SGSS Introduction for NSG

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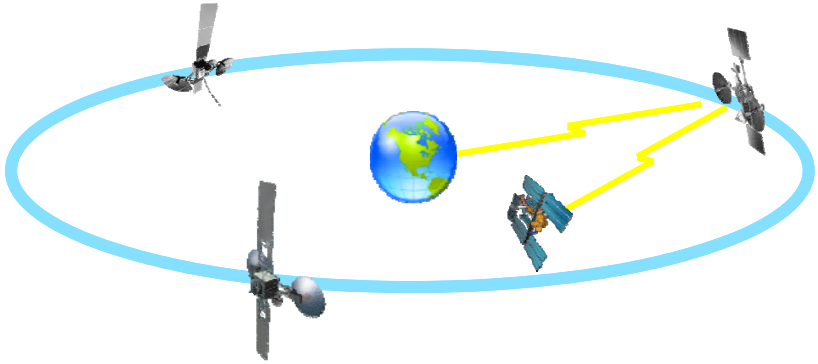
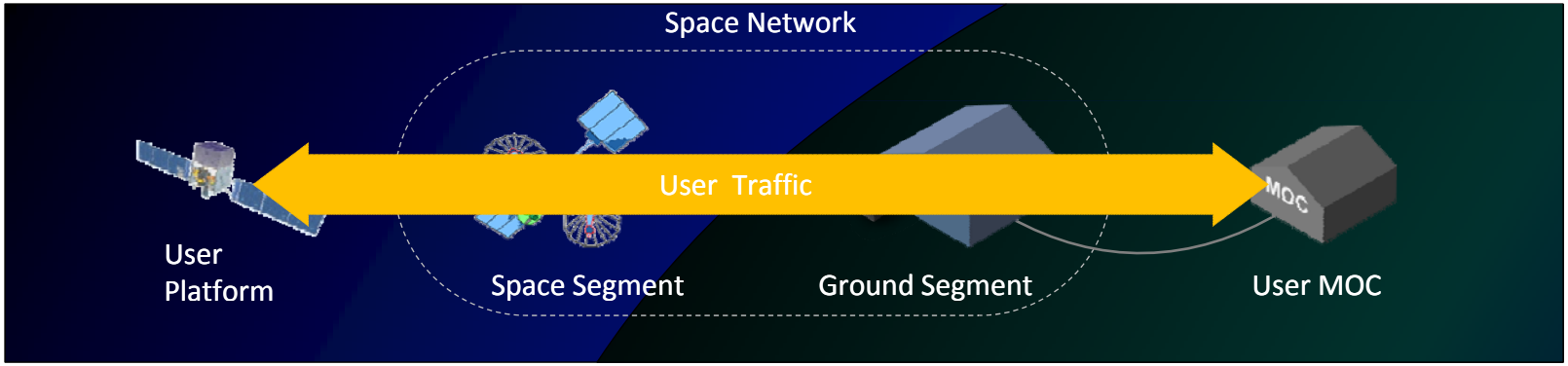
SGSS Mission

- The Space Network Ground Segment Sustainment (SGSS) will implement a flexible, extensible, scalable, and sustainable SN ground segment, which:
  - maintains existing SN capabilities, interfaces, and high level of service,
  - accommodates new users and capabilities,
  - reduces the effort required to operate and maintain the system, and,
  - transitions operations from legacy without disrupting service



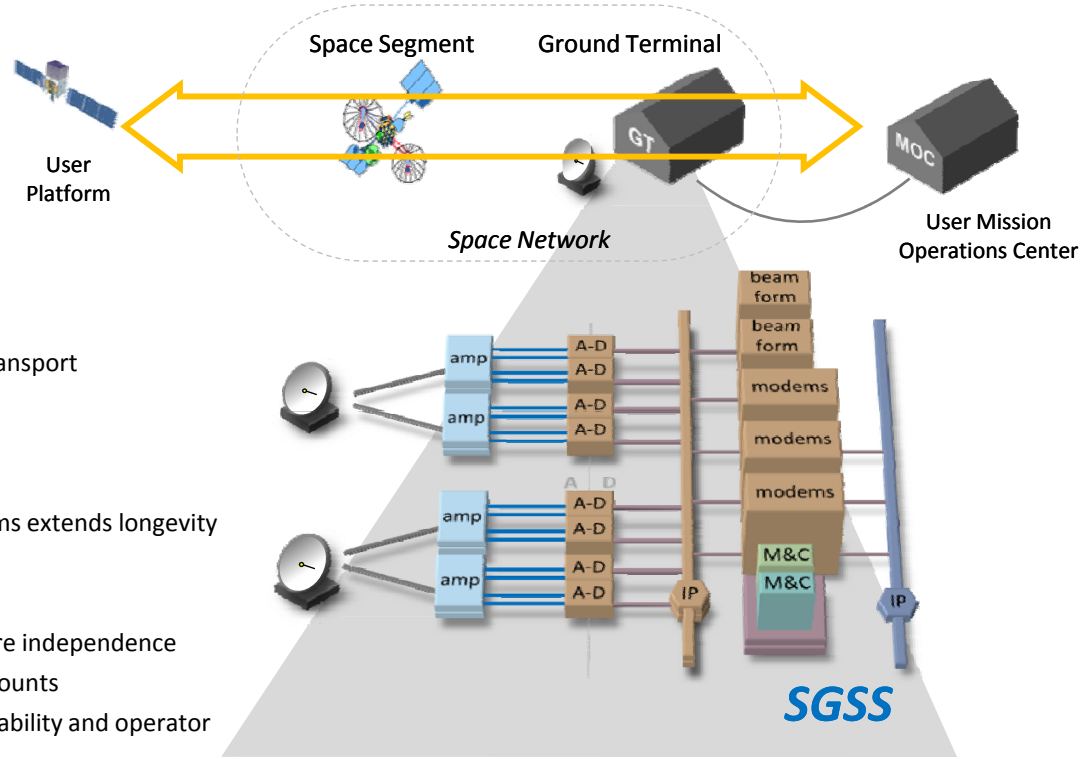


SGSS in Context

SGSS will replace the existing Space Network ground terminals in New Mexico and Guam and will build a new terminal in Maryland

