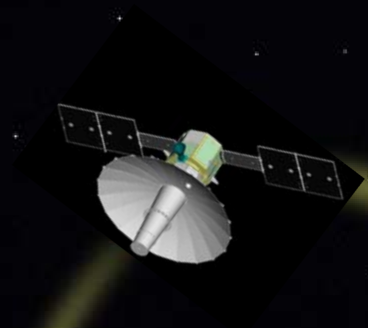

SpaceWire for Operationally Responsive Space (ORS) as Part of TacSat-4

International SpaceWire Conference 2007

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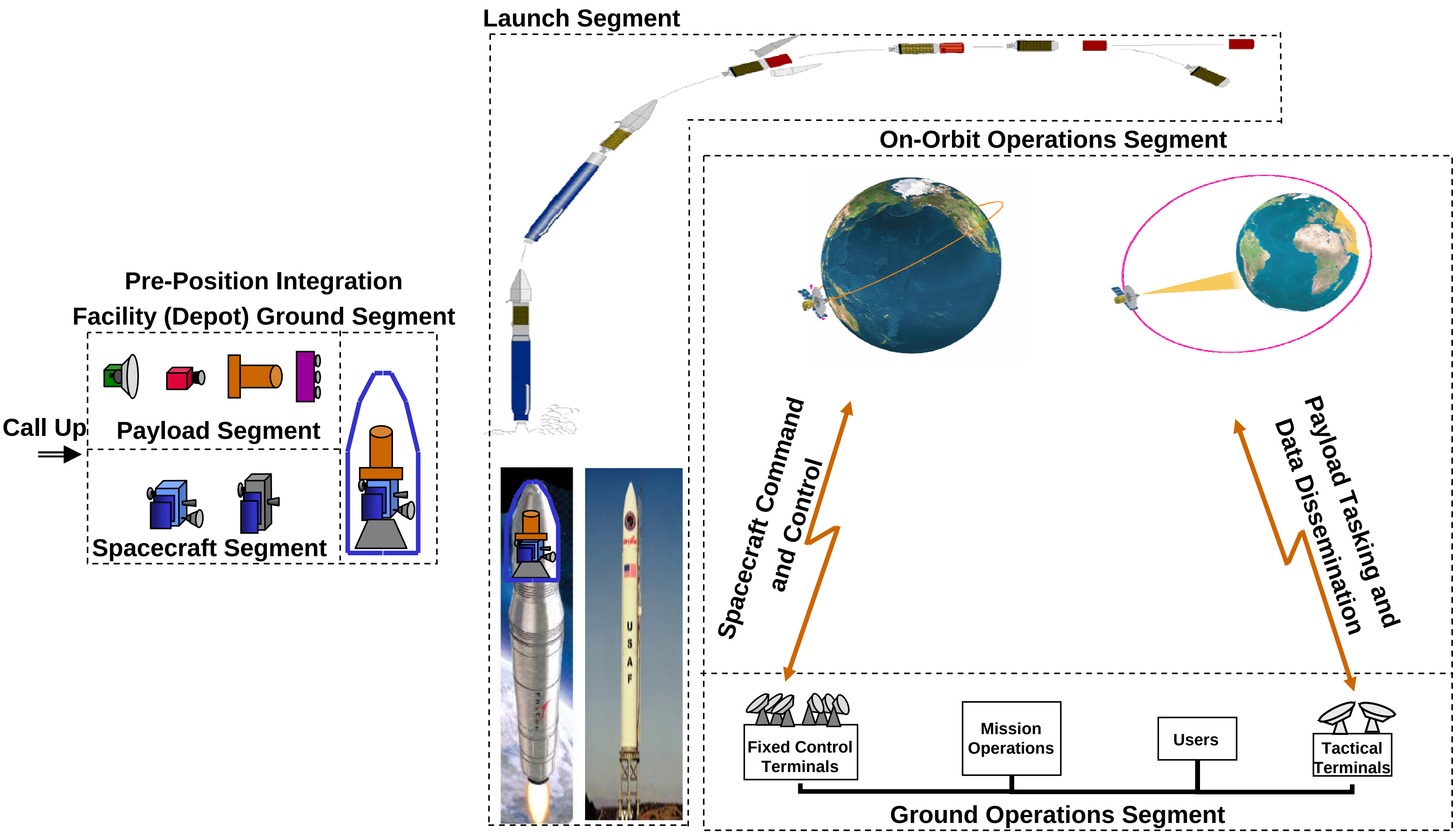
Operationally Responsive Space: Reacting in a Timely Manner to Emerging Needs with Space Assets

