Application of ANSI Standards for Ground Transfer of Space Vehicle Command and Telemetry

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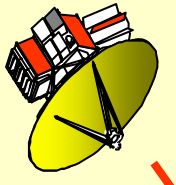
Topics

- **Background**
- **AIAA Satellite Control Network Data Transfer Committee on Standards**
- **Approach to developing ANSI/AIAA Satellite Control Network standards**
- **Target data flows supported by the ANSI/AIAA Satellite Control Network standards**
- **Use of ANSI/AIAA standards in support of additional data flows**
- **Status of the standards**
- **Acknowledgements**
- **Contact information**

Background

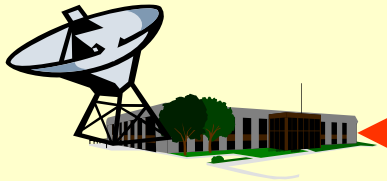
- **NASA, NOAA, and DoD signed "Satellite Operations Architecture Transition Plan" in Nov 2000**
- **SMC/SCNG (AFSCN acquisition agency) -sponsored AFSCN *Interoperability Project* (IOP)**
  - **Telemetry and command functions**
  - **Scheduling functions**
- **Upgrades to AFSCN ground systems transition to TCP/IP-based connectivity**
- **Consultative Committee for Space Data Systems (CCSDS) Space Link Extension (SLE) services selected as the basis for interoperable interfaces**
  - **SLE operates over TCP/IP**
  - ***Augmentation of SLE services required to handle AFSCN legacy data flows***
  - **IOP prototyping of SLE-based solutions from 2001 through the present**
    - **See GSAW 2007 presentation "Harmonization of USG Satellite Ground Systems" (Ledlow, Spindler, Williams)**

Interoperability Model



Satellite
(US Agency A)

TT&C Network
Ground Station
(US Agency B)



Satellite Operation Center
(US Agency A)

AIAA Satellite Control Network Data Transfer Committee on Standards (CoS)

- **Formed in the Spring of 2005 under the auspices of AIAA (serving as agent for ANSI)**
- **Purpose**
  - **Development of standards for interoperable data transfer services for US civil, military, and commercial ground control systems**
  - **Accreditation as ANSI standards**
- **Scope**
  - **Support for 6 interoperable legacy command and telemetry data flows among US Government agencies and commercial TT&C service providers**
  - **Structured to ease reusability for other data flows**

