

# SPACE DEVELOPMENT AGENCY

## DELIVERING CAPABILITIES

### DRIVING COLLABORATIVE PNT EFFORTS: PROLIFERATED WARFIGHTER SPACE ARCHITECTURE (PWSA)

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Space Development Agency

DSI Assured PNT Summit  
May 29-30, 2024

*SEMPLER CITIUS*



## **SPEED. DELIVERY. AGILITY.**

Recognized as the Department of Defense’s constructive disruptor for space acquisition, the Space Development Agency (SDA) will quickly deliver needed space-based capabilities to the joint warfighter to support terrestrial missions through development, fielding, and operation of the Proliferated Warfighter Space Architecture. SDA capitalizes on a unique business model that values speed and lowers costs by harnessing commercial development to achieve a proliferated architecture and enhance resilience. SDA will deliver a minimum viable product – on time, every two years – by employing spiral development methods, adding capabilities to future generations as the threat evolves.

“Space is critical. Adversaries are going to attack space. It’s critical on the ground as well as in space, and a disaggregated architecture becomes more resilient and that matters in terms of creating combat capability.”

Gen. B. Chance Saltzman, Chief of Space Operations, *Air and Space Forces Magazine*, Jan 13, 2023

# SDA IN THE DEPT. OF THE AIR FORCE



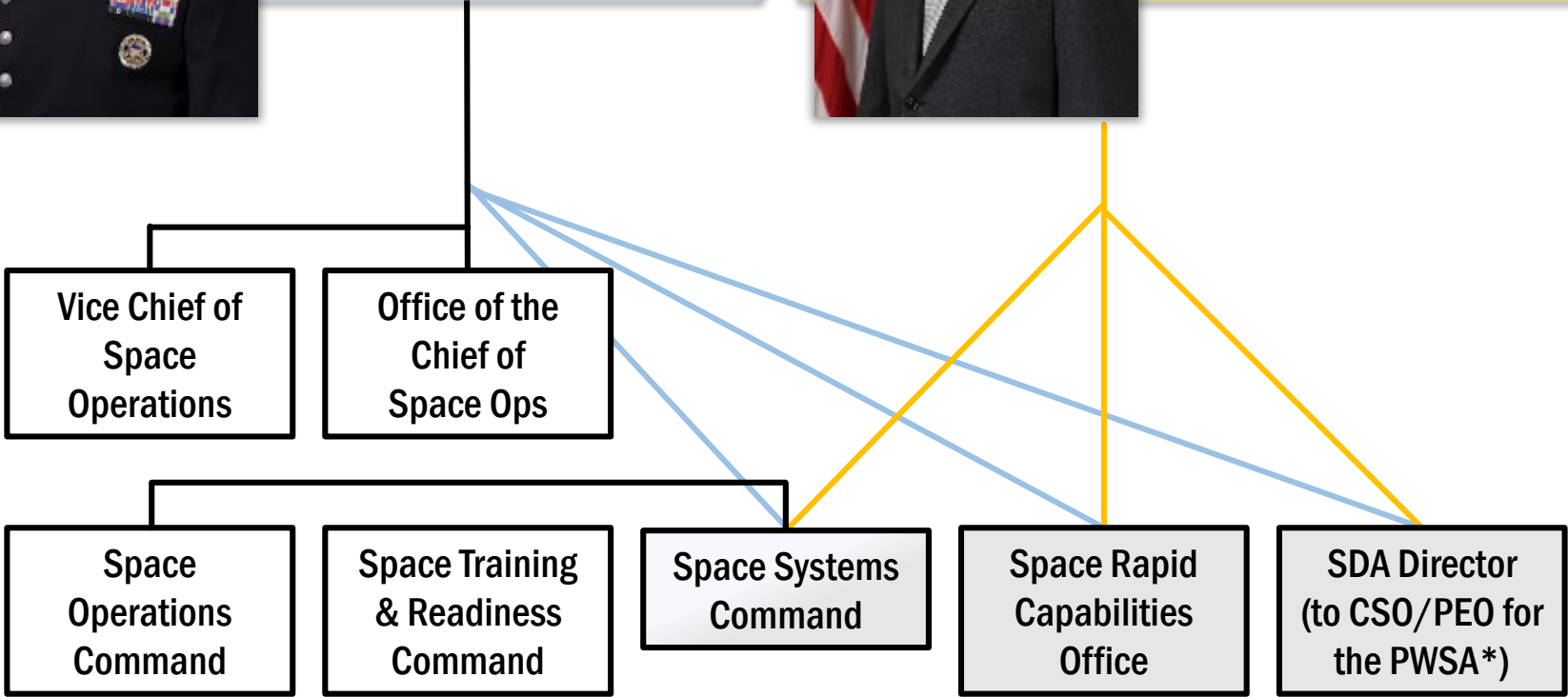
**GENERAL B. CHANCE SALTZMAN**

Chief of Space Operations,  
United States Space Force




**FRANK CALVELLI**

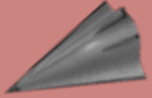
Assistant Secretary of the Air  
Force for Space Acquisition and  
Integration



