

# ***FUTURE INTEROPERABLE SATELLITE CONTROL NETWORKS – COMMUNICATIONS ARCHITECTURE AND ISSUES***

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**Prepared By  
JOHN C. CHIANG, Ph.D.  
(310) 336-5124  
John.c.chiang@aero.org**

**THE AEROSPACE CORPORATION  
EL SEGUNDO, CALIFORNIA**

# TOPICS

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## ✓ ARCHITECTURE

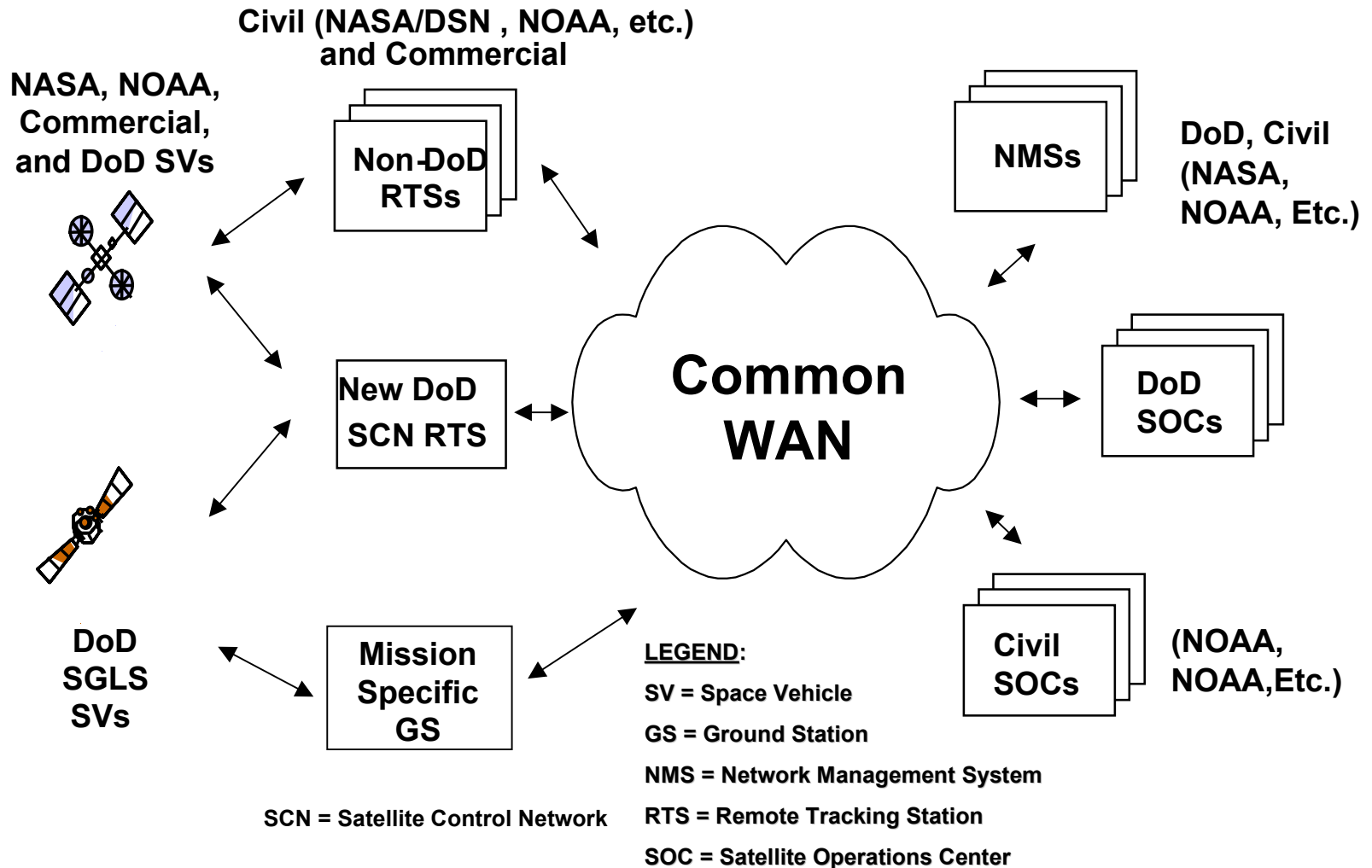
- Goals
- Interoperable Satellite Control Network (SCN) Concepts
- SCN Open Interfaces

