Transformational Satellite Communications System (TSAT) Network Architecture

Dr. Vineet Mehta,
Mr. Joshua Haines,
Jeff Pulliam,
and Scott Boone

Overview

- What is TSAT?
- TSAT Operational Concept
- TMOS Network Management and Operations
- Network Architecture Scope
- TSAT Network Elements
- TSAT Network Features

TSAT Vision

The internet-like transport architecture of the Global Information Grid (GIG) linking space, air and ground nodes using IPv6

- Integrated Space, Air and Ground Networks

- Global access to deployed / mobile Users (Comm On The Move)

- Timely delivery of air and space data to Theater and CONUS (Airborne Intelligence, Surveillance, Reconnaissance (ISR))

- Automated, dynamic, high assurance network operations

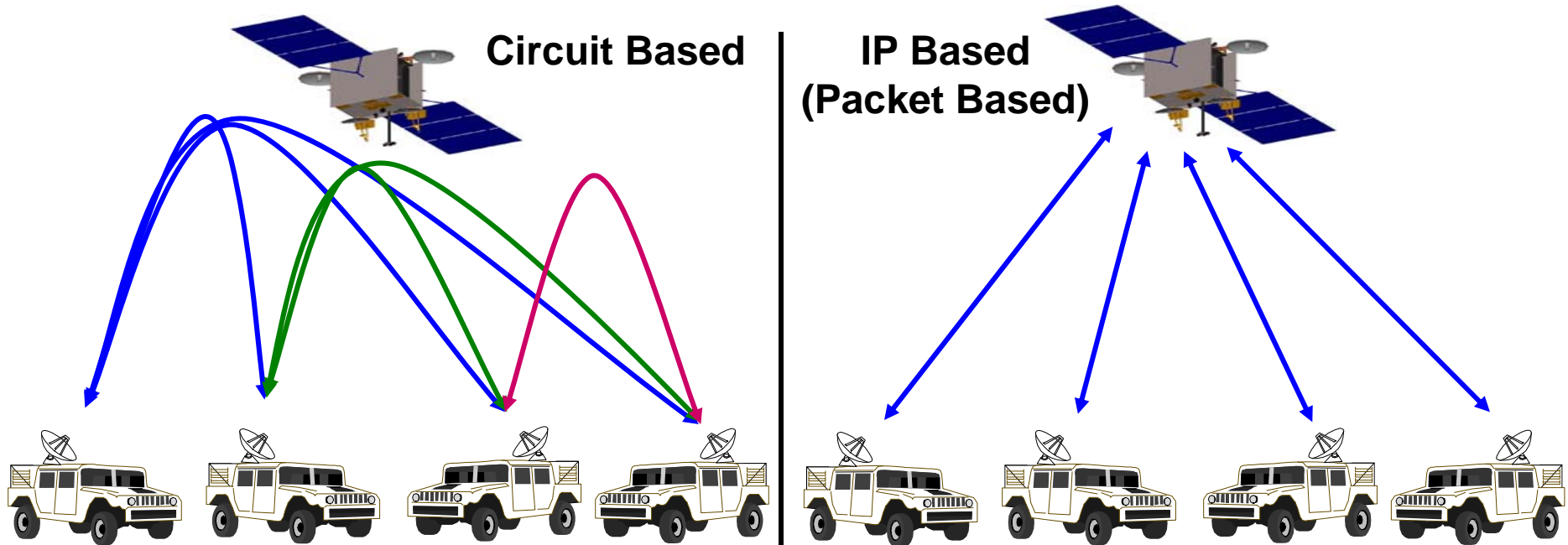- Increased capacity and connectivity: RF communications network

Enable Future Innovations and Growth Through A Flexible Yet Secure Network Architecture

What is TSAT? (TSAT CONOPS)

- TSAT - Transformational Satellite Communications System
  - Provides space based packet and circuit services to deployed GIG users
  - Protected MILSATCOM strategic and tactical communications access for authorized users
    - Anti-jam, low probability of intercept
  - Space backbone for the GIG supporting Network Centric Operations and Warfare
  - Deploys IPv6 capable packet routers to space payloads to provide space based forwarding between terminals
  - High data rate (HDR) access to space to support Intelligence, Surveillance and Reconnaissance (ISR)
  - Network Management / Operations Management - Operational management of TMOS to include: planning, configuration, coordination, operations, monitoring of TSAT components: satellites, CONUS gateway, terminals (RF, modems and selected baseband elements, routers), interfaces to other systems, and other control systems

Military Satellite Communications
1960 - 2015

System Development

Sustainment

Production

Global Information Grid

EHF Protected, Secure

750X plus internet like connectivity

TSAT

AEHF

Milstar II

Milstar I

10X

100X

1X

X, Ka Wideband

X Wideband

DSCS III SLEP

WGS

DSCS III

250X

2200X

Defense Satellite Communications System "DSCS I"

DSCS II

60X

100X

1X

| 1960 | 1971-1979 | 1982-1997 | 1994-1995 | 2000-2003 | 2001-2003 | 2006 | 2008 | 2013 | 2015 |

Continuous communications capacity improvement

Connectivity and Efficiency
why do packet switching in space. . .

Circuit Based

IP Based (Packet Based)

- <u>Connectivity:</u> point to point & multi-point
- <u>Efficiency:</u> double hops to connect hubs
- <u>Flexibility:</u> dynamic switching; does require prior knowledge of needed connectivity
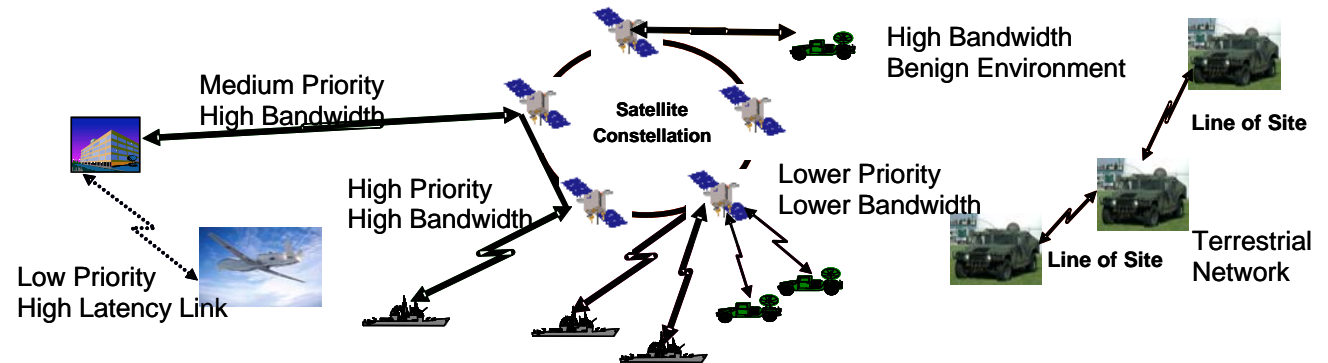
- <u>Connectivity:</u> full mesh connectivity to all GIG users—connects anyone to everyone
- <u>Efficiency:</u> 2x-8x improvement over circuits
- <u>Flexibility:</u> full routing; does not require prior knowledge of needed connectivity

