National Aeronautics and Space Administration

Improving Mass and Efficiency in Space Power Systems for Enhanced Science Return

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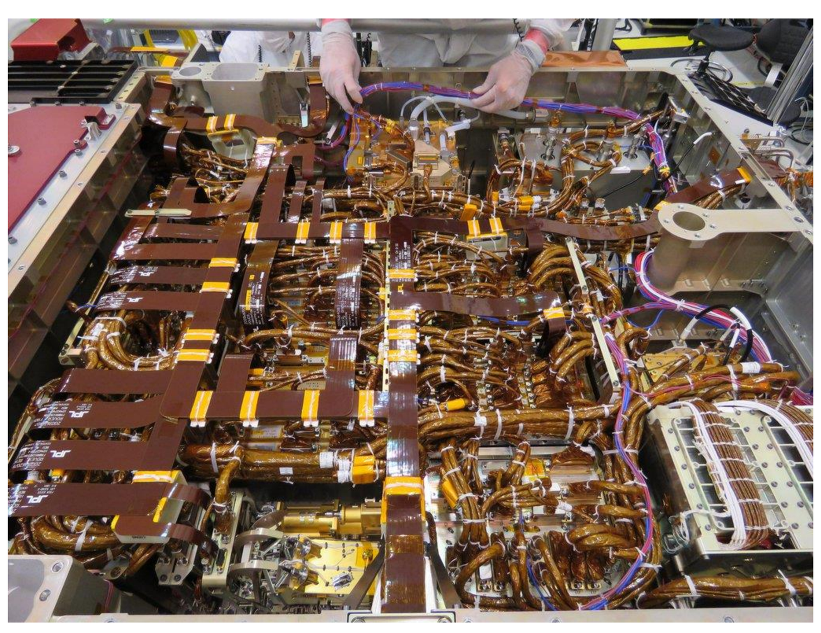
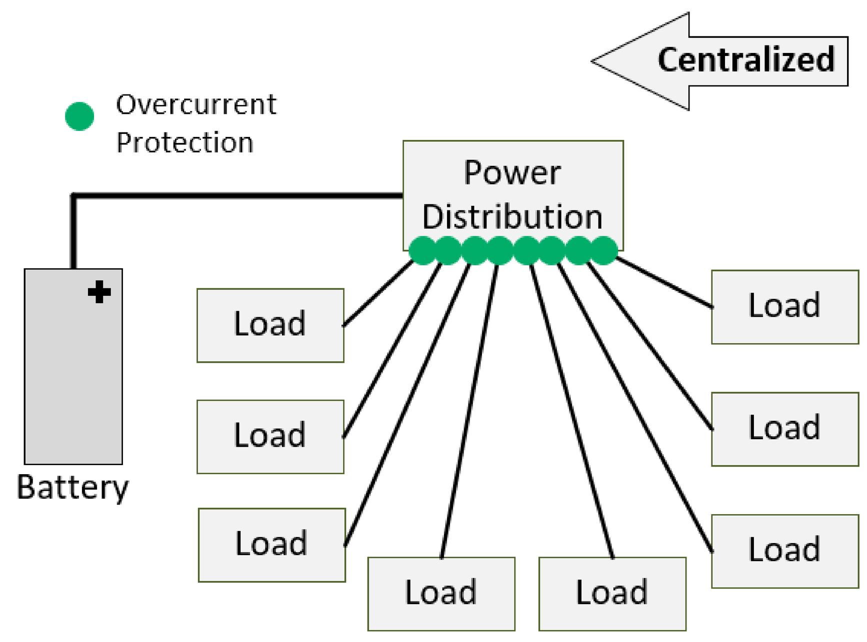
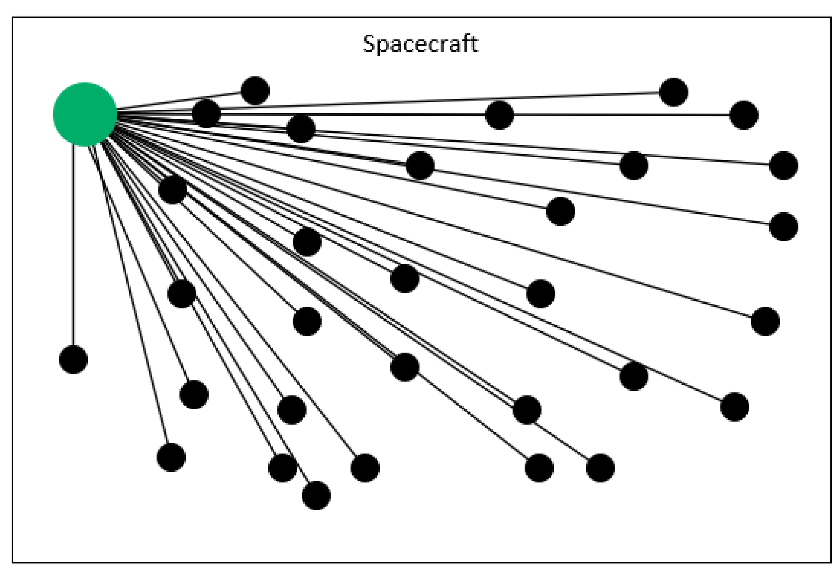
Where We Are: Centralized Power Architectures