\*Proliferated Warfighter Space Architecture



**Beyond-Line-Of-Sight (BLOS) targeting for time-sensitive ground and maritime targets**



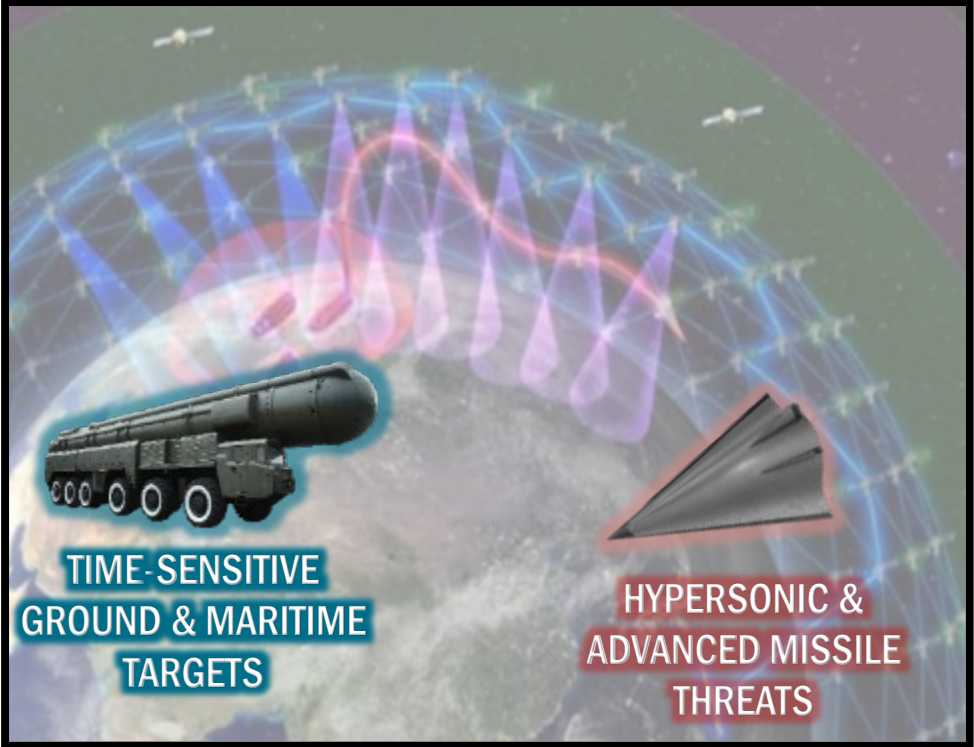
**Hypersonic and advanced missile threat warning and tracking**

SDA's architecture endeavors to perform the following functions from space:

- Detect threat systems
- Track threat systems
- Identify threat systems
- Develop targeting solutions
- Distribute targeting data directly to warfighters

...to close kill chains precisely and at a currently unattainable pace

**Deliver the Department's threat-driven hybrid space architecture by fielding next-generation space capabilities on two-year spirals.**



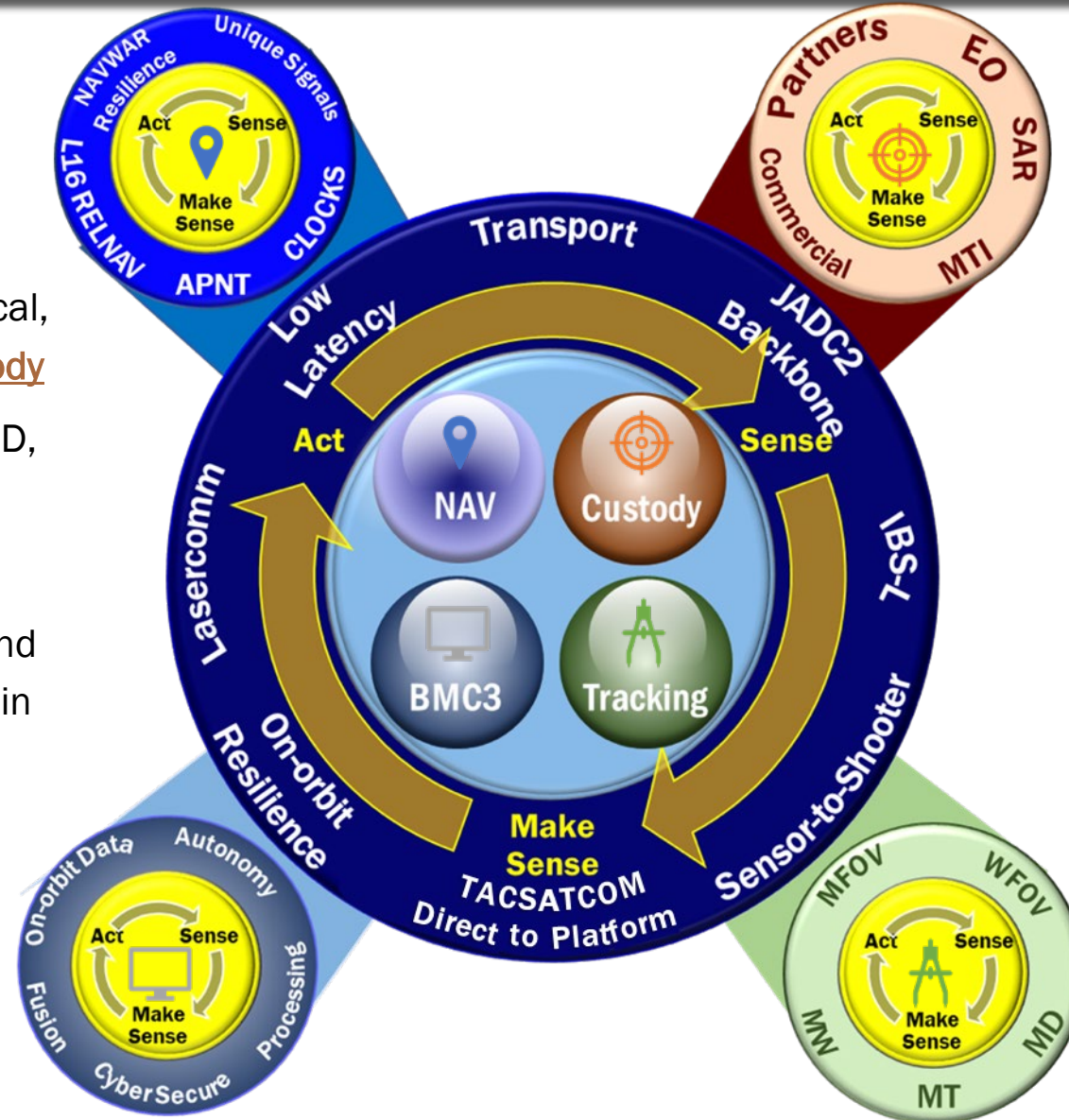
**TIME-SENSITIVE GROUND & MARITIME TARGETS**