- The idea is to preposition launchers, spacecraft buses, and payloads for quick deployment when needed.
- This should allow for mass production and bulk buys, perhaps by coalitions of countries, to reduce costs.
- One or two common bus designs should be able to support about a dozen payload types to satisfy different missions.
- Spacecraft buses and payloads must necessarily support a standard interface to be interchangeable.
- SpaceWire is an element of that standard interface for this ORS effort.

ORS System Architecture



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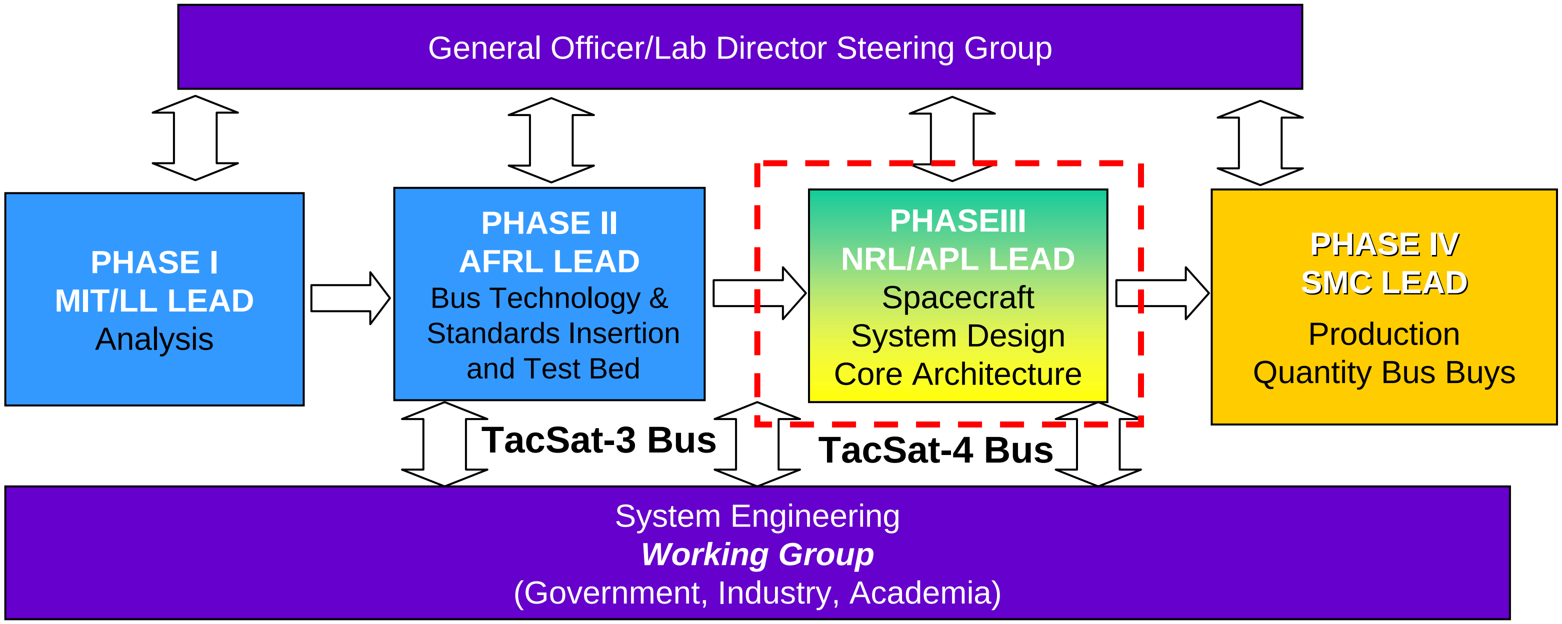
Four Phase ORS
Standardized Bus Development