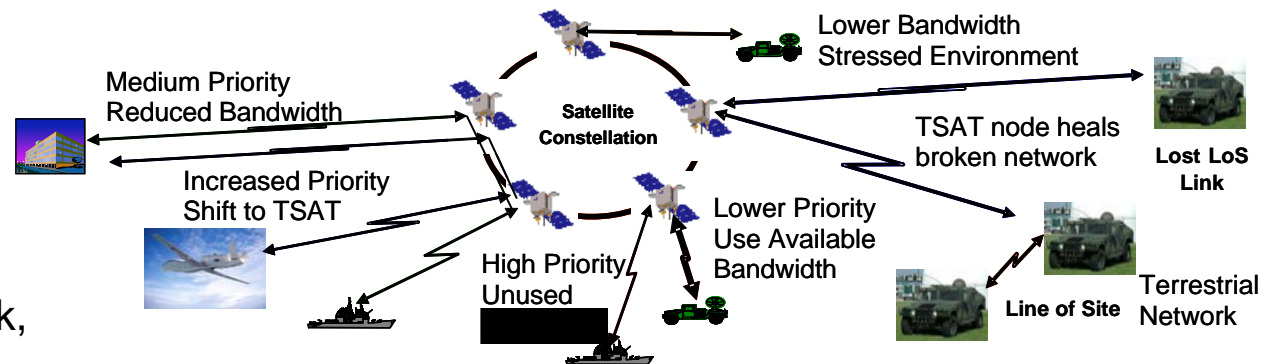## IP requires fewer resources and simplifies mission planning

TSAT Mission Operations System (TMOS) Network Management & Operations

- Plan
- Configure
  - Convert plan into action
- Monitor changes
  - Mission/user priorities
  - User needs
  - System health
  - Environment (e.g. weather, jamming)
- Adjust
  - Re-configure network, automatically where possible

High Bandwidth Benign Environment

Medium Priority High Bandwidth

Satellite Constellation

Line of Site

Lower Priority Lower Bandwidth

High Priority High Bandwidth

Line of Site

Terrestrial Network

Low Priority High Latency Link

Planning & Configuration: Optimized for initial conditions

Lower Bandwidth Stressed Environment

Medium Priority Reduced Bandwidth

Satellite Constellation

TSAT node heals broken network

Lost LoS Link

Increased Priority Shift to TSAT

Lower Priority Use Available Bandwidth

High Priority Unused

Line of Site

Terrestrial Network

Monitor & Adjust: Responsive reaction to change

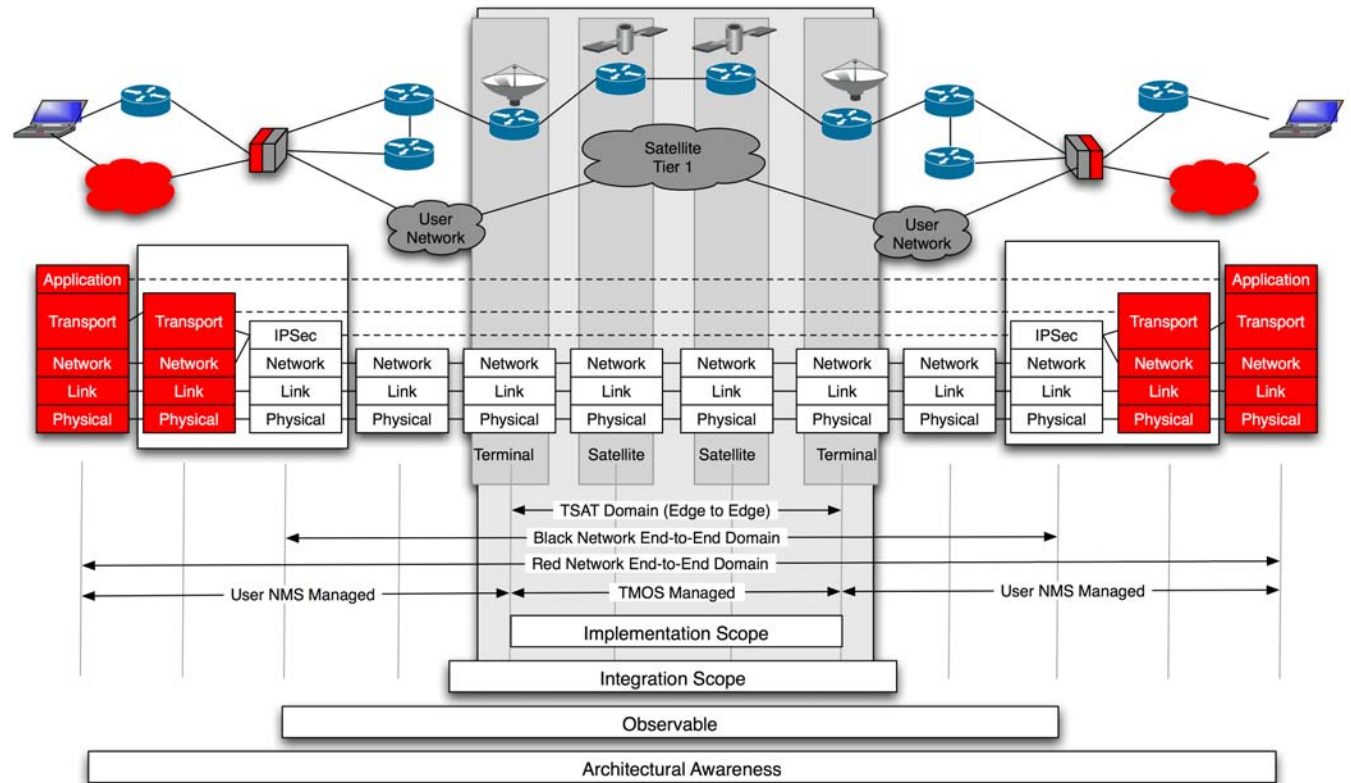**Right data in the right place, at the right time**