SGSS architectural features …

- ✓ Low-loss digital signal distribution allows unlimited lossless signal replication
- ✓ Highly efficient ground resource utilization
- ✓ High system & service availability (>99.99%)
- ✓ Pooled processing architecture allows SGSS to do "more with less" and scale easily
- ✓ Multiple-failure tolerance … maintenance becomes routine rather than "an emergency"
- ✓ Shared, redundant virtual machine processing
- ✓ Reliable internal communication, consistent use of IP transport
- ✓ Isolated information planes
- ✓ Integrated security
- ✓ Improved maintainability
- ✓ Decoupled application software from operating platforms extends longevity
- ✓ Distributed intelligence
- ✓ Controlled life-cycle costs
- ✓ Service-oriented software architecture enables hardware independence
- ✓ Line replaceable unit counts are low, reducing sparing counts
- ✓ Modern enterprise management improves system availability and operator visibility while reducing required staffing



SGSS can easily be kept current …

- ✓ Modularity, extensibility, software architecture, and application isolation support non-disruptive upgrades, enabling a continuous refresh cycle
- ✓ Networked architecture, distributed intelligence improve scalability
- ✓ Significantly reduces maintenance costs associated with system or component obsolescence

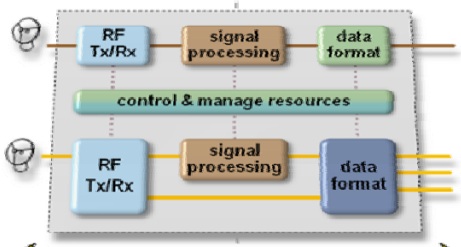
SNGS vs. SGSS

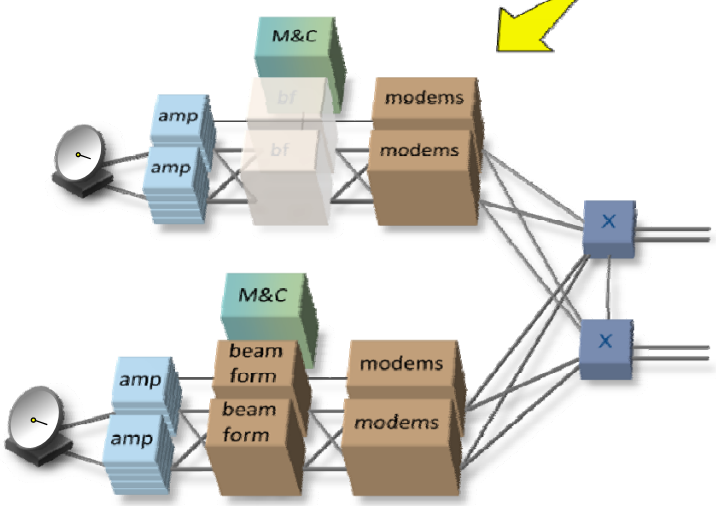
Legacy SNGS

- Analog signal distribution
- Dedicated 2x signal and baseband processing (per satellite)
- User data uses serial circuits to on-site interfaces
- Application SW (Ada) tightly coupled with VMS OS and HW

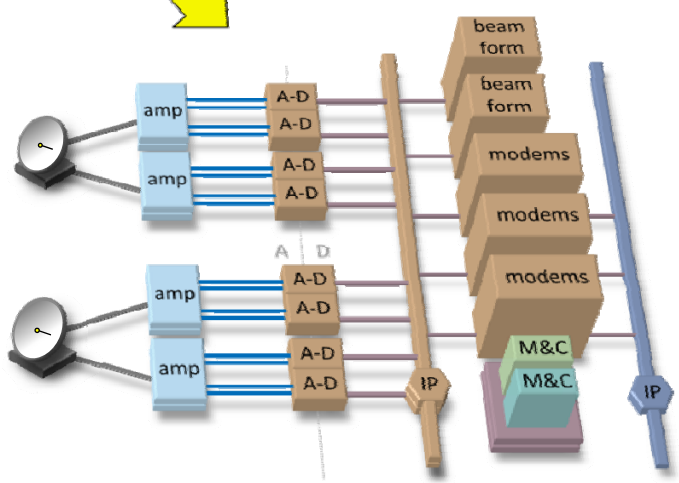
Updated SGSS

- Digital signal distribution
- Pooled signal and baseband processing (per site)
- IP LAN/WAN for internal system M&C and user data transport
- Service-oriented SW architecture, independent of HW