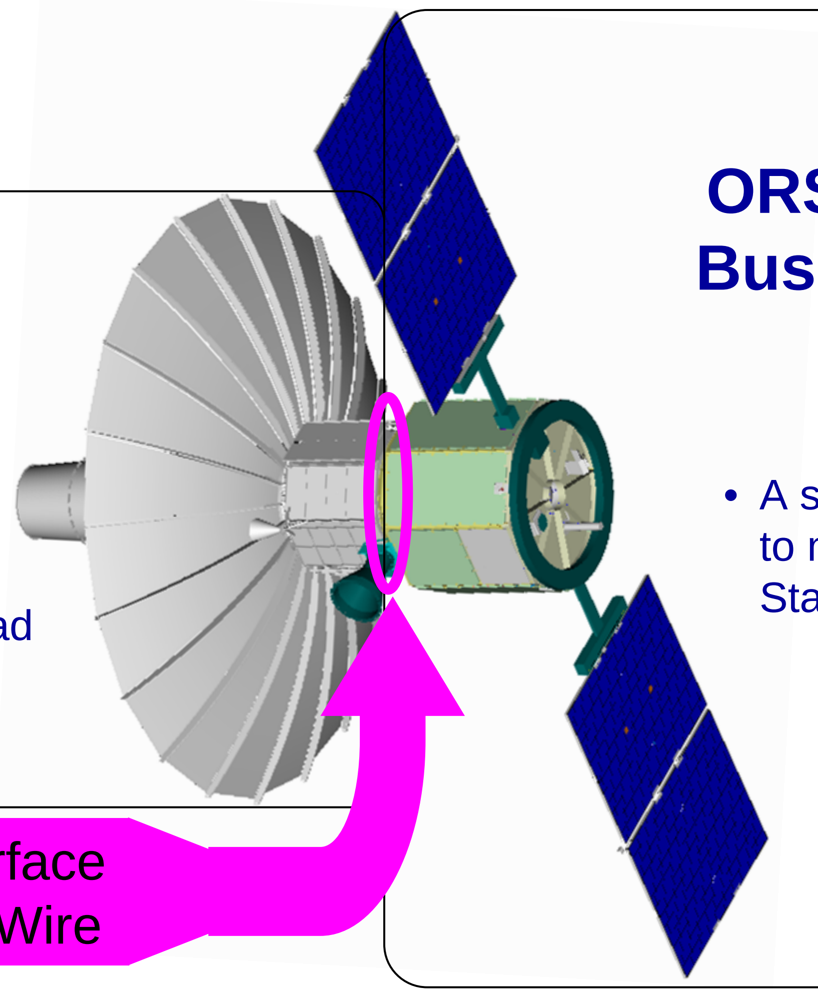
- Phase I – Analysis and Team Building Led by MIT/LL
- Phase II – Test Bed and Standard Avionics Led by AFRL
- Phase III – Gov't / Industry Prototype Standardized Bus System Development
  - – Led by Naval Research Lab (NRL) and JHU Applied Physics Lab (APL)
- Phase IV – Production Phase Led by SMC



All Phases Supported by the Nation's Collective System Engineering Expertise

Derived from a slide authored by Mike Hurley

Tacsat-4 Space Vehicle



CommX Payload

- An example of a payload designed for use with a standardized bus

ORS Phase 3 Bus Prototype

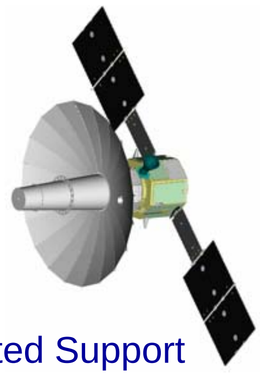
- A spacecraft bus built to meet the ORS Bus Standards