Network Architecture Scope

Architecture:

• *Components, connections, constraints, mechanisms, and behaviors of the TSAT Network*

• *Circuit and packet services, and supporting functions and features*

• *Implementation, integration, and awareness scope are different based on "how networks work."*

Architecture Scope

•Implementation scope includes features and functions necessary to build the TSAT network - "terminal to terminal"

•Integration scope extends to the complete service delivery interface - edge to edge

•Observable scope extends to the end host of the black network and the effect of network architecture on end to end delivery -black network end to end

•Architectural Awareness extends to the user network end host - red network end to end

Network Elements

1. TSAT Satellite Payload
2. TSAT Terminal Suite
3. TSAT Network Operations Management (TNOM)
4. TSAT Network Services Element (TNSE)
5. TSAT-GIG Border Element (TGBE)
6. Teleport
7. Red/Black Boundary Element
8. TSAT Satellite Operations Element (TSOE)
9. CONUS-GIG Gateway Element (CGGE)
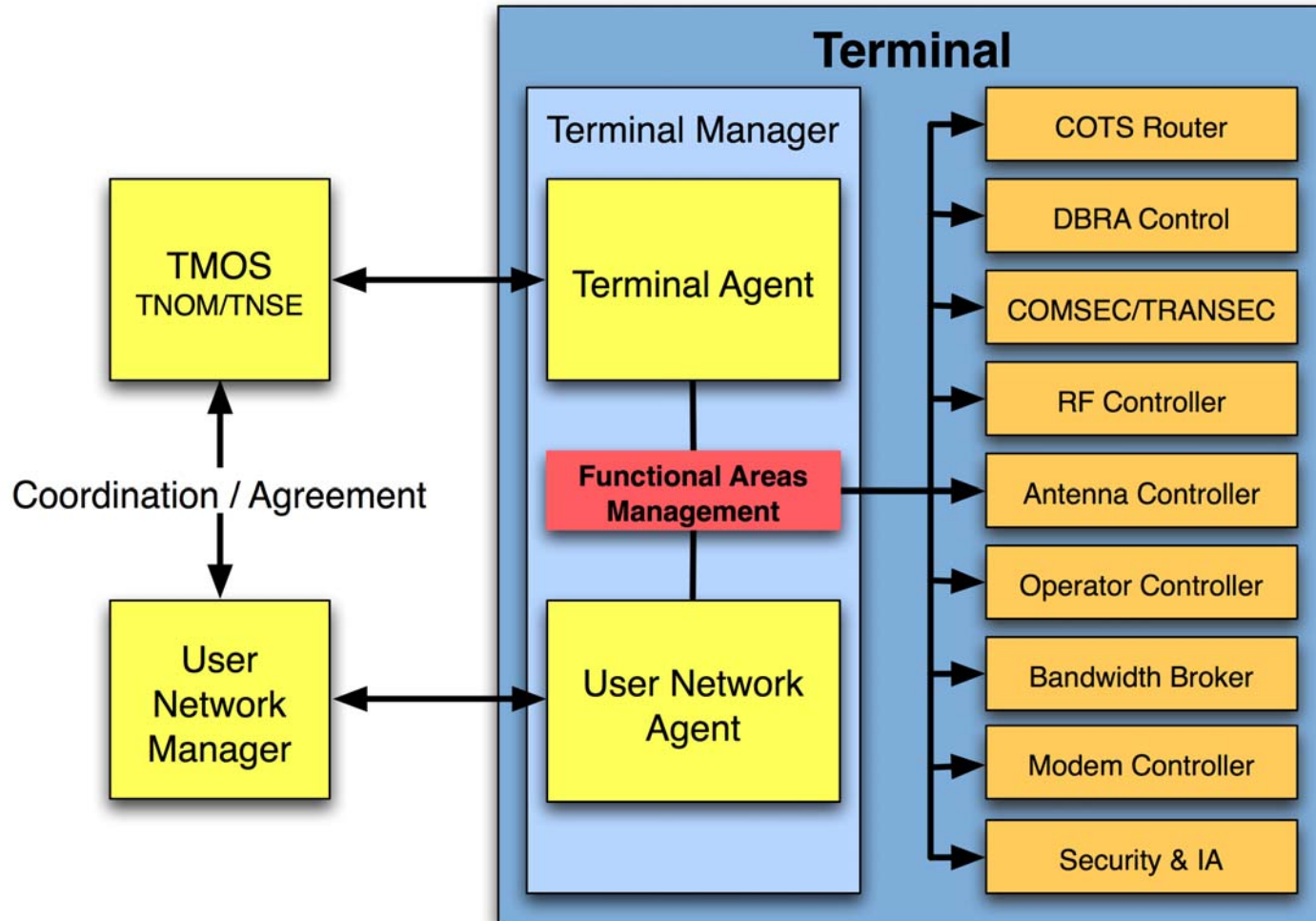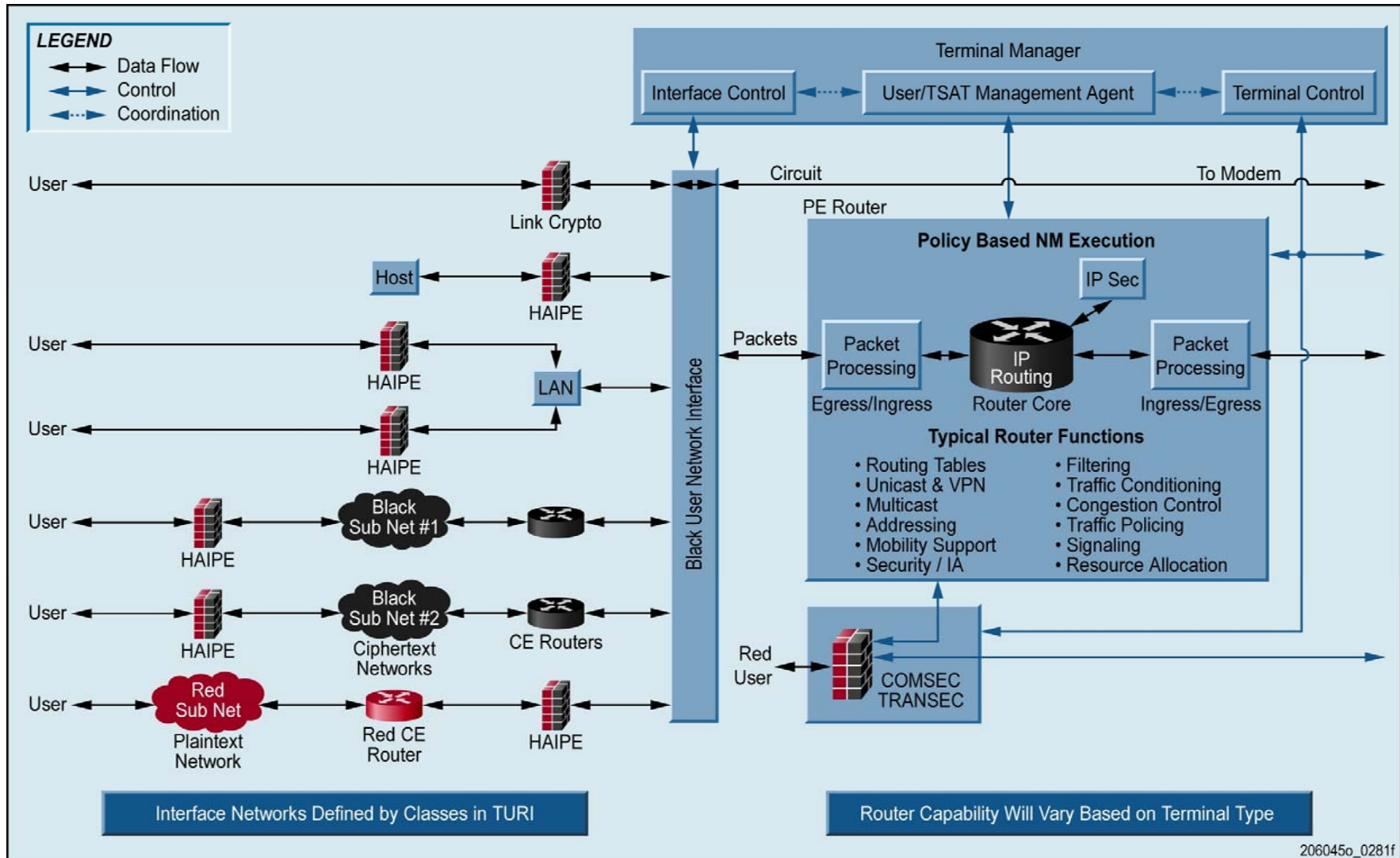
SV-2 : Network – Physical Connectivity