**HYPERSONIC & ADVANCED MISSILE THREATS**

**Resilient military sensing and low-latency data transport by means of a proliferated low-earth orbit space architecture**

# THE PROLIFERATED WARFIGHTER SPACE ARCHITECTURE: A GLOBAL WEAPONS SYSTEM

- **Vision:** Space-based systems of systems providing surveillance and targeting as a service
- **Cornerstones**
  - Mission partner (National, tactical, commercial)-based target **Custody**
  - 24/7/365 **Tracking** (MW, MT, MD, fire control quality information)
  - On-orbit, cyber secure **BMC3**
  - Alternate Position, **Navigation** and Timing providing critical anchor in GPS-denied environments
- **Enabled** by a proliferated, resilient, low-latency, global, mesh **Transport** network
- **Advanced** by infusing ecosystem-wide **Emerging Capabilities**



## On-orbit

Mission Demonstrations

**Tranche 0 (FY22) – *Warfighter immersion:*** Demonstrates the feasibility of a proliferated architecture in cost, schedule, and scalability towards necessary performance for beyond line of sight targeting and advanced missile detection and tracking.

## TRR

Test Readiness Review

**Tranche 1 (FY24) – *Initial warfighting capability:*** Regional persistence for Link 16, advanced missile detection, and beyond line of sight targeting plus demonstration of UHF and S-band tactical satellite communications.

## PDR

Preliminary Design Review

**Tranche 2 (FY26) – *Enhanced warfighting capability:*** Global persistence for all in Tranche 1 plus demonstration of advanced tactical data link(s) and future proliferated missions.