A Standardized Interface that Includes SpaceWire

TacSat-4 Mission Summary

Spacecraft and Payload Highlights

- Satellite [Space Vehicle]:
  - 452 kg (Incl. Prop, Margin, Sep Sys)
  - Payload Power: 200-700W
  - Low HEO (4 Hr) Orbit
  - 1 Year Life
- Payload Capability:
  - Data-X (>1W) and BFT
  - COTM
    - Legacy Radio and IP Netted Support
    - MUOS-Like Wideband Capability



Objectives

- Demo High Dwell ORS Capability via a HEO Orbit
  - Augment Poor/No Coverage Areas
- Evaluate and Mature Phase 3, System Level Bus Standards in Realistic Design, I&T, Launch, and Flight Operations Environment
- Provide TACSAT/ORS Comms-on-the-Move Capability (Legacy, Netted, and MUOS-Like)
- Collect BFT Devices in Underserved Areas
- Perform Buoy/Sensor Data-X on Moderate-to-High Power Transmissions

Ground Equipment

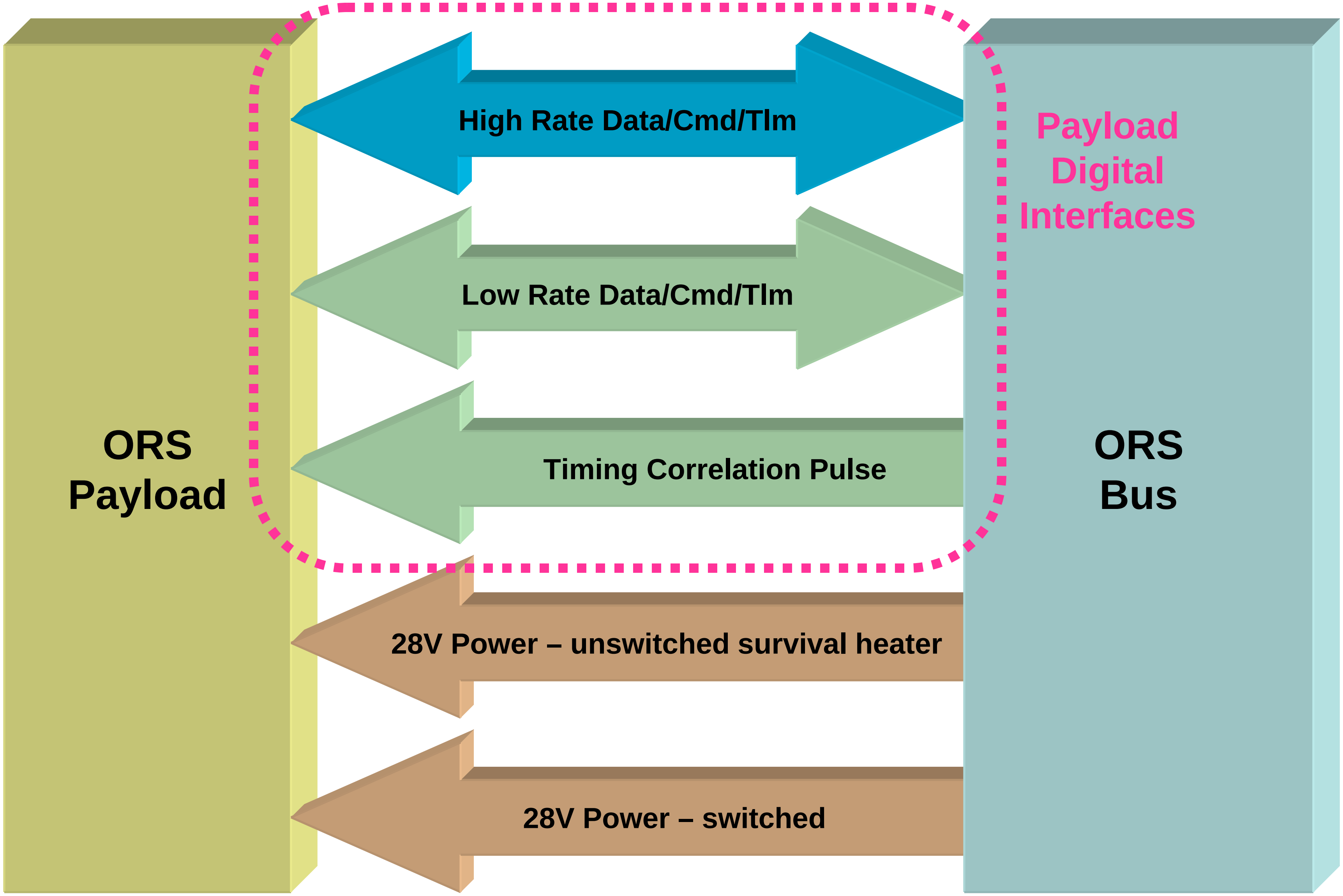
- BFT Devices: MTX, Grenadier Brat, Others
- COTM: Legacy Radios and Compatible UHF Wideband Radios
- Data-X Buoys and Gnd Sensors >1 Watts
- Ground Terminal: One Per 2000 nm Theater
- Spacecraft Cmd and Cntrl: Blossom Point, MD
  - Additional Coverage From AFSCN
  - Payload Tasking on SIPRNET VMOC