SV-2 : Network Physical/Link Layer Connectivity Nov. 29, 2006

TSAT Terminal Suite

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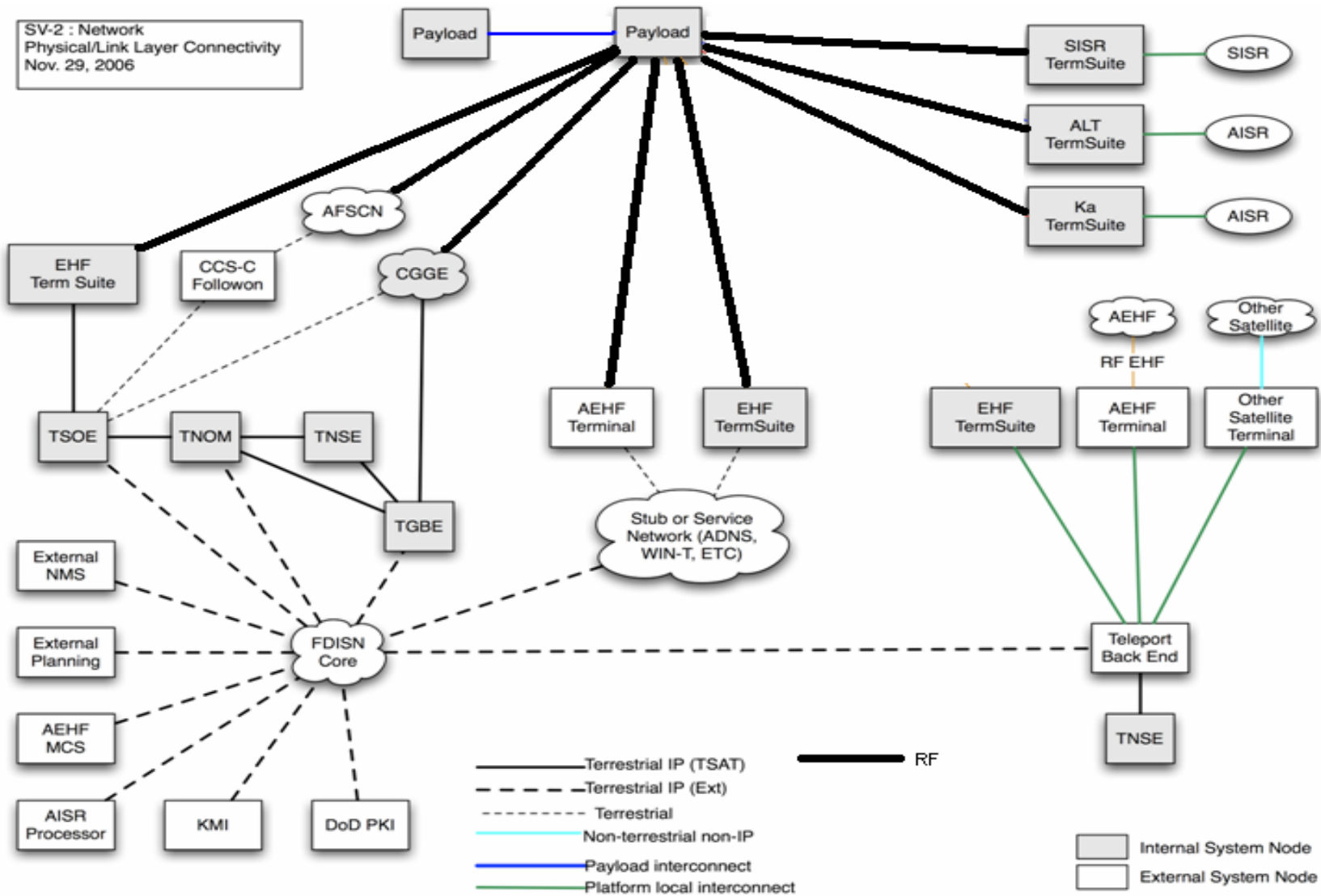