## ISSUES

- DoD Unique Issues
- Heritage/ Backward Compatibility
- Interoperability
- WAN Alternatives
- Security
- Quality of Service
- Candidate Standards

# DESIRED FUTURE SCN ARCHITECTURE

## Communications Concept



# **COMMUNICATIONS NETWORK DESIGN GOALS**

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## **❑ OBJECTIVES:**

- **Enhance Interoperability among DoD, Civil, and Commercial Satellite Control Networks**
- **Reduce Upgrade Grade Risks to Cost, Schedule, and Performance by Greater Use of COTS Equipment and Services**
- **Improve Efficiency and Performance to Meet Future Requirements**

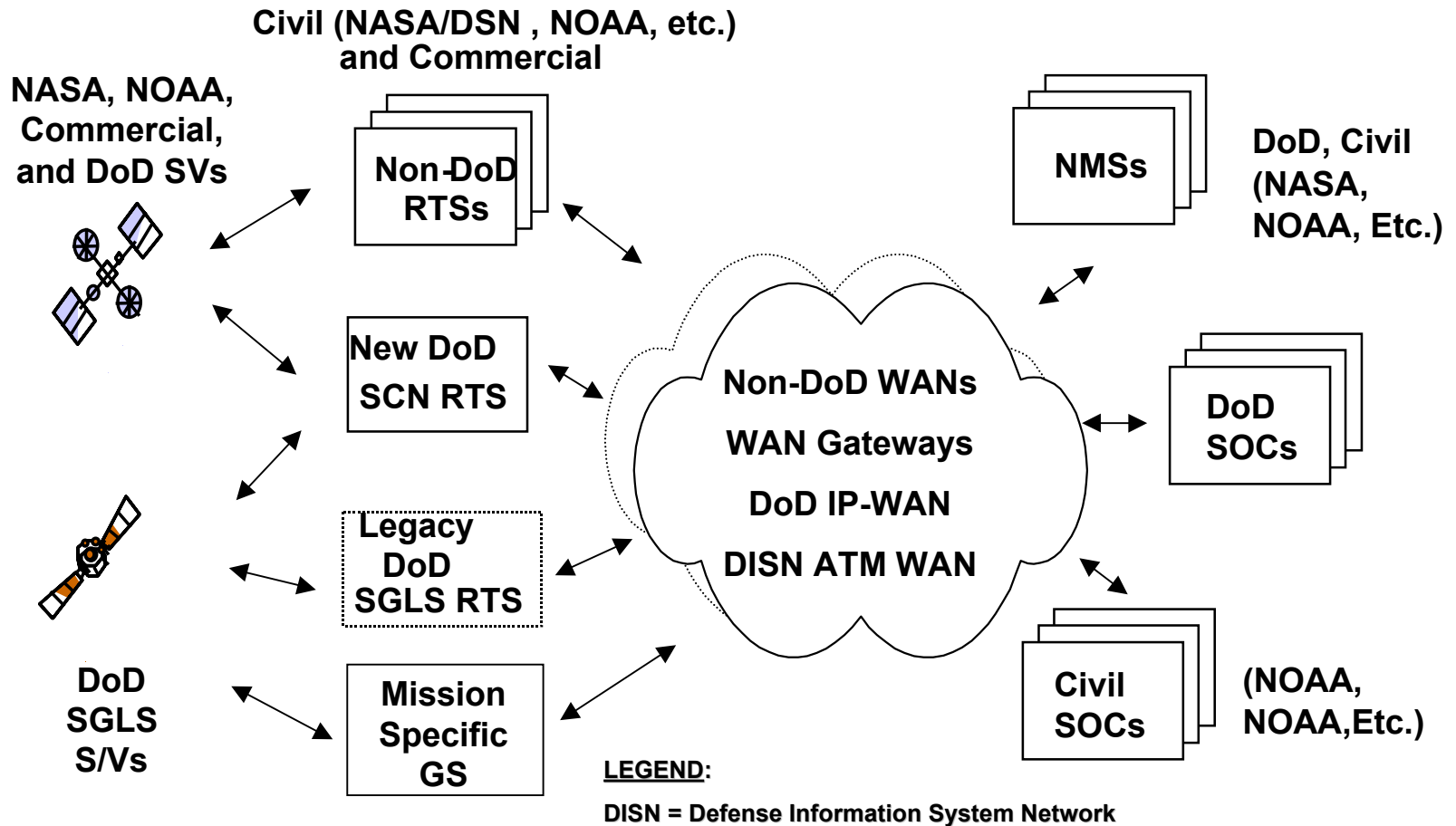
## **❑ PROVIDE STANDARD WAN INTERFACE**

## **❑ SUPPORT MULTIPLE PROTOCOLS**

## **❑ PROVIDE STANDARD SCHEDULING AND NET STATUS INTERFACES**

# INTEROPERABLE SCN IN TRANSITION

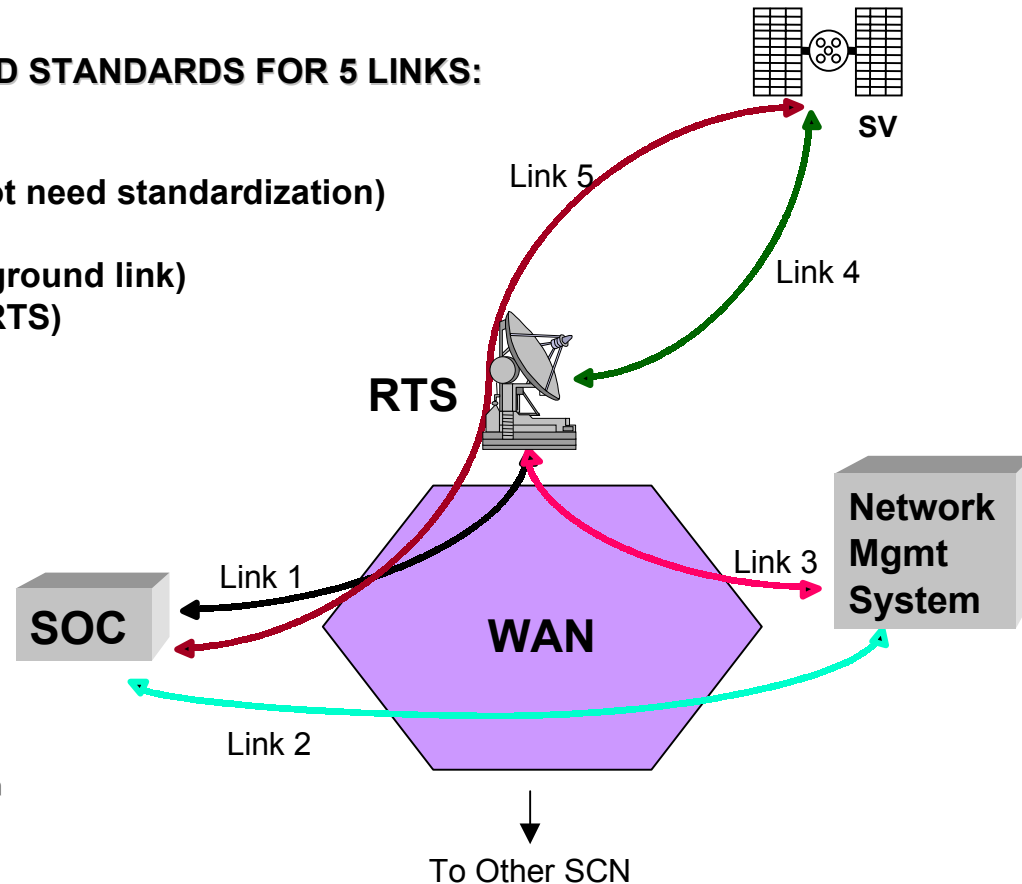
## Communications Concept



# SCN OPEN INTERFACES

## DETERMINE PROTOCOLS AND STANDARDS FOR 5 LINKS:

- LINK 1: RTS-SOC
- LINK 2: SOC-NMS (does not need standardization)
- LINK 3: RTS-NMS
- LINK 4: SV-RTS (space to ground link)
- LINK 5: SV-SOC (through RTS)