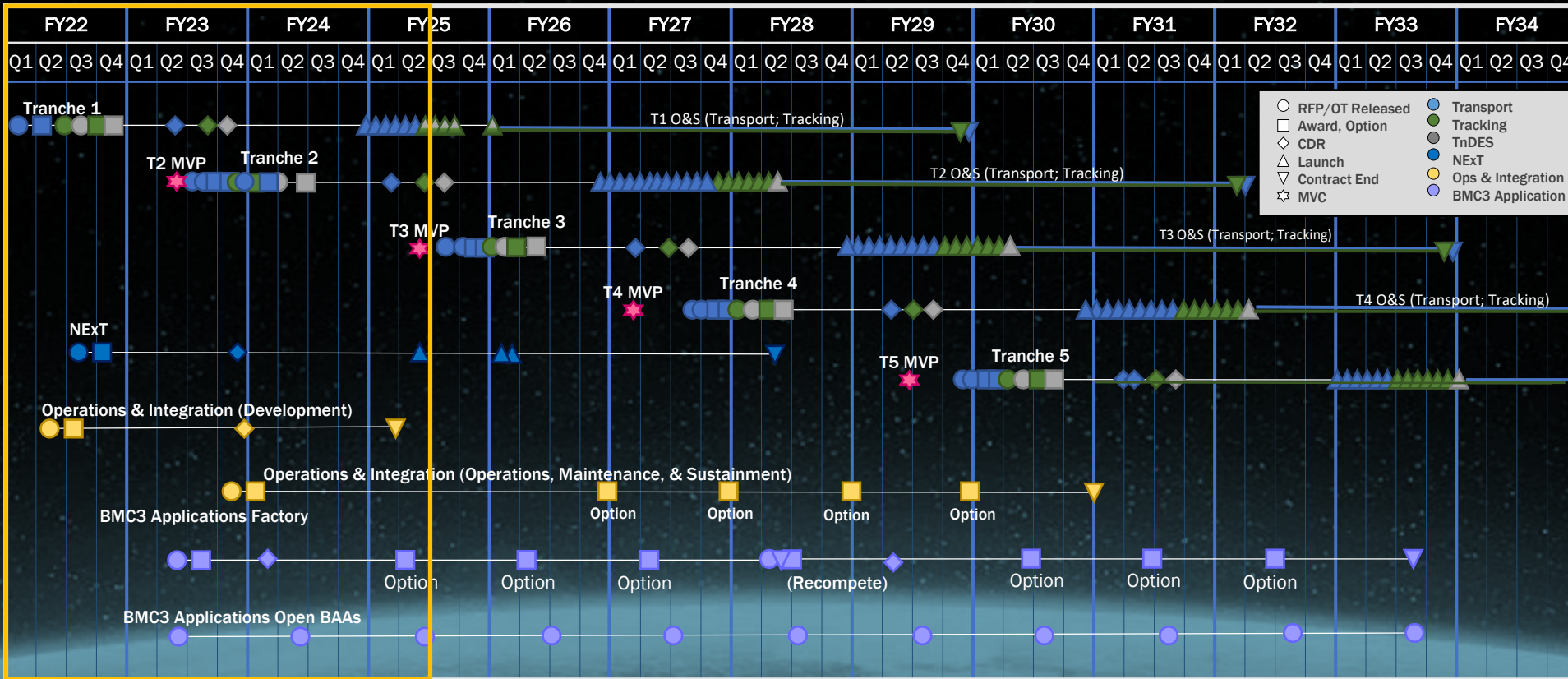
## MVC

Minimum Viable Capability

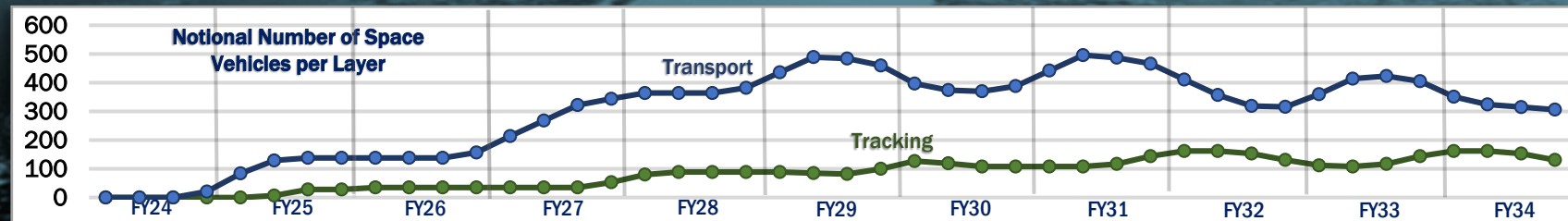
**Tranche 3 (FY28) – *Sustained capability:*** Advanced improvements over Tranche 2 plus future warfighting applications. This includes better sensitivity for missile tracking, better targeting capabilities for BLOS, additional PNT capabilities, advances in lasercom, protected RF communications, and advancements in autonomous operations.

**Tranche 4 (FY30) – *Autonomous operations:*** continual advances across the architecture.

# PWSA DEPLOYMENT



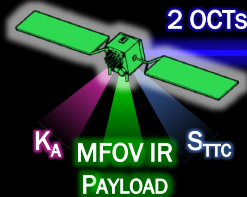
**BMC3:** Battle Management Command, Control, Communications  
**PWSA:** Proliferated Warfighter Space Architecture  
**NExT:** PWSA Experimental Testbed  
**TnDES:** Tranche n Demonstration and Experimentation Systems



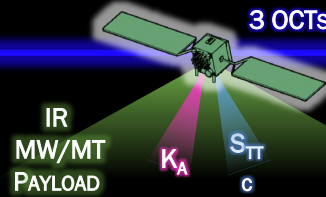
# TRANCHE 1 PROLIFERATED WARFIGHTER SPACE ARCHITECTURE (2025)



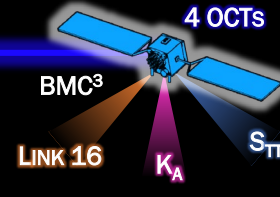
4 MFOV TRACKING SVs  
(4 PLANES, MTD)\*



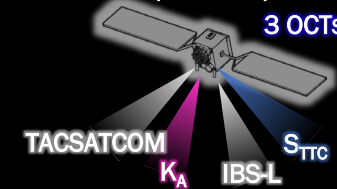
35 WFOV TRACKING SVs  
(5 PLANES, MWTD)



