

CCSDS: What's New?



ETSC 2015, Toulouse France Rob Ritter – <u>rritter@integralmkting.com</u>

PROPRIETARY: The contents of this briefing are the property of RT Logic. Information herein is not to be distributed outside of the training class, its participant's and the respective program or conference without written permission from RT Logic. © 2014 by RT Logic. Published by The European Telemetry Standards Committee with permission



RT Logic Proprietary



- Consultative Committee for Space Data Systems
 - Key Members are the Major Space Agencies
 - Recommendations Span RF Links to Ground Transports
 - Related Areas for Ground Standards Include
 - Cross Support Services (SLE, Service Management)
 - Mission Operations and Information Management Services (MOIMS)
 - Recommendations can be Used Together or Separately

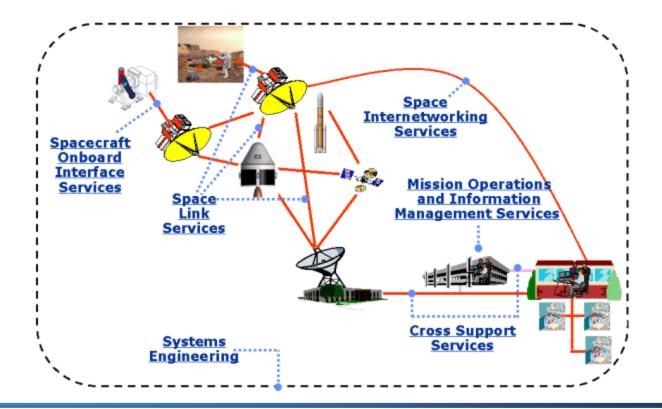




- 1981 NASA and ESA met and formed a working group to address space data standards with particular interest in Packet Telemetry and Packet Telecommand
- 1982 The CCSDS was officially formed
- 1991 CCSDS joined the ISO Technical Committee 20, for Aircraft and Space Vehicles
- 2003 CCSDS organized in the IETF Model with the following Working Group "Areas" of discipline
 - Space Link Services
 - Space Internetworking Services
 - <u>Spacecraft Onboard Interface Services</u>
 - <u>Cross Support Services</u>
 - <u>Mission Operations and Information Management Services</u>
 - <u>System Engineering Services</u>
- <u>2015 CCSDS Runs out of "Space"</u>
 - Unified Space-Data Link Protocol



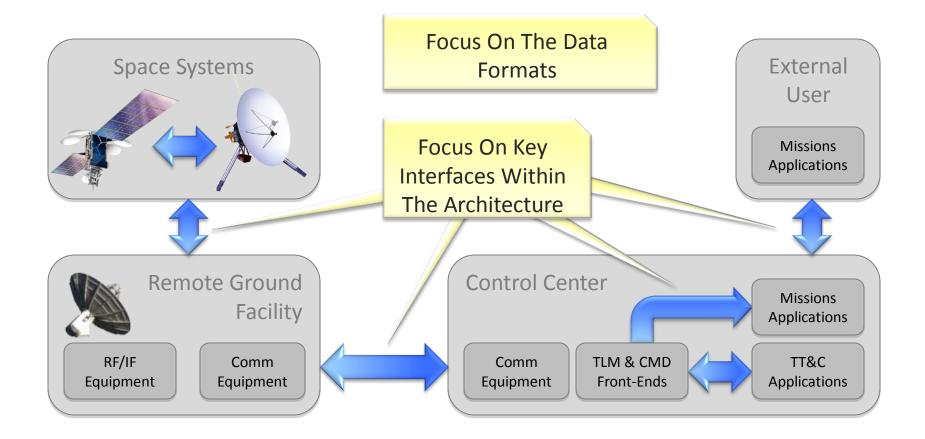
- CCSDS Standards Span the Space and Ground Links
 - Define Telemetry & Command Formats
 - Define Ground Transport Protocols
 - Working on Control & Status Standards





- Protocols Optimized for High-Latency, Error-Prone Links
 - Command Structure
 - Frame and packets for complex payload
 - Onboard FEC decode with low processing power
 - Telemetry
 - Frame and packet structure for diverse payload functions and easy demux
 - Easy transition to IP on ground
 - Low spacecraft power requirement to encode data with strong FEC
 - RS, LDPC, Convolutional
 - Optimized file transport layer for on-board stored data transfer
 - Optimized IP packet encapsulation
 - COTS equipment for on-board and ground equipment
- Standard Ground Protocol (SLE)
 - Standard data encapsulation, timing, quality metrics, security, etc.
 - Standard commanding with scheduling, authentication, verification







