Air Force Satellite Control Network Interoperability Progress Report

Ground Systems Architecture Workshop
31 March 2004
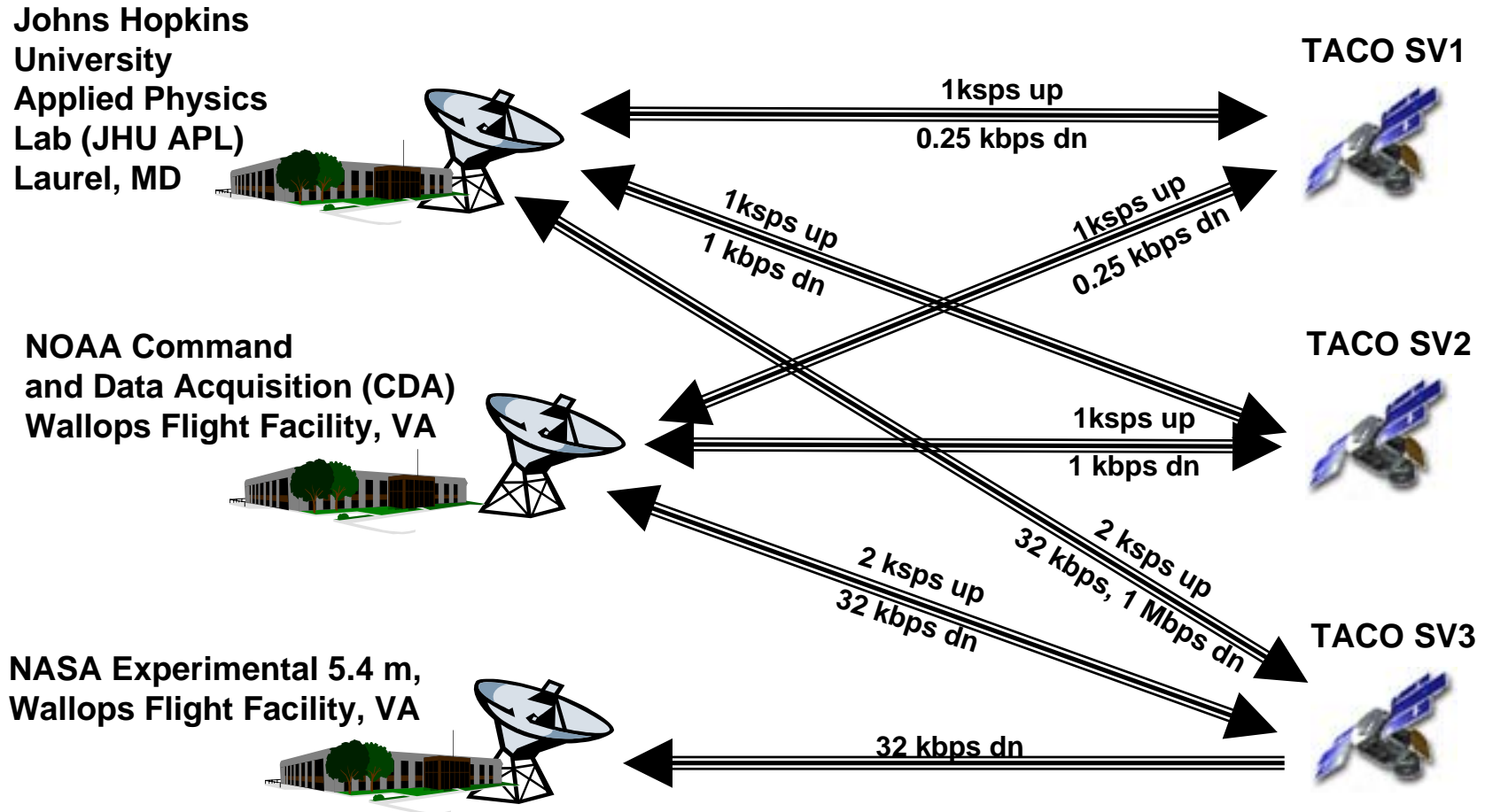
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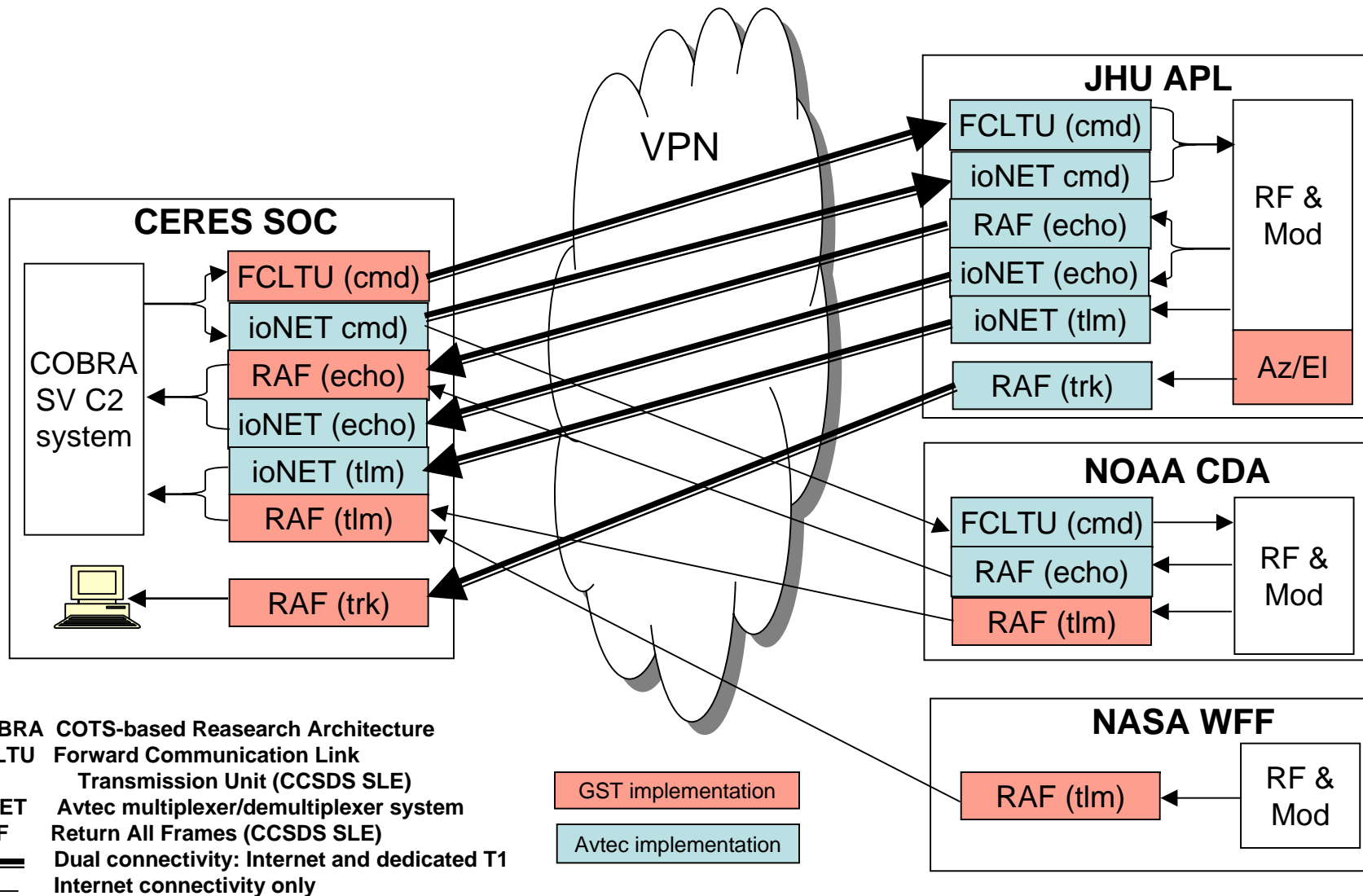   - Spring-Summer 2004