126 TRANSPORT SVs  
(6 PLANES, BLOS)



12 TACTICAL  
DEMONSTRATION SVs\*  
(4 PLANES)



\*NOT PART OF TRANCHE 1  
OPERATIONAL ARCHITECTURE

ALTITUDE (KM)	1000
INCLINATION (DEG)	81.3

DIRECT DOWNLINKS  
TO THEATER  
TARGETING CELLS

IR MISSILE WARNING  
AND TRACKING WITH  
GLOBAL ACCESS

LOW-LATENCY HIGH-VOLUME  
DATA TRANSPORT WITH  
OPTICAL CROSS-LINKS

BEYOND LINE OF SIGHT  
TACTICAL DATA LINK  
CONNECTIVITY

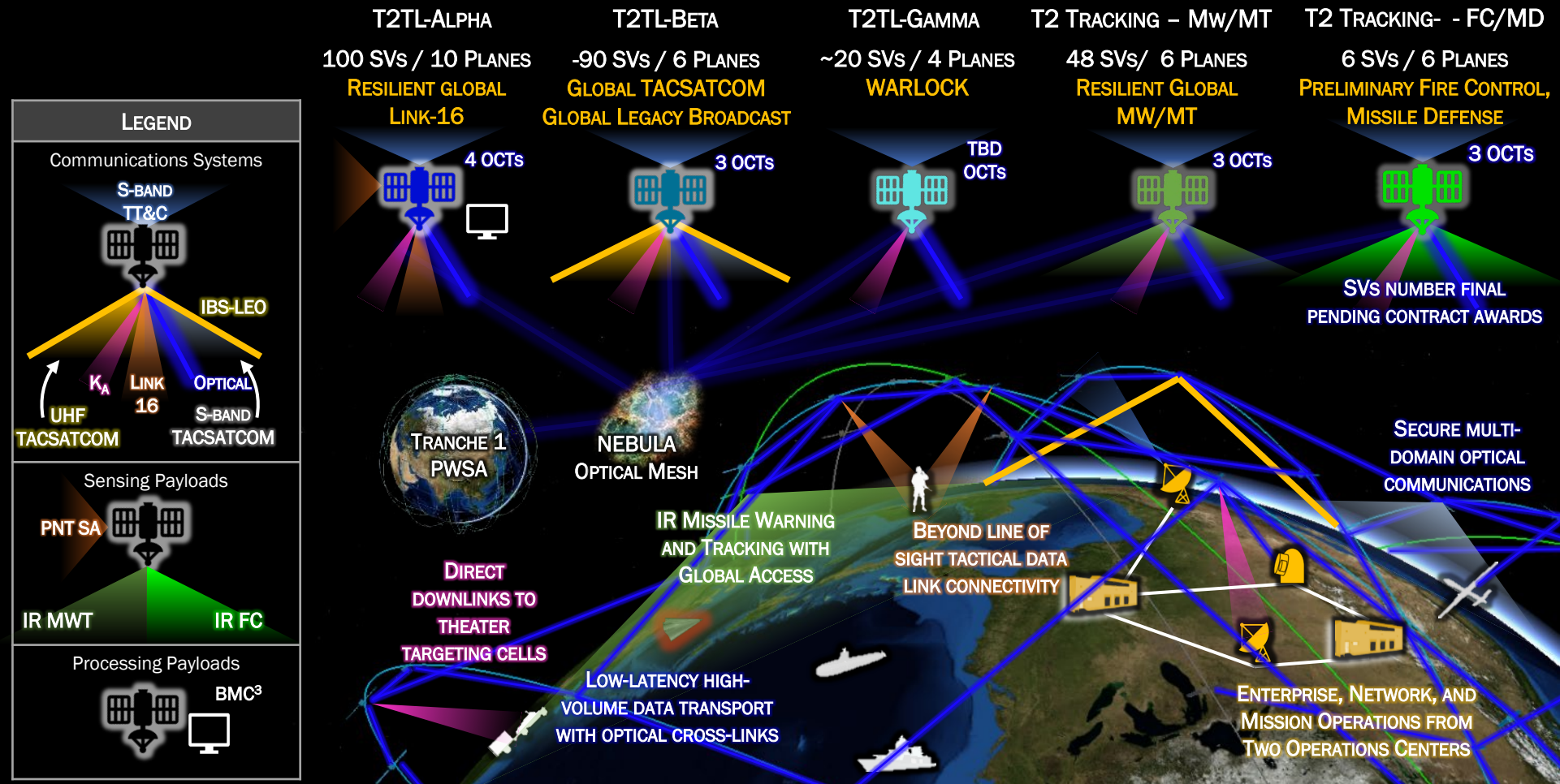
ENTERPRISE, NETWORK, AND  
MISSION OPERATIONS FROM  
TWO OPERATIONS CENTERS

BMC3 MISSION  
ENHANCEMENTS

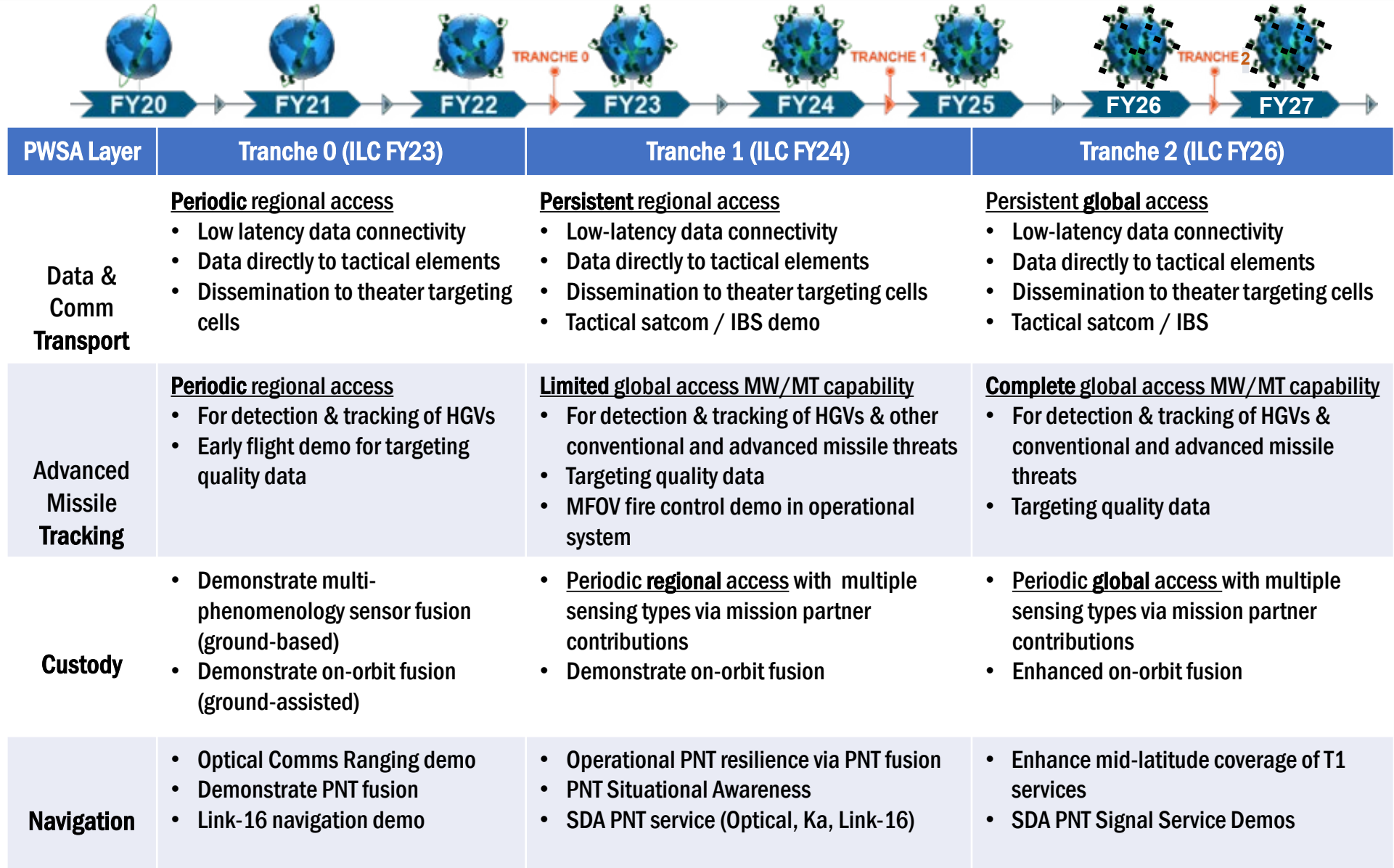
SECURE MULTI-  
DOMAIN OPTICAL  
COMMUNICATIONS

