ISS Science Payload Command & Data Handling

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Background

The Command and Data Handing (C&DH) avionics system enables reliable data distribution of the many science payloads installed aboard the ISS. International Space Station science payload experiments are conducted internally and externally:

- Internal science payloads are commonly stored in International Standard Payload Racks (ISPRs). The common ISPRs are known as Expedite the Processing of Experiments to Space Station (EXPRESS) racks.
- External science payloads are commonly stored in one of four Express Logistics Carriers (ELCs)

These internal racks and external storage carriers send data through three main media Mil-Std-1553, Fiber / High Rate Data Link (HRDL), or ethernet.

MIL-STD-1553B

The standard interfaces to the ISPRs include a MIL-STD-1553B Payload Bus that uses twisted shielded wire pairs. Commands to the payloads from the ground, crew, and onboard automated procedures are delivered via this 1553B connection as are health, status, safety, and ancillary data types. Each payload location is allowed one remote terminal on the bus. Payloads send health and status on the 1553 bus to Payload Multiplexers Demultiplexers (MDMs). The 1553 bus support a maximum of 1Mbps data rate. The PL MDMs then mux the data to the top command and control MDMs, and then downlink on S-band to the ground station.

Fiber / High Rate Data Link (HRDL)

Each ISPR is provided optical fiber that connects rack iPEHGs to an input and output port on the iAPS for distribution of data between racks or for downlinking via the Ku-band system. Many rack PEHGs have been upgrade to iPEHG, increasing the data rate from 10Mbps to 100Mbps.

Ethernet Joint Station LAN (JSL)

An 802.3 local area network is distributed to the ISPR locations within the U.S. Lab, JEM, and Columbus for telemetry, file transfer, and laptop communications. The ethernet LAN has been upgraded from 10Mbps to 100Mbps, and there is an upcoming plan for 1Gbps data rate LAN.

- The Ethernet interface is a more common and easier interface to implement for payload developers already familiar with Ethernet protocol in their labs
- The Ethernet interface allows for a more distributed payload architecture. Connections can be placed in locations not serviced by the 1553 bus

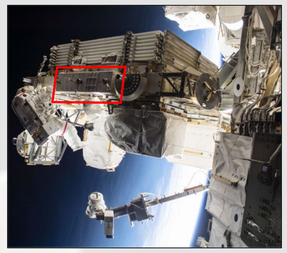
Gigabit ethernet

The legacy Automated Payload Switch (APS) was a switching device used to route ISS payload data. The data comes in on 44 fiber optic input channels and is output on 36 fiber optic output channels. Data from any one of the inputs can be routed to one or more of the outputs. The legacy APS power supply limits the maximum number of routes to 20.

The iAPS replaces the APS controller and switch matrix cards to alleviate inefficiencies of the legacy APS. Several low rate input data channels may be combined into one aggregated output channel which improves the overall data throughput. A new power supply allows as many as 24 routes to be created. A High-Speed Data Interface, implemented as 1000Base CX Gigabit Ethernet, provides connectivity to the Ku-band Integrated Communications Unit (ICU).

Payload Data Handling

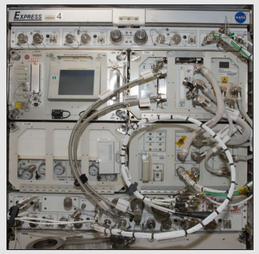
External Payload Data Handling



The ExPRESS Logistics Carrier Avionics Assembly (ExPCA)

- ExPCAs enable Mil-Std-1553 command and control of the payloads and controls the heater systems on the ELC
- ExPCA utilizes a fiber optic link to send high rate payload data to the iAPS

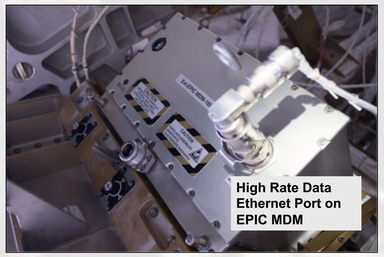
Internal Payload Data Handling



Payload ISPRs

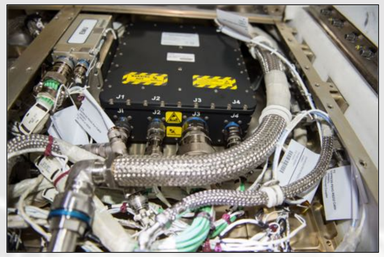
- Express Racks, HRF, Avionics rack contain iPEHGs-1 and 2
- Translates ethernet data to fiber and sends to iAPS
- Sends payload health and status to MDMs via 1553

Hardware Components



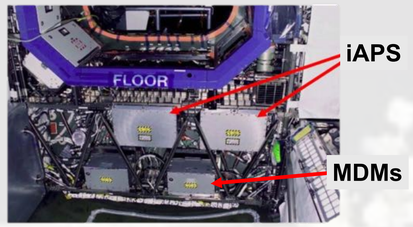
Multiplexer / Demultiplexer (MDMs)

- Receives analog and 1553s data and aggregates to send it up through tiers
- Payload and C&D MDMs send 1553 and extended telemetry via ethernet



Improved Payload Ethernet Hub Gateway (iPEHG)

