Standardized Modular Power Interfaces for Future Space Explorations Missions

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AMPS: Advanced Exploration Systems Modular Power Systems

- Introduction to AMPS
- Need for Standardized Modular Power Interfaces
- AMPS Approach Standard
  - Levels of Assembly
  - Common Framework
- Electrical Interfaces
  - Primary Power Backplane/Module
  - Secondary Power Backplane/Module
- Command and Data Interfaces
  - Spacecraft Data Interface
  - Internal Data Bus
- Summary

AMPS: AES Modular Power Systems

AMPS seeks to develop a common set of Modular Power Building Blocks for future Exploration missions

- **Long distances, long durations**
- **No logistics support**
- **Missions composed of multiple vehicles, multiple power architectures**

Improve Operational Supportability:

- **Reduced Logistics with Common Spares**
- **Spare at lower levels of assembly**
- **Common Maintenance Processes**
- **Common Diagnostics**

Preserve Power Architecture Flexibility

Opportunity: **Salvage power hardware from spent stages to exploit hardware as Spares or reuse in new mission applications.**

AMPS Standardized Modular Power Interfaces

AMPS is drafting a proposed standard that is:

- **Applicable to NASA exploration,**
- **Accommodates variations in power architecture**
- **Supports mission flexibility (configuration changes)**
- **Defines the common infrastructure needed to support the modular design**
- **Standardizes Data, Electrical and Mechanical Interfaces**

The intent is to guide power system developers without restricting design or technology options.

- **Adopts existing standards where applicable**
- **Emphasize Interchangeability and Interoperability**

AMPS Standardized Modular Power Interfaces

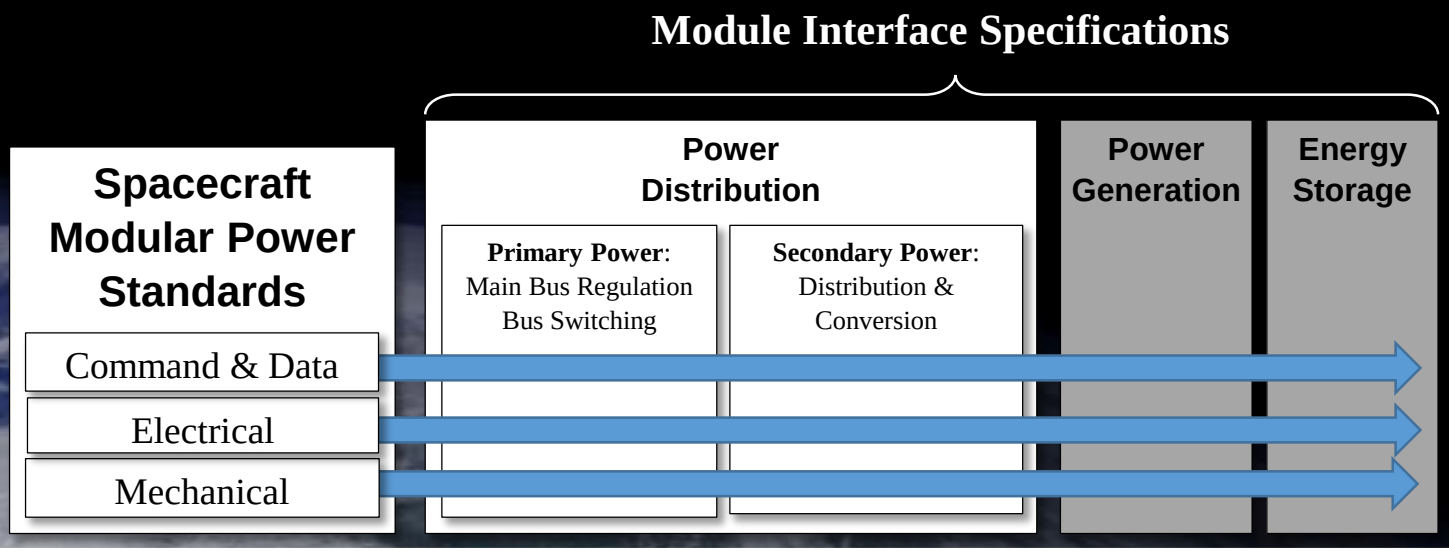
AMPS Modular Approach

- **Extend the modularity of International Space Station to lower Levels-of-Assembly**
- **AMPS defines modules as "encapsulated units" that are accessible, replaceable, and interchangeable,**

