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A Communications Data Processor For ISS Ground Systems Using Standards and Software-Based Architectures

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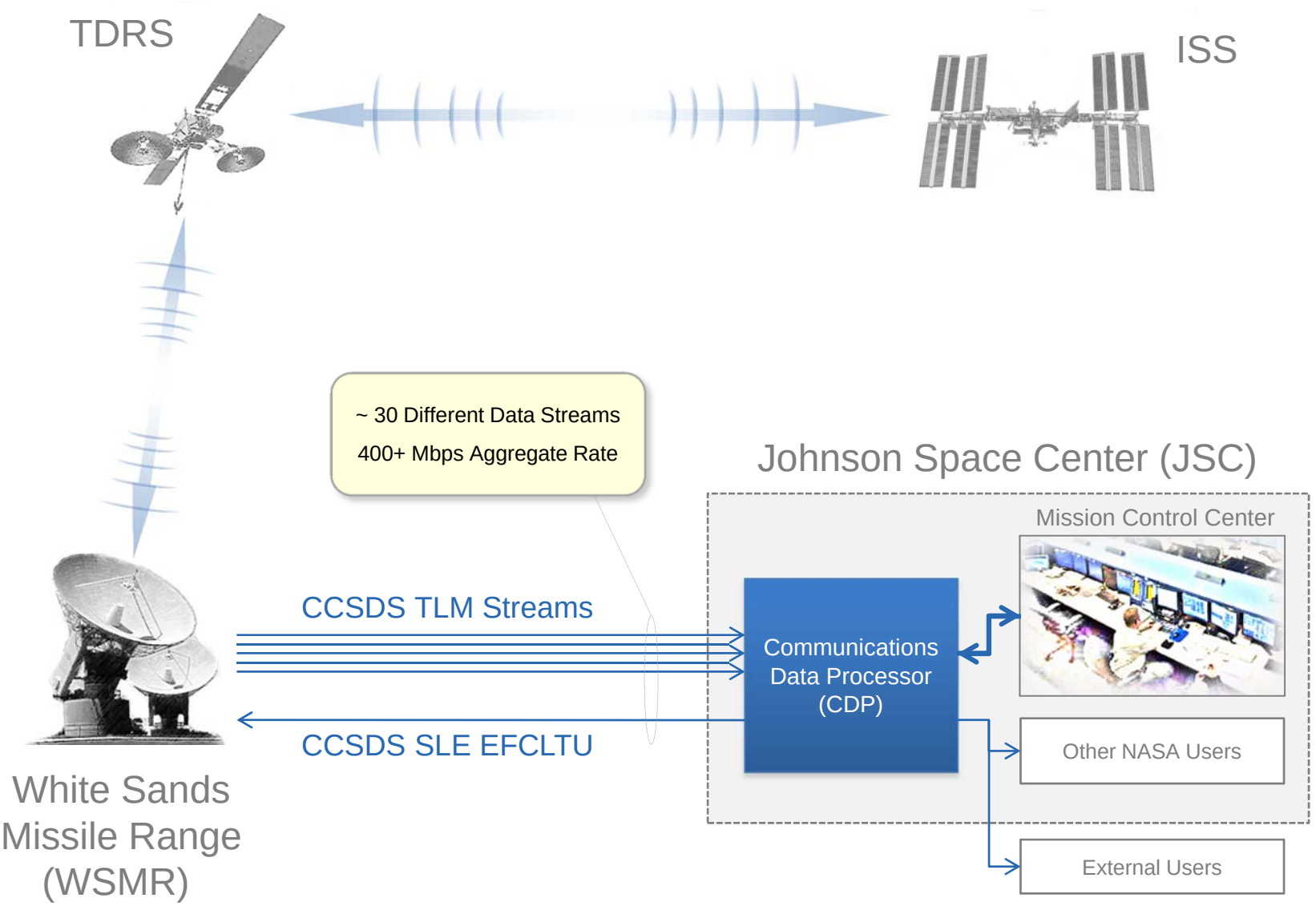
Overview

- **The International Space Station Easily Represents The Largest Most Complicated Vehicle in Space**
  - It has influenced many of the CCSDS standards
  - Continues to stretch the boundaries of these standards

