Gigabit Ethernet, provides connectivity to the Ku output channel which improves the overall data throughput. A input data channels may be combined into one aggregated output channels. Data from any one of the inputs can be transmits to Ku output channels. Each input has a dedicated output channel which can either be used for data transmission or for telemetry.

The legacy Automated Payload Switch (APS) was a switching system that distributed data between racks or for downlinking via the EXPRESS Gateway (iPEHG), increasing the data rate from 10Mbps to 100Mbps downlink. This was achieved through three main media: 1553, Fiber / High Rate Data Link (HRDL), or ethernet. The Gigabit ethernet interface allows for a more distributed telemetry, file transfer, and laptop communications. The Ethernet interface is a more common and easier way for engineers to communicate with payloads installed aboard the ISS. Familiarity with Ethernet protocol in their labs is common.

The Command and Data Handling (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 EXPRESS Racks, HRF, and Express Logistics Carriers (ELCs).
- 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: 1553, Fiber / High Rate Data Link (HRDL), or ethernet.

**Mini-STD-1553**

The standard interfaces to the ISPRs include a Mini-STD-1553 Payload Bus that uses twisted shielded wire pairs. Commands to the payloads from the ground, crew, and onboard automated procedures are delivered via this 1553 bus 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 to input and output ports 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 852.3 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 100Base CX Gigabit Ethernet, provides connectivity to the Ku-band Integrated Communications Unit (ICI).

**Fiber / High Rate Data Link (HRDL)**

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

**Improved Automated Payload Switch (APS)**

- Each APS has 44 input channels and 36 output channels with one gigabit Ethernet channel connected to Ku-band Integrated Communication Unit (ICI).
- Enables reliable data distribution of the many science experiments onboard the ISS.
- Supports bandwidth upgrades from 10Mbps to 100Mbps.

**Fiber / High Rate Data Link (HRDL)**

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

**ISS Science Payload Command & Data Handling**

Paul Muri, Deputy System Manager ISS C&DH

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**Results**

- The C&DH system operates stably occasional single event upset (SEU) radiation sizzling 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 10Mbps payload data rates to 100Mbps.

**Future Work**

- For ISS, there are plans to continue upgrading the Joint Station LAN from 100Mbps 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 baddoone with traffic class for critical time-triggered, rate constrained, and non-critical best effort traffic.
- Gateway is considering USB payload power Downlink will be a toggleneck initial on gateway. Traffic management, and store for lower rate transmission will be implemented.

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