- Heritage power architectures in most NASA missions are large, bulky, and inefficient, requiring large resource allocations to support complex harnessing schemes and overcome system power losses in point-to-point harnessing
- By reducing spacecraft complexity and cutting out wasted mass, these critical resources can instead be diverted toward instruments and science return

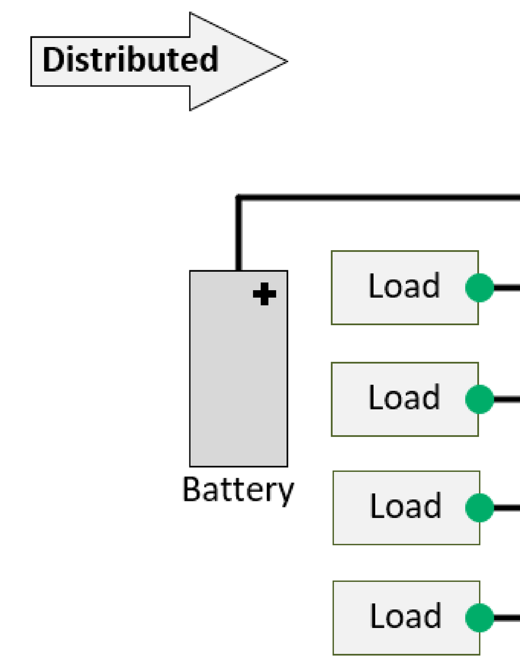


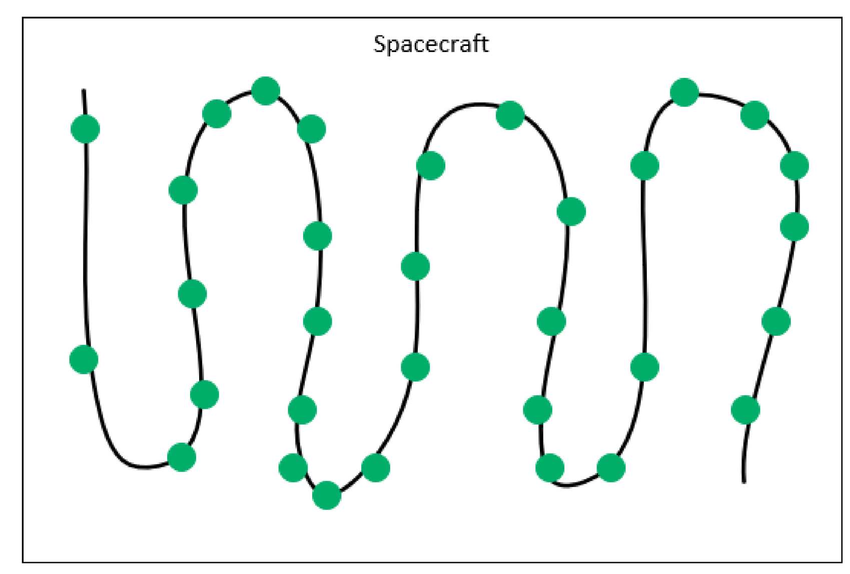
Exposed belly of the Perseverance rover





Where We're Going: Distributed Power Architectures

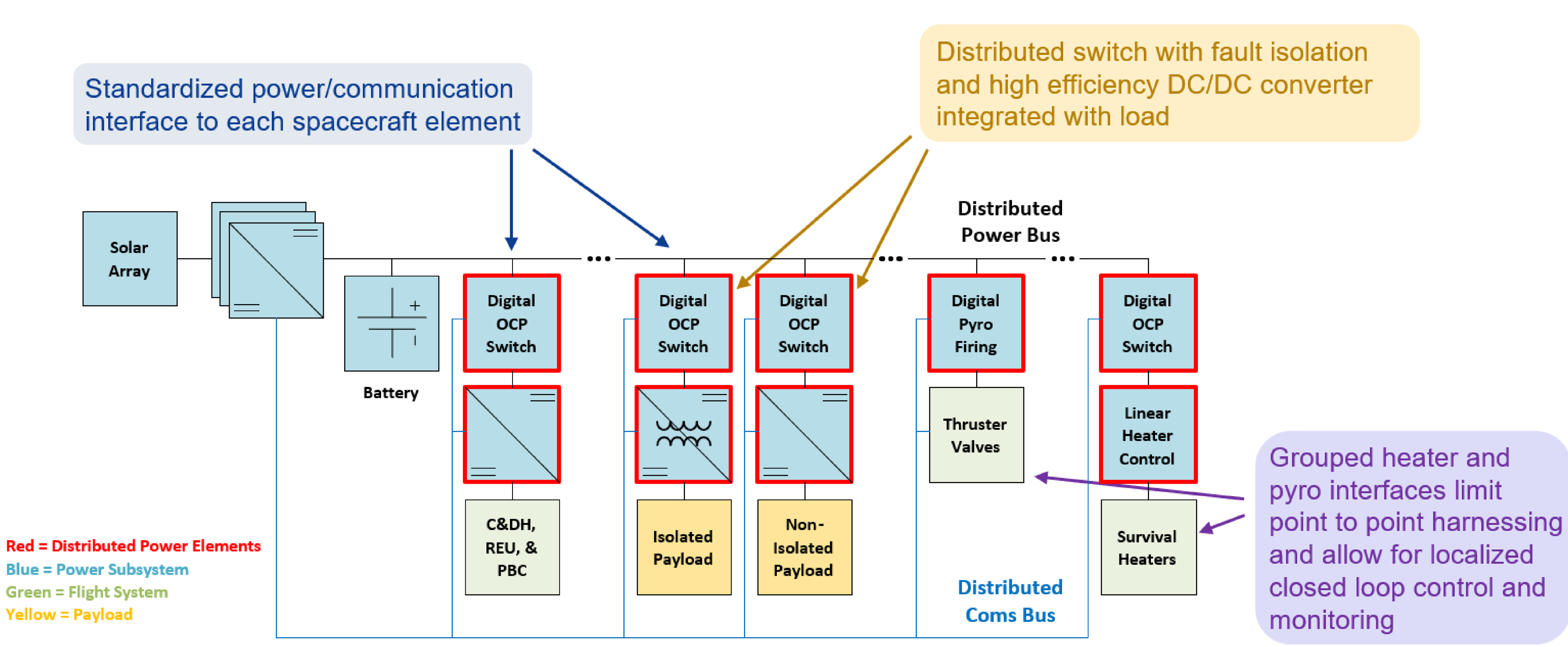




- Point to point harnessing is eliminated by moving power system elements throughout the spacecraft with standardized interfaces
- Standardized interfaces promote efficiency improvements across the system by encouraging modular designs
- Communication systems are simplified to enable lighter and compact architectures
- Increased subsystem visibility to diagnose SMAP like power converter failures

Large flagship missions and future decadal survey missions can benefit from efficiency and power density optimization by allocating more spacecraft resources toward instruments, science return, and mission operations