Derived from a slide authored by Ken Weldy

Programmatics

- ONR Payload, Flt Ops, Test Bed Sponsor
- OFT Bus Sponsor – "Phase 3" Bus Prototype
- AFSPC, SMC-12 Provided Launch (M-IV Star 48)
  - Launch Targeting mid 2008 From VAFB
  - Funding Being Worked
- NRL Program Manager
- STRATCOM to Assign COCOM Priorities for Use and Exercises
- Multi-Service Participation Planning Is Underway

ORS Payload / Bus Electrical Interfaces



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ORS Digital Interface Standards Development

- A primary goal of ORS Phase 3 is the development and promotion of standards for Operationally Responsive Space.

- The digital interfaces between ORS payloads and buses are a prime candidate for standardization.

- The work done in ORS Phase 2 and by the Integrated Systems Engineering Team (ISET) shaped a digital interface standard that includes high rate command and telemetry, low rate command and telemetry, and a time synchronization signal. These interfaces could be combined in the future.

Integrated System Engineering Team (ISET)

- The trades concluded in January 2006 were performed for the further development of the ORS Bus Standards and the consequent selection of interfaces for the ORS Phase 3 Bus prototype.

Implications of Network Layers

- Different interface standards specify to differing degrees how the layers should be implemented.
- Physical interface standards can be combined with higher layer standards for a more completely described set of ORS Standards.
- Selecting a hardware standard without implementing standards in the other network layers is of minimal benefit to the ORS Standards effort.
- The scope of this investigation was largely confined to the selection of suitable physical interface standards.
- Operating system support is likely to be a factor in comparing palatability of different higher level network layers.
- There are several efforts to standardize the higher layers of the network model, including many to implement Plug-and-Play and Internet Protocol on specific physical interfaces.