SNGS



SGSS

SNGS vs. SGSS

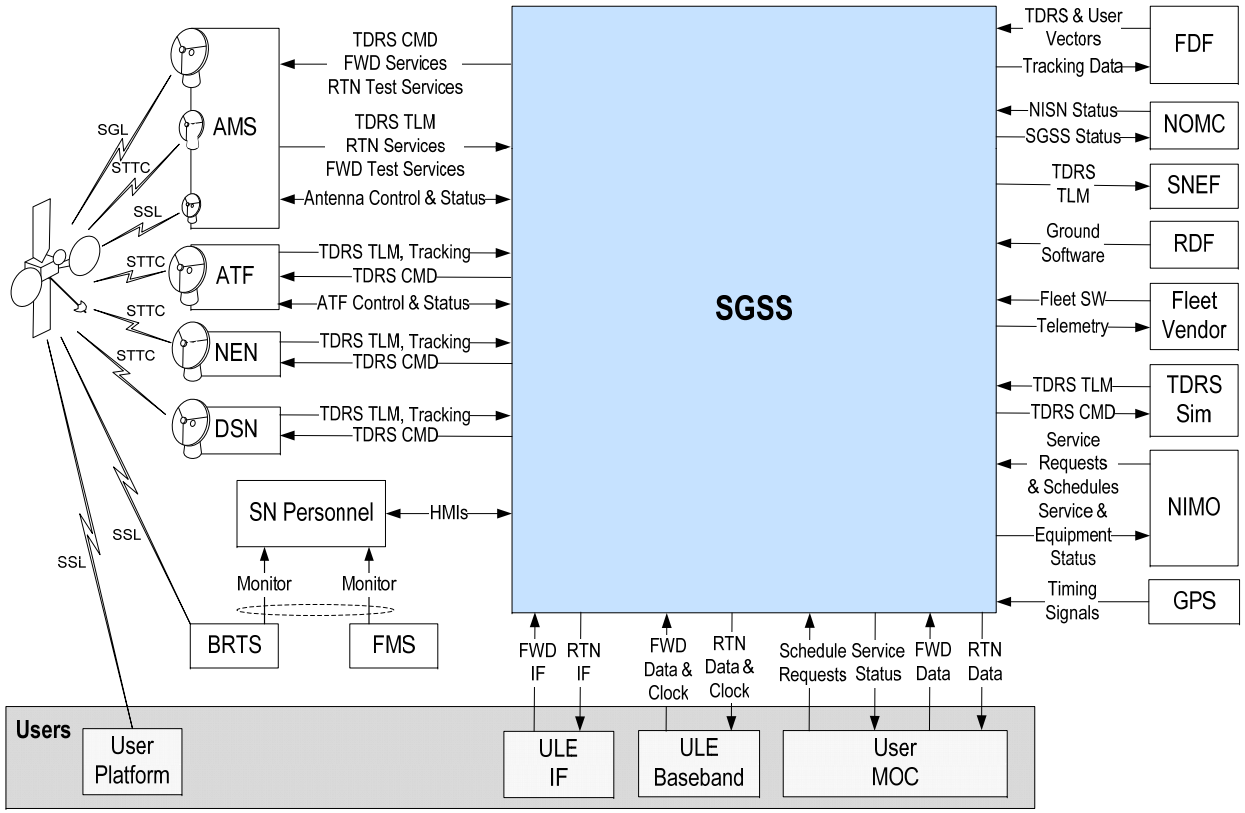
	Current System	SGSS	Comparative Benefits
TDRS Support	Each equipment string is dedicated to a specific TDRS	Any TDRS can be supported by any antenna or terminal	Improves flexibility, decreases equipment counts
Service Topology	Dedicated signal processing tied to individual ground antennas	Pooled signal processing resources in each ground terminal	Provides more services and allows more efficient equipment utilization with less hardware and improves fault tolerance
Ground Terminal Infrastructure	Heterogeneous systems with some IP	Enterprise messaging, largely TCP/UDP/IP	Improves performance and extensibility
Signal Distribution	Analog signals largely confined to distribution within a single ground terminal	Digital signal distribution limited only by available inter-facility bandwidth	Unlimited signal replication. Signals easily recorded, stored and distributed
Fault Tolerance	Multiple single point failures due to the 'stovepipe' architecture	Multiple failure tolerance due to pooled equipment configuration	Improves service continuity and availability, reduces required maintenance staffing
Monitor and Control	Monolithic control computers with dedicated, unique subsystem controllers	Distributed intelligence within and between terminals	Improves scalability, maintainability and reduces complexity
Customer Data	Serially switched paths internal to the ground terminal	Routed IP, adapts to legacy interfaces at specific demarcation points	Stable internal transport, can remove adapters as customers evolve
Software Architecture	Monolithic, tightly coupled, hardware dependent Ada/VMS	Distributed, loosely coupled Service Oriented Architecture. C, C++, C#, Java, Linux, Windows	Improves maintainability and portability. Allows access to an expanded maintainer base
Enterprise Management	Multiple, independent, dispersed management domains	Single enterprise concept, using industry standard tools & protocols	Improves system visibility and availability, reduces required staffing
Processing Platforms	VMS-compliant (VAX, Alpha)	x86 compatible (x86, x86-64)	Multi-vendor, extends longevity
Modem Technology	Hybrid analog/serial digital systems, serial baseband processing, proprietary platforms limit upgrade possibilities	Pure digital modulation and demodulation over IP, IP distribution at baseband, telco-standard uTCA platforms, FPGA upgradeable waveforms	Extensible at all levels (software, firmware and interfaces). Enables straightforward waveform and/or device insertions

SGSS is composed of 7 Principal Elements

Element	Functional Description
Space-Ground Link (SGL)	Provides the physical interface between the TDRS Fleet and SGSS. The SGL supports user data flow, and the flow of TDRS Telemetry, Tracking, and Commanding (TTC) signals. SGL includes the electronics for Intermediate Frequency/Radio Frequency (IF/RF) conversion, and antenna systems for radiating/collecting RF. Also includes the SGSS timing and frequency references.
Digital Signal Processing (DSP)	The DSP provides signal processing functions for creating and managing TDRSS Communication Channels (extracting User and TTC Return Link data and inserting User and TTC Forward link data). The digital conversion (ADC/DAC) and Sub-Band tuning / combining (SBT/SBC) are included, as is the beamforming capability. Support for Tracking Services is provided by DSP in the form of range and Doppler measurements.
User Services Gateway (USG)	The User Services Gateway Element provides remote and local user interface to SGSS. The USG function includes remote user service interface support (Space Link Extension service interfaces, IP Gateway, legacy NASCOM 4800 BB Gateway, tracking and clock correlation messages), user data services (AOS/ENCAP processing, rate buffering), and user data recording (recording and playback of return service data).
Service Management (SM)	SM orchestrates the delivery of SGSS TT&C and User services. It provides the remote SN user service management interfaces and local SN operator interfaces for managing SN services. It ingests service requests; generates schedules using mission priorities, ground and space planned equipment availability, using optimization rules. SM allows automated and manual scheduling of emergency or real-time requests and distributes scheduled provisioning directives and reports on collected metrics, including user service accounting data.
Fleet and Ground Management (FGM)	The FGM Element manages and controls the TDRS Fleet, and manages the Ground Segment. Management and Control is isolated from user or TTC bearer data wherever possible. The Element provides distinct capabilities in an integrated Element – Fleet Management, Fleet Control, Ground Management, and Ground Control.
Enterprise Infrastructure (EI)	The Enterprise Infrastructure Element provides common SW and HW components used across the SGSS system. Unlike the other system Elements, EI does not typically participate at the application level. Exceptions to this include enterprise messaging and common services such as logging. EI provides the system foundation for processing and networking supporting all other Elements. EI provides HW servers that host all application SW centers, including all M&C processing.
Maintenance & Training (MT)	The MT Element provides independent environments for maintenance, testing, and training capabilities and is deployed in the Maintenance and Training Facility (MTF). It includes tools and equipment for analyzing and resolving failures that occurred in the operational systems as well as for testing software and hardware updates before deploying to the operational systems. The MT Element also includes TDRS Simulators, Ground Segment simulators and various analysis models.