### LEGEND:

SV = Space Vehicle  
NMS = Network Management System  
RTS = Remote Tracking Station  
SOC = Satellite Operations Center  
SCN = Satellite Control Network

# TOPICS

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## ARCHITECTURE

- **Goals**
- **Interoperable Satellite Control Network (SCN) Concepts**
- **SCN Open Interfaces**

## ✓ ISSUES

- **DoD Unique Issues**
- **Heritage/ Backward Compatibility**
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# ***DOD UNIQUE ISSUES***

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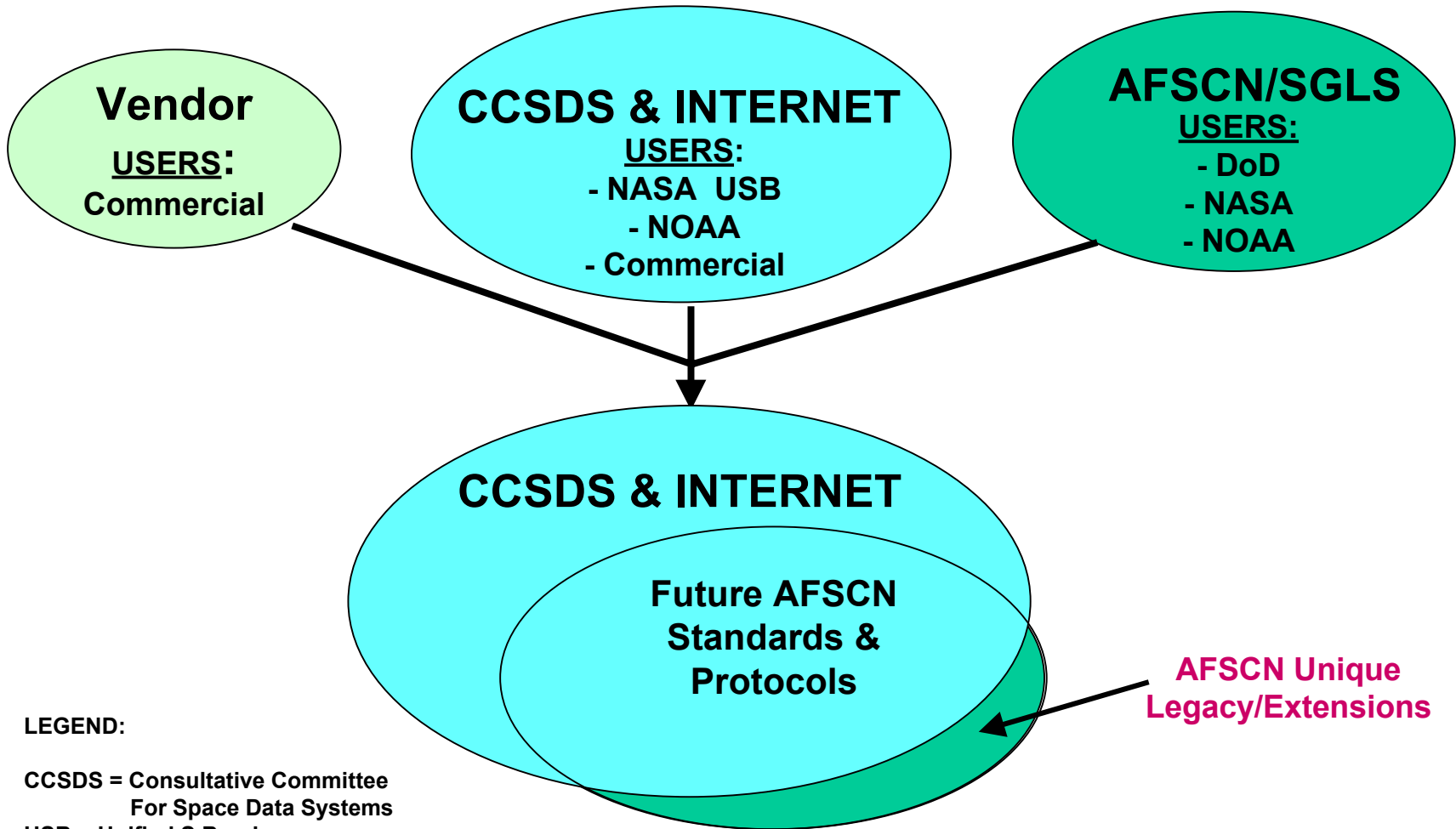
## **□ TIME AND DATA CORRELATION**