Version: 2023-12-01

# PROLIFERATED WARFIGHTER SPACE ARCHITECTURE TRANCHE 2 (2027)



# DELIVERING CAPABILITY





# PWSA NAVIGATION CAPABILITY TO WARFIGHTER

*SEMPER CITIUS*

## SDA PNT Continuity of Operations and NAVWAR Resilience

- Fusing SDA ground and satellite PNT ranging measurements to ensure continuity of operations when GPS is degraded, untrusted, or unavailable

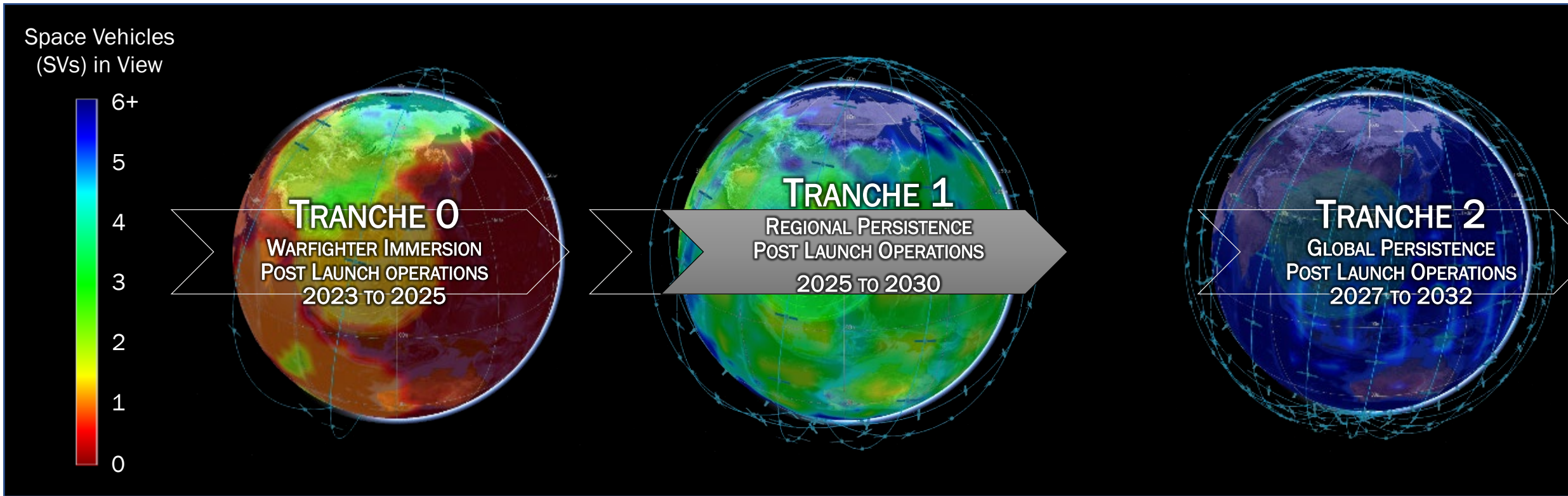
## GPS/GNSS PNT Situational Awareness (PNT SA) Data

- Record raw GPS/GNSS which measurements and spectrum samples from space. Deliver this raw PNT SA data in near real time to the ground for consumption by Services PNT SA analysis tools.