AFSCN Interoperability Project Background

- Project is managed by SMC/RN as part of AF Satellite Control Network modernization program
- Goals
  - Adopt/define services that will facilitate interoperation among US government satellite ground control networks
  - Base services on packet-switched network technology to continue the AFSCN's migration from circuit-switched technology
- Approach
  - Adopt existing space data standards where available and appropriate
  - Adapt standards where necessary
  - Feed enhancements back to standards community for broader acceptance
  - Feed results into SCNC Architecture development
- Multi-phase study and demo project started in 2001
  - Phase 1: Standards assessments and lab tests
  - Phase 2: Field tests with AF R&D assets
  - Phase 3: Field tests with commercial and civil agency ground stations
  - Phase 4: Develop standards profile for national infrastructure, field test vendor implementations

Phase 3 Ground Stations and Space Vehicles

Johns Hopkins University Applied Physics Lab (JHU APL) Laurel, MD

NOAA Command and Data Acquisition (CDA) Wallops Flight Facility, VA

NASA Experimental 5.4 m, Wallops Flight Facility, VA

TACO SV1

TACO SV2

TACO SV3

1ksps up
0.25 kbps dn

1ksps up
1 kbps dn

1ksps up
0.25 kbps dn

1ksps up
1 kbps dn

2 ksps up
32 kbps, 1 Mbps dn

2 ksps up
32 kbps dn

32 kbps dn

Phase 3 SOC-Ground Station Interfaces: Telemetry, Command, Echo & Tracking

VPN

JHU APL

FCLTU (cmd)
ioNET cmd)
RAF (echo)
ioNET (echo)
ioNET (tlm)
RAF (trk)

RF & Mod

Az/El

CERES SOC

FCLTU (cmd)
ioNET cmd)
RAF (echo)
ioNET (echo)
ioNET (tlm)
RAF (tlm)

COBRA
SV C2
system

RAF (trk)

NOAA CDA

FCLTU (cmd)
RAF (echo)
RAF (tlm)

RF & Mod

NASA WFF

RAF (tlm)

RF & Mod

COBRA	COTS-based Reasearch Architecture
FCLTU	Forward Communication Link
	Transmission Unit (CCSDS SLE)
ioNET	Avtec multiplexer/demultiplexer system
RAF	Return All Frames (CCSDS SLE)
━━━	Dual connectivity: Internet and dedicated T1
───	Internet connectivity only

GST implementation

Avtec implementation

Phase 3 Service Management Interfaces

JHU APL

DataLynx Ops Center
Columbia, MD

DataLynx Sched/Mgmt system

Email client & SLE-SM provider application

Internet

1/sec service status messages

NASA WFF

WFF Sched/Mgmt system(s)

Email client & SLE-SM provider application

Service Request and Response XML file email attachments

CERES SOC

Email client

Service Request and Response XML files

- SLE-SM SOC application
- Service status display

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Summary of Phase 3 Results*

- Telemetry
  - Use of TCP and data buffering (~2-4 seconds additional delay) provided reliable delivery of the serial telemetry stream
  - Telemetry TDC of SLE RAF implementation was accurate to within several tens of milliseconds, but not required 1 msec
  - ioNET TDC was accurate to within 1 msec, but 170kbps digitized IRIG-B signal deemed overly consumptive of bandwidth
- Command
  - Time-critical commanding was successful using both the FCLTU and ioNET based implementations
- Command echo
  - Command echo was successful using both the RAF and ioNET based implementations
- Service Management
  - Contacts scheduled using SLE standard format schedule requests/responses
  - Ad hoc methods needed for tracking data and RTS status