- **Users Require Bit-Serial Telemetry Data Be Time Tagged**
- **This Should Be Done on the SV; But Most DoD SVs Do Not Have This Capability**
- **Complicating the Issue, the SV Encrypts the Telemetry Data**
- **Currently, the RTS Provides the Telemetry Receive Time**
- **The Challenge Is to Append the RTS Telemetry Receive Time to the Decrypted, Constant-Rate Telemetry Data at the SOC**
  - This process/ issue is known as Time and Data Correlation (TDC)

## **□ TIME CRITICAL COMMANDING**

- **Certain DoD Missions Require Commands Be Transmitted at Precise Times**

# HERITAGE/BACKWARD COMPATIBILITY

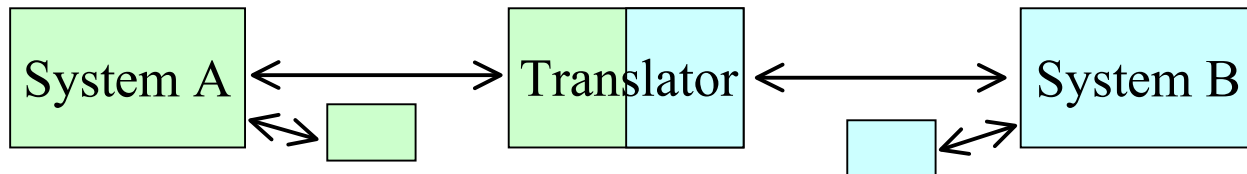


**LEGEND:**

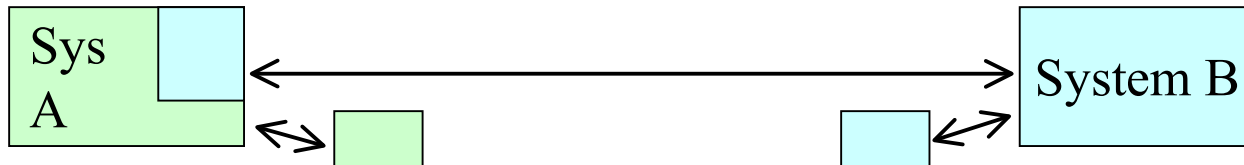
CCSDS = Consultative Committee  
For Space Data Systems  
USB = Unified S Band