Interface Comparison Notes

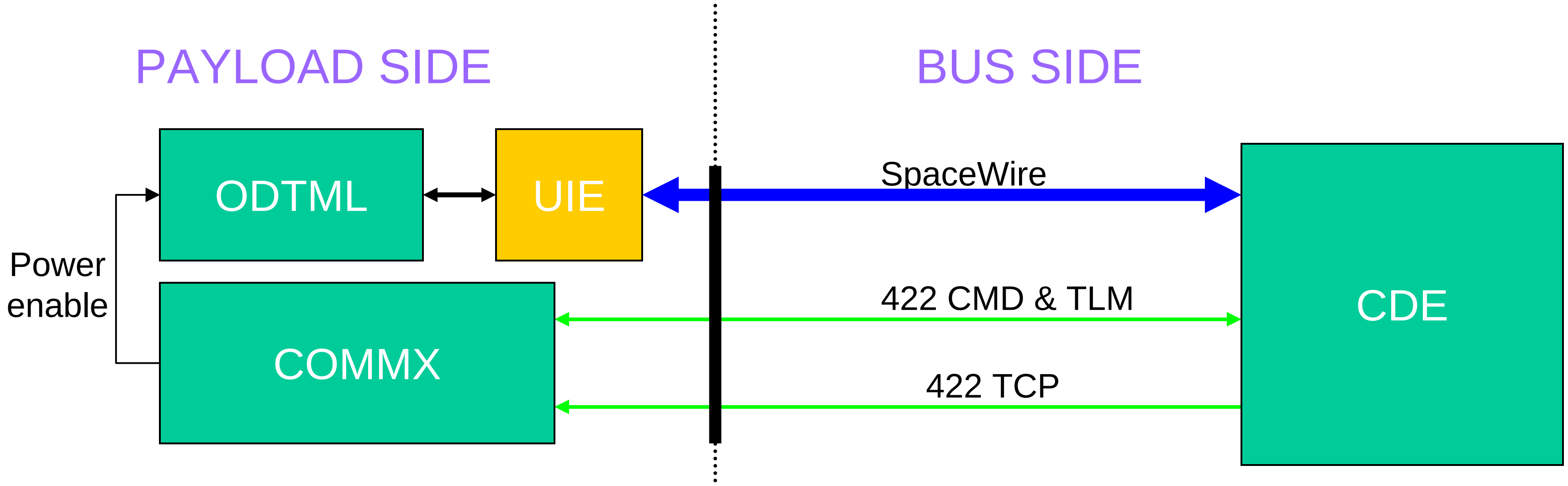
- Some ratings were partially subjective or represent approximations or extrapolations of available data
- Assessments were typically for the “best” or most common implementation of the interface
- This comparison is a meta-analysis, and is not a substitute for lab testing and comparison of the different interfaces
  - Many factors affect speed, throughput, and packet overhead. It may be difficult or impossible to determine optimal or actual performance without lab testing using different schemes and data types. Without controlling for various factors, comparisons may be misleading or invalid. Some such factors include:
    - Number of nodes
    - Protocols used
    - The nature of the data
      - Desired error tolerance
      - Latency requirements
      - Compressibility

High Rate Interface Comparison

	Firewire	SpaceWire	Ethernet
Speed (Mbps)	100, 200, 400	2 through 600	10,100,1000
Packet Overhead	Medium	Low	Medium
Standard Maturity	High	Medium	High
Radiation Tolerance (TID/SEE)	High	High	Being tested
Space Heritage	Low	Medium	Low
Rad Tolerant Flight HW Availability	Possibly soon	Yes	>6 months
Ground Equipment Availability	Yes	Yes	Yes
Flexibility / Expandability	Medium	High	High
Power @ 50Mbps loading	~3W	~1W	~2W
Mass per node	Low	Low	Low
Complexity	High	Medium	High
Estimated monetary cost	Medium?	Medium	No basis