CCSDS Modeled After OSI

- Open Systems
 Interconnection (OSI)
- Utilize a Layered Approach
- Each Layer can be used Independently
- Each Layer Serves the Layer Above

OSI SEVEN-LAYER REFERENCE MODEL

то)P	Application Layer	Allows applications to access network services. FTP, Telnet, and Simple Mail Transfer Protocol (SMTP) operate at this level. NOTE: Actual software applications fall outside the scope of this model.
		Presentation Layer	Manages data translation, compression, encryption, and conversion.
		Session Layer	Establishes and maintains communication between applications.
		Transport Layer	Transmits data, provides flow control, and handles errors. TCP, <i>Transmission</i> <i>Control Protocol</i> , operates at this level making sure that every packet sent is accounted for.
		Network Layer	Routes data between nodes. This layer handles network or logical addressing via routing protocols. IP, <i>Internet Protocol</i> , is a protocol that operates at this level. In terms of hardware, routers and gateways work at this layer.
		Data Link Layer	Handles physical addressing, packing data into frames, sequencing data frames, and performing checksums. It has two sublayers: Logical Link Control (LLC) and Media Access Control (MAC). Ethernet and ATM are standards that are used at this level. Bridges and Network Interface Cards (NIC) also work at this level.
30T	том	Physical Layer	This is the electrical or mechanical layer of the OSI model where information is transmitted over the network medium. In terms of hardware, this layer includes passive hubs, repeaters, and cables.



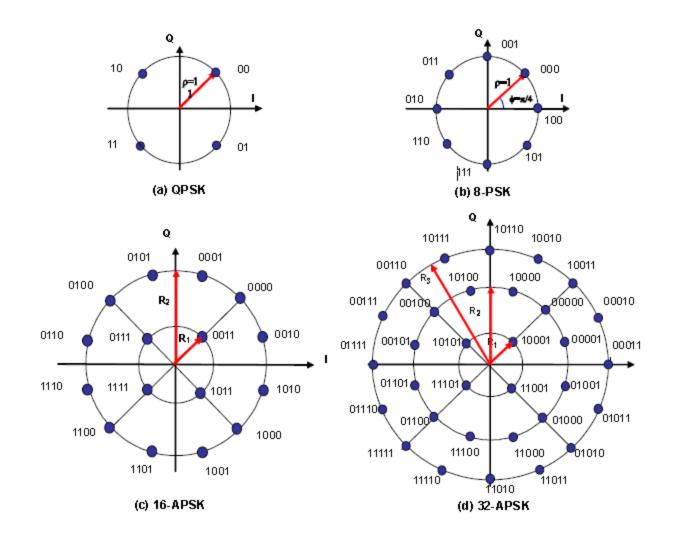
 We will Touch on Lossless Data Compression **APPLICATION** Many of these DTN LAYER SCPS-FP FTP Through the Node **Remainder of the CCSDS** File BP Course SCPS-TP Delivery TRANSPORT LAYER TCP UDP Protocol LTP (CFDP) SCPS-SP We Encourage You to Learn More IPv4 IPv6 **NETWORK** SCPS-NP Space Packet Protocol LAYER Encapsulation DATA LINK PROTOCOL **TC** Space **TM** Space **AOS Space** SUB-LAYER Data Link Data Link Data Link Protocol Protocol Protocol Proximity-1 TC Sync and SYNC AND CHANNEL Space Link Channel TM Sync and Channel Coding CODING SUB-LAYER Protocol Coding PHYSICAL **RF** and Modulation Systems LAYER



Higher-Order, Variable, and Adaptive Modulations

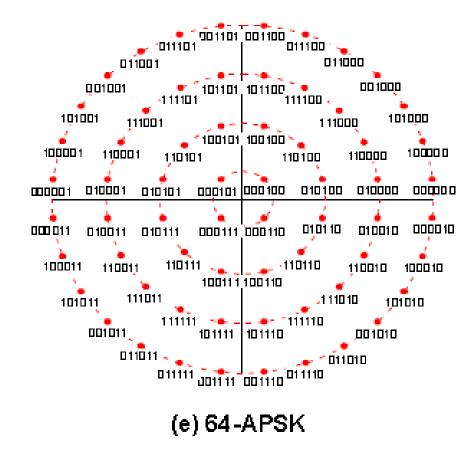


Bit Mapping for Higher Order Modulation





6 Bits Per Symbol in 64 APSK





- Variability in high-speed downlink conditions
 - Lower-rate coding, and lower-order modulations for challenged link
 - Higher-rate coding, and higher-order modulations for strong links
- Adaptive Coded Modulation
 - Measurement of computation of link quality
 - Feedback mechanism to vehicle to change rate and/or modulation