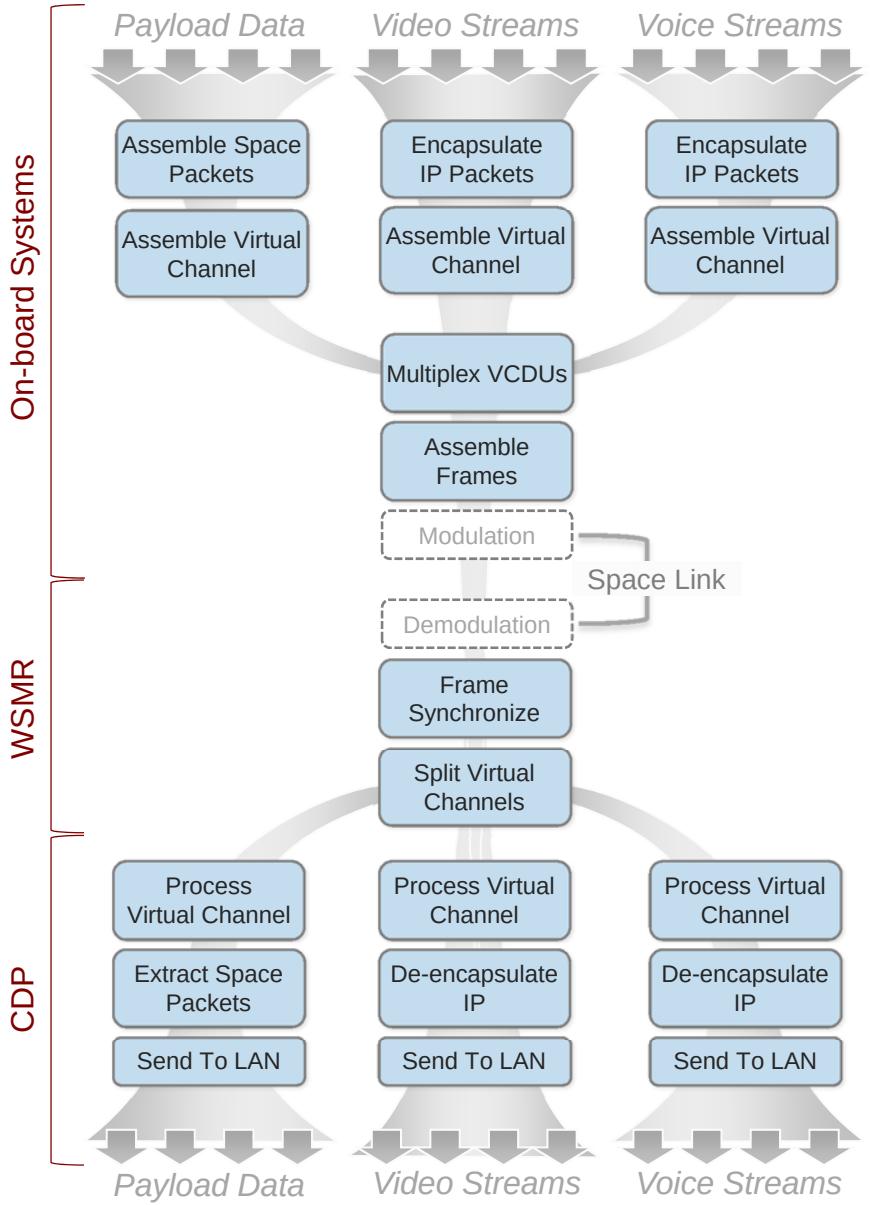
- **Unique Challenges**
  - Manned space flight
  - Complex end-to-end path
  - Large number of data streams
  - Multiple sources/destinations
  - Strict latency requirements
  - Different priorities per stream
  - Custom data processing

ISS Signal & Data Flows



Example Return Link Data Flows

- **Multiplexed Data Streams**
  - Includes a Variety of Data Types
    - Encapsulated IP
    - Space Packets
    - Binary Bit Streams
    - Transfer Frames
  - CCSDS Features/Customizations
    - Secondary header processing
    - Conditional stripping of headers
    - Data insertion at various levels
    - SLE EFCLTU Orange Book
  - Additional Customizations
    - Custom network headers
    - Prioritized queuing
    - Recording
    - Rate limiting
  - Encapsulated IP
    - Adds embedded data streams
    - Filtering, processing etc.