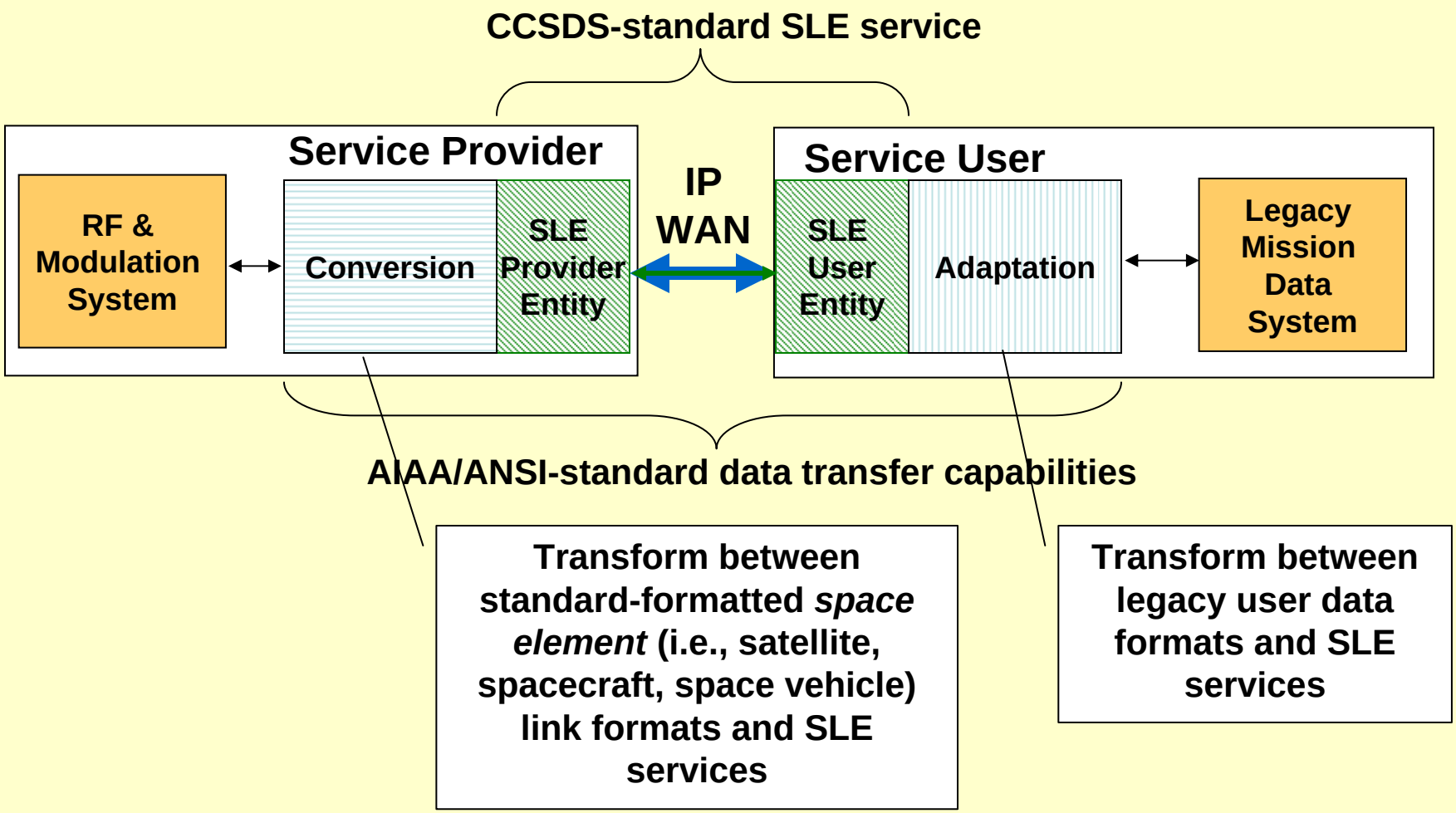
AIAA Satellite Control Network Data Transfer CoS Organizational Composition

- **User Community**
  - **SMC/SCNG (representing DoD and AFSCN)**
  - **NASA JPL (representing NASA)**
  - **Harris Corporation (representing NOAA)**
  - **Honeywell DataLynx (commercial)**
  - **Universal Space Networks (commercial)**
- **Vendor Community**
  - **Avtec Systems**
  - **L3 Communications**
  - **RTLogic!**
- **General Interest and Support**
  - **Aerospace Corporation**
  - **Global Science and Technology**
  - **Scitor Corporation**
- **Non-Voting Members**
  - **Northrop Grumman Corporation (AF SCNC; secretariat)**
  - **AIAA (liaison)**

Approach to Developing ANSI/AIAA Satellite Control Network Standards

- **Build on AFSCN IOP prototype augmentations of CCSDS SLE standards**
  - **NASA and NOAA are members of CCSDS**
- **SLE services are augmented through *adaptations* and *conversions* of SLE for legacy DoD, NASA, and NOAA space data types**

Adaptations and Conversions of CCSDS-standard SLE Services



ANSI/AIAA Standards

- ***Adaptations and Conversions of CCSDS Space Link Extension Forward Communications Link Transmission Unit Transfer Service***
  - **ANSI/AIAA S-123-2007**
  - **Defines adaptations and conversions to transport command data from mission ground facility to ground station via the SLE FCLTU transfer service**
  - **Hereinafter referred to as the *FCLTU A&C Specification***
- ***Adaptations and Conversions of CCSDS Space Link Extension Return All Frames Transfer Service***
  - **ANSI/AIAA S-124-2007**
  - **Defines adaptations and conversions to transport telemetry data from ground station to mission ground facility via the SLE RAF transfer service**
  - **Also used to support command echo**
  - **Hereinafter referred to as the *RAF A&C Specification***