## Space-based PNT Signal Sources

- Provide additional position, navigation, and timing sources to the warfighter

# SDA NAVIGATION LAYER CAPABILITIES EVOLUTION

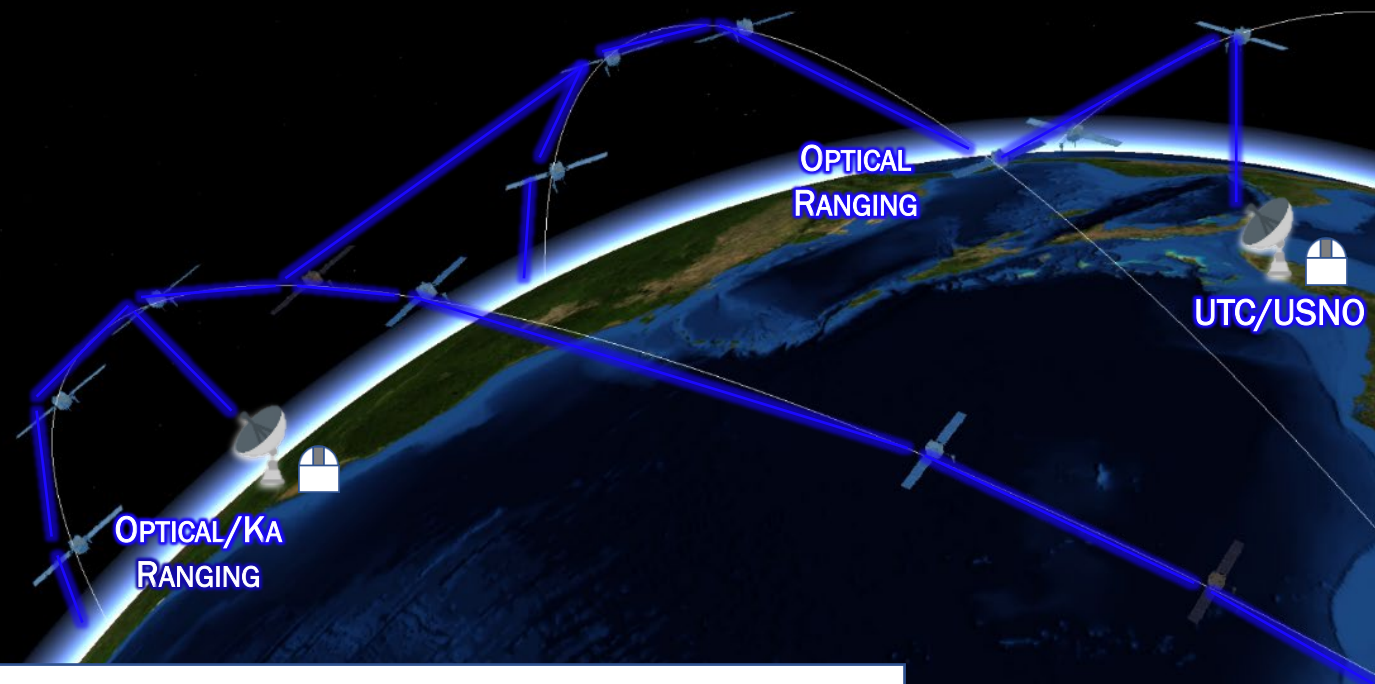


Capability	T0	T1	T2	
NAVWAR Resilience	Demo	Operational	Operational	GPS independent constellation navigation TWTT and ranging from space comm Space-based RELNAV service Global, persistent GPS RFI collection Service defined PNT signal service
NAV-over-Ka and Optical	Demo	Initial Operations	Initial Operations	
NAV-over-Link 16	Demo	Advanced Demo	Service Path	
GNSS Situational Awareness		Operational	Operational	
PNT Signal Service		Demo (NExT)	Demo (T2DES)	

# SDA PNT CONTINUITY OF OPERATIONS AND NAVWAR RESILIENCE



- The SDA optical mesh network is fundamental to the PWSA operations, providing real-time high-speed data transport to all layers of the PWSA.
- By embedding ranging/timing within the optical signal, the PWSA can leverage the resulting crosslink ranging/timing measurements to determine a GPS independent estimate of the constellation positioning and relative timing.
  - This enables PWSA operations in a completely GPS denied environment.
  - Also enables the PWSA to provide a complementary PNT service and potential GPS backup capability to support the warfighter.