Software-Based Solution - softFEP

- **Can This Be Solved With a COTS Solution?**
  - Yes, as long as the architecture allows for customizations in all the right places.
  - After all the customizations, can it still be called COTS? **Yes!**
- **Software Devices and Processing Chains**
  - CCSDS telemetry and telecommand standards lend themselves to a layered or ‘pipelined’ implementation
  - We handled this by defining ‘Software Devices’ for each layer
  - Software Devices are then chained together to define the end-to-end data transformation
  - Custom Software Devices replace standard ones as needed
- **Ground Equipment Monitoring Service (GEMS)**
  - Object Management Group (OMG) Standard
  - Provides direct Control & Status of every Software Device

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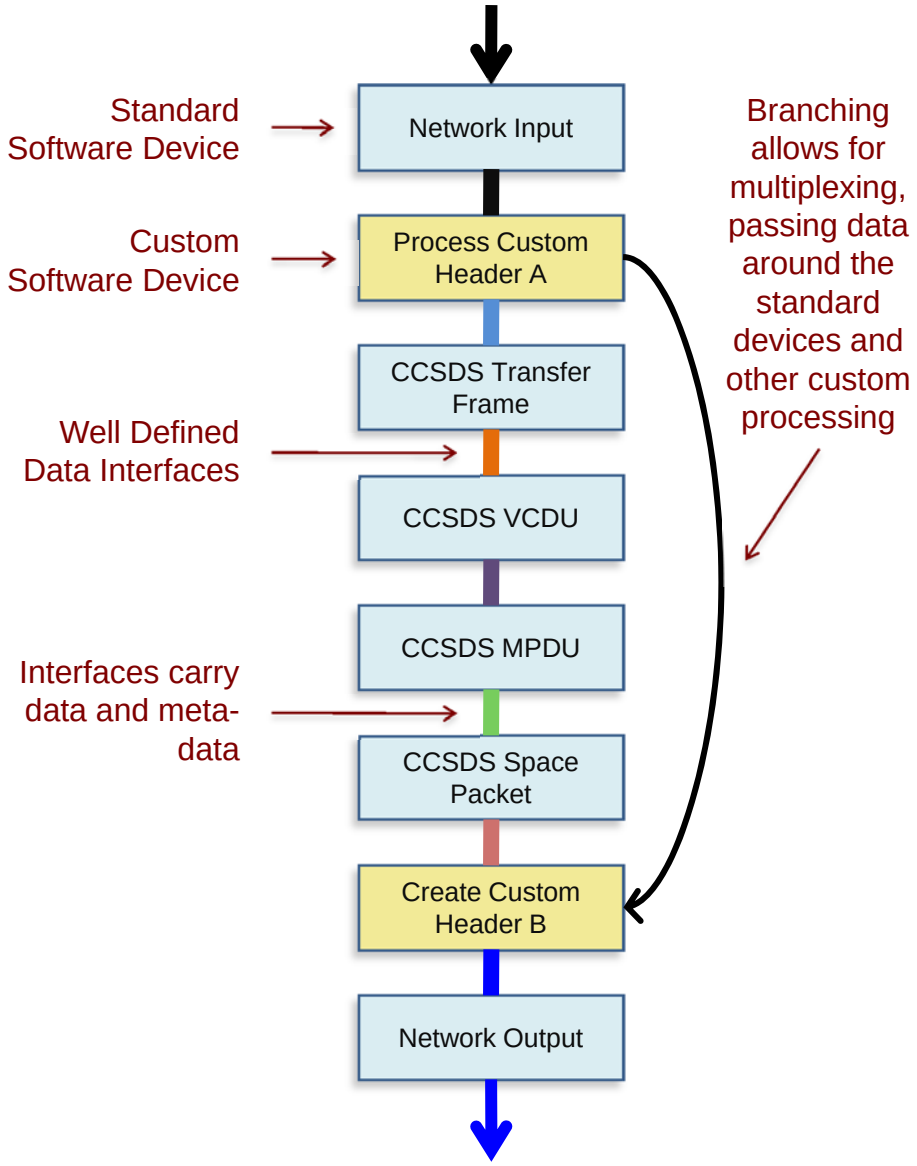
Data Processing Chains