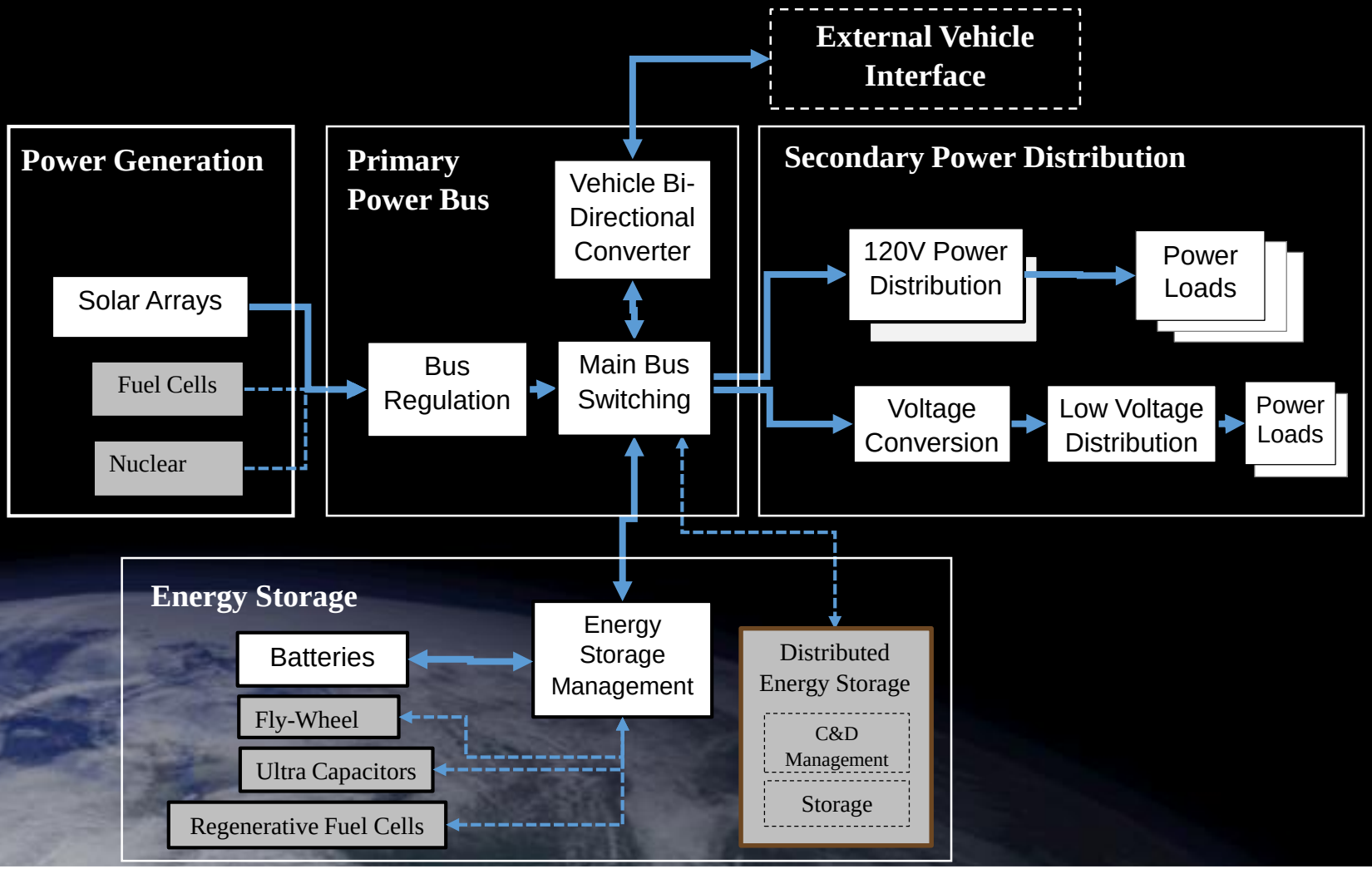
Levels of Assembly	Example
Assembly: Composed of sub assemblies and component parts [typical Avionics LRU or ISS ORU]	Battery Charge Discharge Unit Main Bus Switching Unit Power Distribution Unit
Sub Assembly: replaceable grouping of components on a substrate or support frame	Circuit Cards that may support lower level modules.
Component: lowest level of encapsulated replaceable hardware	Point of Load Converters, Switching Units, Battery Cell, (as plug in modules or mezzanine Cards)

AMPS Standardized Modular Power Interfaces

- **Establish a common framework for Data, Electrical, Mechanical interfaces.**
- **Apply the Standards to 3 segments of a Power Architecture**
  - Define interfaces between modules and internal to modules
  - Create Interface Specs for
    - Assemblies,
    - Subassemblies
    - Components



Generic Power Architecture



Standardization Frameworks

Electrical Interface section addresses modular approach that is flexible, configurable, and supportable

- Breaking an architecture into functional blocks
- Grouping functions as common modular elements
- Creating an interconnection framework of Common Backplanes
- Defining the characteristics that make up Modular Interface Specs

Command & Data Interface section addresses the Communication protocols and Software with emphasis on interoperability standards.

- Power modules will support automatic ID, Digital Configuration and Integration. (i.e. Plug-and-Play)
- Internally, modules adopt protocols suited power applications but must support the higher level Interoperability requirements.

Mechanical Interface section addresses the mechanical needs in terms of structural support, encapsulation and thermal control.

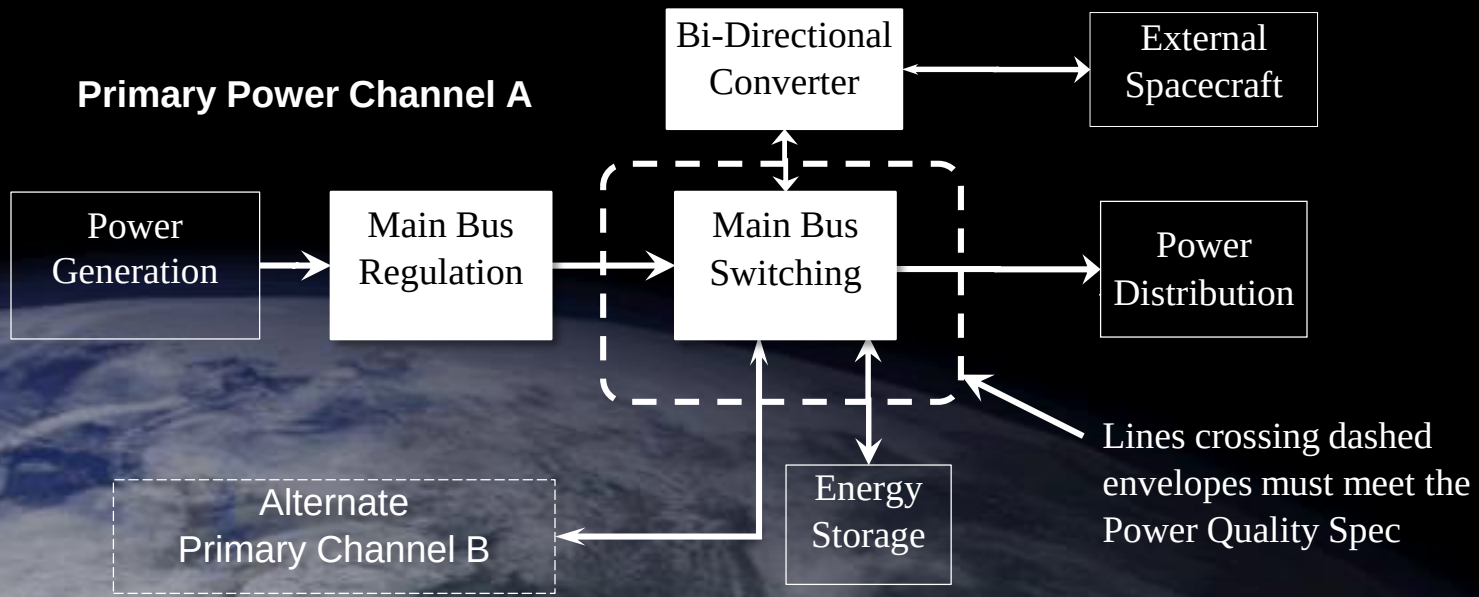
- Modules and backplanes must support static and dynamic loads while providing a means of transferring thermal loads.
- Mechanical interfaces must assure ease of access and interchangeability.