SGSS System Context

- The SGSS system must live within a context characterized by existing SNGS-internal and external physical and functional interfaces
- SGSS "modernizes" a major portion of the existing SNGS…but not all



SGSS Functional Elements

Maintenance &Training (MT)
- Offline support for the SGSS
- System/SW maintenance, debug
- System-wide training access
- HW+SW

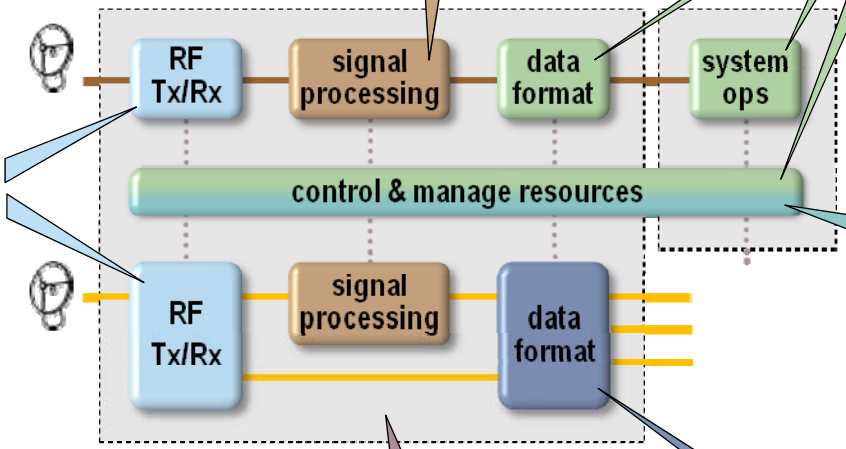
The MT element is not part of the operational system.

Digital Signal Processing (DSP)
- Convert analog <> digital signal
- Modulates, demodulates, encodes, decodes traffic
- Ground-based beam-forming
- High-Speed IF signal distribution
- HW+FW+SW

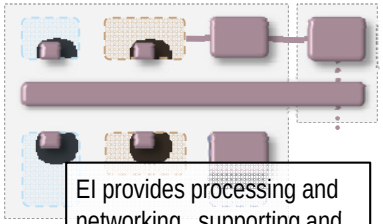
Fleet & Ground Mgmt (FGM)
- Control and manage the TDRS fleet
- Manage the ground resources
- Manage the entire SGSS enterprise
- SW only

These element color codes are consistently used throughout our system documentation

Space-Ground Link (SGL)
- Forms the link between the antenna feed and the signal processing equipment
- Provide precise timing and frequency references
- HW+SW



Service Management (SM)
- Plan, schedule, and execute user service sessions
- Monitor and report user service performance
- SW only



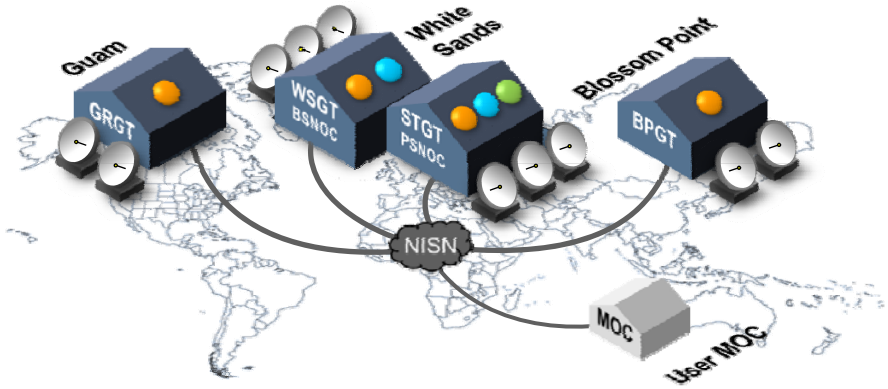
EI provides processing and networking, supporting and connecting the other elements

Enterprise Infrastructure (EI)
- High-availability operating environment to host applications system-wide
- Accessible set of common *services*
- Internal system networking resources
- Network/boundary protection
- CMD and TLM encryption/decryption
- HW+SW

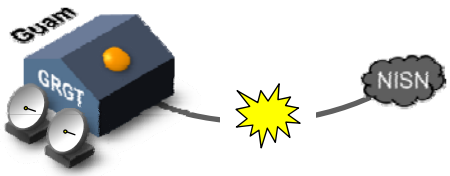
User Services Gateway (USG)
- External interfaces for forward and return user traffic
- Data format, protocol translation
- Signal/baseband record and replay
- user service simulation for end-to-end testing
- HW+FW+SW

SGSS Global Perspective

- SGSS consists of globally-networked Ground Terminals (GT) and Operations Centers (SNOC)
  - GT located at Guam (GRGT), White Sands (WSGT, STGT), and Blossom Point (BPGT)
  - Primary SNOC at STGT, Backup at WSGT
  - Maintenance & Training Facility (MTF) located at STGT
  - NISN IONet provides reach to user MOCs, NASA Support facilities, vendor support
- GT continues local operations when contact with SNOC is lost
  - Distributed intelligence, local control, mgmt
- SGSS can be extended simply
  - GT or SNOC added anywhere within the NISN reach
    - Each site includes operational independence improving scalability
  - Any GT can be extended due to its standard network construction
    - Modular processing and pooled resources yield simple extension without disruption



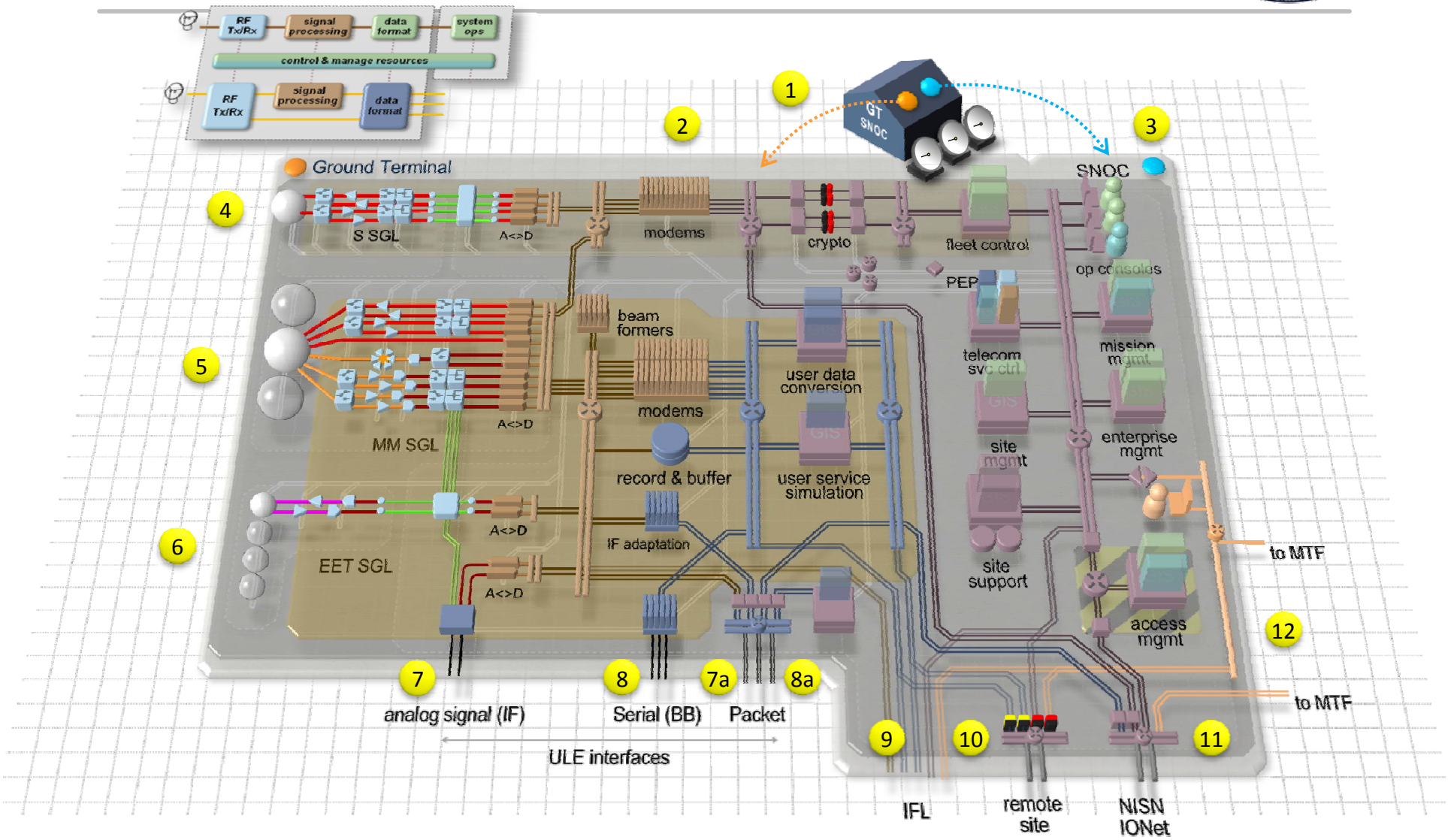
GT operations continue when disconnected



