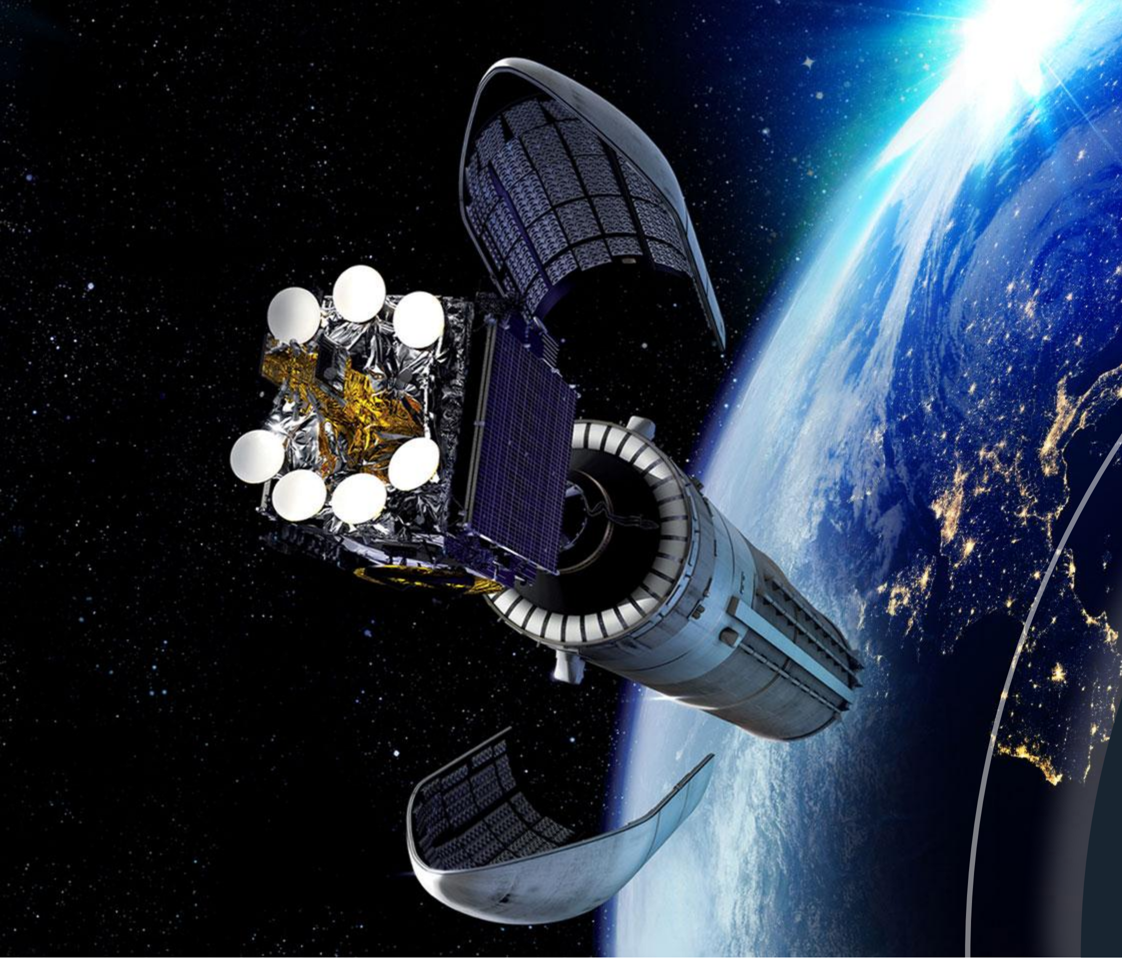

Space PowerLink ASIC Development

ADCSS 2017 18th October 2017 @ ESTEC

“Harness Reduction Session”

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ThalesAlenia Space
a Thales / Leonardo company