- VCM is a built-in feature of:
 - SCCC codes in CCSDS 131.2-B-1, "Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry Applications," Blue Book. Issue 1. March 2012.
 - BCH+LDC codes in CCSDS 131.3-B-1, "CCSDS Space Link Protocols over ETSI DVB-S2 Standard," Blue Book. Issue 1. March 2013.
- VCM is not feature of
 - Convolutional, RS, concatenated, turbo, and AR4JA/C2 LDPC codes in CCSDS 131.0-B-2, "TM Synchronization and Channel Coding," Blue book. Issue 2. August 2011.
- Status of adaptive coded modulation (ACM):
 - None of the three standards above specify an ACM protocol (although the term "ACM" is used in the Blue Books)
 - This is because these standards relate to *downlink* only. As such, they do not specify a protocol for estimating signal quality or feeding channel-state information back to the spacecraft for the purpose of selecting a new transmission mode.
 - The SCCC and DVB-S2 standards are compatible with ACM: the transmission modes may be modified and the slicer must be able to apply the change without losing Transfer Frames



- New Generation of Digital Video Broadcast coding
- Developed 2003 and ratified 2005
- A powerful <u>coding</u> scheme based on a modern <u>LDPC code</u>. For low encoding complexity, the LDPC codes chosen have a special structure, also known as Irregular Repeat-Accumulate codes.
- BCH Outer code for AWGN simple decode
- Supports higher order modulations (e.g. 32APSK), IP transport, MPEG4
- VCM (Variable Coding and Modulation) and ACM (Adaptive Coding and Modulation) modes, which allow optimizing bandwidth utilization by dynamically changing transmission parameters.
- CCSDS Blue Book 131.3-B-1



Code Type	Required Eb/No (dB) for 10E-05 BER
PSK – No coding	9.6
Reed Solomon (255/223)	6
Conv. (R1/2,K=7)	4.1
RS + Conv	3.8
RS + Conv Interleaved	2.2
LDPC (8160/7136)	~0



• Exclusive Internet Layer

 CCSDS Recommends IPE as the preferred (i.e., only) means for sending internet (IPv4/IPv6) packets over a CCSDS space link

IPE Packet

- Header identifying type of IP Packet in the payload
- Header based on a Cisco standard that supports header compression

IPE	Data (defined by header)
Header	

IPE Header Value	Protocol Encapsulated
33	IPv4 datagram
35	Frame Relay IP Header Compression Control Protocol (NOTE 1)
87	IPv6 datagram
97	FULL_HEADER
99	COMPRESSED_TCP
101	COMPRESSED_TCP_NO_DELTA
103	COMPRESSED_NON_TCP
105	COMPRESSED_RTP_8
107	COMPRESSED_RTP_16
109	COMPRESSED_UDP_8
111	COMPRESSED_UDP_16
113	CONTEXT_STATE



IP Encapsulation with CCSDS

ENCAP Header

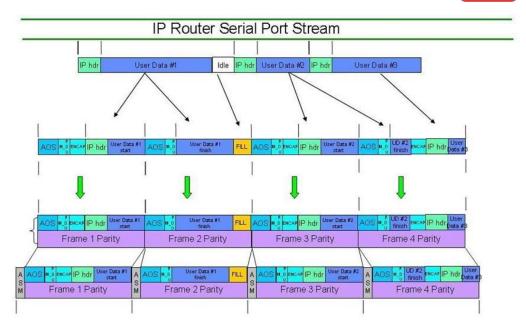
- Ver = 111

– PID

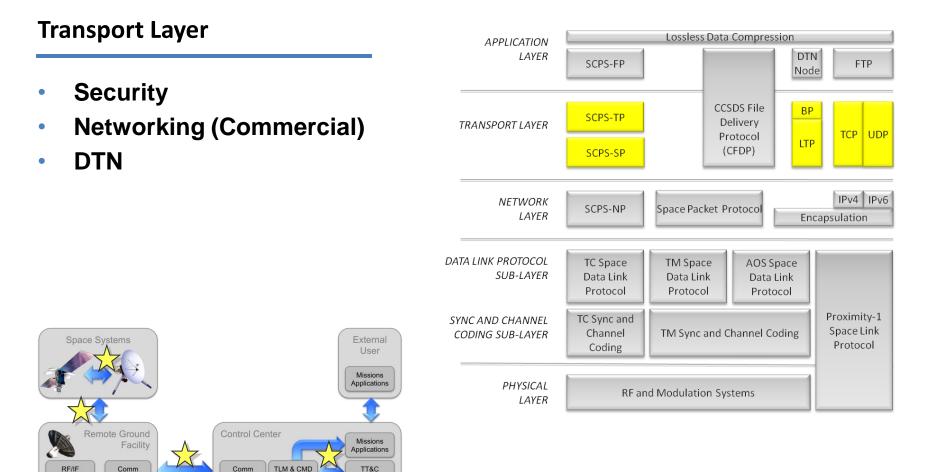
- 000 = fill
- 001 = IPv4 packets (removed)
- 100 = IPE (IP Encapsulation) Packet
- 011 = CFDP PDU
- 111 = Arbitrary aggregation of bits