New GT or SNOC easily added

Any GT easily extended

Physical Architecture Perspective

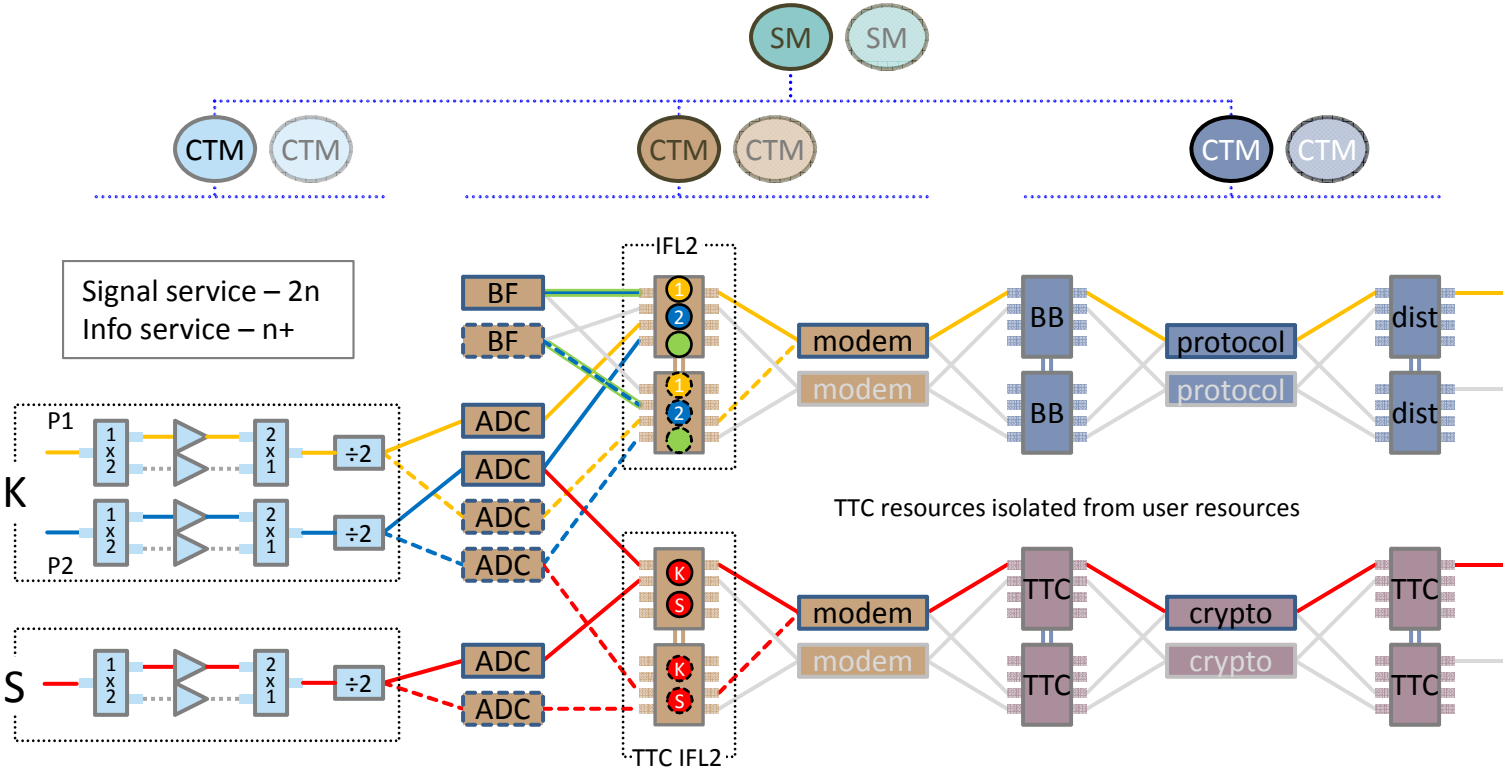


Physical Architecture Perspective

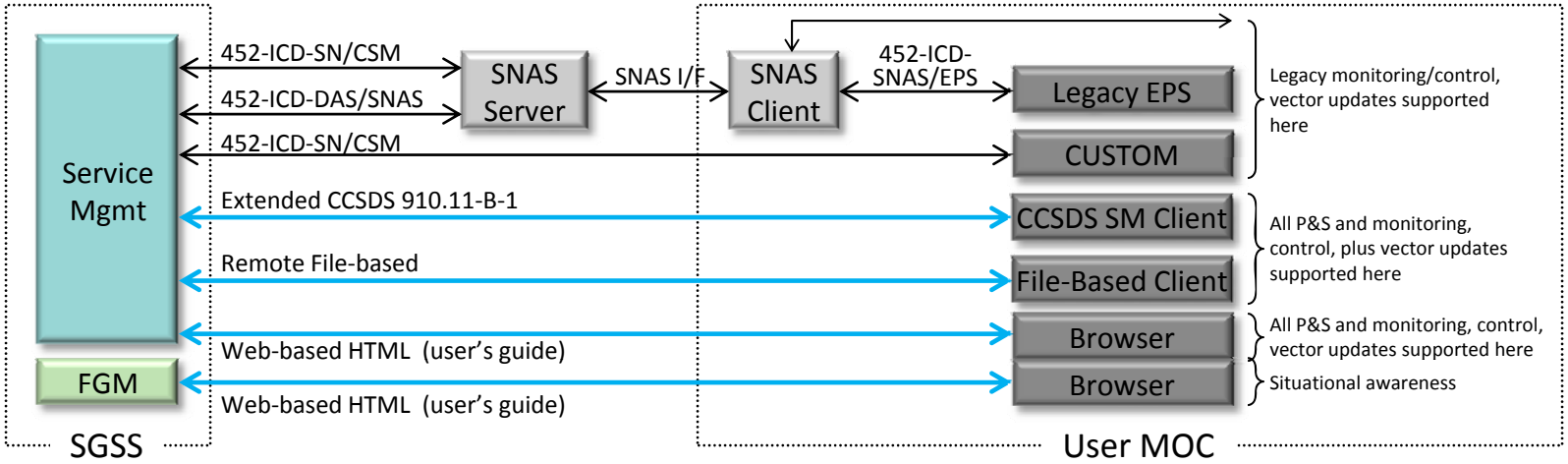
1	SGSS forms a global communications network consisting of consistent, repeatable Ground Terminal (GT) and Operations Center (SNOC) building blocks.	
2	GT can be scaled, replicated, and located anywhere with NISN connectivity, growing the ground system in step with the fleet. Initial SGSS includes 4 GTs (WSGT, STGT, GRGT, BPGT)	
3	SNOC can be located anywhere with NISN service. Complete SGSS network is operable from any SNOC site. Initial SGSS includes a primary SNOC and a backup SNOC, both located at WSC	
4 5 6	Fleet interfaces include stand-alone s-band (4), combined Ku-band+S-band main mission (5), and Ku, S, and Ka band end to end test antennas (6)	Fleet
7 7a	User Local Equipment (ULE) interfaces for delivery (ingress and egress) of intermediate frequency (IF) signal data. 7 is the analog interface, 7a, the packet digital interface	ULE
8 8a	User Local Equipment (ULE) interfaces for delivery (ingress and egress) of baseband information. 8 is the serial interface, 8a, the packet interface	ULE
9	IFL interface directly connects the two GTs at the WSC, extending the GT internal LAN structure, allowing sharing of resources and providing some geographical redundancy.	
10	Existing only at WSGT, the remote-site interface provides encrypted GT internal LAN extension to GRGT and BPGT. Along with the IFL, this interface connects extends SGSS LANs system-wide.	NISN
11	SGSS interface to the NISN IOnet. Via the GT-resident DMZ, provides controlled user-MOC access to SGSS planning, scheduling, awareness information, along with M&C interfaces to support facilities. TTC Network interface reaching to off-net NASA apertures. Protected connection allows TTC of TDRS via NEN and DSN.	NISN