- **Each Software Device is Focused On An Atomic Function**
  - By using standards and well defined functionality, these can be used on many different programs
- **Highly Efficient Interfaces**
  - Defined for a specific layer in the CCSDS processing stack
  - Include time information
  - Supports gigabit rates in software
- **Additional Benefits**
  - Requirements mapped directly to the software devices
  - Extensive testing at system, chain and software device level
  - Increased user base
  - ISS Engineers can easily understand and even modify the chains post delivery



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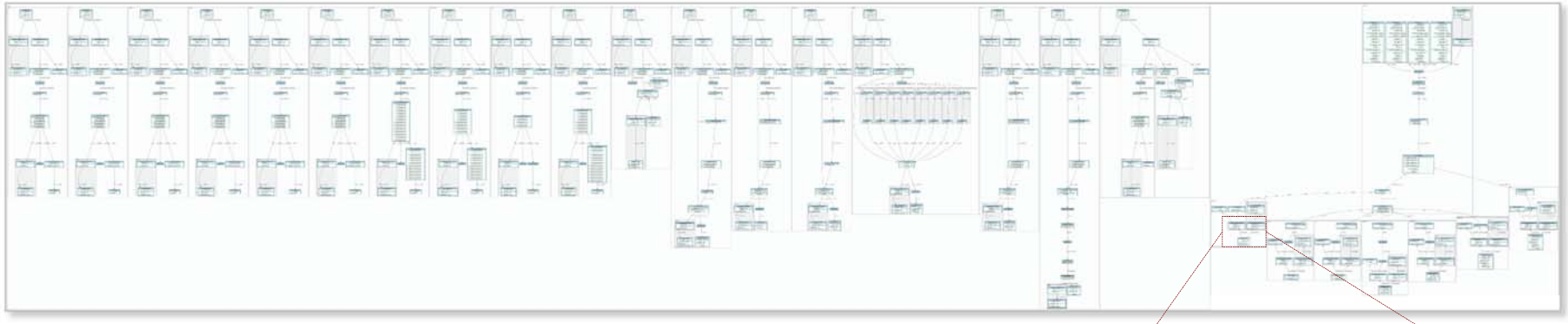
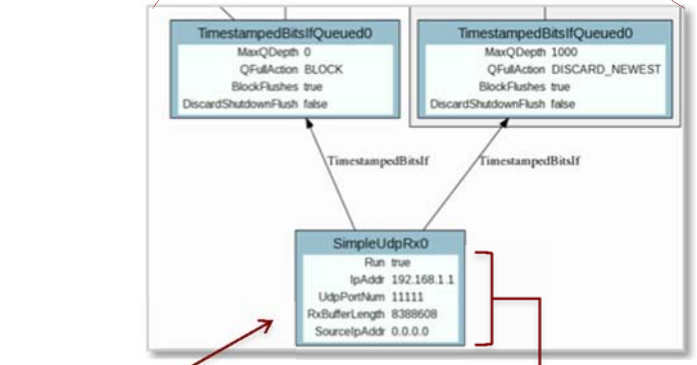
Some More Details



- **Diagrams Generated At Runtime**
  - Represent the actual runtime configuration
- **Able To Achieve ~70% Reuse With Existing Software Devices**
  - And this is for the International Space Station!