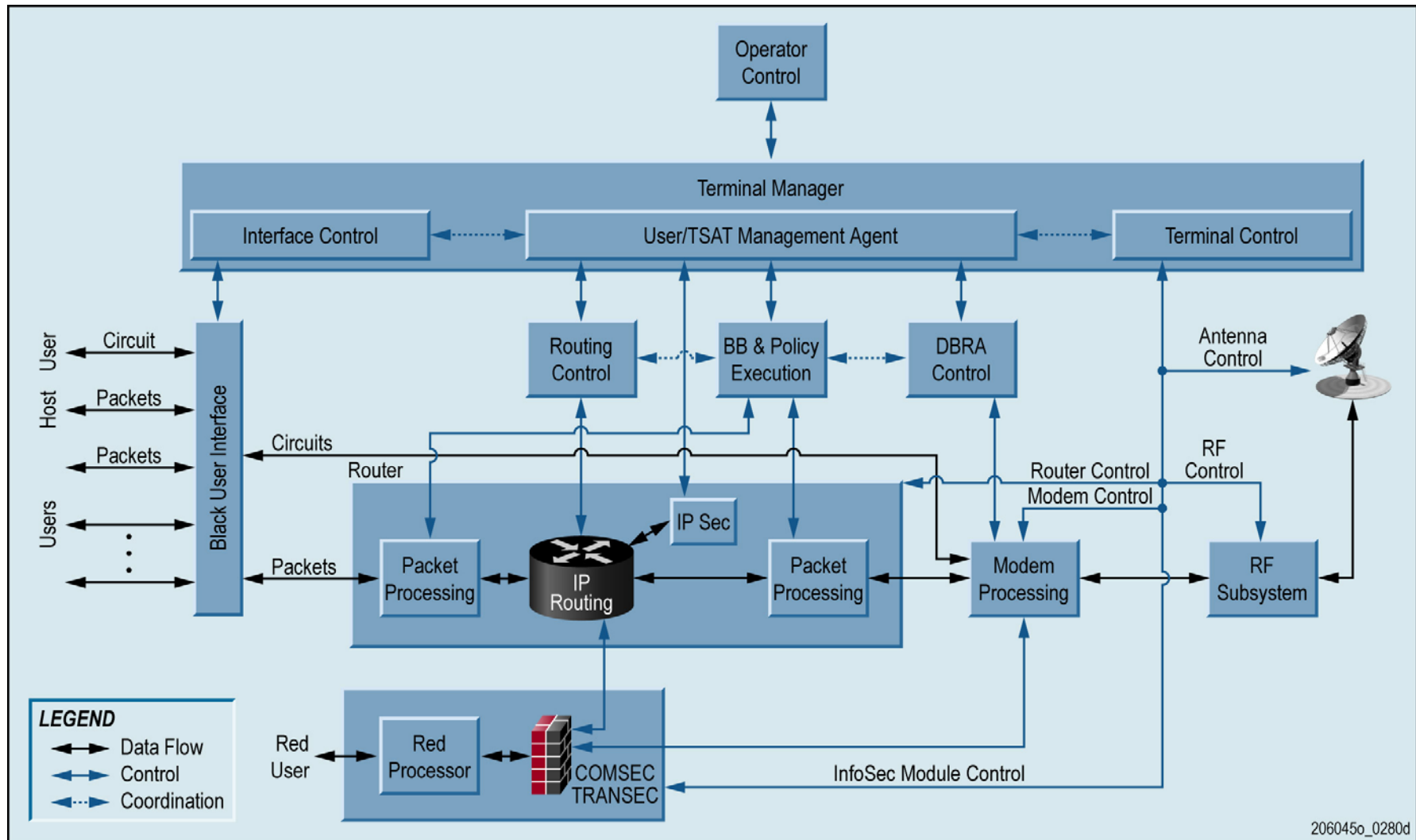
TSAT Terminal Suite

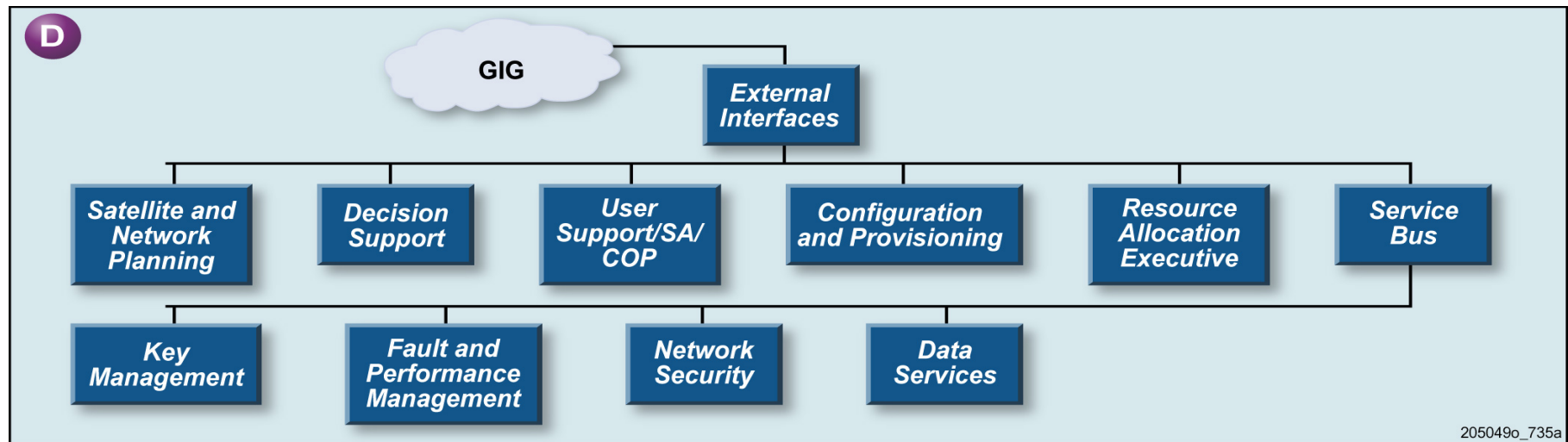## *Terminal Manager Activities and TMOS Interface*

