

***Applying CCSDS Standards
to the
Air Force Satellite Control Network
(AFSCN)***

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AFSCN Interest in CCSDS Standards

- **AFSCN interest in CCSDS standards**
 - The AFSCN is investigating the feasibility of evolving from a circuit-switched network architecture to an IP packet-switched architecture
 - The AFSCN has a longer-range interest in assessing the suitability of CCSDS link protocols, SLE services, and SCPS
 - » Greater use of commercial products and services
 - » Interoperability with NASA and other TT&C networks
 - Issues affecting application of SLE in AFSCN
 - » Current AFSCN client spacecraft don't use CCSDS link protocols and data units
 - SLE services are formally based on the CCSDS link protocols
 - Slow turnover of spacecraft means legacy space link protocols must be supported for many years
 - » Tight latency and timing-preservation requirements
 - Can SLE infrastructure be “stretched” to cover AFSCN legacy clients?
 - » Ease transition to use of CCSDS link protocol and interoperability with other TT&C networks

Current AFSCN TT&C Block Diagram

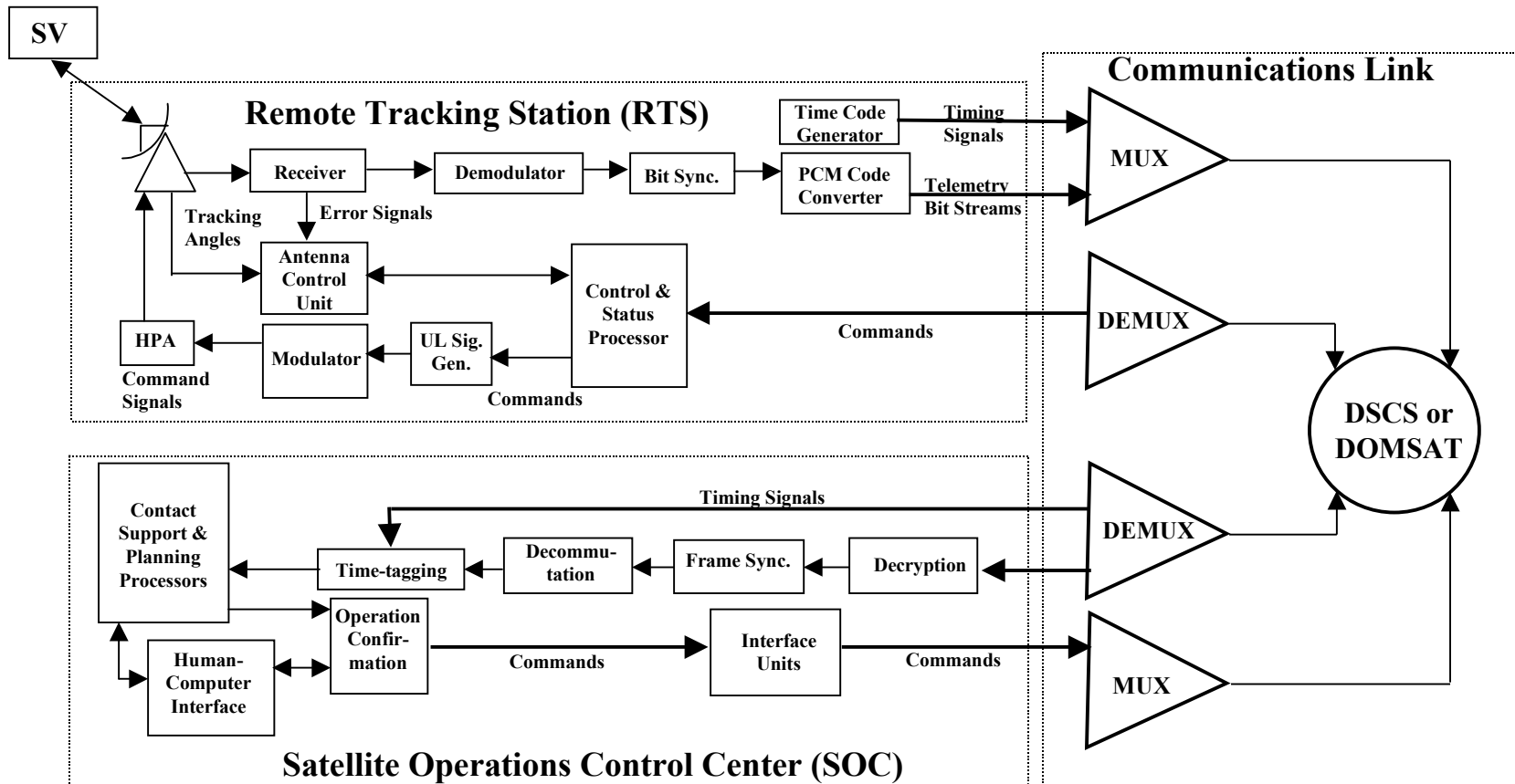
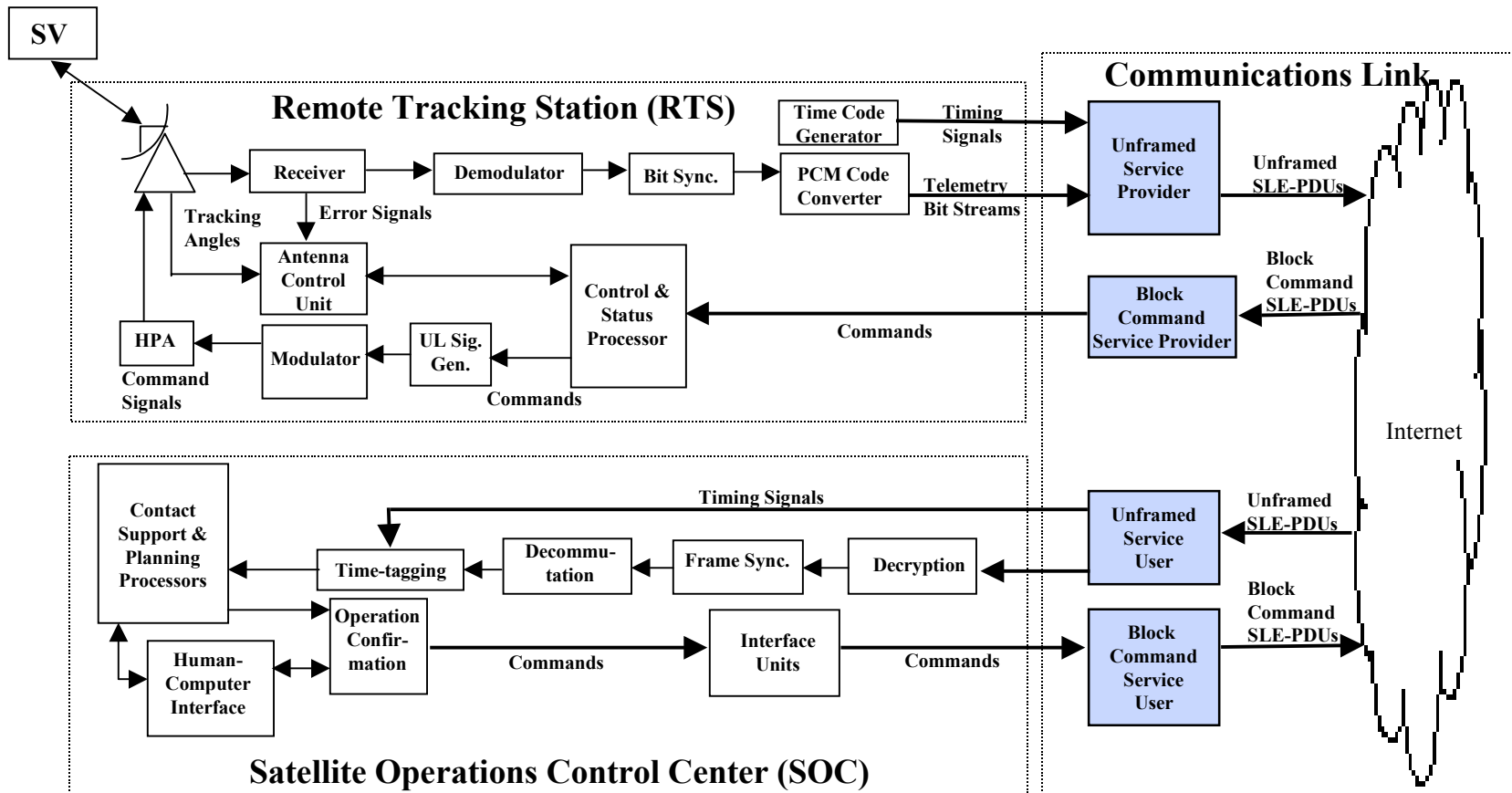