Content

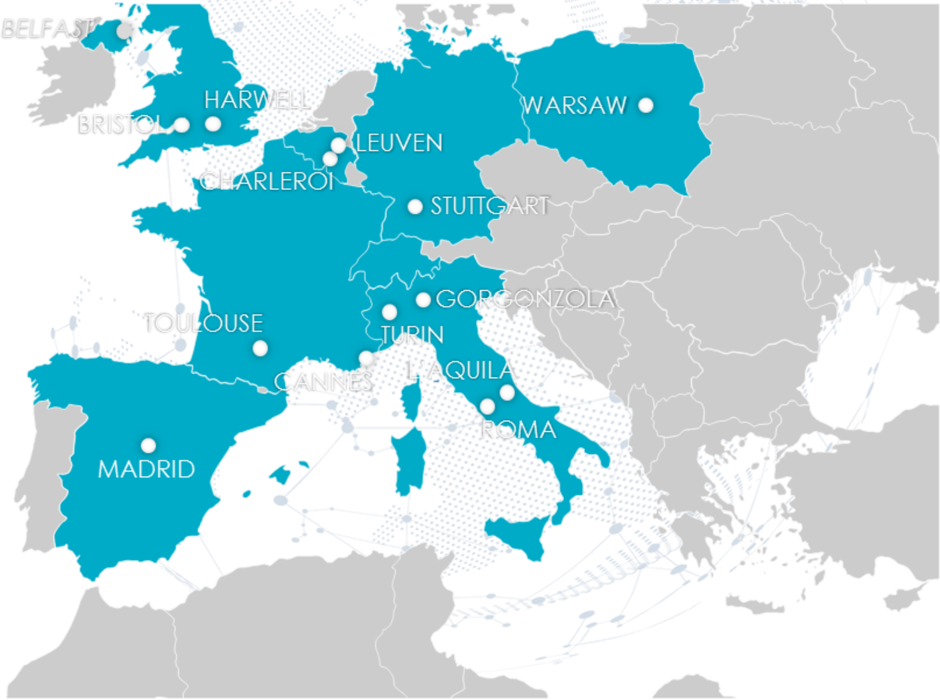
TAS European industrial footprint

GB Bristol and Harwell

- Engineering and space flight hardware
- Propulsion systems and engineering
- >116sqm clean rooms
- Access to RAL Space AIT facilities
- List X facilities in Bristol

N.I Belfast

- Backbone of the TAS industrial strategy for propulsion
- 550sqm cleanroom
- Manufacturing and test means



Thales Alenia Space in the UK

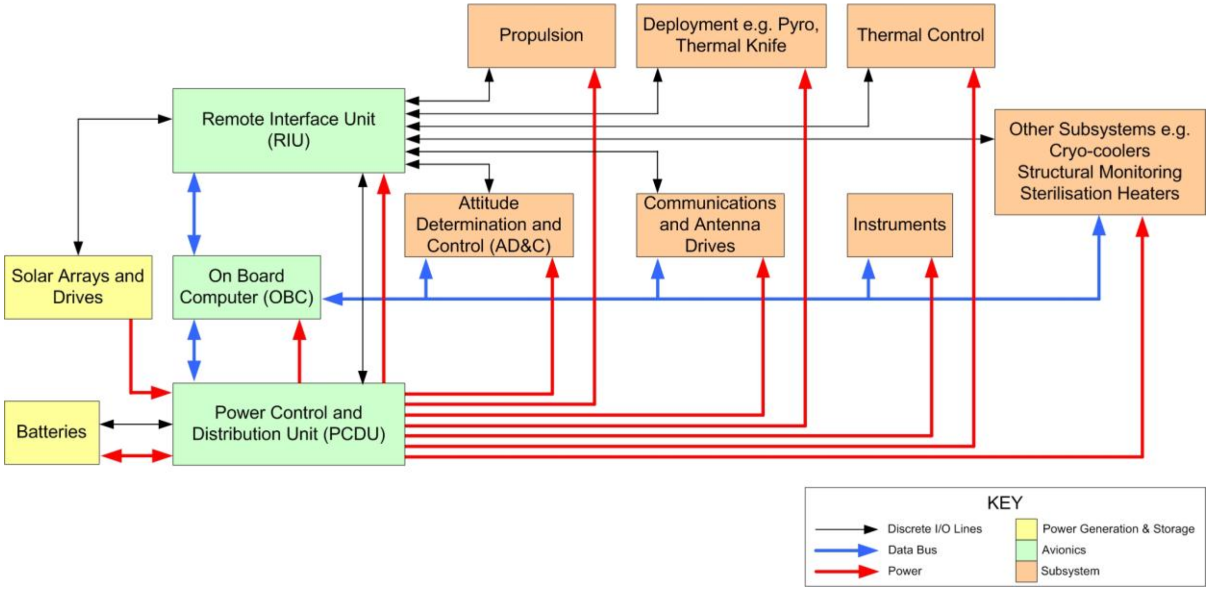
- TAS UK Legal Entity formed in **August 2013**
- Office occupied in Harwell **January 2014**
- Completion of the acquisition of SEA's space business **June 2014**
- New propulsion integration facility opened in Belfast on **October 2016**
- Current sites :
    - Bristol
    - Harwell - located in the ATLAS Centre
    - Belfast - as part of Thales Belfast
- Growth is anticipated to continue by 2019.