Standard Data Flows Supported by the Adaptation and Conversion Standards

- **Discrete and streaming ternary symbol commanding and command echo return**
- **Streaming binary commanding and command echo**
- **Time-correlated unframed telemetry**

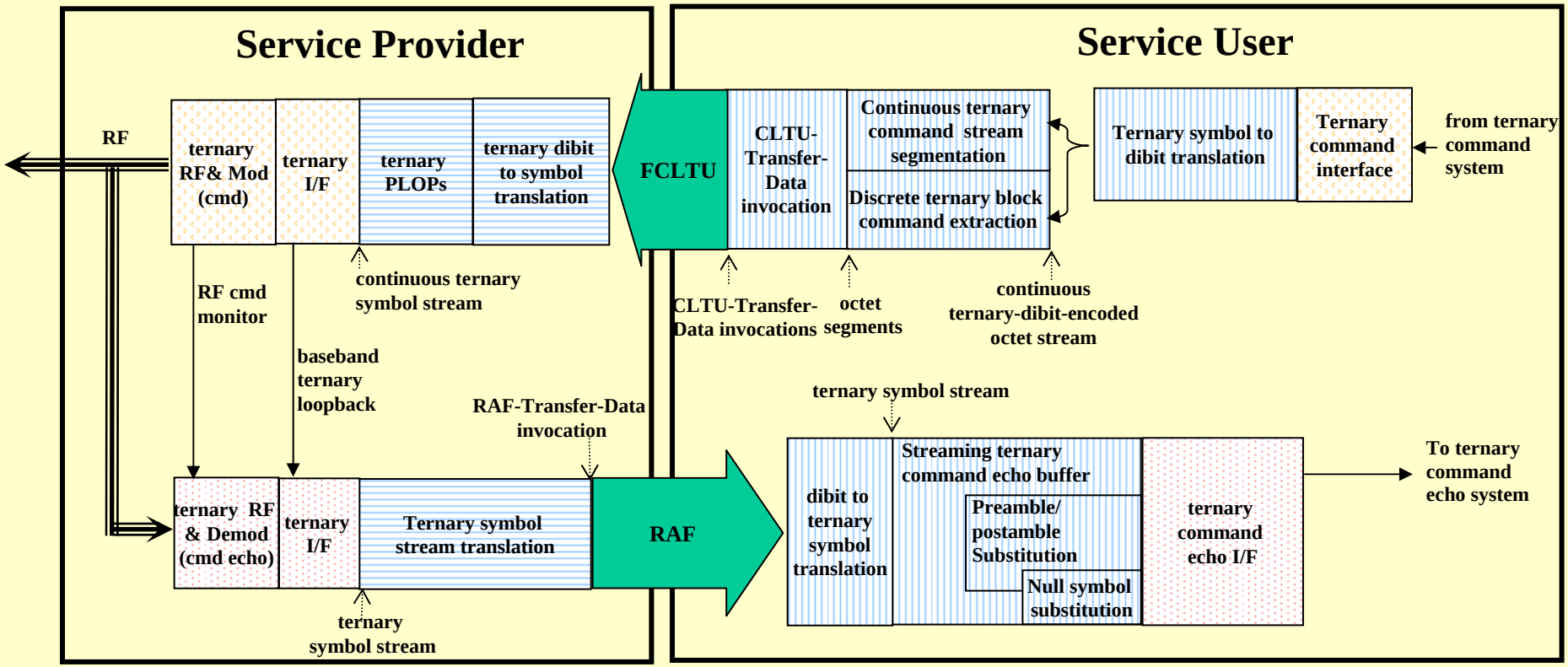
Ternary Symbol Commanding

- **Characteristics of ternary symbol commanding**
  - **'0', '1', and 'S' symbols are used to command the Space Element**
    - **AFSCN SGLS carries these symbols as FSK-modulated tones on the space link**
  - **Multiple legacy ground protocols exist for transporting these system across terrestrial networks**
- **Ternary symbol commanding capabilities of the ANSI FCLTU A&C Specification**
  - **Continuous symbol stream mode**
    - **Transfers all ternary symbols generated by the user**
    - **Used when exact symbol count spacing must be maintained between commands**
  - **Discrete ternary block commands**
    - **Transfers only *block commands*; no intermediary idle symbols**
    - **More robust and has lower bandwidth utilization than continuous mode**
  - **Maintains constant delay across WAN**
  - **Supports idle pattern of either all 'S' symbols or no ('null') symbols to be put on the uplink in the absence of user data**