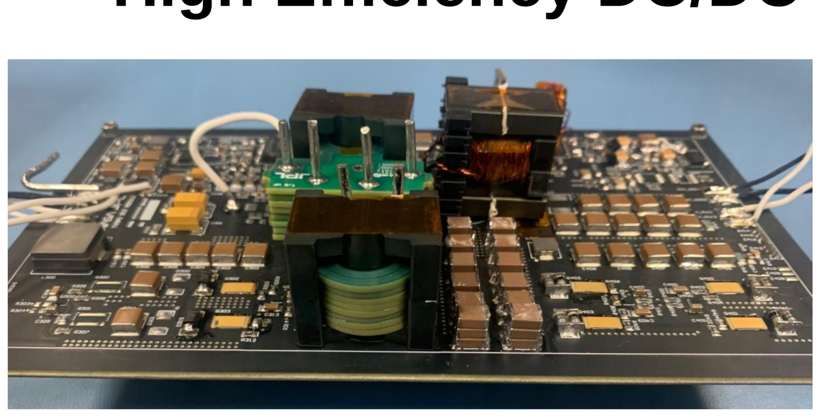
The Breakthrough Distributed Power Architecture



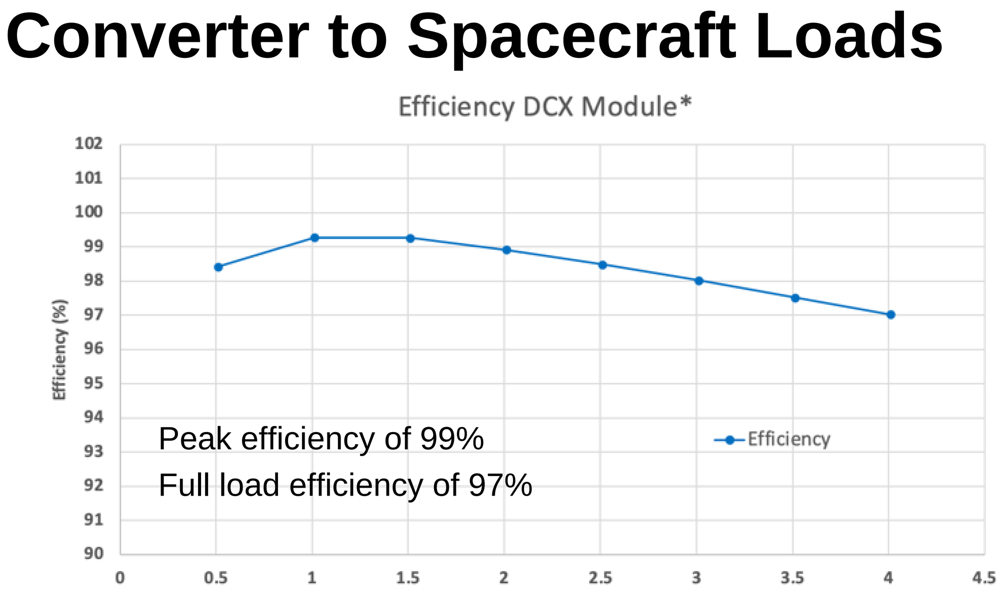
Distributed Power Switch to Spacecraft Loads

- A distributed load switch IC handles fault protection and commanding directly at the load through a small form factor to eliminate point-to-point harness to loads
- Functions include:
  - Resettable overcurrent (eFuse)
  - Reverse current protection
  - Inrush limiting
  - Voltage and current telemetry