ExoMars Rover IMU


Spacebus NEO


EarthCare BBR

Classical Centralised Spacecraft Architecture



Propulsion

Deployment e.g. Pyro, Thermal Knife

Thermal Control

Remote Interface Unit (RIU)

Other Subsystems e.g. Cryo-coolers Structural Monitoring Sterilisation Heaters

Attitude Determination and Control (AD&C)

Communications and Antenna Drives

Instruments

Solar Arrays and Drives

On Board Computer (OBC)

Batteries

Power Control and Distribution Unit (PCDU)

KEY

→ Discrete I/O Lines

→ Data Bus

→ Power

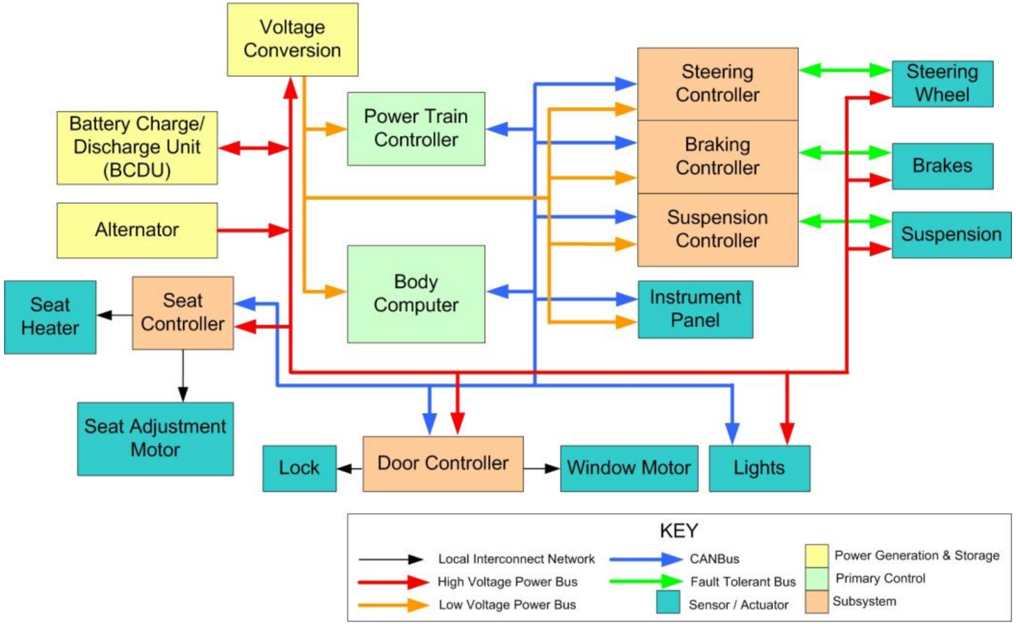
🟨 Power Generation & Storage

🟩 Avionics

🟧 Subsystem

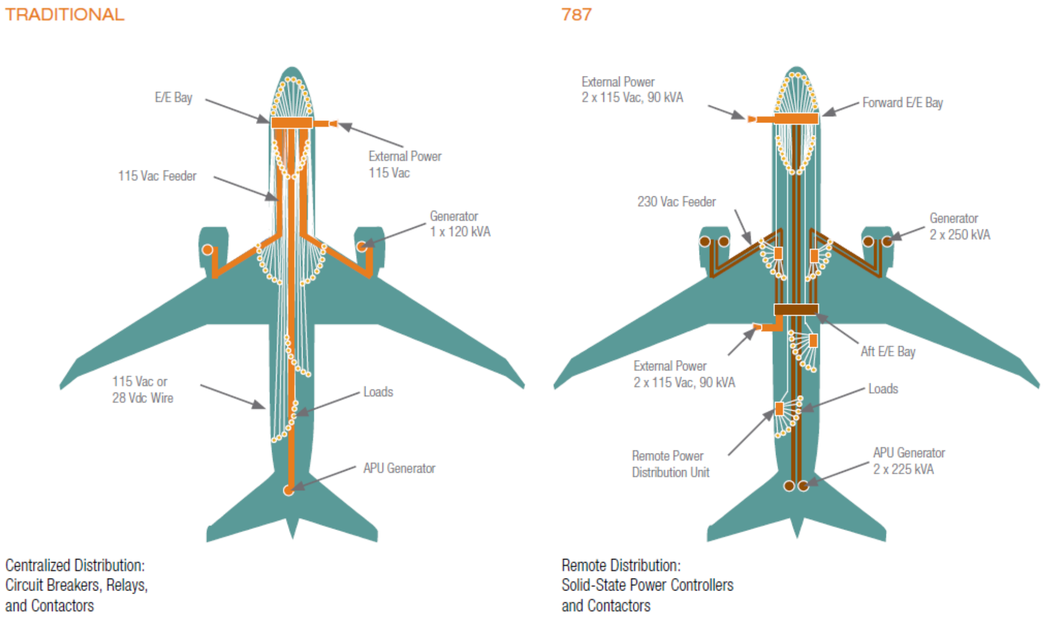
Summary of a Typical Satellite or Exploration Vehicle Electrical Architecture