	Total	COTS	Custom
Types	48	34	14
Instances	343	238	105

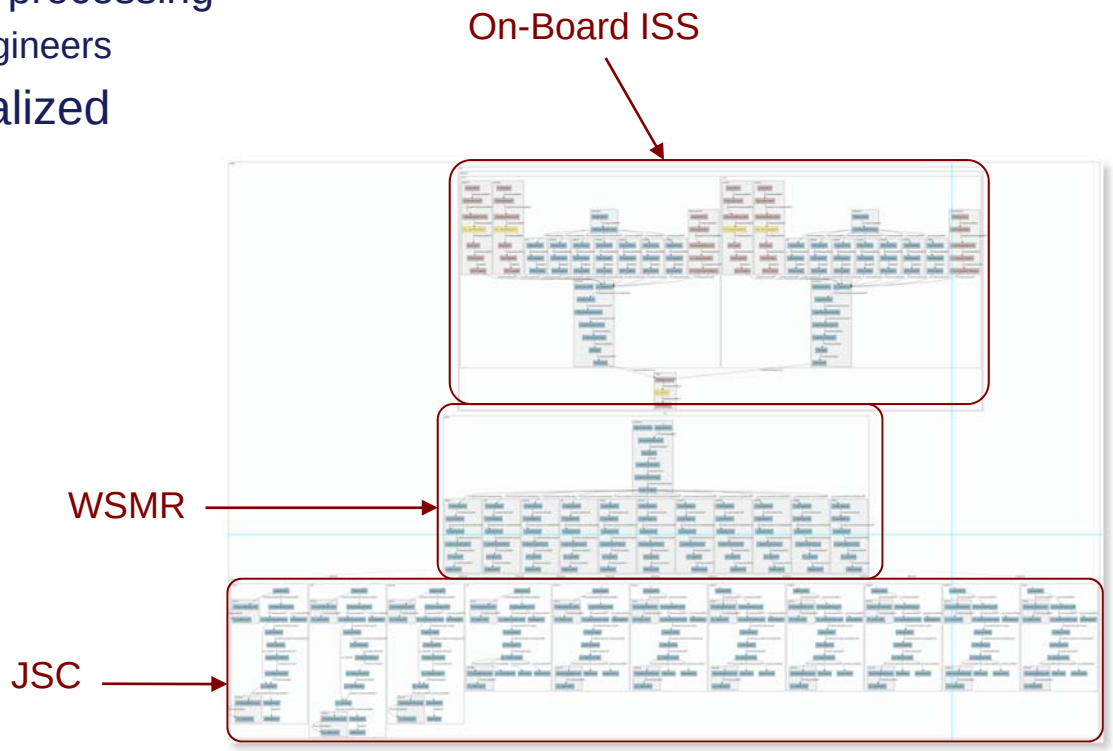


NOTE: Parameters do not represent actual settings

Unexpected Benefits

- **Simulation & Training**
  - Full simulation of the end-to-end communication system
    - On-board, WSMR, and JSC
  - Processing chains were quickly modified to include:
    - Simulation of malfunctions
    - Custom voice and video processing
      - developed by JSC engineers
  - Entire system was virtualized

And this is only about half of the system



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Significant Benefits To This Approach

- **What Did We Learn?**
  - Scales to very large systems quickly and efficiently
  - Easily handles changing requirements
    - Even late in the development cycle and after delivery
  - End customer directly sees the design
    - Reduces design errors
    - Aids in troubleshooting
  - Software-defined systems are fully capable of processing these rates
    - Rates in excess of 1 Gbps possible
  - Standards, in particular CCSDS, work
    - Even with customizations, the long-term benefits are being realized
    - Shared code base between projects even with unique processing
  - GEMS provides easy-to-use control & status
    - Very few issues/questions regarding the network API
    - Support for both GEMS-ASCII and GEMS-XML
  - Extends Easily and Quickly To Simulation & Training Environments

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Future of Ground System Processing

- **Focus on Standards!**
  - CCSDS Telemetry and Command Data Formats Work
    - Today's systems can easily accommodate any additional overhead
    - Benefits increase as more satellite programs use these standards
  - OMG GEMS Standard allows for common Control & Status code
    - Simple standard that solves a specific problem
    - Only need to write the message processing logic once
    - Relatively easy to swap out one vendor's system for another
- **Software Defined Data Processing Systems Are Reality**
  - No need for custom hardware, ridged firmware or monolithic designs
  - Commercial servers provide all the horsepower needed.
  - Adds unprecedented flexibility and long-term supportability
  - End-user can modify/maintain the system themselves

Questions?

Special Thanks to NASA and Lockheed Martin for their time reviewing this presentation.

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