TSAT Terminal Suite

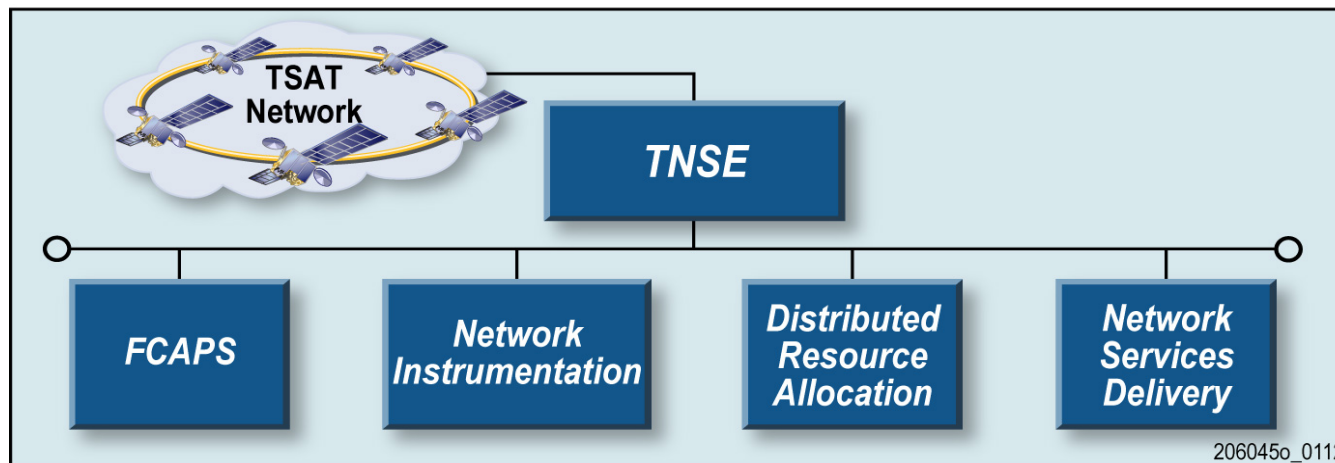## User Network Connections to TSAT Terminal Suite

TSAT Network and Operations Management (TNOM)

CDRL A022 - Figure 4.1.4-1. TSAT Network Operations and Management (TNOM)

# TSAT Network Services Element (TNSE)

CDRL A022 - Figure 4.1.5-1. TSAT Network Service Element

TSAT Network Services Element (TNSE)

- TNSEs facilitate TMOS distribution of OM/NM functions to the edge
- Primary locations are Teleports ~ 1 per satellite, 1 per TGBE site.
- Provide directly connected to the network location for management and instrumentation function
- Provide autonomy and endurance capability to manage connected satellite and supported terminals.
- Characteristics of TNSE:
  - <u>Reliability</u> – redundant systems continue to provide service despite failure of individual instantiations.
  - <u>Latency</u> – reduce/eliminate satellite hops – place services where most needed and used.
  - <u>Survivability</u> – partitioned areas receive services from local TNSEs.
  - COI direct support – distributed TNSEs speed response to local COIs.
  - <u>Autonomous and Endurance mode operations</u>
    - TNSE continues to provide services despite loss of primary or alternate.
    - Each TNSE's configured to provide redundancy for other TNSEs
    - Discovery supports fidelity of operations during exception states

TSAT GIG Border Element (TGBE)
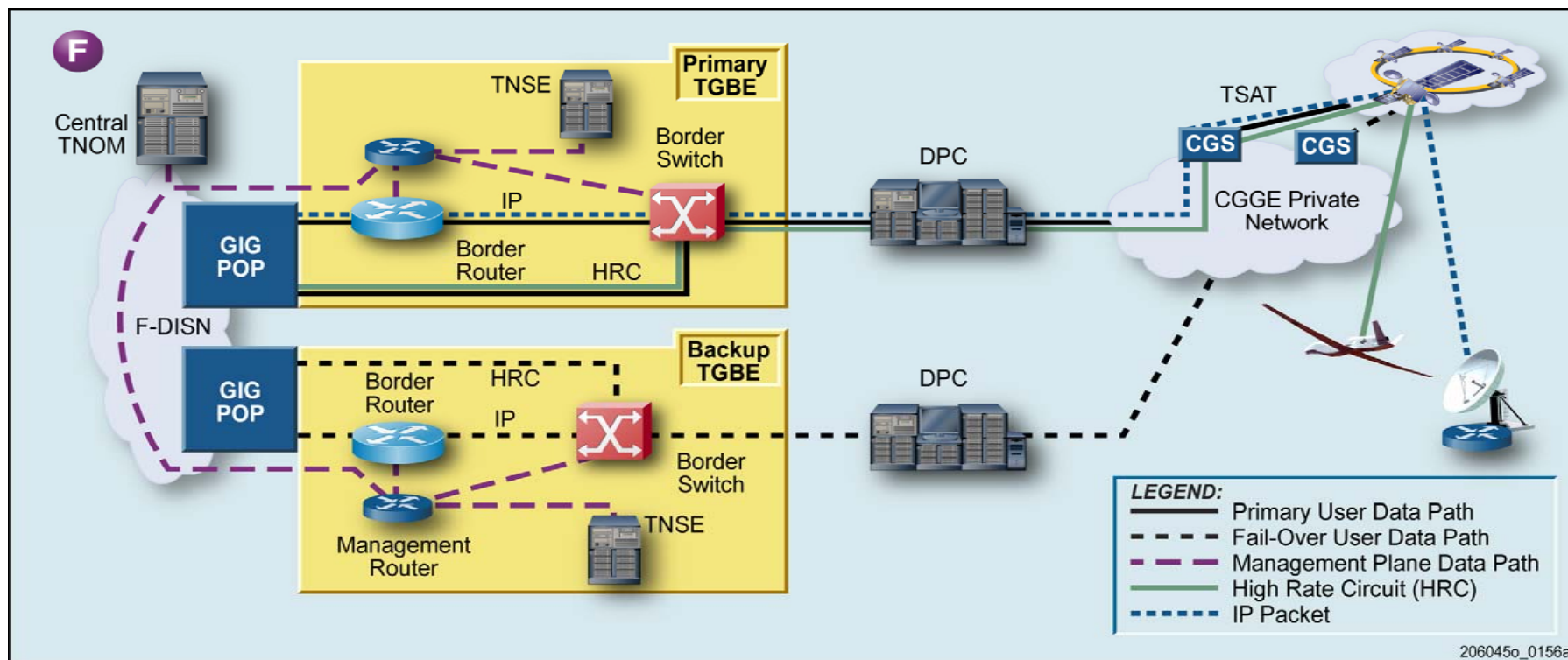
- TGBE provides the interface between CGGE Private Network and the terrestrial GIG Point of Presence (POP). The TSAT system plans to utilize terrestrial GIG resources to transport data between internal components of the CGGE, as well as using the GIG-BE to provide connectivity between the TSAT "border" and external users.