Decentralised Automotive Power & Data Architecture



Summary of a Typical Drive-by-Wire Automotive Electrical Architecture

Aircraft Power Distribution Architectures



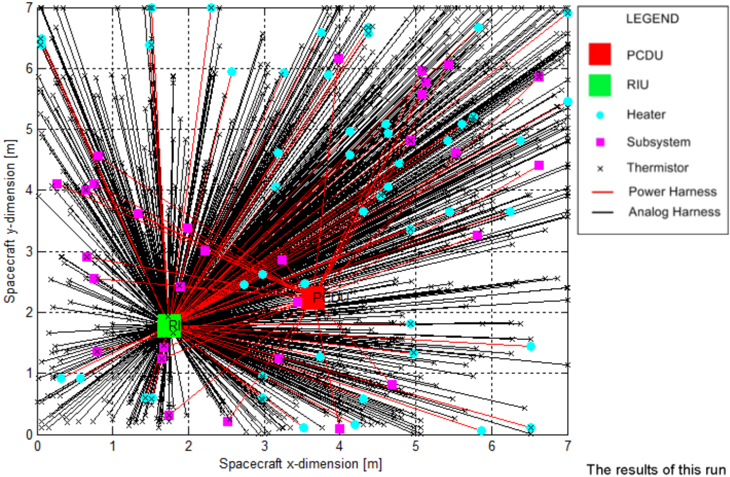
The 787’s electrical system uses a remote distribution system that saves weight and is expected to reduce maintenance costs.

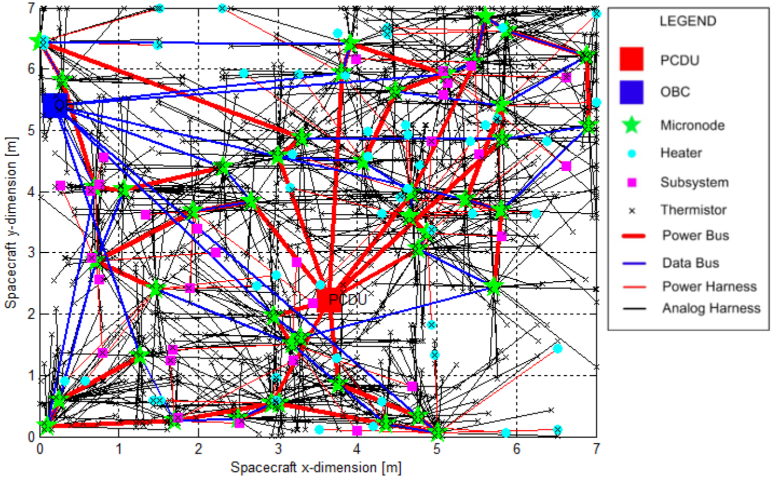
www.boeing.com/commercial/aeromagazine
aero quarterly qtr_04 | 07

Traditional Large Aircraft Verses Boeing 787 Power Distribution Architecture

Centralised vs De-centralised Architectures for Rosetta Spacecraft

A MATLAB spacecraft harness simulation model was created to do quantitative analysis on the mass and power consumption impacts of switching from a centralised to a decentralised µRTU harness architecture.
The model represents the 3-D interior of a spacecraft as an unfolded 2-D grid, with elements distributed and connected across its surface





The results of this run were:

	Centralised	Decentralised
Total Mass	78.27Kg	26.32Kg
Total Power	35.22W	34.73W

Centralised vs De-centralised Architectures for Different Size Spacecraft

	ExoMars (small)		Bepicolombo (Medium)		Rosetta (Large)	
S/C Total Mass	200Kg		1150Kg		1500Kg	
S/C Total Power	200W		500W		2000W	
	Mass	**Power**	**Mass**	**Power**	**Mass**	**Power**
Centralised (inc. redundancy)	8.75Kg	3.65W	29Kg	9.13W	163.4Kg	33.6W
Decentralised (inc. redundancy)	4.75Kg	4.28W	11.2Kg	9.88W	52.2Kg	33.3W
Change	-4Kg	+0.63W	-17.8Kg	+0.75W	-111.2Kg	-0.3W
Change (%)	-45.7%	+17.3%	-61.4%	+7.6%	-68.1%	-0.9%
	% of S/C	**% of S/C**	**% of S/C**	**% of S/C**	**% of S/C**	**% of S/C**
Centralised	4.4%	1.8%	2.5%	1.82%	10.9%	1.68%
Decentralised	2.4%	2.1%	1%	2%	3.5%	1.67%
Change	-2%	+0.3%	-1.5%	+0.18%	-7.4%	-0.01%

The table above shows that a change from traditional centralised harness architecture to a µRTU decentralised one can result in an over 7% decrease in spacecraft dry mass. In some cases the power consumption can be increased by up to 0.3%, but the additional power generating mass is unlikely to outweigh the benefits of reduced overall mass.

	ExoMars (small)		Bepicolombo (Medium)		Rosetta (Large)	
S/C Total Mass	200Kg		1150Kg		1500Kg	
S/C Total Power	200W		500W		2000W	
S/C Est. Number of Thermistors	104		192		1056	
	Mass	**Power**	**Mass**	**Power**	**Mass**	**Power**
Centralised (inc. redundancy)	4.3Kg	1.57W	15.24Kg	2.9W	101.6Kg	15.9W
Decentralised (inc. redundancy)	2.6Kg	1.4W	6.26Kg	2.23W	37Kg	12.3W
Change	-1.7Kg	+0.17W	-8.98Kg	-0.67W	-64.6Kg	-3.6W
Change (%)	-39.5%	-10.8%	-58.9%	-23.1%	-63.6%	-22.6%
	% of S/C	**% of S/C**	**% of S/C**	**% of S/C**	**% of S/C**	**% of S/C**
Centralised	2.2%	0.8%	1.3%	0.58%	6.8%	0.8%
Decentralised	1.3%	0.7%	0.5%	0.45%	2.5%	0.6%
Change	-0.9%	-0.1%	-0.8%	-0.13%	-4.3%	-0.2%

The above results show that a decentralised µRTU sensor only architecture would still result in significant mass and power reductions at both a subsystem and spacecraft level.

Summary Conclusion is that decentralising a typical Spacecraft Architecture **DOES SAVE** Spacecraft Dry Mass

