Avionics Block Diagram

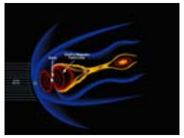


Integrated Avionics Backplane:

- High Speed SpaceWire Bus

- Low Speed I2C Bus (heritage for build to print cards)

- Power Bus



Internal Backplane Communications

- **Low speed communications between integrated avionics subsystems will occur over an internal I2C bus**
  - This bus is used because of heritage build to print boards
    - power system electronics boards
  - This bus will be eliminated in future integrated avionics systems

- **Higher speed communications between integrated avionics subsystems will occur over an internal SpaceWire backplane.**
  - Remote Memory Access Protocol will support I/O and memory transactions.
  - Distributed Interrupt Time-Code mechanism will support sideband signaling.
    - Require multiple side band signaling
    - Need to investigate handshaking mechanism for system operation to see if it will meet requirements
  - Time Code Protocol will support internal time distribution.

- **SpaceWire will replace the traditional cPCI bus for MMS**

Backup
SpaceWire Advantages for MMS

– SpaceWire backplane should be simpler than cPCI.

– Reduces the number of interfaces between the Instrument Suite and the Spacecraft.

- 1553, Custom LVDS, and RS-422 UART Interfaces were replaced by a single SpaceWire Interface.
- Reduces the number of harnesses between the Instrument Suite and Spacecraft.

– Reduces the technical risks associated with custom interfaces.

- Designing to an industry standard reduces the risk of ICD custom interface misinterpretation.

– Reduces interface complexity between the Instrument Suite and the Spacecraft.

- A single SpaceWire interface is simpler than a mixed bag of two standards (1553 and RS-422) and one non-standard (custom LVDS) interface.

– Provides a more flexible architecture.

- Enables easier cross-strapping between the A and B sides.
- Allows variable data rates.
- Packet sizes are not restricted (1553 restricts packets to < 64 bytes).
- Enables communication from the Instrument Suite to the IRAS, Communications Card, or the Single Board Computer over a single interface link.

– Improvements in Observatory Integration and Test.

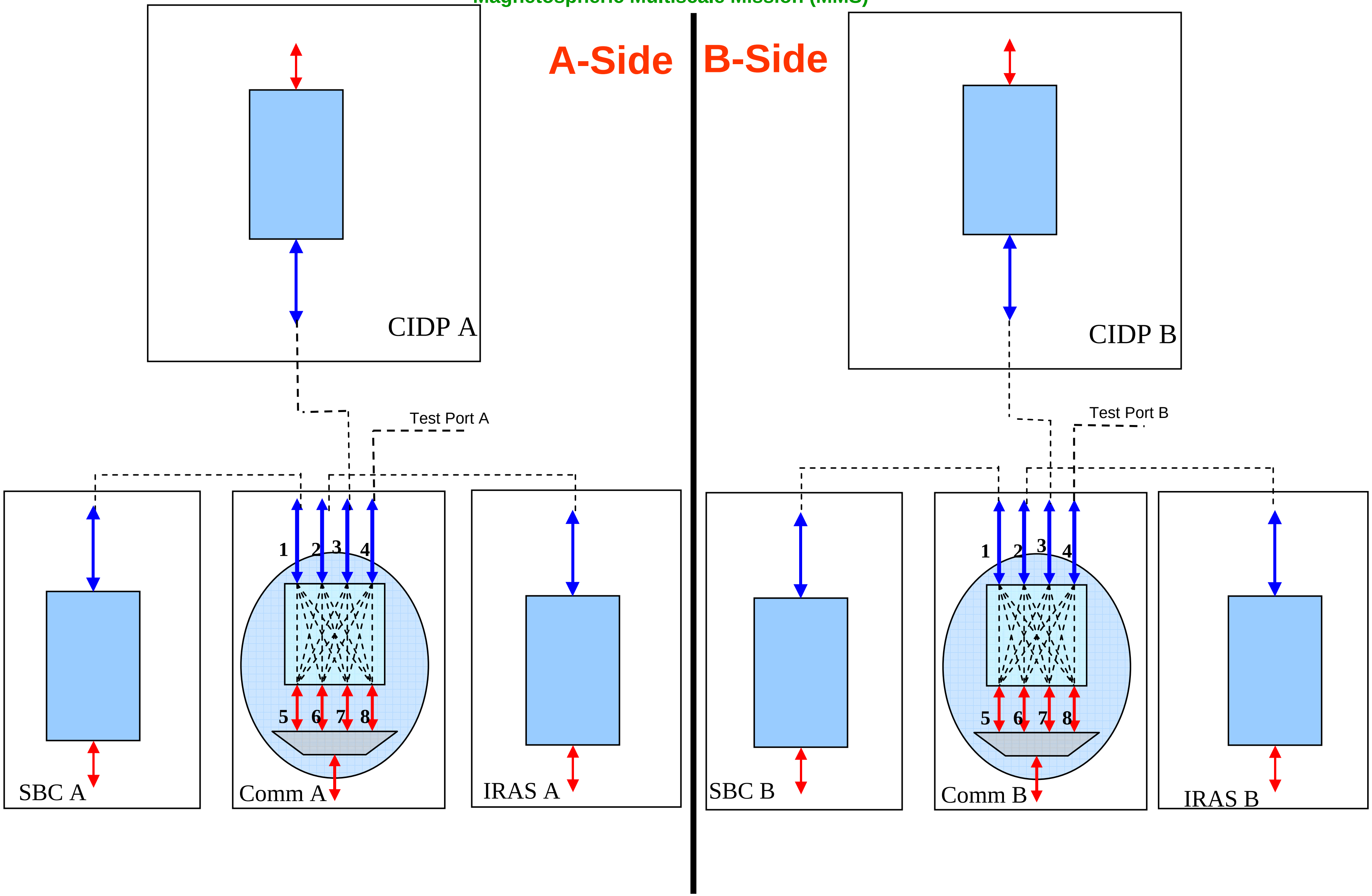
- I&T is simplified with a single SpaceWire interface between the IS and SC.
- Enables remote I&T between GSFC and SwRI.

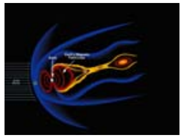
– Reduces GSE development engineering.

- SpaceWire GSE exists for JWST and LRO. Should be able to re-use this GSE for MMS with minor changes.

MMS Avionics SpaceWire Network

Magnetospheric Multiscale Mission (MMS)





Summary of MMS SpaceWire Implementation

Magnetospheric Multiscale Mission (MMS)

- **NASA is interested in the SpaceWire Backplane Standardization for MMS and future flight missions.**
- **MMS should be the first NASA mission to fly several new SpaceWire protocols including:**
  - Remote Memory Access Protocol
  - Distributed Interrupt Protocol
  - Standardized Backplane
- **We look forward to working with the SpaceWire Working Group to help make the new SpaceWire protocols successful for MMS and future missions.**

MMS Avionics Development Schedule

- **ETU fabrication is scheduled to begin in Fall 2008.**
- **Flight fabrication is scheduled to begin in Spring 2009.**
- **The SpaceWire Backplane Connector Standard and connector flight qualification program would need to meet the MMS ETU and Flight fabrication milestones.**
- **Need SpaceWire Backplane Standard definition and flight qualified connector by Spring 2008**
  - Would like to be part of the SpW backplane connector working group
- **Distributed Interrupt TC requires a clear message (poll message) to enable another TC**
  - Some systems simply want to have more side band signals and from multiple sources