High Efficiency DC/DC Converter to Spacecraft Loads

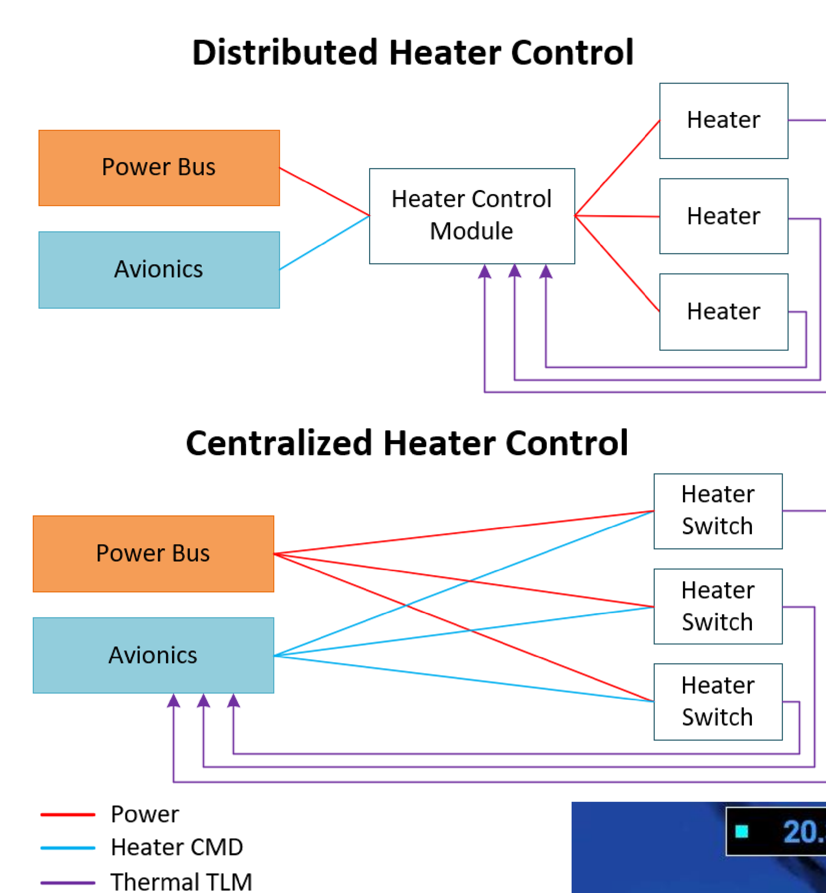


Parameter	State of the Art	Actual Measurement
Isolated Converter Efficiency	85%	97-99%
Converter Power Density	0.3 W/cm³	0.471 W/cm³
Converter Specific Power	250 W/kg	296 W/kg

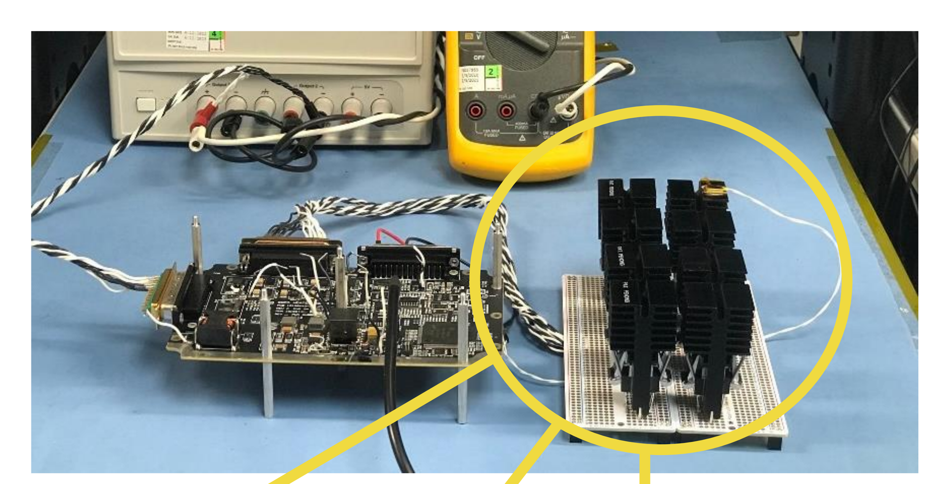


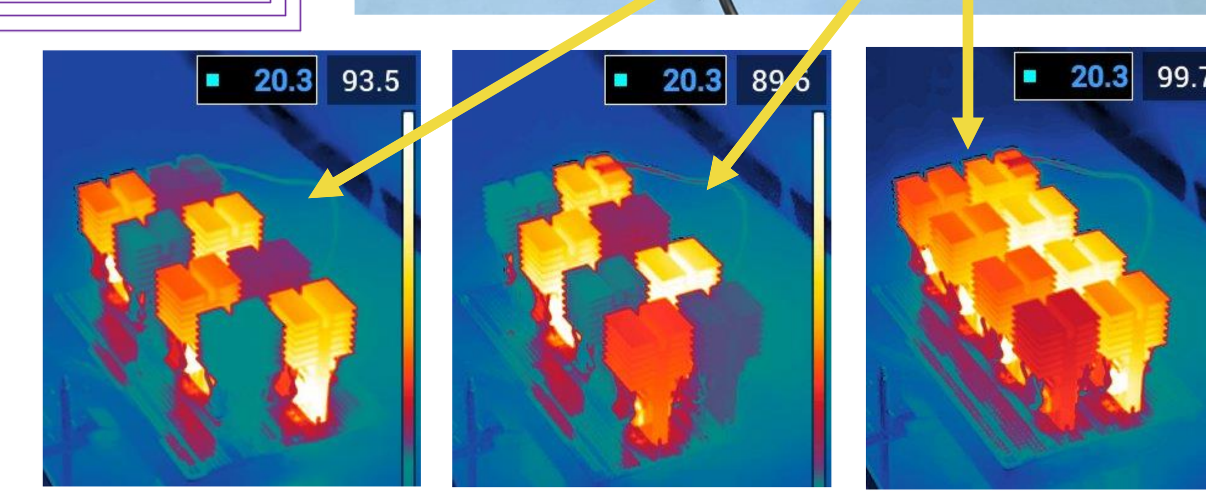
- Standardized interfaces encourage modular design, allowing cutting edge power conversion approaches to be utilized across the spacecraft for holistic efficiency improvements