Ternary Symbol Command Echo

- **Characteristics of ternary symbol command echo**
  - **Command symbols are turned around by the ground station and "echoed" to the user**
  - **Turn-around point varies by service provider**
- **Ternary symbol command echo capabilities of the ANSI RAF A&C Specification**
  - **Continuous symbol stream is transferred across the WAN via the RAF transfer service**
    - **Transfers all ternary symbols that have been output to the transmitter**
  - **Supports optional detection and removal of preambles and postambles**
  - **Supports optional capability to insert idle 'S' symbols in the absence of echoed symbols from the service provider**
  - **Supports optional substitution of 'S' symbols for 'null' symbols in echoed stream**

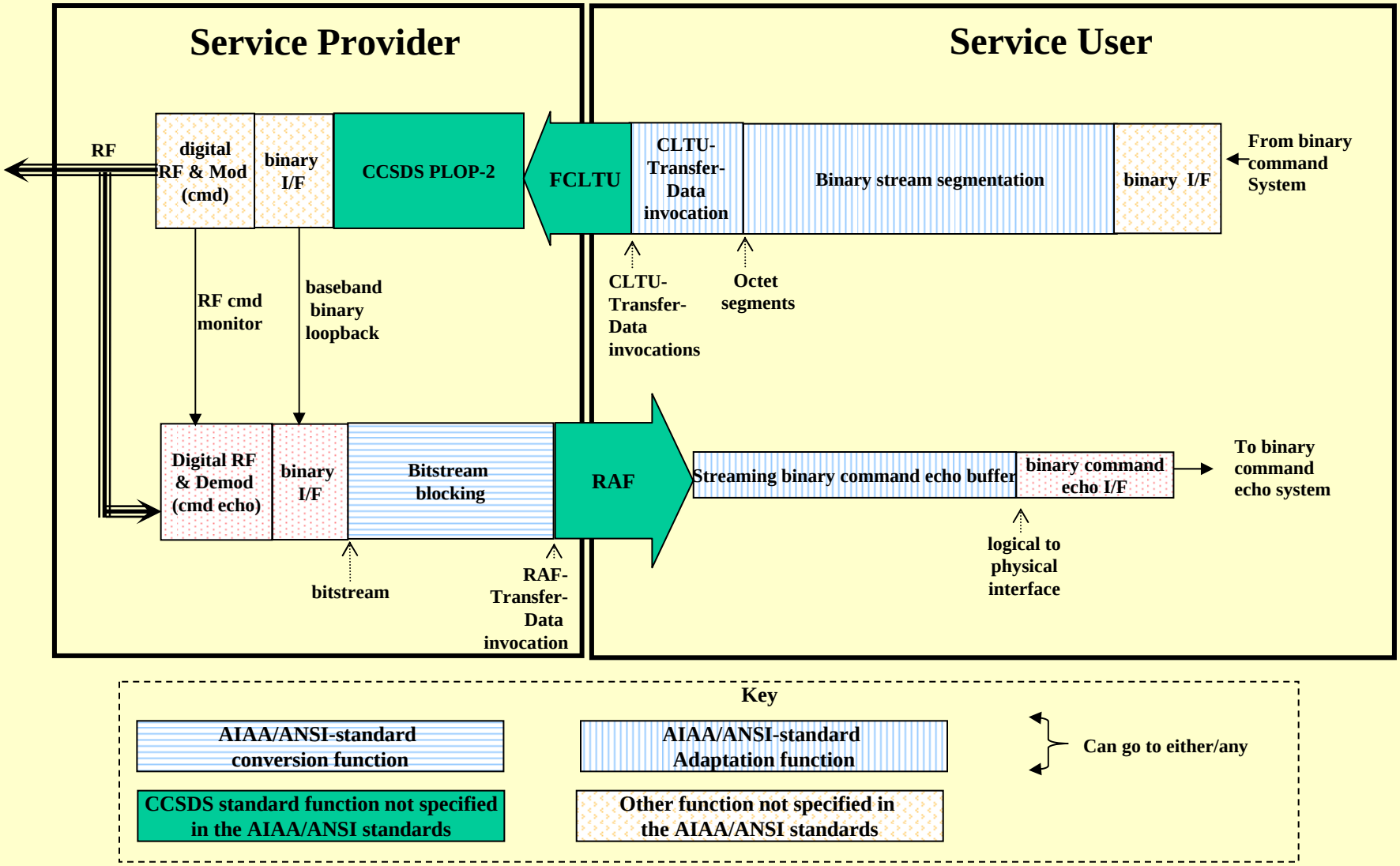
Ternary Commanding and Command Echo



Binary Commanding and Command Echo

- **Characteristics of binary commanding (as supported by the current ANSI standards)**
  - **Continuous stream of bits (0/1) is used to command the Space Element**
  - **Command structure within the bitstream is not identified**
  - **Typically, these bits are BPSK-modulated onto the space link**
- **Binary commanding capabilities of the ANSI FCLTU A&C Specification**
  - **Transfers continuous bitstream containing all bits generated by the user**
  - **In the absence of user-generated binary data, uplink is modulated with alternating 0/1 idle pattern (CCSDS-standard)**
- **Binary command echo capabilities of the ANSI RAF A&C Specification**
  - **Continuous bitstream is transferred across the WAN via the RAF transfer service**
  - **Supports optional capability to insert alternating 0/1 idle pattern in the absence of echoed data from the service provider**