Electrical Interface Standards

Electrical Power Standard

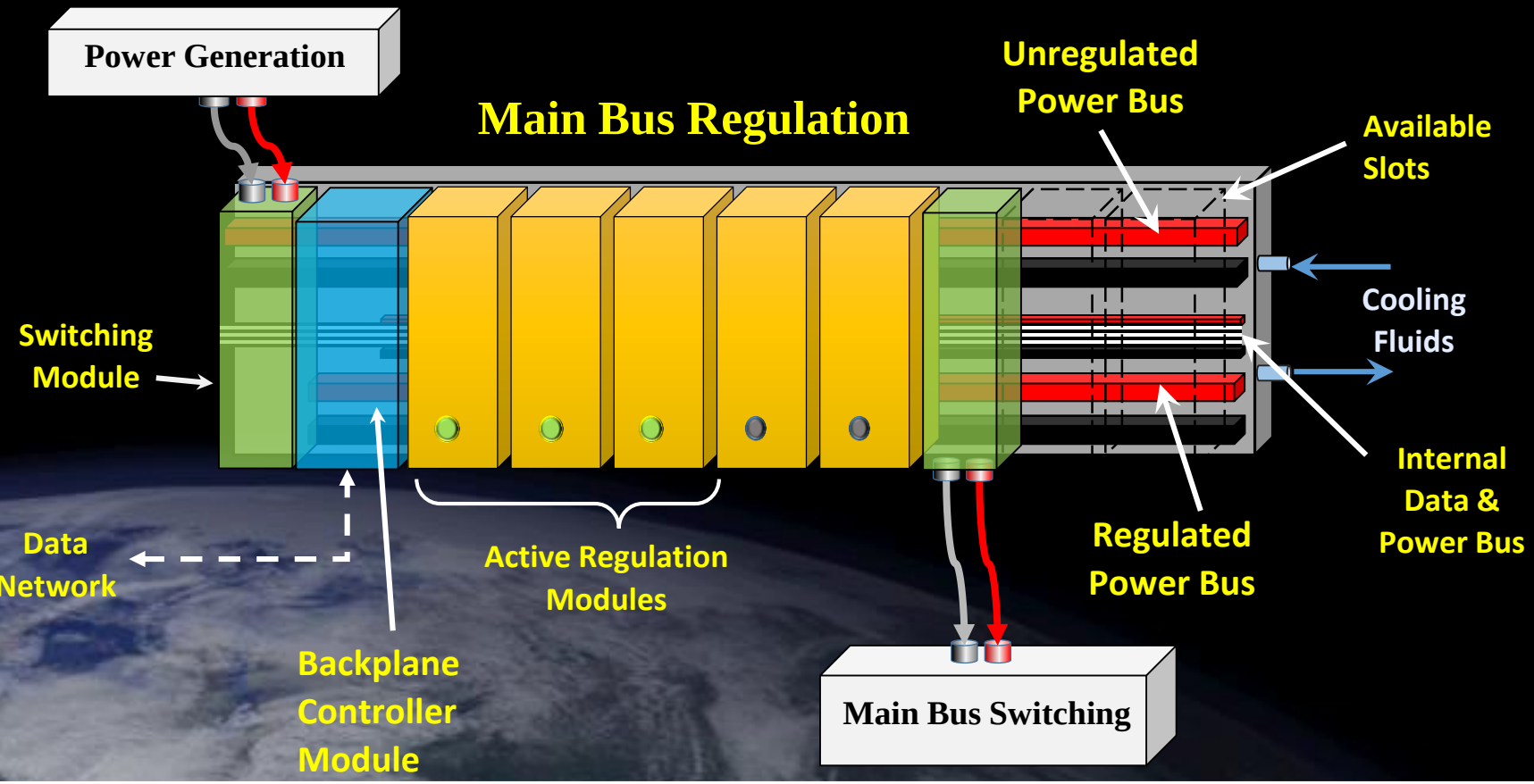
Primary Power:

- Hub between Power Generation, Energy Storage and Power Distribution.
- Main Bus Voltage Regulation, Switching, Directional Conversion
- Follows SAE AS5698 Power Quality Spec