Typical Harness Illustration on BepiColombo

BepiColombo Remote Interface Unit (RIU) during Space-craft Integration Testing

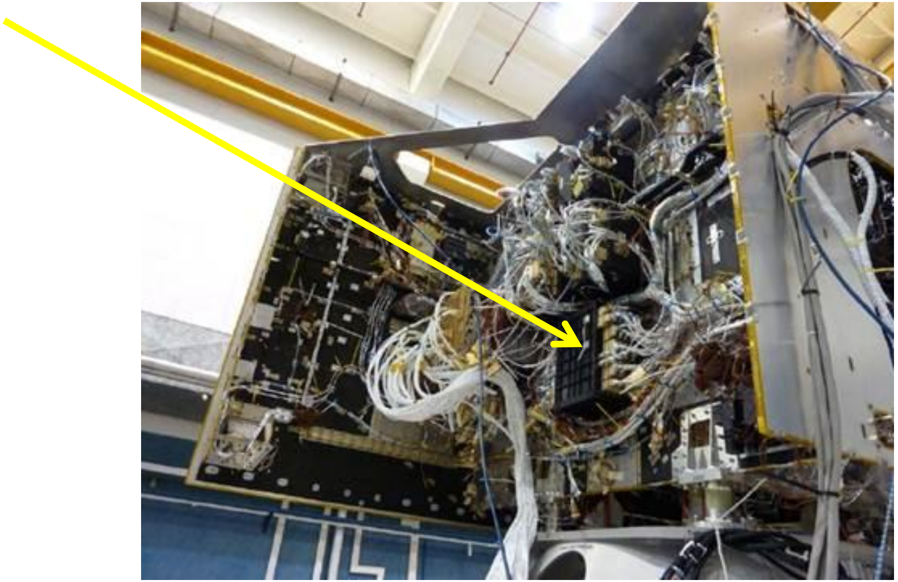


Photo: ESA

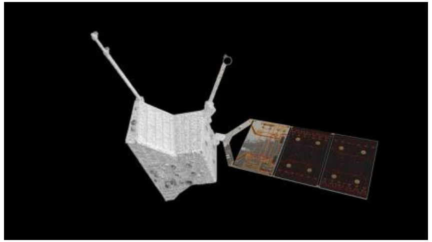
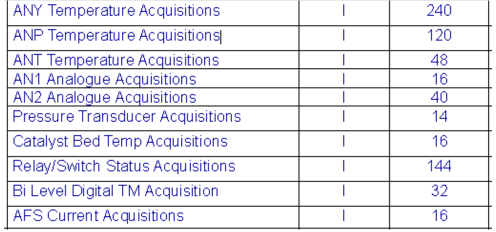


Photo: ESA

BepiColombo RIU Number of Sensor Acquisitions



ANY Temperature Acquisitions	I	240
ANP Temperature Acquisitions	I	120
ANT Temperature Acquisitions	I	48
AN1 Analogue Acquisitions	I	16
AN2 Analogue Acquisitions	I	40
Pressure Transducer Acquisitions	I	14
Catalyst Bed Temp Acquisitions	I	16
Relay/Switch Status Acquisitions	I	144
Bi Level Digital TM Acquisition	I	32
AFS Current Acquisitions	I	16

Space-PowerLink ASIC

An on-going ESA ITT led by Thales Alenia Space in the UK as part of the ESA TRP funding is developing a Space PowerLink ASIC (SPA) which will help to enable a distributed sensor/actuator architecture approach for Spacecraft.

“Space PowerLink” – A single two wire cable transports both a dc voltage and a 1Mbps data exchange to multiple distributed “Terminals” for sensor acquisition and node actuation.

Current Spacecraft Architectures include segregated data communication for monitoring discrete lines and power lines. This leads to a bulky and heavy harness (e.g. up to 15% of the dry mass).

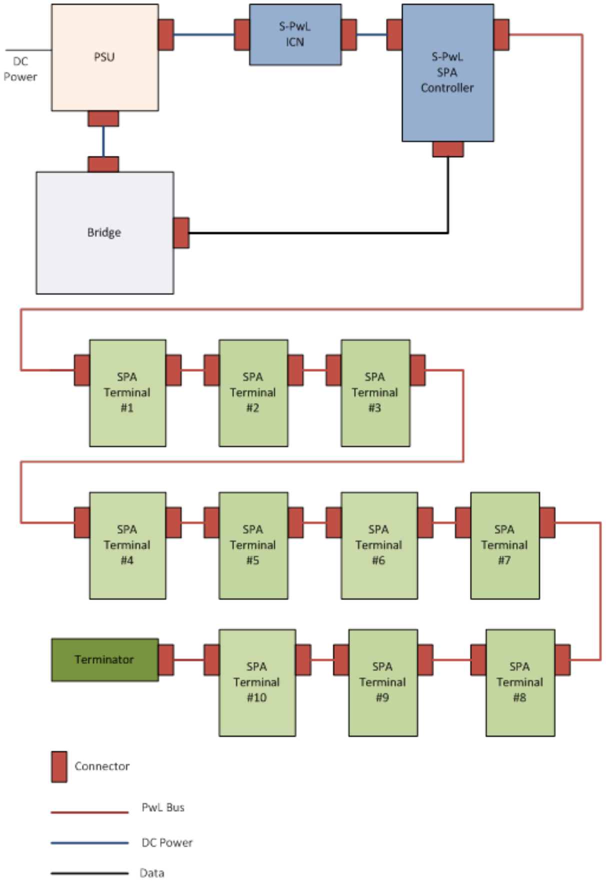
S-PwL can help reduce this harness mass/complexity by implementing a lower mass, low power distributed control and monitoring using only a 2 wire bus (26 AWG twisted pair ~10m) and multidrop “S-PwL Terminals”.

Space PowerLink System Overview

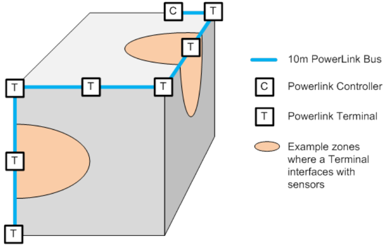
One S-PwL Branch consists of;

- One Impedance Control Network (ICN)
- One S-PwL Controller
- Up to 10 off S-PwL Terminals
- 1 off end of line Terminator

One Bridge can communicate with numerous S-PwL Branches and One PSU can power numerous S-PwL Branches.