- Funnels the payload ethernet data for downlink by converting payload data to fiber optic signals and sending to the iAPS

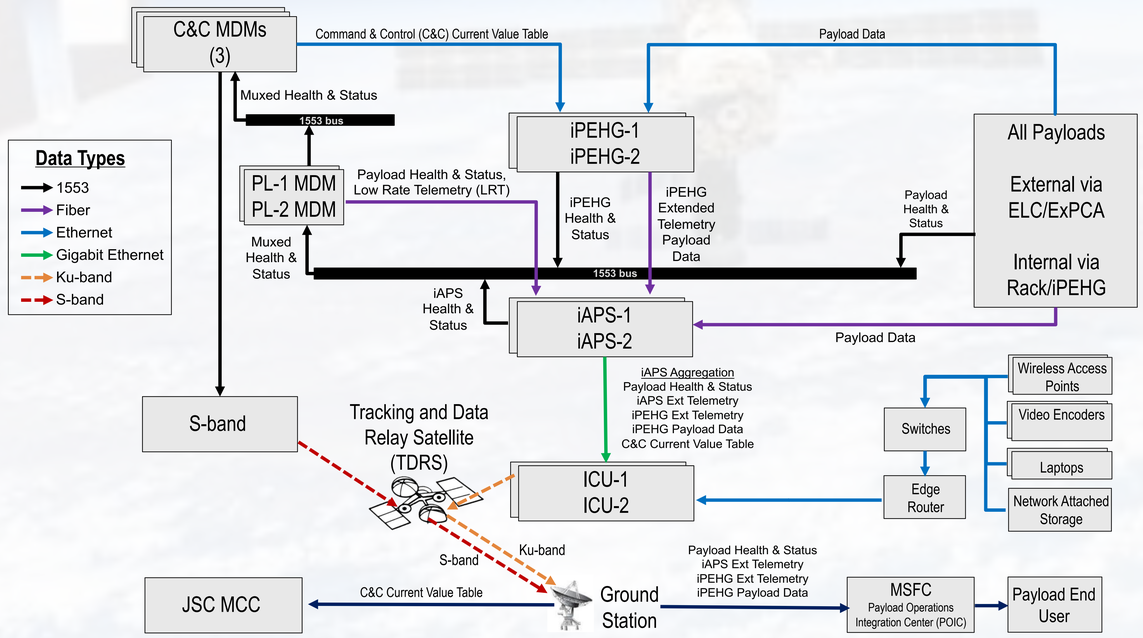


Improved Automated Payload Switch (iAPS)

- Each iAPS has 44 input channels and 36 output channels with one gigabit Ethernet channel connected to Ku-band Integrated Communication Unit (ICU)

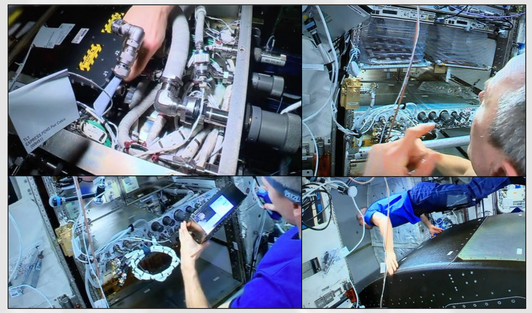
System Design

High-Level Architecture Data Flow



Results

- The C&DH system operates stably occasional single event upset (SEU) radiation stalling the hardware. Often a power cycle of the hardware restores operation.
- PEHG to iPEHG upgrades were made from 2013 through 2019 in payload racks increasing 10Mbit payload data rates to 100Mbit.



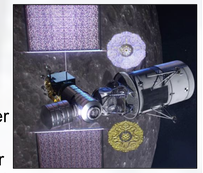
iPEHG Upgrades on ER3 5/31/2018 Drew Feustel

iPEHG Location	iPEHG Installation Date
iPEHG-2 US Lab Avionics Rack 3	5/1/2013
iPEHG-1 US Lab Avionics Rack 2	5/3/2013
Columbus Rack	8/23/2013
Express Rack 5	6/10/2016
Express Rack 7	1/20/2017
Express Rack 6	4/11/2017
Window Observational Research Facility (WORF)	7/13/2017
Express Rack 4	8/3/2017
Express Rack 8	11/1/2017
Express Rack 3	5/31/2018
Express Rack 2	9/20/2018
Express Rack 1	03/13/2019

PEHG to iPEHG Upgrade Schedule

Future Work

- For ISS, there are plans to continue upgrading the Joint Station LAN from 100Mbilt to Gigabit data rates
- There is also consideration for more PEHG to iPEHG upgrades in racks
- In addition, there is continuing expansion of the Wireless Access Points
- Per the commercial elements requirement a commercial element docking with ISS must interface with the 1553 critical bus.
- Gateway will utilize a Time-triggered ethernet C&DH network backbone with traffics class for critical time-triggered, rate constrained, and non-critical best effort traffic.
- Gateway is considering USB payload power
- Downlink will be a bottle neck initial on gateway. Traffic management, and store for lower rate transmission will be implemented.



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- Reference Guide to the International Space Stations https://www.nasa.gov/mission_pages/station/overview/index.html
- SSP 51071 External Payloads Proposer's Guide to the International Space Station