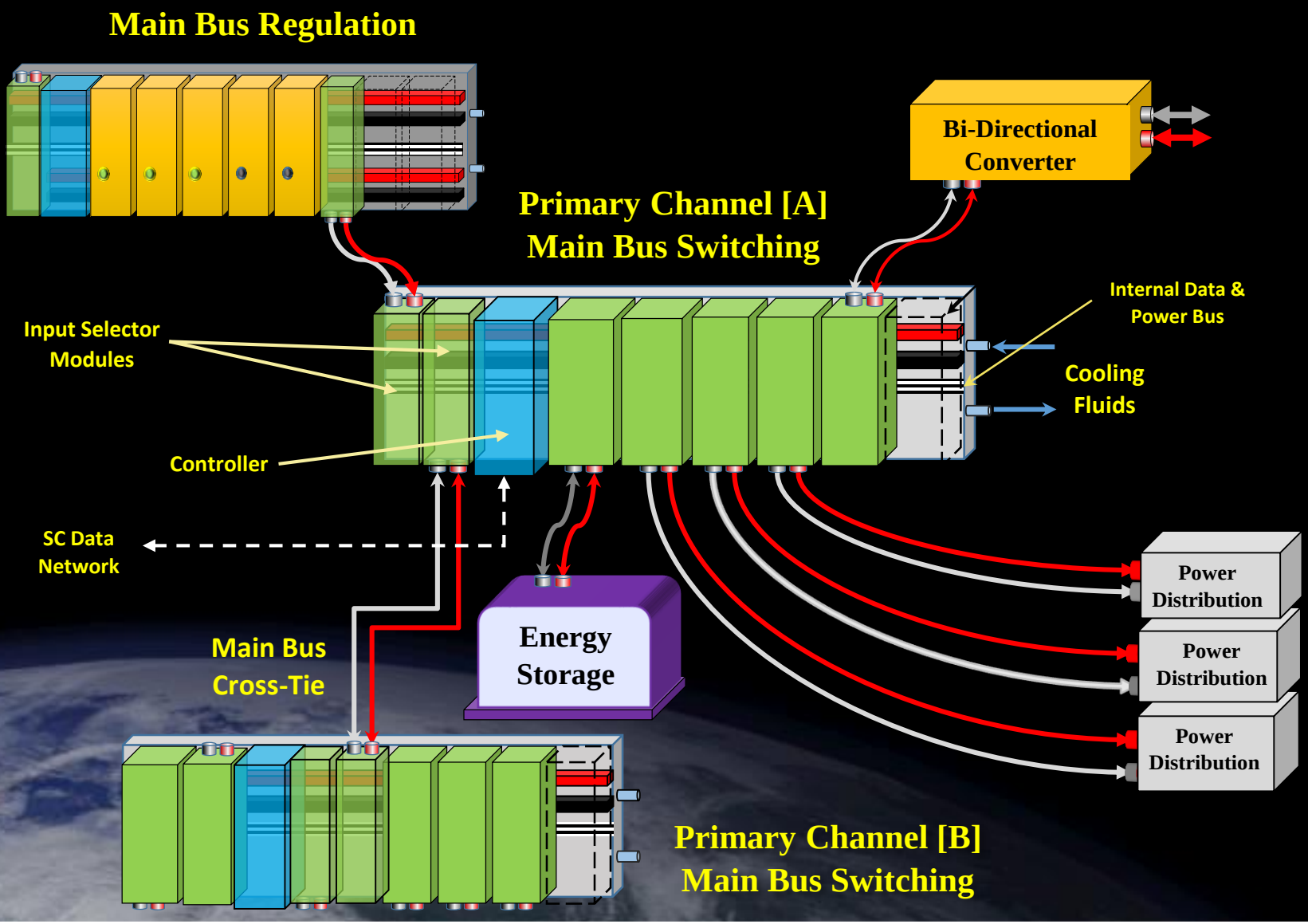


Primary Power Regulation Backplane-Module

Modules mounted on a Assembly Level Backplane.
Unregulated & Regulated Power, Data and Structural and Thermal Interfaces
Modules: Switching, Regulation, Unit Control



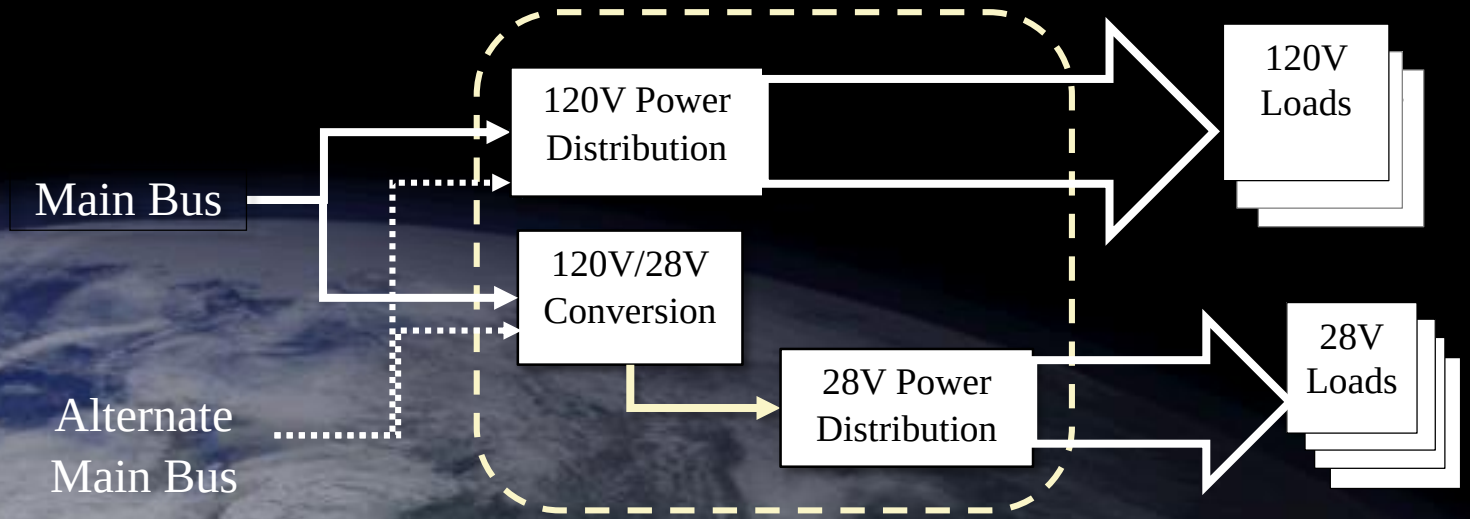
Primary Power Assembly Backplanes-Modules