12	MTF connectivity exists only at STGT, providing user MOC access to test facilities, including off-line planning & scheduling. Drop-box allows exchange of SW, data between operational SGSS and the MTF.	

SGSS Service Redundancy Strategy

- Redundant control applications, operate on separate HW
  - Heartbeat detection
- Configurable bearer redundancy
  - per-service redundancy from 0 to >2N
- Nominal bearer operations
  - Signal side is fully 2N
  - Information side operates single string, assembles redundant string upon failure indication or prediction
    - May operate TTC strings as 2N



User MOC Management & Control Interfaces



- All existing interfaces are maintained
  - SN/CSM and DAS interfaces
  - SNAS client applications will perform without change

- New interfaces added
  - Secure Web-based MMIs – Extension of CCSDS SCCS-SM and File-based
    - Clients talk directly to the SN MMIs – no need for SNAS client
    - All features of SGSS planning and scheduling and service performance and control

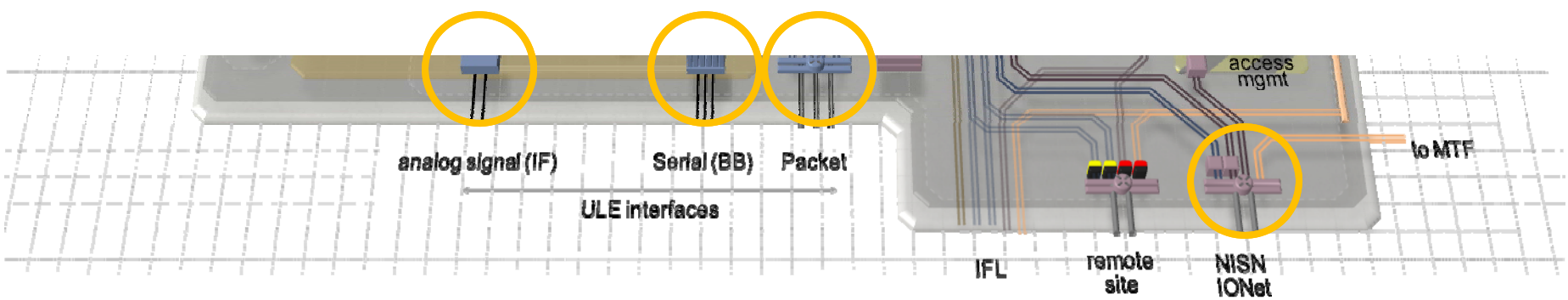
- New interfaces added
  - Secure Web-based HMIs - SNAS in a browser, plus…
    - SN resource planning calendar (up to 3-months out)
    - Additional options for recurrent scheduling
    - New scheduling features for events - multi-event binding/coupling, continuous events (DAS TDRS-Any for any service)
    - modify service profile and mission scheduling constraints
    - Access to modern reporting tools for service performance and SN planning reports

User Bearer Interfaces

- Existing interfaces maintained
- New interfaces added
  - opportunity to advance
- Packet transport is the preferred method for new or upgraded applications