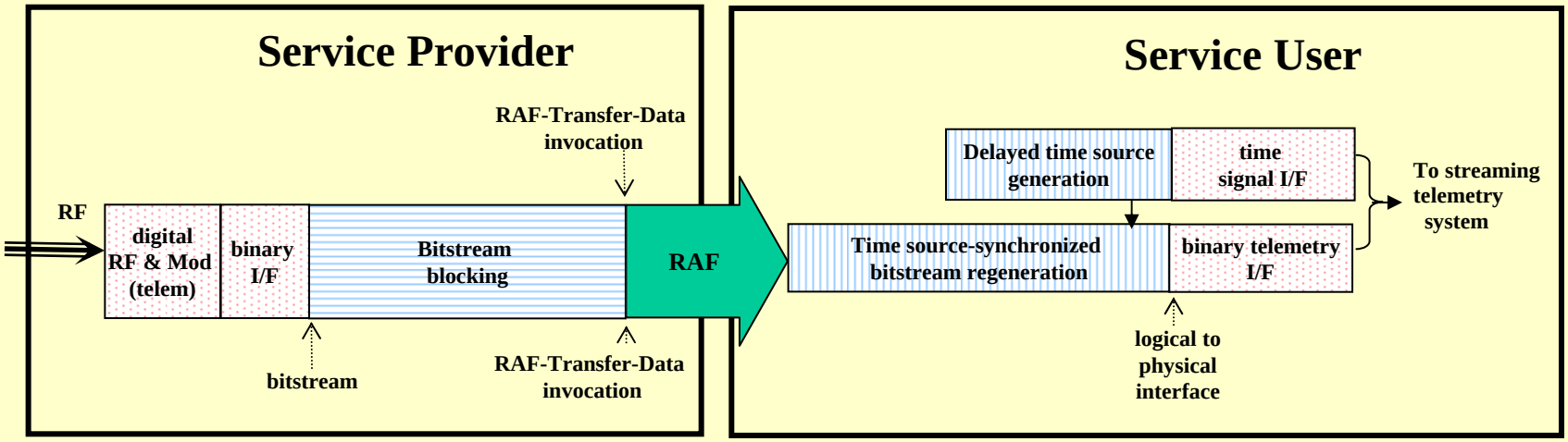
Binary Commanding and Command Echo

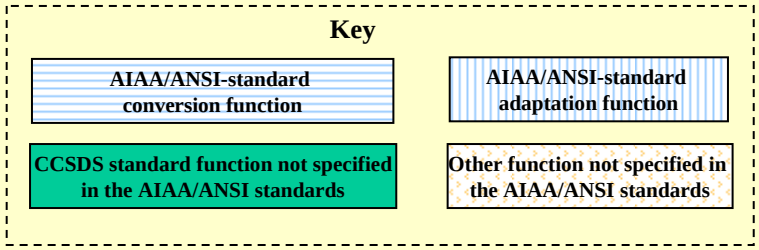


Time-Correlated Unframed Telemetry

- **Characteristics of time-correlated unframed telemetry**
  - **Continuous telemetry bitstream**
  - **Framing structure within the bitstream is not identified**
  - **Release of bits to user telemetry system must be correlated to a continuous time signal (e.g., IRIG-B) that represents the original time of receipt at the ground station**
- **Time-correlated unframed telemetry capabilities of the ANSI RAF A&C Specification**
  - **Continuous bitstream is segmented, transferred across the WAN via the RAF transfer service, and reserialized for input to the user telemetry system**
  - **Bits are clocked out to the user telemetry system correlated to a time signal that replicates the time of receipt at the ground station**
  - **Supports optional capability to insert alternating 0/1 idle pattern in the absence of telemetry from the service provider**