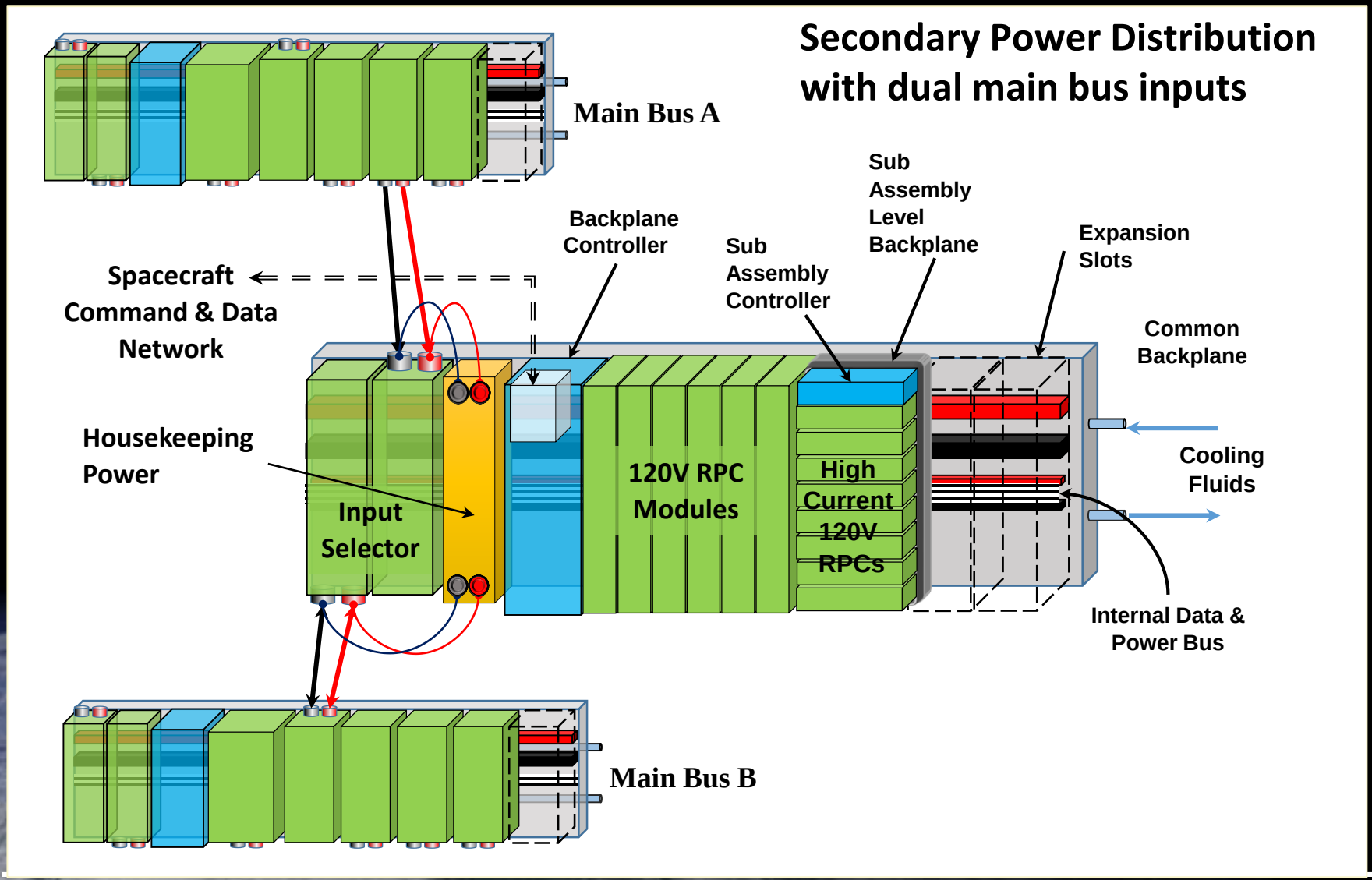
Secondary Power

Secondary Power:

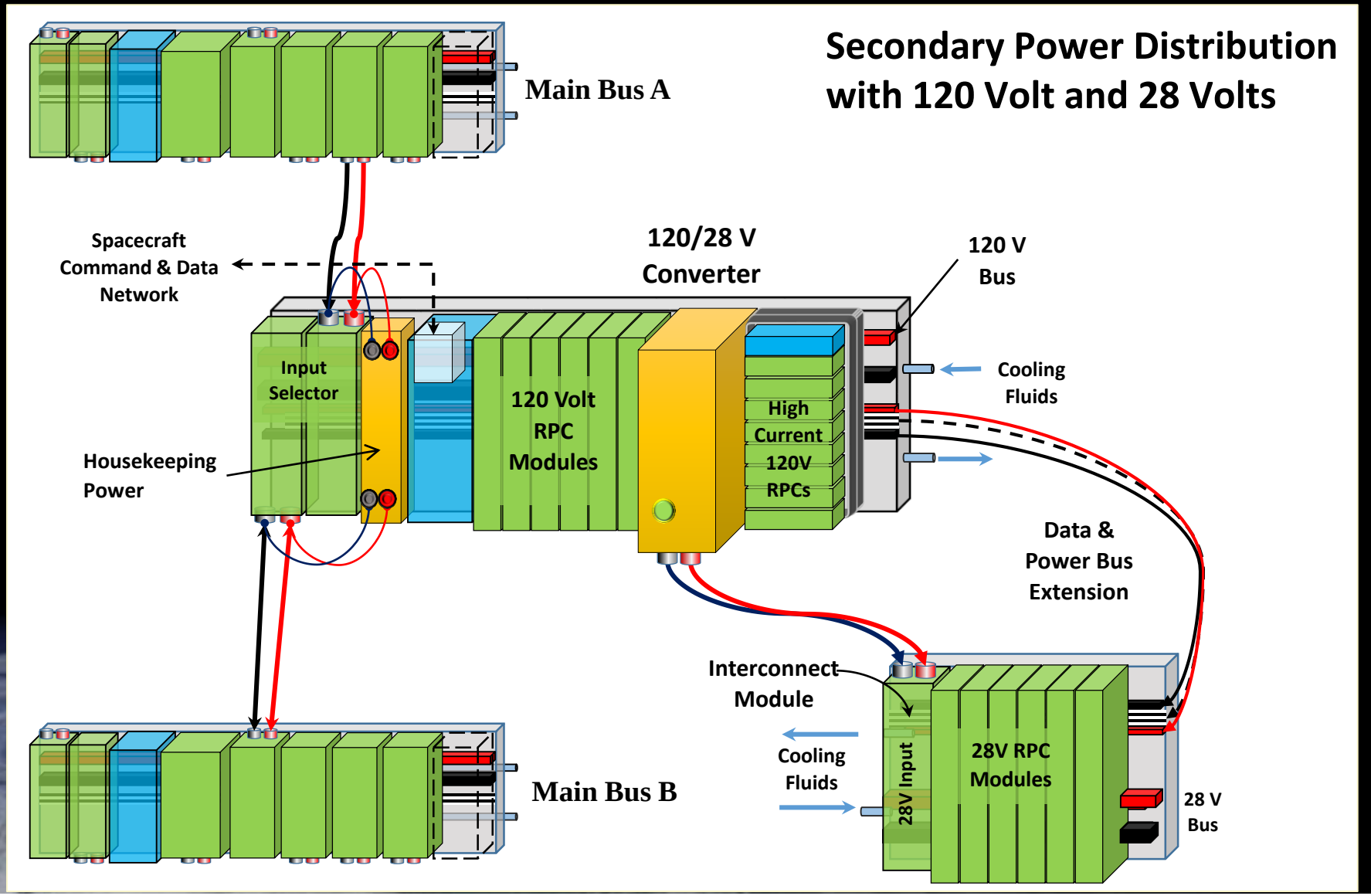
- **Power Distribution Units transfer Main Bus power to loads.**
- **May involve voltage conversion (120V to 28V) and distribution**
- **May allow switching to an Alternate Main Bus**
- **Output channels controlled by a Remote Power Controllers (RPC)**
  - Switching, Automatic Fault Interruption, Current Limiting
  - Covered by SAE AS5698