# APPROACH TO INTEROPERABILITY

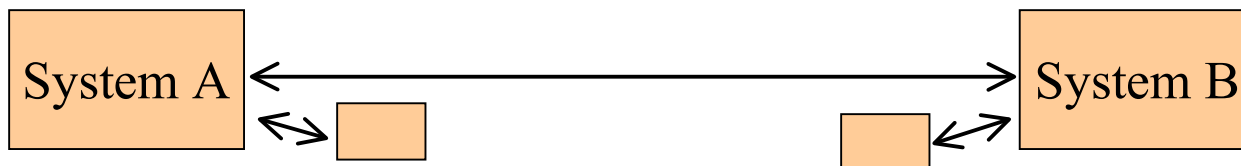
- **Translator**



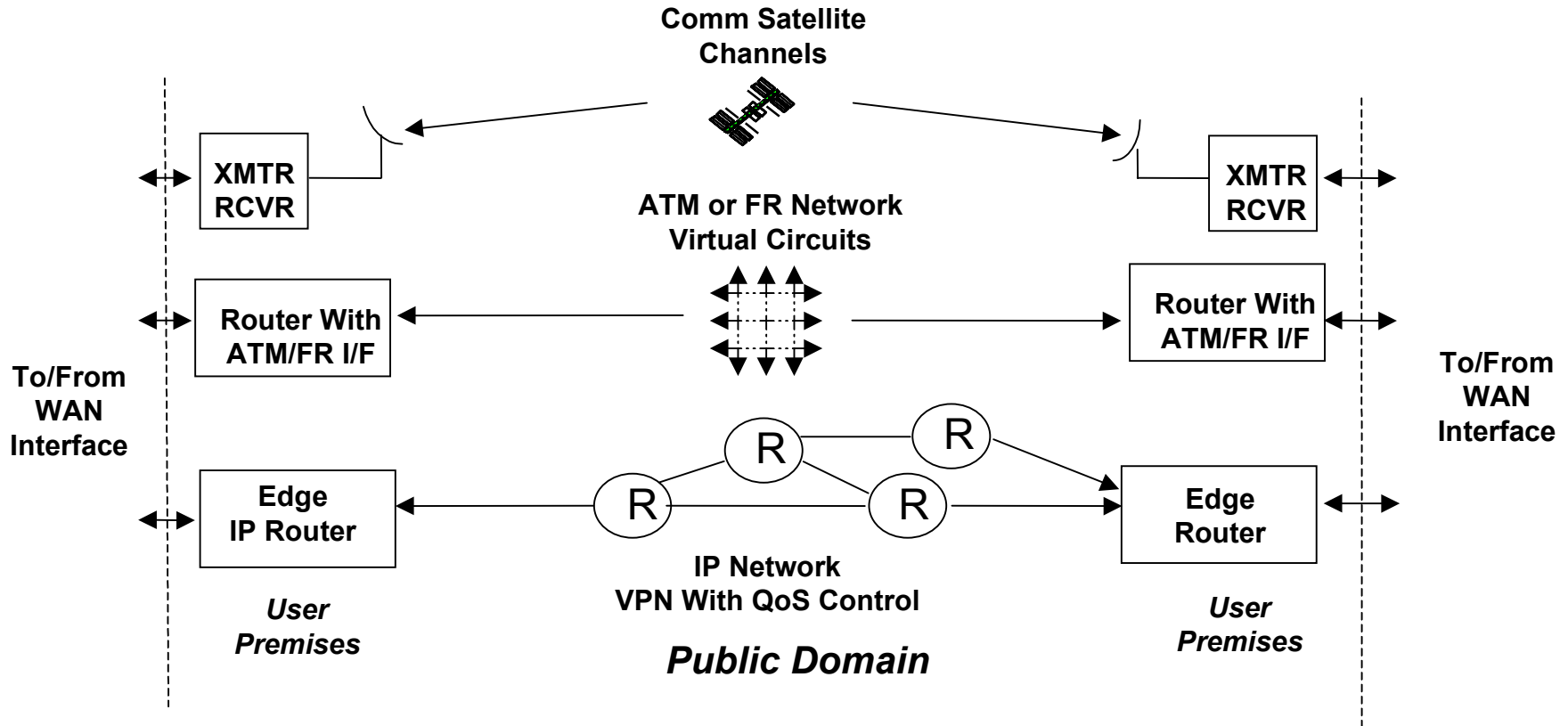
- **Implement the other side**



- **Implement new standards – “The Goal”**



# WAN ALTERNATIVES



ATM = Asynchronous Transfer Mode    FR = Frame Relay    I/F = Interface  
 FT1 = Fractional T1    R = Router  
 VPN = Virtual Private Network    QoS = Quality of service