Teleport
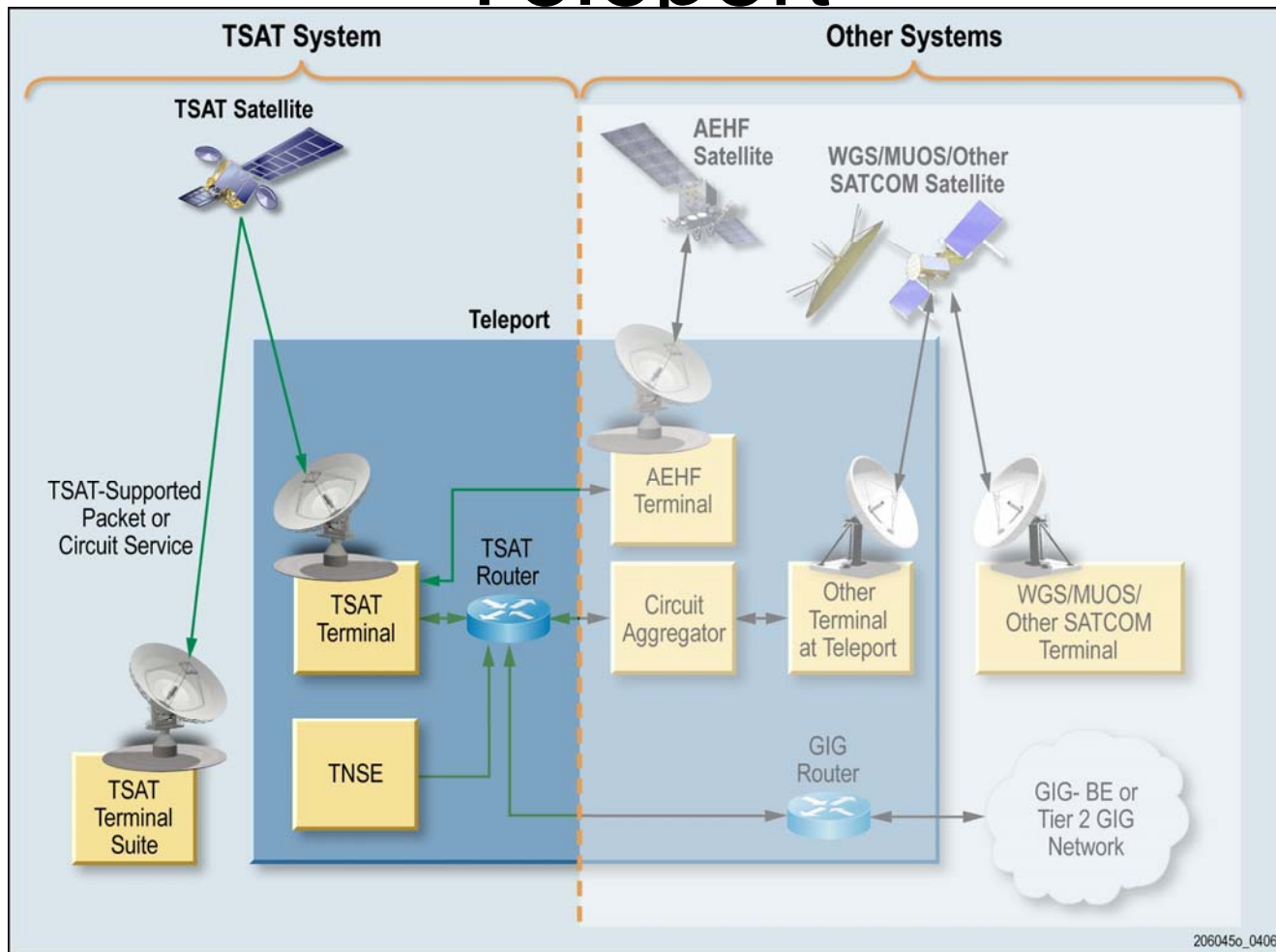
- **Provides interoperability between TSAT and AEHF, WGS, MUOS (with narrowband non-survivable traffic), commercial SATCOM, and other terrestrial and SATCOM systems**

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Red/Black Boundary Element

- External element to TSAT, included as a TSAT architecture element because it is crucial to delivering network services to the warfighter who is in the red network.

- HAIPE - the device that implements the red/black boundary, encrypts/decrypts traffic for the purpose of protecting the traffic as it transit a black network such as TSAT.

- HAIPIS v3.0 provides bypass of DSCP bits through the red/black boundary which will support differentiated services, but guaranteed services are not yet supported as a signaling bypass mechanism has not been formalized.

CONUS Ground Gateway Element (CGGE)

- CGGE is the primary interface between the space and the terrestrial network, receiving data from the satellite and processing it for injection into the terrestrial GIG.