The maximum bus length is determined by the Spacecraft dimensions
If we consider a Spacecraft to be represented by a 3m cube, then a bus length of ~10m is sufficient this permits the bus to be routed from one extreme to the other



Spacecraft as a 3m cube

Space PowerLink System Fault Handling

The S-PwL system will be robust against faults and SEE/SEU and the S-PwL Breadboard Demonstrator was successfully tested at the EMC facility at ESTEC.

Fault handling is hierarchical:

- Onboard computer detects and recovers failures of the S-PwL Bridge and Power Supply
- S-PwL Bridge manages faults at PwL branch level
- CRC used to detect communication bit upsets on S-PwL links and to reject the corrupted packet
- Controller retries to overcome transient faults and bit errors
- Controller can reset Terminal by command
- Local watchdog resets upset Terminal
- S-PwL Bus Fault protection as part of Terminal design (Over-current/ Over-Voltage & Data short)

Redundancy:

- Each PwL Branch is non-redundant however redundancy can be provided by duplication of the Branches, the Power Supply and the Bridge

S-PwL System Command and Telemetry Exchange

- Command and Telemetry messages are exchanged on the PwL Bus between the Controller and the Terminal(s).
- Typically commands are short, telemetry from the sensors are the bulk of the data transferred
- A simple Master – Slave protocol is utilised with a:
  - Command packet
  - Response packet
- Error detection via a CRC is undertaken on both the Controller and Terminals which is considered mandatory to avoid false interpretation of data or commands

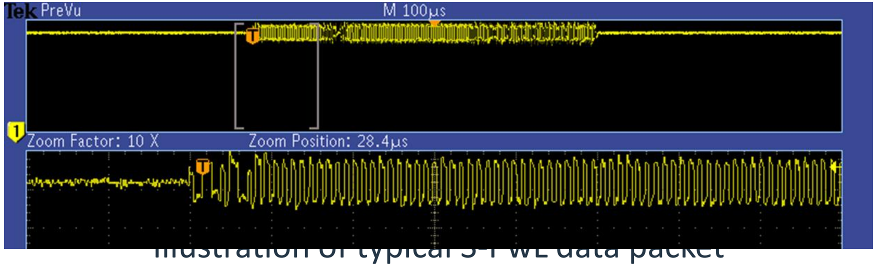
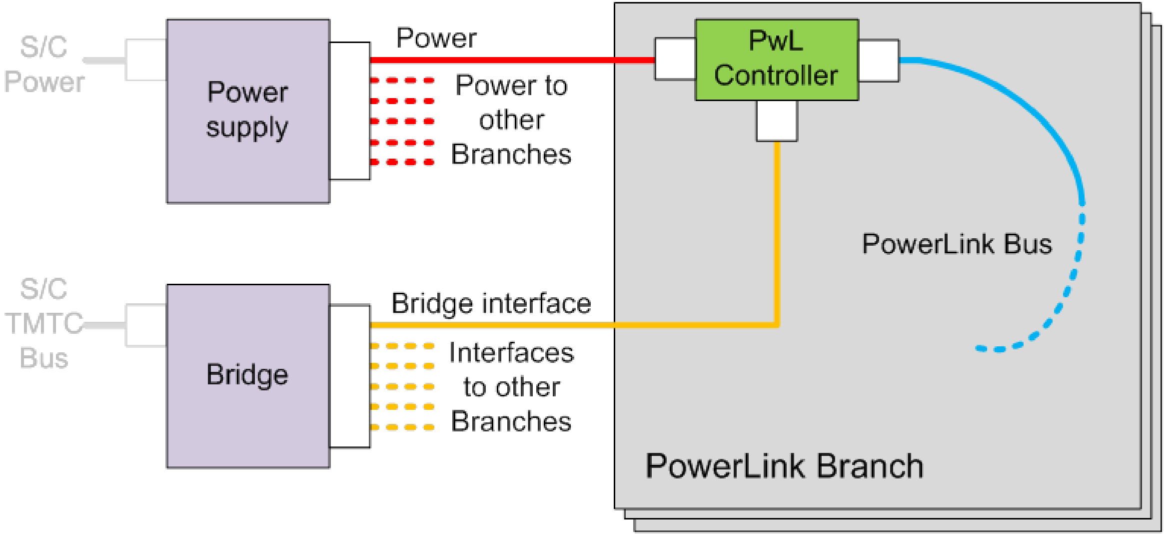