Secondary Power Assembly Backplane-Modules



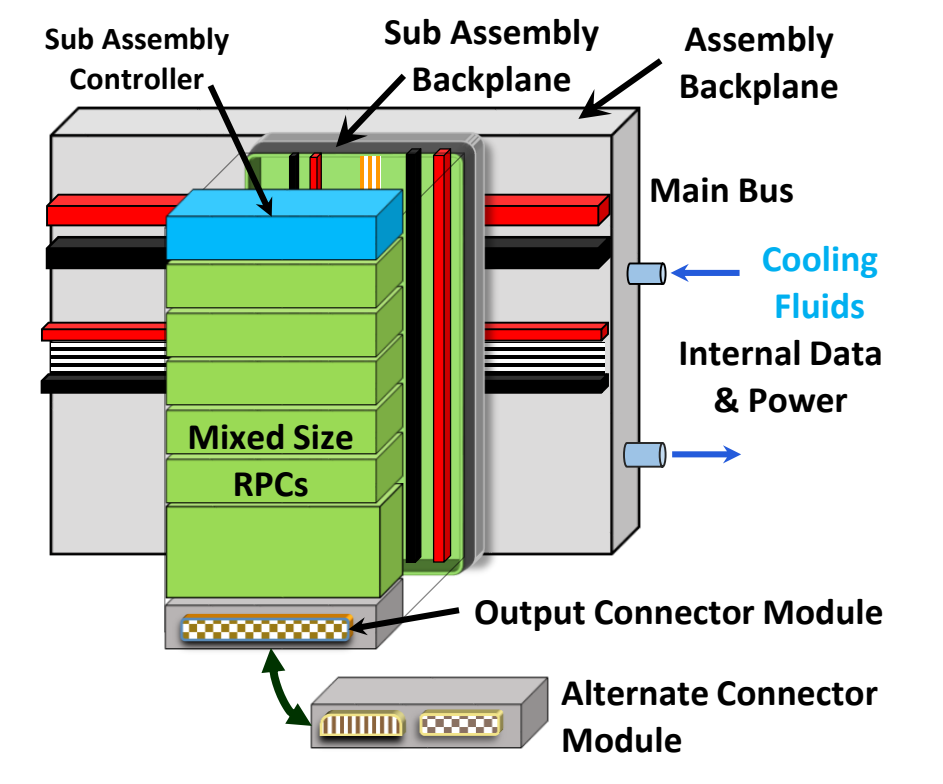
Secondary Power Assembly Backplane-Modules



Subassembly Backplane-Module

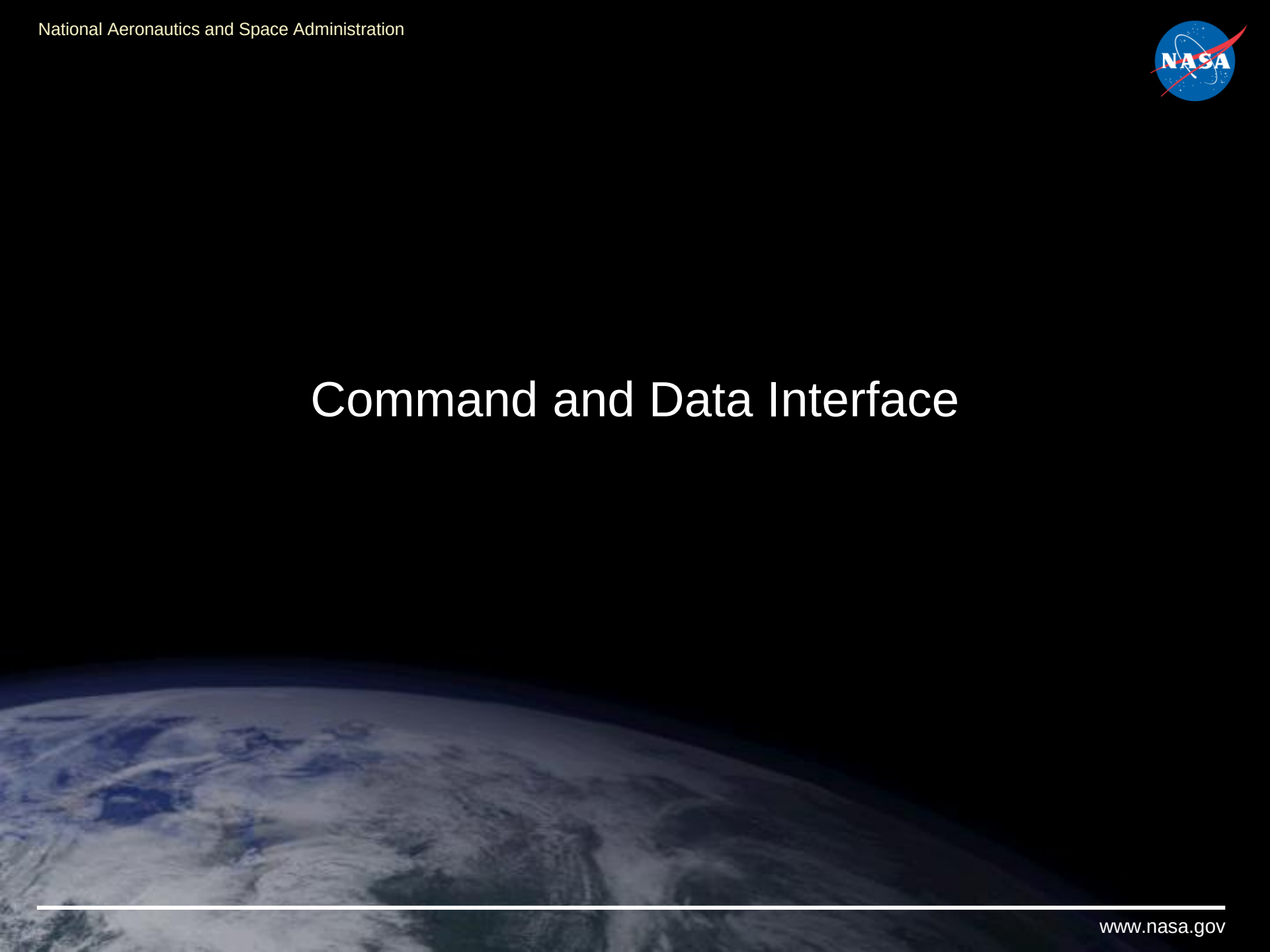
Subassembly level backplanes support component level modules.