- Length of Length

- 00 = Single byte fill
- 01 = 1 octet
- 10 = 2 octets
- 11 = 4 octets
- Length
- IPE Packet
 - IPE header multiplexes
 - IPv4 Uncompressed
 - IPv6 Uncompressed
 - Other header compression codes







Equipment

Equipment

Front-Ends

Applications

Equipment



• UDP

- Constant data streaming
- No acknowledgement required
- No error control
- Suitable for streaming voice and video (un-compressed), where timing is more critical than noise or dropout

• TCP

- Guaranteed delivery and packet ordering
- Acknowledgement required to advance the data window. When the data window is full, data flow stops
- Susceptible to slow throughput due to high latency and errors in transmission
- Multiple clients increase bandwidth and memory usage

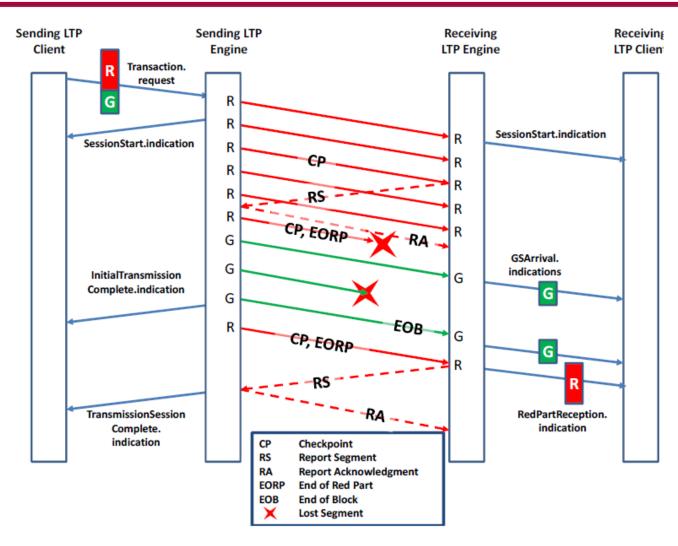


SCPS-TP

- Point-to-point data transport
- Continuous data streaming
- Selective Negative Acknowledgement (SNAK)
- Buffering to re-transmit only specific lost packet(s)
- Packet re-ordering
- Licklider Transmission Protocol (LTP) CCSDS 734.1-R-2
 - Based on RFC 5326
 - Provides reliable, single-hop transport over a non-reliable data links.
 - Uses proven concepts developed for CFDP, but implemented at the transport layer
 - CCSDS LTP PDUs are currently perceived to be delivered using either Space Packets or Encapsulation Packets
- Bundle Protocol (BP) CCSDS 734.1-R-2
 - Based on RFC 5050
 - Sits just above Transport Layer (e.g., LTP)
 - Defines end-to-end, multi-hop (store-and-forward) transfer of applicationaddressed messages between 'Bundle Nodes'
 - Intended to be used with LTP to create a Delay Tolerant Network (DTN)

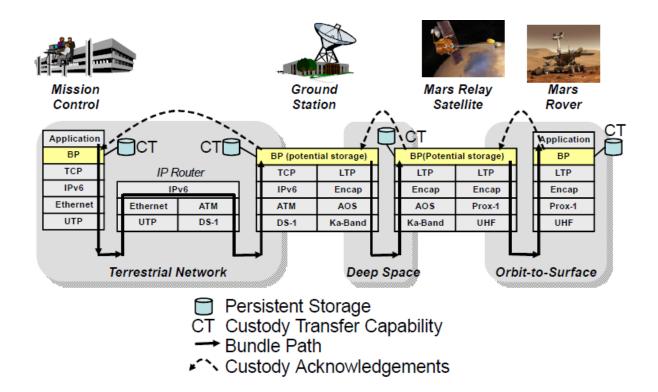


LTP Delivery Diagram





- Bundle Protocol (BP) sits above the Transport layer (e.g., LTP) and provides...
 - End-to-end, multi-hop, store-and-forward operation.
 - Application addressing using Uniform Resource Identifiers (URIs)





• <u>www.ccsds.org</u> for all your needs!