Illustration of typical S-PwL data packet

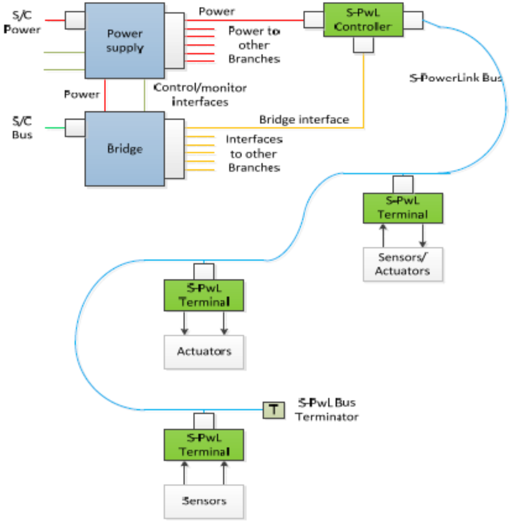
Space PowerLink System Scalability

- A Power Supply and Bridge can interface with multiple Controllers, so additional branches can be added
- Additional Terminals can be introduced into an existing PwL bus branch with no effect to the existing Terminals so long as the maximum number of nodes is not exceeded.



S-PowerLink System and ‘SPA’ ASIC Functionality

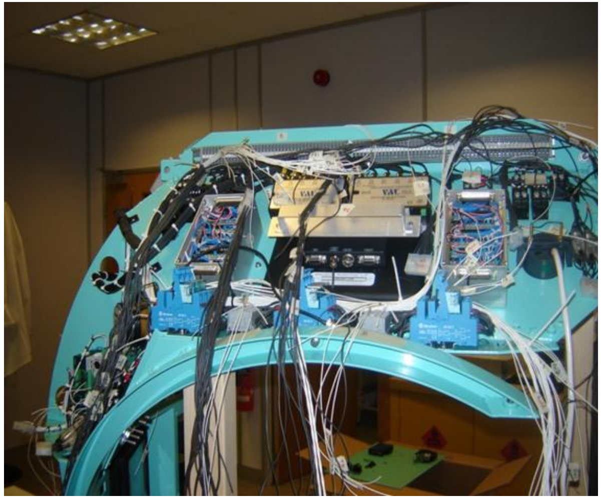
- Space PowerLink (S-PwL) Standard will be compiled during the current contract by Thales Alenia Space in the UK.
- S-PwL Interface Bus Voltage up to 12V dc (min op 6V5 @ end of line)
- S-PwL @Terminal maximum current draw of 200mA based on a 10 Terminal Branch
- S-PwL Interface Core IP Data Package (for ASIC developments) to be distributed to Space Community under ESA specific License Agreement.
- S-PwL Interface Core IP to include the Data Interface to the S-PwL Bus, including Over-Voltage & Over-Current self-protection and data transceiver
- Space PwL ASIC (SPA) device will be Controller or Terminal configuration selectable
- SPA Functionality;
    - ➢ S-PwL Data Bus rate ~1MB/s
    - ➢ POR function
    - ➢ S-PwL Interface data bus transceiver
    - ➢ DC-DC regulation for the Core and I/O voltages
    - ➢ Digital controller block function
    - ➢ Small Internal RAM for Terminals
    - ➢ Timing/PWM block and I/O functions
    - ➢ GPIO and Analog Multiplexing functions
    - ➢ Internal 12bit ADC
    - ➢ Digital control and buffering for External SRAM/ ADC/ DAC
    - ➢ Internal OSC



Potential to Simplify AIT Sensor Acquisition using S-PwL

A S-PwL system could prove useful in simplifying the harness necessary for Spacecraft AIT sensor acquisition during Thermal Vacuum and Vibration Testing.

Also due to the ease of Terminal and branch scalability, increasing or decreasing the number of acquisition/actuator nodes for different projects could save costs.



Space PowerLink Summary

The S-PwL system employs a bus that carries both power and bi-direction data over just 2 wires. This bus is designed to support a high number of sensors such as thermistors and Smart devices in a mass efficient way.
These sensors would otherwise require individual point to point wiring to a central unit such as a Remote Interface Unit (RIU) with a resultant high wiring hardness mass. S-PwL also supports low powered actuators

A key advantage of the S-PwL system is that additional sensors and actuators can be added to the bus simply by adding further terminals with a minimal impact on the higher level controlling units.

The development of the Space PowerLink ASIC (SPA) will allow a Spacecraft user to introduce a low power, low mass decentralised Sensor Data Acquisition architecture.

Thank you!

Any Questions Please …