Diagram taken from "AFSCN Comm Requirements", Krikorian, Y.Y., et al, 12 April 2001, The Aerospace Corporation

AFSCN SLE-Based TT&C Block Diagram



NOTE: New services needed to transfer tracking, antenna pointing, and RTS status and control data flows are not being addressed during Phase 1

SLE-Based Services to Support AFSCN Legacy Missions



- **Prototype production extensions to compensate for legacy environment**
 - **Unframed Telemetry service to deliver bitstreams across a packet-switched wide area network**
 - » **Provide accurate “telemetry received” time over separate channel (IRIG-B)**
 - **Block Command service to transfer block commands from the SOC to the RTS**
 - » **Processing involves receiving continuous data stream of command blocks and idle fill, extracting and transmitting command blocks and inferred timing requirements, and reconstructing the command data stream with proper release timing**
 - **Command Stream service to transfer all bits (including idle bits) from SOC to RTS with consistent delay**

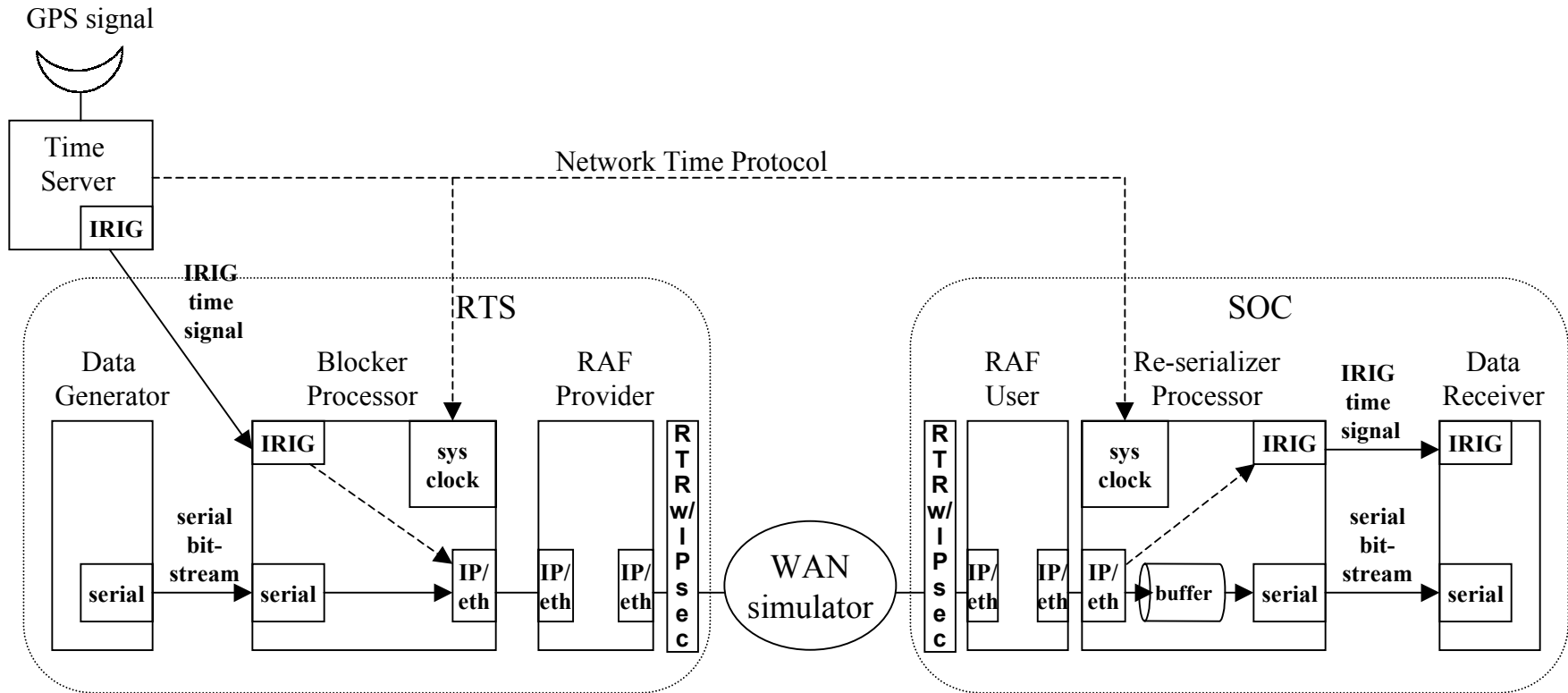
GST Testbed Activity

- **Beginning in June 2001, USAF funded a testbed activity at GST to evaluate TCP, UDP and SLE-based approaches to supporting current-day client space vehicles**
- **Fundamental approach to compensate for varying delay through packet-switched networks**
 - **Transfer of data in minimum time**
 - **Annotation of data to allow recovery of timing aspects of data at the receiving end**
 - **Buffering of data at receiving end until time to release**
 - **Release of data in accordance with timing information**
 - **“Fill data” mechanisms if data fails to arrive in a timely manner**

GST Testbed Activity (concluded)

- **SLE-based services built on existing NASA Jet Propulsion Laboratory (JPL) SLE API software**
- **Minimal-capability TCP and UDP prototypes establish baseline measurements for use of internet protocols to transfer bitstream and time-critical blocked data**
- **Testbed configurations**
 - **Unframed telemetry over TCP or UDP**
 - **Unframed telemetry over SLE RAF**
 - **Block command over TCP**
 - **Block command over SLE CLTU**
- **Experimentation with COTS IPsec (3DES)**
- **Performance measurements include:**
 - **Delay and delay variation**
 - **Data loss and sequence errors (when using UDP)**
 - **Overhead**
 - **Time tagging accuracy**

Unframed Telemetry over RAF: GST Testbed Configuration



- **Performance**