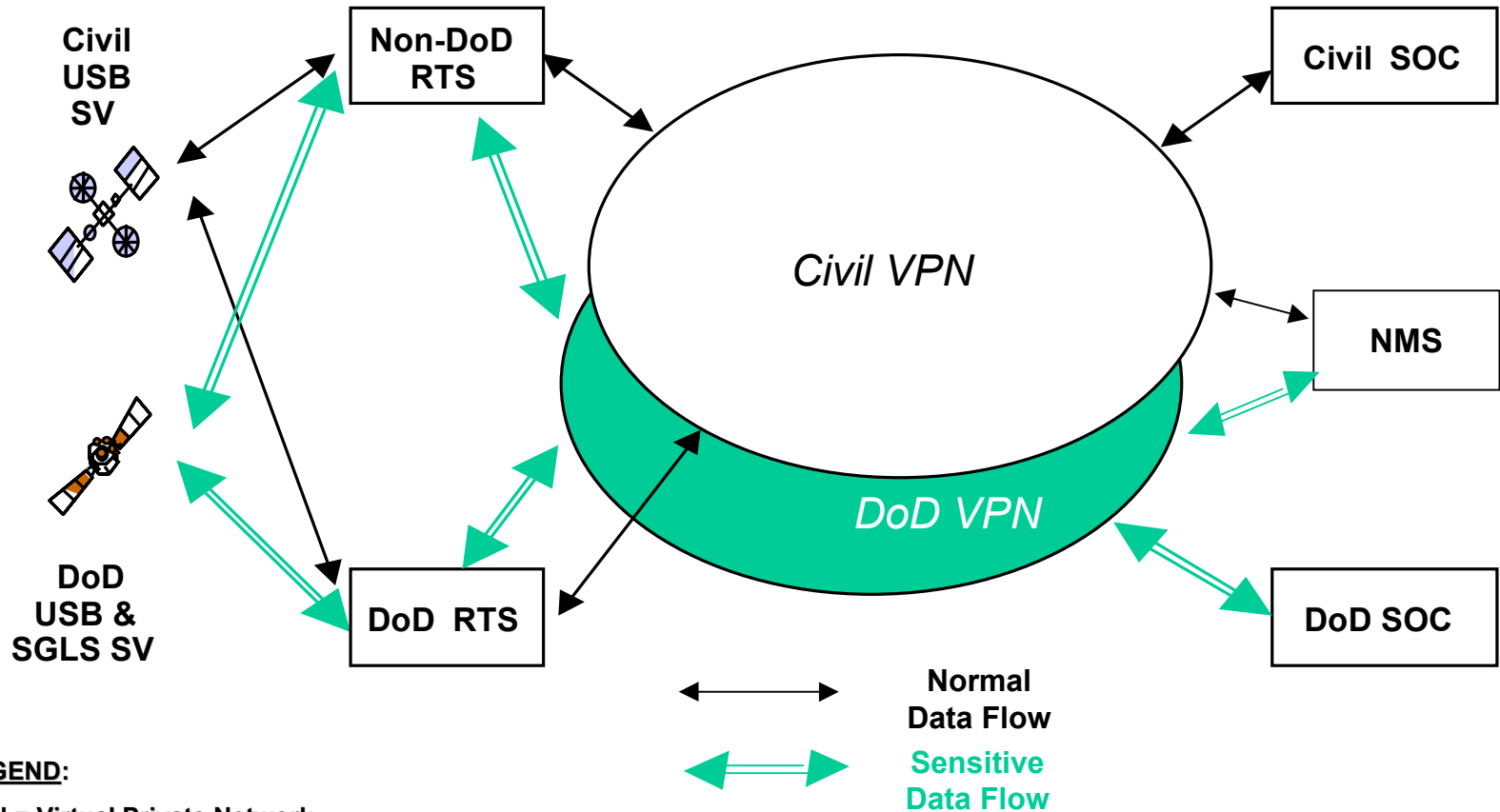
\* All elements shown on this page are either COTS or leased

# SECURITY ISSUES

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- ❑ **NATIONAL SECURITY PROGRAMS DEMAND END-TO-END ENCRYPTION**
  - Current Equipment Supports Only Physical / Application Layers
  - Need New Equipment for Link and Network Layers
- ❑ **TRANSMISSION SECURITY ACROSS WAN**
  - Handling of DoD Data in Non-DoD Premises
  - Stand-alone Devices (e.g., KG-75) vs. Integrated (e.g., IP-SEC Option)
  - Key Distribution
- ❑ **ACCESS CONTROL**
  - Performed in Open Architecture
- ❑ **SERVICE AVAILABILITY**
  - Must Limit Denial-of-Service Attacks
- ❑ **HANDLING OF SENSITIVE TRAFFIC**
  - Separate by Mission or Sensitivity