	Signal		Baseband		
	Digital	Analog			
	User Local Equipment				Network
	Packet	IF/Coaxial	Serial	Packet	Packet
KSAF/KSAR	VITA-49/IP	1350 MHz 370 MHz	RS422, ECL	Multi/IP	Multi/IP[2]
SSAF/SSAR					
MAF/MAR					
MACE R					
Wideband[1] R		1345 MHz			
Time & Freq out	NTP	10 MHz, 1 PPS, IRIG-B,G		NTP	

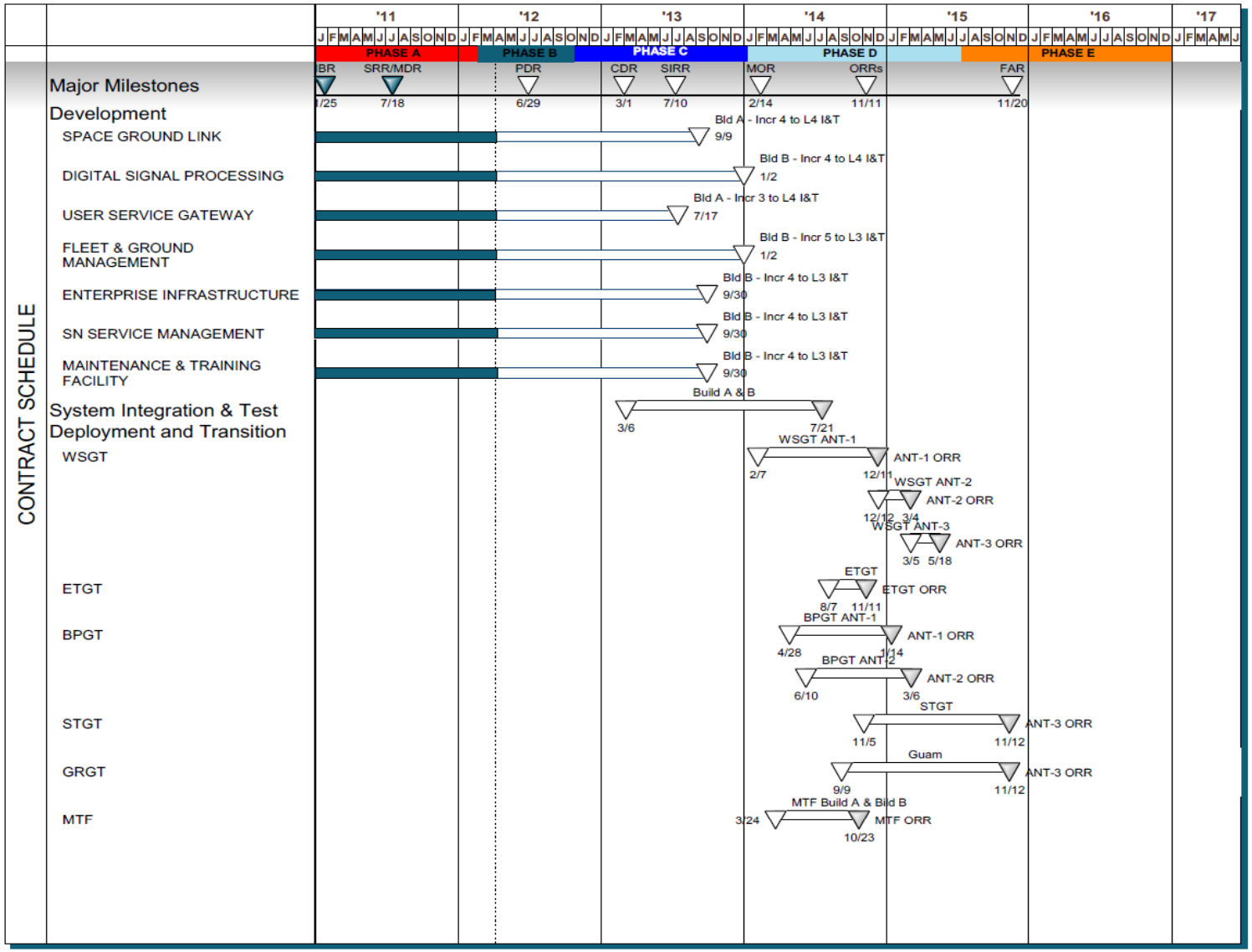
[1]No digital processing for Wideband Analog service. All other analog signals are processed digitally.
[2]High rate services may be limited by NISN-provided network bandwidth



SGSS Improvements

- New Flexibilities
  - SW/FW upgradeable modems accommodate future upgrades
    - Pooled DSP resources allow installation of experimental or test modes, modulations, coding schemes without disrupting nominal operations
  - Pooled DSP resources improve system availability, while reducing required resource count
  - System-wide network extensions enable extended operational control modes
    - WSC aggregated resources can be operated as a single ground terminal
- New Interfaces
  - Local packet interfaces
    - Signal traffic delivery to ULE
    - Baseband traffic delivery to ULE
    - Multiple access channel element (MACE) return service
    - Opportunity to move away from historically problematic interfaces
  - Un-digitized wide-band analog return signal
- New support resources
  - Training resources accessible from every ground site
  - Test Bearer, M&C interfaces available for MOC integration
  - Integrated Asset Management and Maintenance Management
  - MTF can support test/debug, development, and training simultaneously
- New system operations and management
  - Reduce required manual operations to control TCO
    - Field-extensible scripted approach allows in-service selection of manual, semi-auto, or fully automatic
  - Fully-automated service sequencing eliminates the need (but retains opportunity) for operator intervention
  - Extensive, system-wide fault, performance data monitoring and visibility
  - Architecture created to support surgical, incremental, live SW and HW upgrade, eliminating schedule downtime
  - Independent GT operation provides continuing service through inter-site network or SNOC outages