GREEN SHADING = FAVORABLE

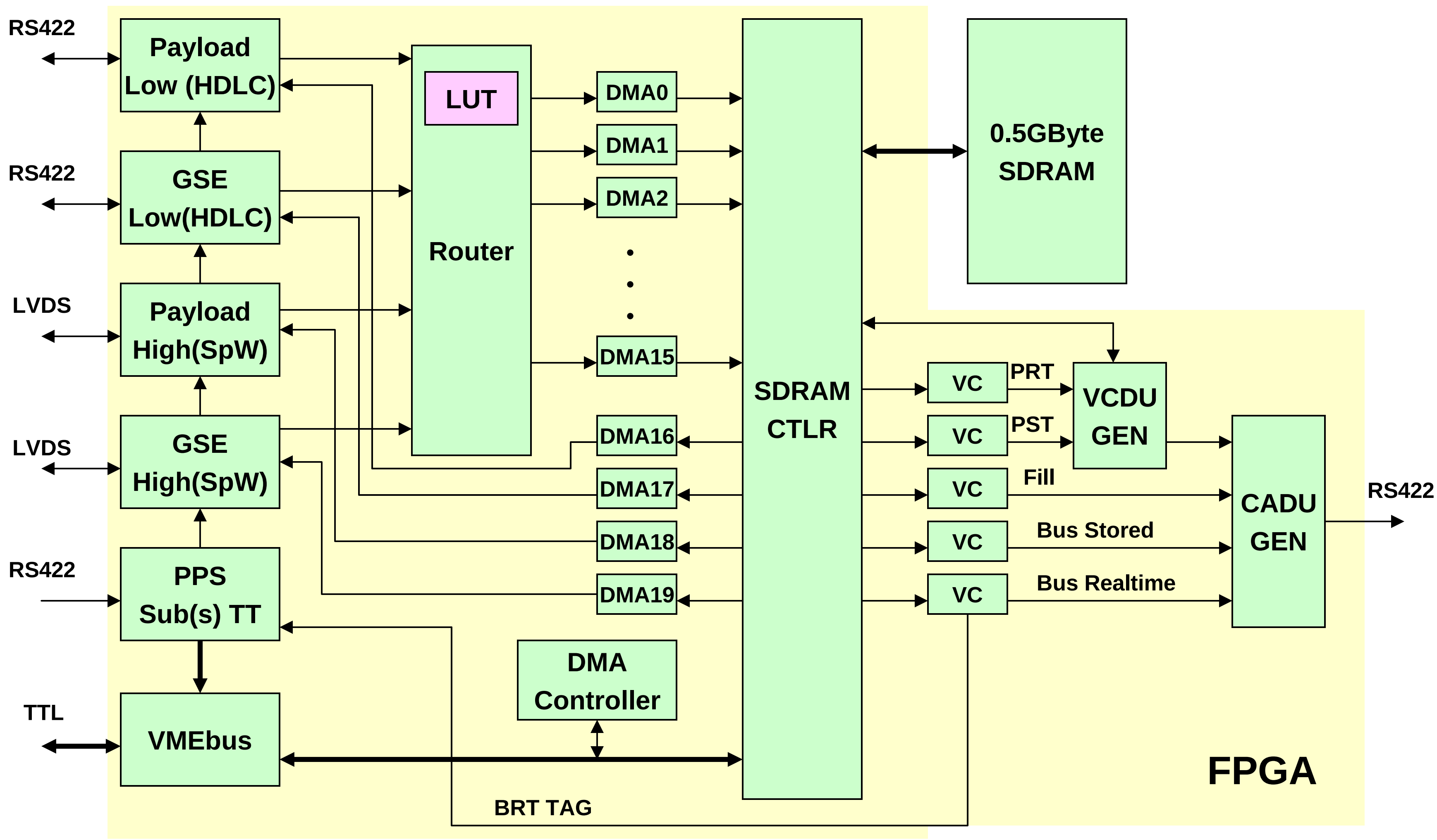
TacSat-4 SpaceWire Implementation



- The bus SpaceWire port is supplied by the Payload Data Handler (PDH), a module in the Command and Data Electronics (CDE) box. An additional ground support equipment SpaceWire port is provided as well; this could be used to support another SpaceWire device in the future. The PDH also includes RS-422 ports, a direct link for a wide band downlink, and 512 MB of data storage.