- Provides an intermediate ***layer of accommodation***
- Common Input Power, Internal Data Bus and Housekeeping power
- Mounting and Thermal loads transfer into Assembly Level Backplane



Subassembly Inputs/Outputs

- Inputs from to Assembly Level Backplane
- Output channels conducted via Multilayer Backplane
- Connector Module gathers outputs to loads
- Connector Module is replaceable to allow alternate distribution and connector options

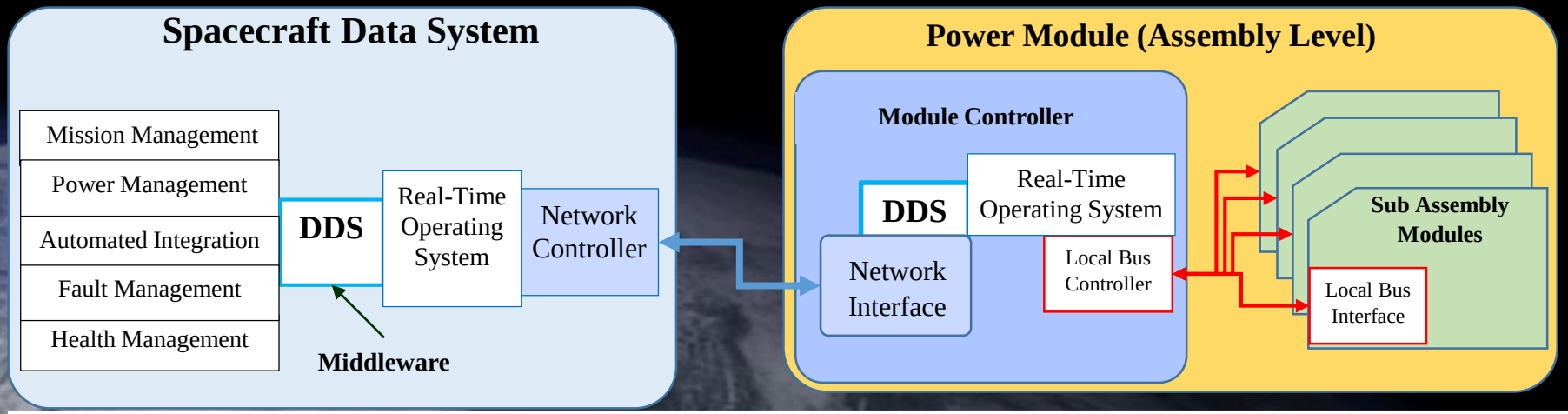


Command and Data Interface

Spacecraft Level Data System Interface

Exploration spacecraft C&DH networks are expected to employ the "DDS" (Data Distribution System**) Interoperability standard**

- DDS is for reliable real-time (low latency) data communications for safety critical distributed systems.
- Originally for DoD systems, DDS is currently used on SLS and Orion
- Employs a Publish/Subscribe scheme
- Encompasses Automated Integration (Plug and Play capabilities).
- Independent of network protocols
  - Time-Triggered Gigabit Ethernet
  - 1553B



Assembly Level Data Architecture

Internal Data Bus for control of Subassembly Level hardware.