* Full results are documented in the *SCNC Interoperability Phase 3 Project Report*, Honeywell Technology Solutions, Inc. 28 October 2003, prepared by Lance Williams
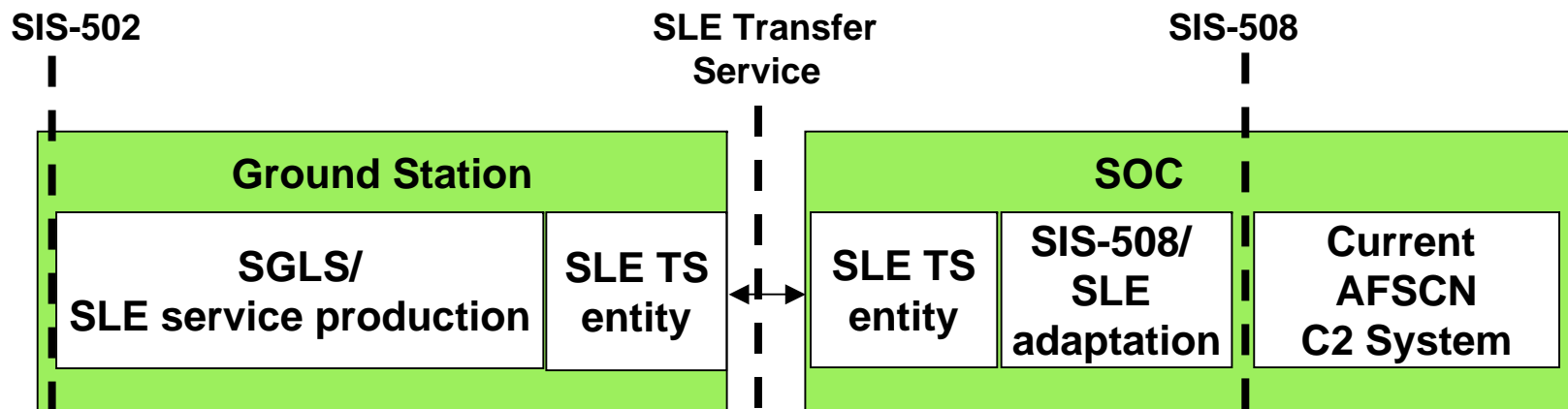
Transition from Legacy to Standards-Based Infrastructure (1 of 3)

- 3 reference points for a transition architecture
  - RF & modulation interface with the SV
    - Currently SIS-502D
  - New standards-based interoperable interface between ground station and SOC
  - Telemetry, command, and command echo interface as seen by the user C2 system
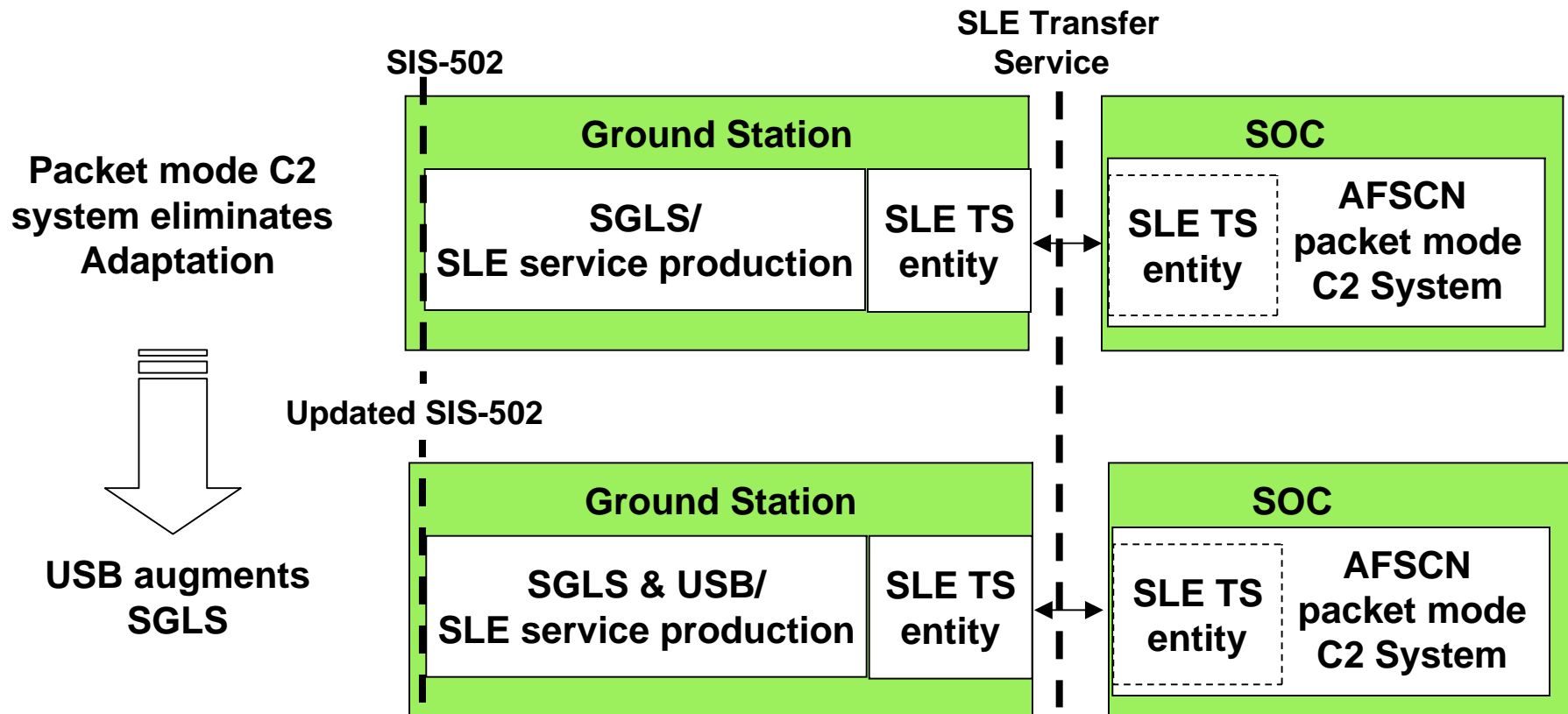   - Currently SIS-508E