Schedule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'12
'13
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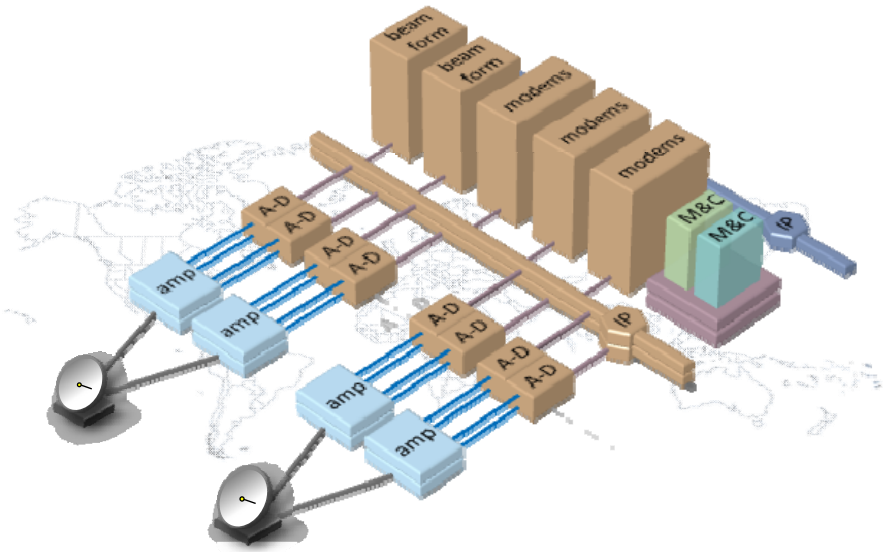
'16
'17
PHASE A
PHASE B
PHASE C
PHASE D
PHASE E
IBR
SRR/MDR
PDR
CDR
SIRR
MOR
ORRs
FAR
Major Milestones
1/25
7/18
6/29
3/1
7/10
2/14
11/11
11/20
CONTRACT SCHEDULE
Development
SPACE GROUND LINK
Bld A - Incr 4 to L4 I&T
9/9
DIGITAL SIGNAL PROCESSING
Bld B - Incr 4 to L4 I&T
1/2
USER SERVICE GATEWAY
Bld A - Incr 3 to L4 I&T
7/17
FLEET & GROUND MANAGEMENT
Bld B - Incr 5 to L3 I&T
1/2
ENTERPRISE INFRASTRUCTURE
Bld B - Incr 4 to L3 I&T
9/30
SN SERVICE MANAGEMENT
Bld B - Incr 4 to L3 I&T
9/30
MAINTENANCE & TRAINING FACILITY
Bld B - Incr 4 to L3 I&T
9/30
System Integration & Test
Build A & B
3/6
7/21
Deployment and Transition
WSGT
WSGT ANT-1
ANT-1 ORR
2/7
12/11
WSGT ANT-2
ANT-2 ORR
12/12
3/4
WSGT ANT-3
ANT-3 ORR
3/5
5/18
ETGT
ETGT
ETGT ORR
8/7
11/11
BPGT
BPGT ANT-1
ANT-1 ORR
4/28
1/14
BPGT ANT-2
ANT-2 ORR
6/10
3/6
STGT
STGT
ANT-3 ORR
11/5
11/12
GRGT
Guam
ANT-3 ORR
9/9
11/12
MTF
MTF Build A & Bld B
MTF ORR
3/24
10/23

Summary

- Low-loss signal distribution and unlimited lossless replication
  - Digital signal transport, storage at IF
- Improved resource utilization, system & service availability
  - Pooled processing architecture allows SGSS to do more with less, and scale easily
  - Multi-failure tolerance…maintenance becomes routine, not emergency
  - Shared-aggregate virtual processing
- Reliable internal communications
  - Consistent IP transport throughout
  - Isolated information planes
  - Integrated security strategy
- Improved maintainability
  - Decoupled application SW from operating platform, extending longevity
  - Distributed Intelligence
- Controlled life-cycle costs
  - Low LRU count reduces required sparing
  - Modern Enterprise Management improves system availability, visibility, while reducing required staffing



- SGSS can be always current
  - Modularity, extensibility, SW architecture, and application isolation support non-disruptive upgrade, enabling a continuous refresh cycle
  - Networked architecture, distributed intelligence improve scalability
  - Significantly reduces maintenance costs associated with system or component obsolescence

Acronyms

A-D	Analog to Digital
Amp	Amplifier
ANT	Antenna
ATF	Australian TDRSS Facility
BPGT	Blossom Point Ground Terminal
BRTS	Bilateration Ranging Transponder System
BSNOC	Backup Space Network Operations Center
CCSDS	Consultative Committee for Space Data Systems
CDR	Critical Design Review
CSM	Customer Service Management
D-A	Digital to Analog
DAS	Demand Access Service
DMZ	Demilitarized Zone
DSN	Deep Space Network
DSP	Digital Signal Processing
EET	End to End Test
EI	Enterprise Infrastructure
Enet	Ethernet
EPS	External Processing System
ETGT	Extended TDRSS Ground Terminal
FAR	Final Acceptance Review
FDF	Flight Dynamics Facility
FGM	Fleet and Ground Management
FTP	File Transfer Protocol
GHz	Gigahertz
GRGT	Guam Remote Ground Terminal
GSFC	Goddard Space Flight Center
GT	Ground Terminal
HMI	Human-Machine Interface
HTTP	Hypertext transfer Protocol
HW	Hardware
Hz	Hertz
ICD	Interface Control Document
IF	Intermediate Frequency
IP	Internet Protocol
IRD	Interface Requirements Document
KHz	Kilohertz
KTTC	K-Band Tracking Telemetry and Command
LAN	Local Area Network
LRU	Line Replaceable Unit
M&C	Monitor and Control
MA	Multiple Access
MHz	Megahertz
MM	Main Mission
MMI	Man-Machine Interface
MOC	Mission Operations Center
MT	Maintenance and Training
MTF	Maintenance and Training Facility

NCCDS	Network Control Center Data System
NEN	Near Earth Network
NIC	Network Integration Center
NIMO	Network Integration Management Office
NISN	NASA Integrated Services Network
NOMC	NISN Operations Management Center
OS	Operating System
OTS	Operational Test Services
PDR	Preliminary Design Review
PKI	Public Key Encryption
POC	Point of Contact
PSNOC	Primary Space Network Operations Center
RDF	Remote Development Facility
RF	Radio Frequency
SA	Single Access
SCCS-SM	Space Communications Cross Support – Service Management
SGL	Space Ground Link
SGSS	Space Network Ground Segment Sustainment
SM	Service Management
SN	Space Network
SNAS	Space Network Access System
SNEF	Space Network Engineering Facility
SNGS	Space Network Ground Segment
SNOC	Space Network Operations Center
SSC	Service Specification Code
STGT	Second TDRSS Ground Terminal
STTC	S-Band Tracking Telemetry and Command
SW	Software
TCP	Transmission Control Protocol
TDRS	Tracking Data Relay Satellite
TTC	Tracking Telemetry and Command
UDP	User Datagram Protocol
ULE	User Local Equipment
UPS	User Planning System
US	User Services
USG	User Services Gateway
VITA-49	VITA Technologies Radio Transport Standard V49
VMS	Virtual Memory System
WAN	Wide Area Network
WSGT	White Sands Ground Terminal
XML	Extensible Markup Language
µTCA	MicroTelecommunications Core Applications (MicroTCA)