Distributed Heater Control



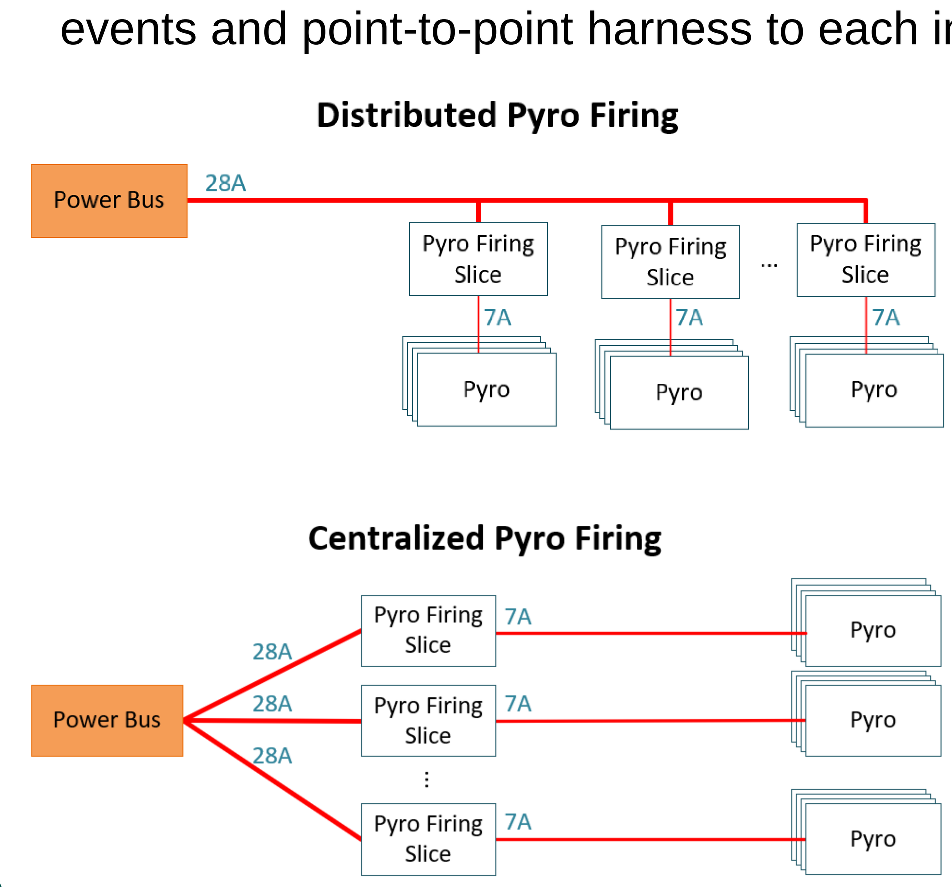
- Localized closed-loop control allows the spacecraft to go to sleep while the heater control board autonomously regulates hardware to the desired temperature





Distributed Pyro Firing

Pyro firing architectures have a high-current harness rated for 3-4 simultaneous pyro events and point-to-point harness to each individual pyro



- In a distributed architecture, point-to-point harness is minimized by locating the control boards near the pyros
- The control boards are powered off of the same high-current harness to take advantage of firing sequences and minimize harness mass
- In a centralized architecture, point-to-point harness length and resistance impede the drive current
- The control boards are designed for a standard impedance for each channel and point-to-point harness needs to comply, resulting in large, bulky harness

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