SIS-502   **interoperable I/F**   **SIS-508**

Ground Station   **SOC**

Range Segment   **Communication Segment**   **Current AFSCN C2 System**

Remains in place as long as compliant SVs are flying

Put in place ASAP

Can be replaced or eliminated as SOC technology and designs evolve

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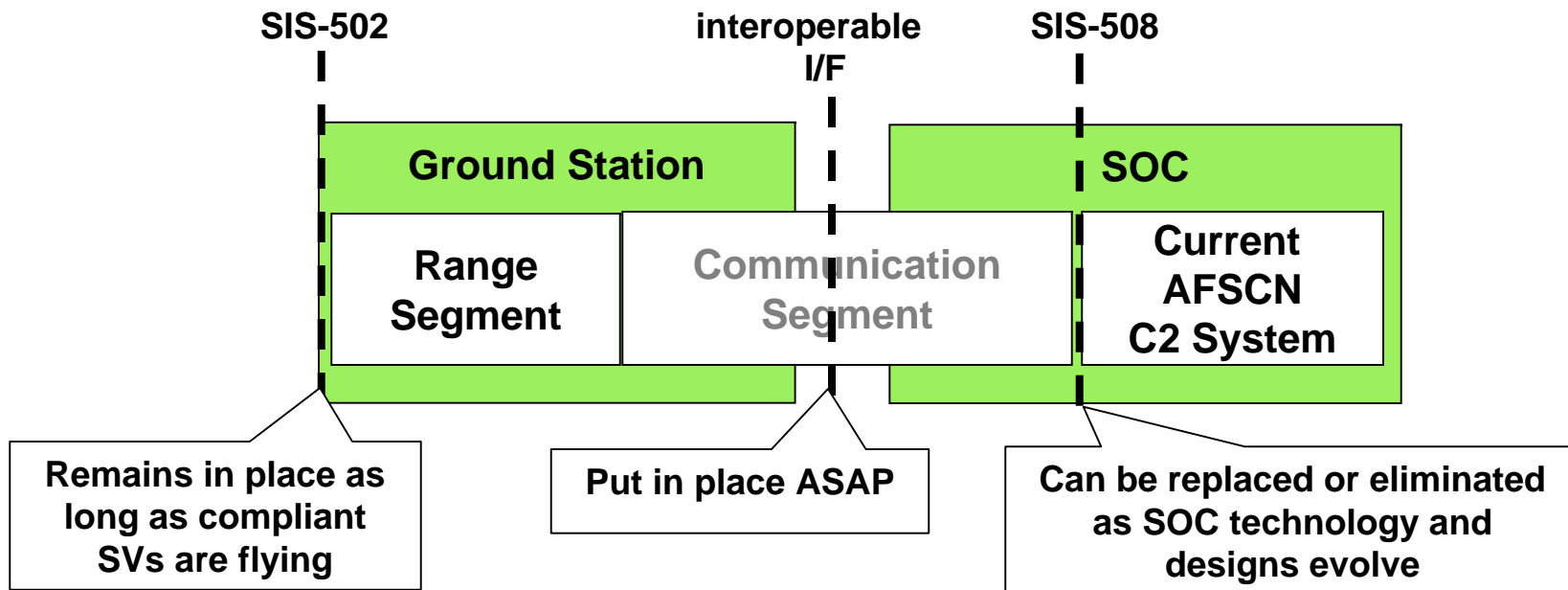
Transition from Legacy to Standards-Based Infrastructure (2 of 3)