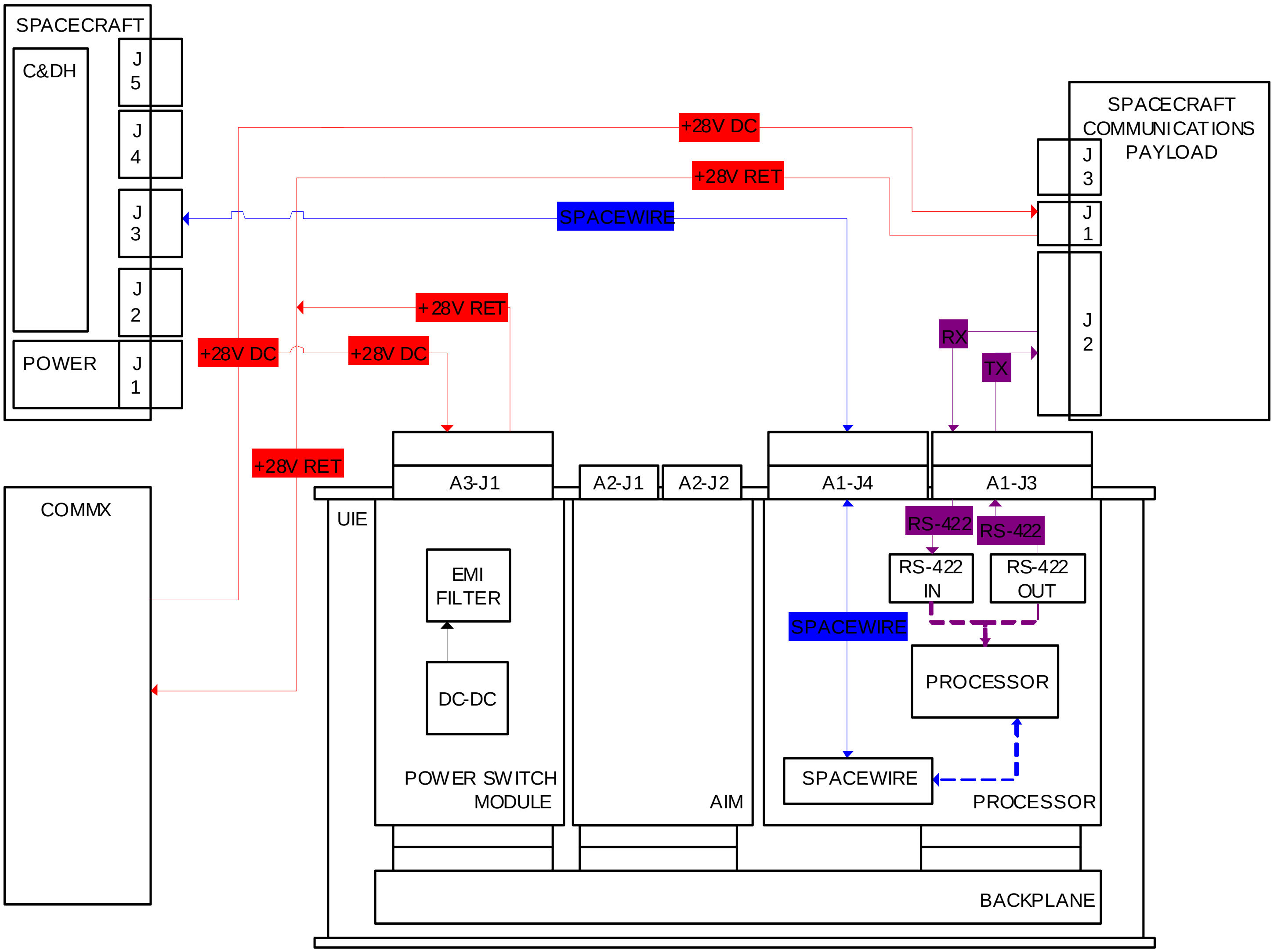
- The Universal Interface Electronics (UIE) box supplies the SpaceWire port on the payload side. The UIE provides numerous other capabilities including other SpaceWire ports, RS-422 ports, analog and digital I/O, data storage, and power switching. The UIE translates data from the Ocean Data Telemetry Microsat Link (ODTML).

Payload Data Handler (PDH) Block Diagram



http://www.silvereng.com/

UIE/TacSat 4 System Block Diagram



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