Time-Correlated Unframed Telemetry

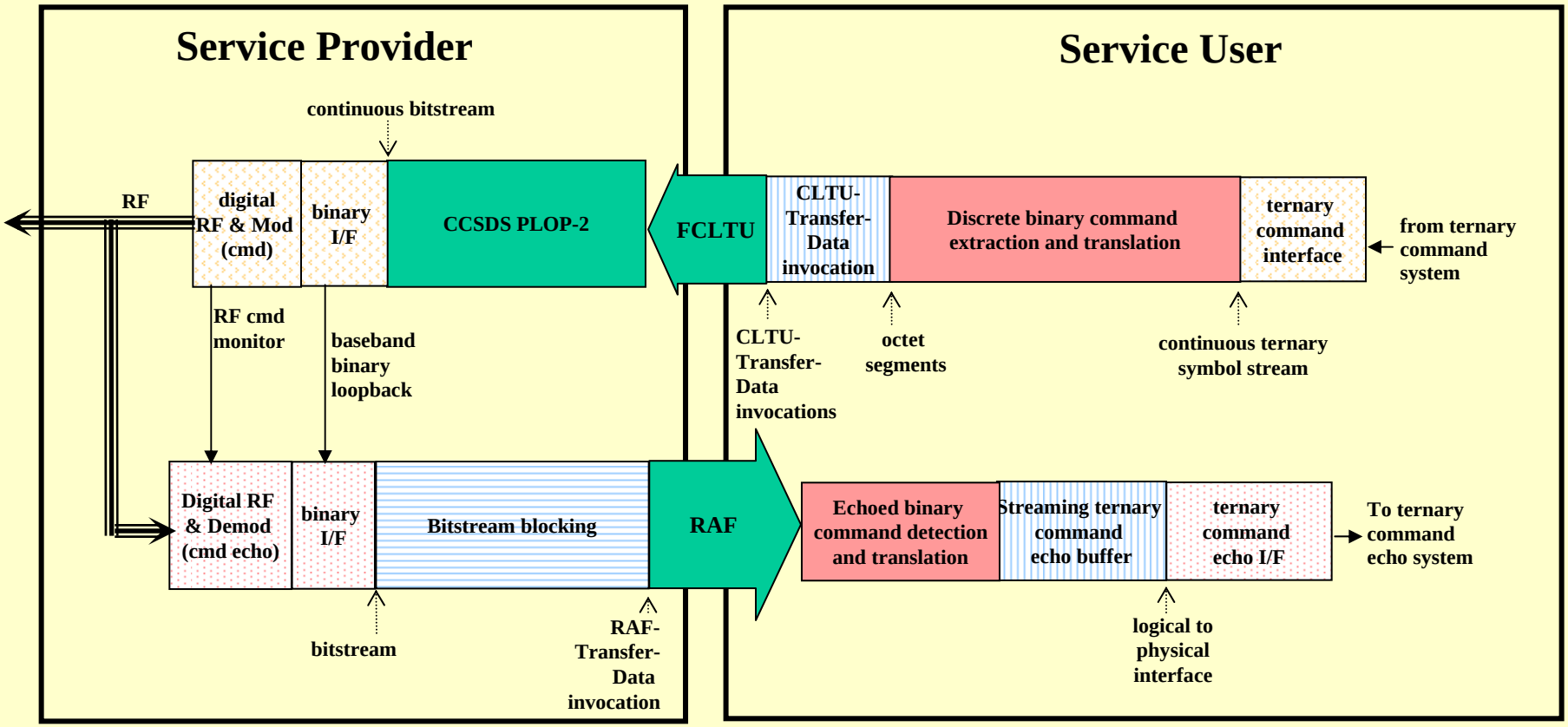


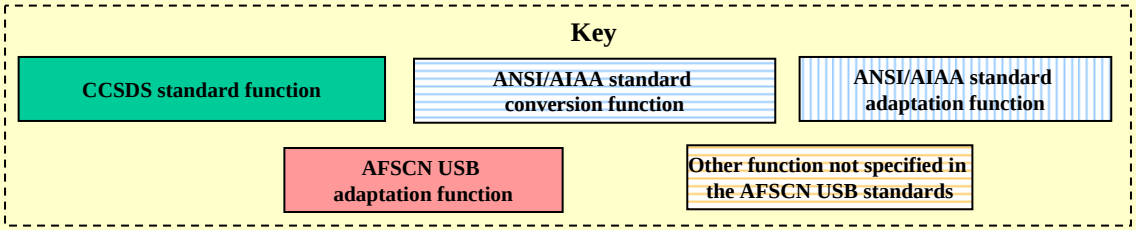


Use of ANSI/AIAA A&C Standards in Support of Additional Data Flows

- **Adaptation and Conversion functions may be used as basis for derived specifications that support other data flows over SLE transfer services**
  - **E.g., subset of time-correlated telemetry functions can be used to delivery “unframed” telemetry**
- **Current activity to derive new AFSCN “ternary over binary” command and command echo services**
  - **Supports a new class of space elements that use binary representation of ternary signals on the uplink**
    - **Supports migration to Unified S-Band (USB)**
  - **Characteristics of ternary-over-binary commanding**
    - **Ternary commands are converted to binary commands on the Service User side**
    - **Binary commands are transferred across WAN and uplinked**
    - **Binary commands are translated back to ternary onboard the space element**

Ternary-Over-Binary Commanding and Command Echo





Status

- First public review occurred during the summer of 2006
- Currently in final public review for accreditation as ANSI standards (ends 2 April 2007)
  - No new review comments to-date
  - To review drafts, please contact Craig Day: craigd@aiaa.org
- Publication on AIAA standards website expected by 13 April 2007
  - FCLTU A&C (ANSI/AIAA S-123-2007) http://www.aiaa.org/content.cfm?pageid=363&id=1643
  - RAF A&C (ANSI/AIAA S-124-2007) http://www.aiaa.org/content.cfm?pageid=363&id=1644
- In-progress draft MOU among AF SMC/SCNG, NASA, and NOAA
  - US Government ground control networks to migrate toward CCSDS SLE and the associated ANSI standards for interoperability

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  - **Technical development of the ANSI/AIAA standards**
  - **Documentation of the ANSI/AIAA standards**
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  - **Lou Moss - NOAA (Harris Corporation)**
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  - **John Vaccarino – Honeywell DataLynx**
  - **Ron Woll – Scitor Corporation**

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