- 3 sets of "standards" to enable interoperability for AFSCN-client SVs using SLE transfer services
  - SLE service *production* specifications that define the processing required to transform the data transferred by the SLE transfer service to/from RF
    - Currently SIS-502D
  - SLE transfer service specifications provide the interoperable interface
  - SLE service *adaptation* specifications that define the required transformations between SLE and legacy user interfaces
    - Currently SIS-508E

SIS-502		SLE Transfer Service	SIS-508	
Ground Station			**SOC**	
SGLS/ SLE service production	SLE TS entity	← →	SLE TS entity	SIS-508/ SLE adaptation	Current AFSCN C2 System

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Transition from Legacy to Standards-Based Infrastructure (3 of 3)

- Adaptations eventually disappear as SOC designs natively incorporate SLE transfer services
- SLE service productions evolve with SV evolution

Packet mode C2 system eliminates Adaptation

SLE Transfer Service

SIS-502

Ground Station

SGLS/ SLE service production | SLE TS entity

SOC

SLE TS entity | AFSCN packet mode C2 System

USB augments SGLS

Updated SIS-502

Ground Station

SGLS & USB/ SLE service production | SLE TS entity

SOC

SLE TS entity | AFSCN packet mode C2 System

Phase 4 Architecture and Plans

- Use Phase 3 results to tune the service architecture

- Implement, demonstrate, and test the resulting set of services in vendor-supported hardware and software

- Develop specifications for the productions, adaptations, and transfer service modifications (where necessary)

- Build national and international consensus for support of these services
  - i.e., standardization

Phase 4 Implementation of SLE Services

- Telemetry
  - Develop new Return All Data (RAD) SLE transfer service
    - Supports AFSCN serial telemetry
    - Supports civil space needs not met by current RAF SLE service
  - Transfer of digital timestamps (not digitized analog IRIG-B)
- Command
  - FCLTU service used to transfer discrete commands
    - No legacy (ADCCP, EXU) framing
    - Idle stripped at SOC, re-generated at ground station
  - FCLTU service used to transfer all command symbols using "streaming" option
- Command Echo
  - RAD service used to transfer serial stream of command echo dibits
- Service Management
  - Continue exploring use of SLE scheduling and configuration standards

Building National and International Consensus

- Telemetry
  - Adopt RAD specification and production as CCSDS Recommendations
    - CCSDS Birds of a Feather (BOF) group formed
  - Adopt time-correlated telemetry adaptation in 508-legacy AFSCN SOCs
- Command
  - Adopt SGLS command production for FCLTU as US national interoperability capability
    - USTAG13 BOF group formed
  - Adopt SGLS discrete commanding adaptation in 508-legacy AFSCN SOCs
- Command echo
  - Adopt SGLS command echo production for RAD as US interoperability capability
  - Adopt SGLS command echo adaptation in 508-legacy AFSCN SOCs

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  – Lance Williams, Interoperability project lead
  – JHU APL ground station
- AF Center for Research Support (CERES)
- NASA WFF and NOAA Wallops CDA ground stations
- Avtec Systems
- General Dynamics Advanced Information Systems

Phase 4 Participants

- U.S. Air Force Space and Missile Systems Center Satellite and Launch Control SPO (SMC/RN)
- Satellite Control Network Contract
- The Aerospace Corporation
- GST, Inc.
- AF Center for Research Support (CERES)
- Avtec Systems
- NOAA WFF
- GD-AIS
- L3Com
- RTLogic
- JPL, NASA