- CGGE consists of many subelements including one or more Gateway Controllers (GWCs), CONUS Ground Stations (CGSs), Data Processing Centers (DPCs) and a CGGE Private Network (CPN) to interconnect the last two subelements.

- CGGE antennas connect the CONUS ground fabric to TSAT satellite systems.

TSAT Network Features

- TSAT will support the following features:
  - Routing
  - Multicast
  - Quality of Service
  - Network Assurance
  - Network Management

Routing

- Multi-AS solution with MP-eBGP
  - TSAT core is in a different Autonomous System (AS) from ground-based terminals
  - The TSAT core AS includes the payloads, the TMOS managed teleports and TGBE resources
  - Multi-Protocol exterior Border Gateway protocol (MP-eBGP) provides dynamic routing from terminals to payloads
- Dynamic routing with MP-iBGP and OSPF
  - Multi-Protocol interior Border Gateway Protocol (MP-iBGP) for transit routing capabilities
  - Open Shortest Path First (OSPF)v3 for internal routing reachability
  - OSPF provides BGP next hop reachability and re-routing capabilities
- Dynamic peering with anycast-BGP
  - provided through the combination of an anycast-BGP peering address and a promiscuous peering capability in the payloads
- PP-VPN with RFC 4364
  - Provider-Provisioned Virtual Private Network (PP-VPN) architecture based on RFC 4364
  - Provider Edge (PE) and Customer Edge (CE) routers residing at the terminal, and the Provider (P) routers are the payload routers

Multicast

- ASM and SSM Service Model Support
  - support both
    - one-to-many applications where the source is known in advance
    - many-to-many applications when the number of sources and their identities are dynamic and unknown
- MLDv2, PIM-SMv2, BGP4+ Support
  - provide the host-to-network interface for announcing multicast group joins and leaves
  - carrying multicast membership announcements through the network
  - advertising routes to use for multicast traffic, respectively
- Hierarchical Multicast Address Allocation Support
  - multicast group addresses are allocated in non-overlapping blocks to avoid conflicts
  - Hierarchical allocation of non-overlapping prefixes provides this functionality

Quality of Service

- Diffserv forwarding plane
  - with standards-based PHBs (Per-Hop Behaviors) and PDBs
  - (Per-Domain Behaviors) provide scalable and effective support for Quality of Service (QoS) services

- Guaranteed Services using ARSVP:
  - Guaranteed services with support for MLPP (Multi-level precedence and preemption) provided
  - Uses RFC-3175 based ARSVP (Aggregate Resource Reservation Protocol) signaling

- Configured Differentiated Services:
  - determined at planning time - configured before need time
  - provide better-than-best-effort services without requiring signaling

- GIG QoS service classes supported
  - as defined in Net-Centric Implementation Documents (NCIDs)

- Policy-based management of QoS resources using distributed Bandwidth Broker architecture
  - provides centralized control (effective management) and distributed execution (fast response)

Network Assurance

- TRANSEC + COVER
  - Space to ground links for XDR and XDR+ terminals use symmetric-key algorithms for time and waveform isolation to achieve packet header and transmission obscurity
- IPsec
  - IPsec (RFCs 4301, 4302, 4303)
  - native in IPv6
  - provide packet integrity and confidentiality as well as endpoint authentication capabilities for IP protocols and applications
- IP filters, policers, and adjacency verification
  - IP Packet Filtering, Policers, and Adjacency Verification provide policy-based packet restrictions and militate against spoofing attacks
- Network ASWR
  - TSAT uses a heterogeneous and distributed set of interface policies and passive probes to monitor black network links for anomalies and volume-associated impairments or attacks
- Service Level Agreement Policy Presence (SLAPP)
  - SLAPP provides distributed authentication and authorization capability for access to network services.

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Network Management

- Polling, monitoring, and configuration
  - provides situation awareness
  - supports fault and performance management
  - maintains operational availability
- Centrally managed, distributed execution, PBNM based
  - Centrally managed PBNM architecture with distributed execution elements provide high degree of automation and quick response times
- NM components:
  - Management Messaging (NetCONF)
  - SIE (Scheduled Information Exchange)
  - Event Monitor
  - Operation Policies
  - Configuration Control
  - Agent Heartbeat
  - Event Based Polling
  - APM (Active Path Monitor)
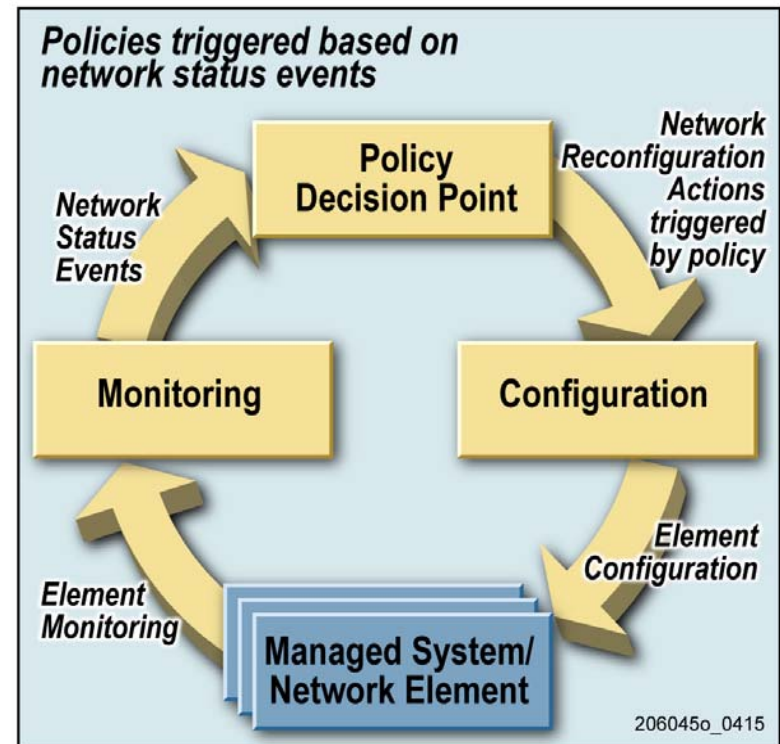
Recap

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- TSAT Functionality Support