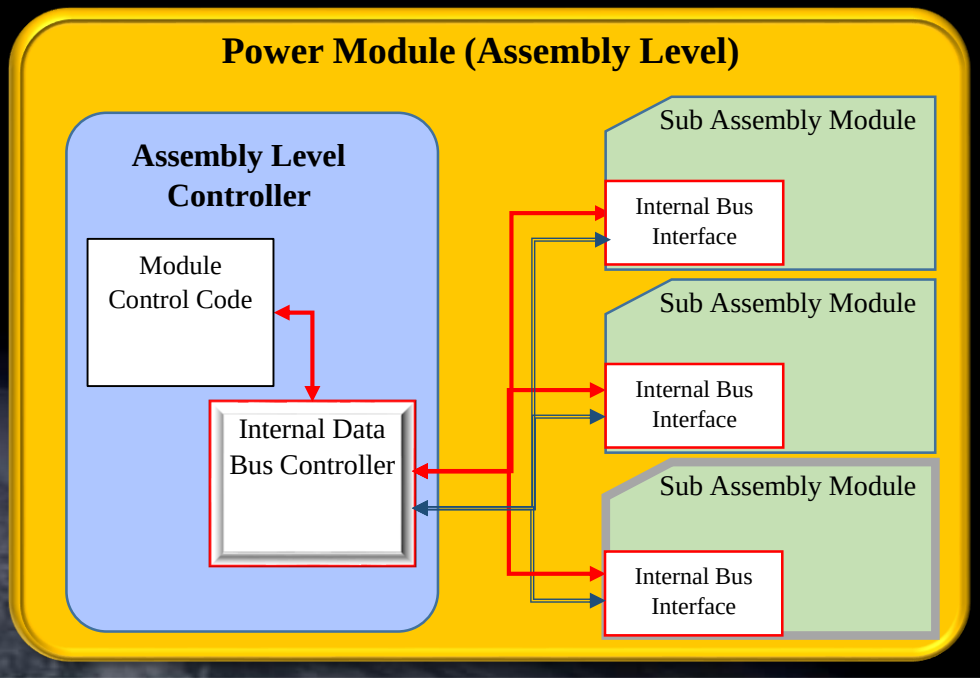
- Currently considering the CAN Bus
- Must be consistent across power system
- Must allow interchangeable spares
- Must support redundancy where needed.
- Must be Visible and Addressable by upper level communications
- Allow Multi-Master control
- Packet Error Checking
- Hardware Based Arbitration

Support Fault Management

- Provide fault detection flags
- Respond to safing actions

Support Health Management

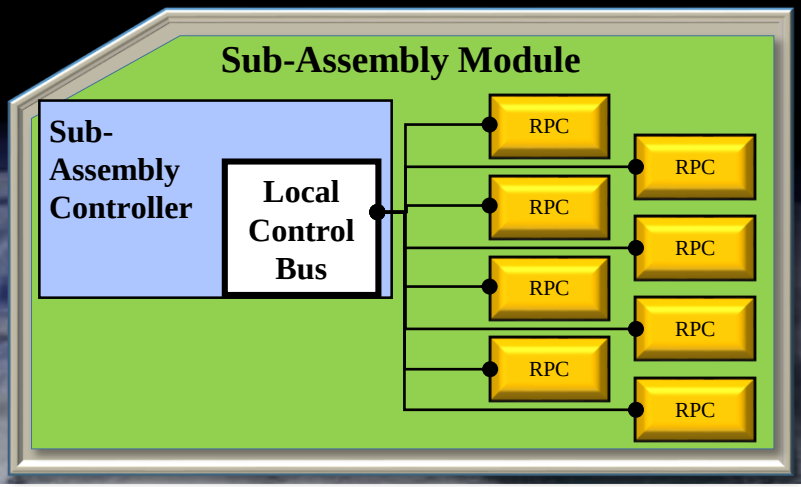
- Diagnostics features
- Prognostics features

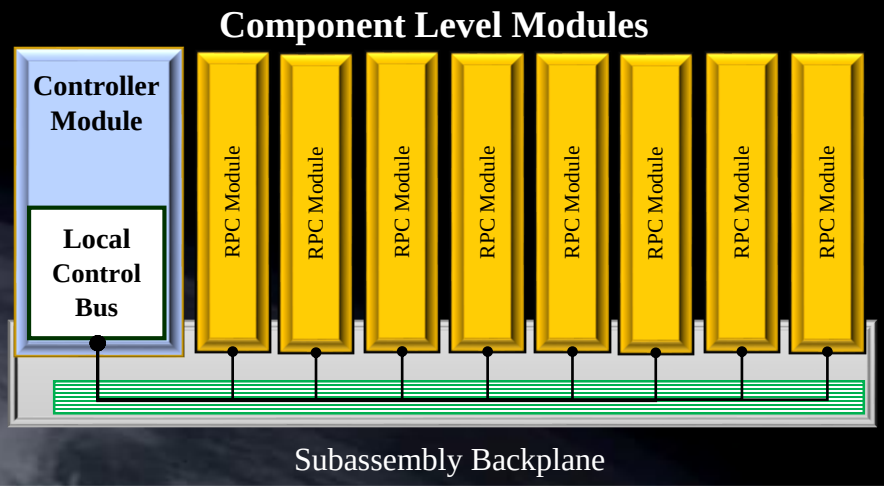


Subassembly Level Data Architecture

Local Control Bus: Subassembly to Component Comm

- Common Commands and Data set
- Components Visible and Addressable by upper level communications
- Support Fault Management detection and safing actions
- Support Health Management Diagnostics and Prognostics
- Allow Multi-Master control
- Packet Error Checking
- Hardware Based Arbitration
- Suited for single board or backplane mounted modular components





Subassembly Level Data Architecture

SMBus Standard: Based on a PC Industry Standard and derived from I^2C a device-to-device serial bus.

- Use a simple address scheme
- Multi-Master/Slave control
- Uses a hardware based bus arbitration scheme
- Packet Error Checking
- Dedicated Host Interrupt line

PMBus: SMBus with specific power management features, commands and status.

Smart Battery System (SBS): SMBus with specific a battery management features, commands and status

A number of IC manufacturers produce, SMBus, PMBus, and SBS compliant devices

Modular Specification Summary

- **Electrical Interface**
  - Applicable to Primary and Secondary Power
  - Defined Assembly & Subassembly Level Backplanes
    - Provides a common interface for Modules
    - Provides a "layers of accommodation" for more options
    - Replaceable Regulation, Switching, Controller, Input/Output Modules

- **Command and Data Interface**
  - Adopt DDS Interoperability standard
  - Supports Plug and Play features
  - Allows a power specific internal control bus

- **Mechanical Interfaces** (ongoing work)
  - Standardize Structural and Thermal interfaces
  - Define Physical Encapsulation required to create interchangeable modules.

Forward Work

- **Work with *Interagency Advanced Power Group* to establish modular standards from a multi-agency perspective**
- **Compare AMPS Data Standard with other standards**
  - AIAA Plug and Play spacecraft avionics standard.
  - Applicable Mil-Standards
- **Complete the Electrical Interface definition for distribution**
- **Develop Mechanical Interfaces Standards for the Backplane**
- **Build a backplane/module demonstrator.**

Thanks for your Attention

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