# SEPARATE VPN CONCEPT FOR FUTURE WAN



**LEGEND:**

VPN = Virtual Private Network

# QUALITY OF SERVICE

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## PACKET DELAY AND DELAY VARIATION

- Use Packet Prioritization to mitigate

## PACKET ERROR RATE

- Real-Time Data Use RTP/UDP/IP with FEC if Needed
- Less Time Sensitive Data Use TCP/IP for Complete Reliability

## PACKET LOSS RATE

- Use Packet Prioritization to mitigate

# CANDIDATE STANDARDS

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- **SPACE – GROUND LINK**
  - CCSDS telecommand and telemetry
  - Bandwidth Efficiency: SQPSK, FQPSK, GMSK
- **SOC – RTS**
  - Basic WAN transport: TCP/IP, ATM, Sonet
  - Space Link Extension (data transfer plus management)
- **SECURITY:**
  - Physical/link level crypto
  - IP-SEC, or SCPS SP, NSA HAIPE, Fastlane
- **SOC – SPACE VEHICLE (end-to-end)**
  - Internet standards (for higher layer protocols)
  - SCPS (optimized variant of Internet protocols)
  - CCSDS File Delivery Protocol
  - CCSDS Data Compression, Time Codes, Navigation Data
- **STATUS AND SCHEDULING**
  - Orbit Data formats

# ***FUTURE DIRECTION***

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## **❑ EVALUATE CANDIDATE STANDARDS**

- **Testing SLE Support for DoD Missions**
- **Use of CCSDS Space Link for Some DoD Missions**
- **Testing TCP/IP for Time Critical Mission**

## **❑ DEMONSTRATE EVOLUTIONARY PATH**

- **WAN Interface (WANIF) at RTS that Supports Legacy and New Standards**
- **Interoperability Test with Civil Space Assets**

# ACKNOWLEDGMENTS

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**Other Contributors: Wayne Otsuki, Dr. Bill Deng, Dr. Ashok Mathur, Dr. Debora Downs, and Wayne Sloan**

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**Other Contributors: Dr. James Hant, Dr. James Yoh, Tom Tam, Yogi Krikorian, Kuang Tsai, and Dr. Chit-Sang Tsang**

# DESCRIPTION OF THE 5 LINKS

INTERFACE		DESCRIPTION
1. RTS-SOC	1.a From RTS to SOC	<ul style="list-style-type: none"> <li>S/V command echo data message or S/V telemetry data</li> <li>Status and test report messages and Retransmit request message</li> <li>Measured spacecraft angular position messages and Ranging data</li> </ul>
	1.b From SOC to RTS	<ul style="list-style-type: none"> <li>Configuration messages for pretest, readiness test and performance test</li> <li>ARTS equipment setting messages and Antenna pointing message</li> </ul>
2. SOC-NCC	2.a From SOC to NCC	<ul style="list-style-type: none"> <li>Contact request and S/V orbital data</li> <li>Network status</li> </ul>
	2.b From NCC to SOC	<ul style="list-style-type: none"> <li>Contact Schedule</li> <li>Network Status</li> </ul>
3. RTS-NCC	3.a From RTS to NCC	<ul style="list-style-type: none"> <li>Status and test report messages and Test response messages</li> <li>Maintenance request</li> </ul>
	3.b From NCC to RTS	<ul style="list-style-type: none"> <li>Contact schedule and Maintenance schedule</li> <li>Reconfiguration directives and Orbital information</li> </ul>
4. S/V-RTS	4.a From RTS to S/V	<ul style="list-style-type: none"> <li>Command startup messages (acquisition and Lock-on)</li> <li>Ranging signals and Other uplink Data</li> </ul>
	4.b From S/V to RTC	<ul style="list-style-type: none"> <li>Command verification and S/V status and SOH</li> <li>Ranging signal return and Other telemetry data or data</li> </ul>
5. S/V-SOC (via RTS)	5.a From SOC to S/V	<ul style="list-style-type: none"> <li>Command sequences and command uploads</li> <li>Other Uplink data</li> </ul>
	5.b From S/V to SOC	<ul style="list-style-type: none"> <li>Telemetry</li> <li>Other data</li> </ul>

## Legends:

ARTS = Automated RTS

SOH = State of Health