 - **TCP met a delay goal of 1.25 seconds for lower data rates and network delay/error values. Higher rates and/or network propagation delays required additional delay to ensure reliable delivery.**
 - » **Standard TCP slow start, congestion recovery, and retransmission window size are largely responsible for observed performance limits**
 - » **Preliminary tests with variants of TCP, such as Vegas and Tranquility (SCPS-TP), improved performance**
 - **SLE RAF performance is marginally less than that of straight TCP, but not prohibitively so**
 - » **Delay needed averages 194 millisecc more for RAF than TCP for comparable network delays and error rates**
 - » **Due to added complexity of RAF software and state machine, but also artifacts of testbed configuration (e.g., distributed processing across multiple processors)**

Results and Observations (concluded)

- **Performance (concluded)**
 - IPsec protocol (with 3DES) has negligible effect on performance
 - » No multiplication of packet loss, insignificant added delay
 - » Performance in real-world situations will depend on selection of services (e.g., authentication, privacy, etc.) and security algorithms, which will be mission-dependent
- **Applicability of SLE services to AFSCN**
 - SLE services allow for annotations (e.g. timestamps) to be added in a standardized and interoperable way, but benefits of other capabilities of SLE depend on upgrade of SOC and RTS processing systems
 - » Legacy command and telemetry processing systems have no way of handling SLE notifications and reports
 - » Upgrade of command and telemetry processing systems could utilize SLE notifications and reports, even while the format of the spacecraft data itself remains unchanged
 - To provide interoperability of legacy support services, standardization of the blocking and time correlation functions is just as important as the transfer service interface specifications

Next Steps

- **GST is incorporating into the prototypes some of the enhancements identified in Phase 1**
- **GST will install prototype systems at the QRD (Kirtland AFB) and CERES SOC (Schriever AFB) in March/April**
 - **Tests and demonstrations in late spring/summer**
- **Longer-term follow-on testbed activities may include further refinements of enhanced SLE and TCP/UDP services, experimentation with SLE service management, and experimentation with the Space Communications Protocol Standards (SCPS)**