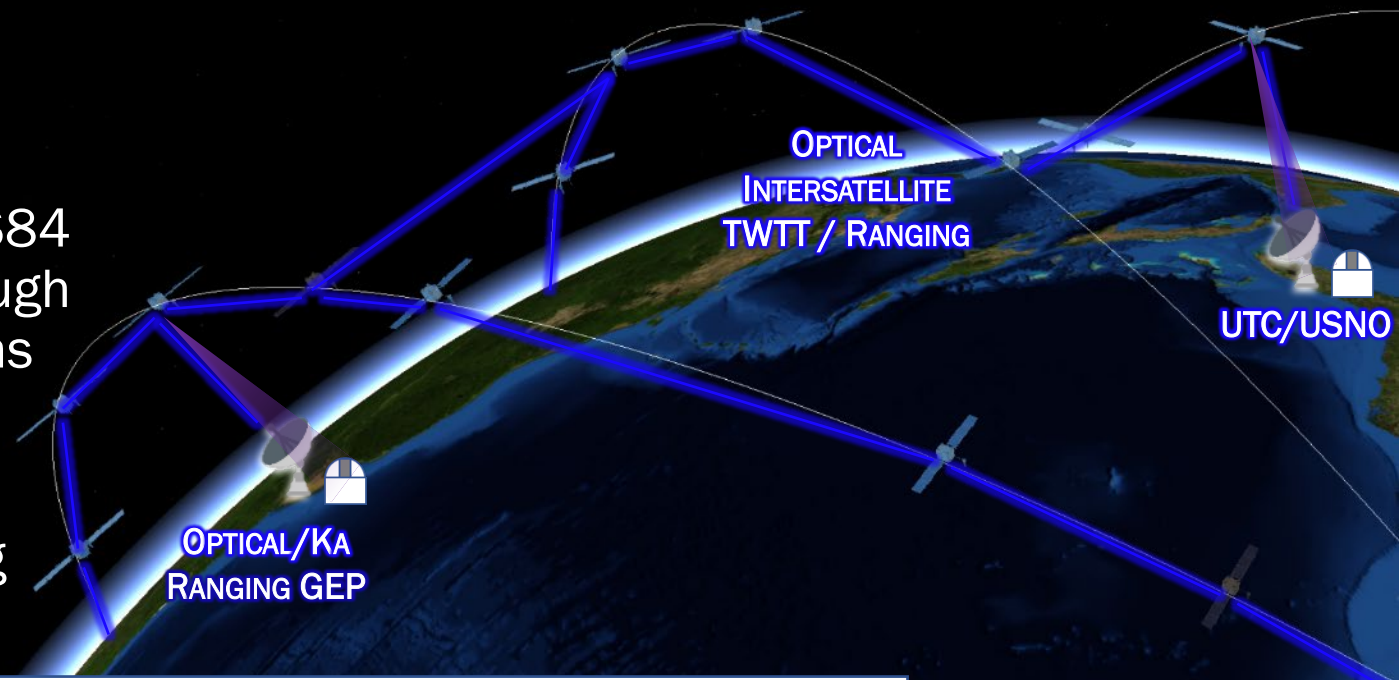


**PWSA NAVWAR resilience extends to the warfighter from SDA PNT services**

# CONSTELLATION SPEED, TIME ATTITUDE AND RANGING (COSTAR)



- The COSTAR OCDA fuses all optical crosslink and space to ground ranging/timing measurements to formulate a constellation wide self-navigation and timing system.
- In future tranches, SDA will pursue operating COSTAR as a space-based distributed application minimizing the need for ground entry points (GEPs).
- Ground operations obtain time reference through GPS-independent time transfer traceable to UTC(USNO).
- Position and timing from GEP UTC and WGS84 references is provided to constellation through optical and Ka-band space to ground comms from surveyed GEPs.
- Onboard chip-scale atomic clocks with high performance ground clocks maintain timing holdover from COSTAR.



**COSTAR maintains ns timing and m level SV positioning across the PWSA**



# **PWSA NAVIGATION CAPABILITY TO WARFIGHTER PNT SITUATIONAL AWARENESS**

*SIMPLER CITIUS*

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# PNT SITUATIONAL AWARENESS (SA) IN TRANCHE 1



- Commercial LEO constellations have been reporting effects on GPS receiver arising from terrestrial RF interference.
- GPS receiver native to most commercial constellation space vehicles are available to act as detectors and provide on-orbit GPS interference SA data.
- SDA Tranche 1 Transport Layer (T1TL) will soon place 126 USSF operated satellites into LEO, each with GPS/GNSS receivers capable of returning terrestrial interference data.
- SDA prescribed modifications to T1TL GPS/GNSS receivers are optimized for PNT SA data collection, leveraging the SDA transport layer optical mesh to bring data to users in near real time.
- PNT SA data from T1TL will flow into the DoD Unified Data Library to share with US COCOMS/DOD Services/Civil US Agencies/Allied partners for post-processing to inform global operational environments.

## Balance on-orbit GNSS receiver tracking while maximizing Earth coverage

**Raw GPS measurements pass to the ground via optical mesh in near real time, globally 24/7.**

- GNSS Automatic Gain Control State
- GNSS Carrier to Noise Density Ratio
- GNSS Code Phase
- GNSS Carrier Doppler frequency
- GNSS Carrier phase measurements
- GNSS Pseudorange measurements
- GNSS Tracking Status
- GNSS Navigation Messages
- GNSS PVT solution

**Raw PNT I/Q spectrum snapshots will be recorded over specified geographic regions, potentially for extended period ranging from hours to months.**

- Millisecond snapshots of all three GNSS bands are possible (L1, L2, L5)
- Tens of millisecond snapshots of one specific GNSS band possible

- Tranche 2 carries forward PNT SA data return into the mid-inclined Alpha Transport layer
  - Adds over 100 space vehicles
  - Closes T1 visibility gaps
- T3 minimum viable capability (MVC) will propose adding M-code signal monitoring.
  - Low-cost GPS Inc 1 receivers are being qualified for LEO survivability.
- T3 MVC will propose adding automatic queuing of GPS/GNSS spectrum snapshots.
- PNT SA antenna pattern and direction will be further refined from T3 orbit analysis.



# **PWSA NAVIGATION SERVICE TO WARFIGHTER** **SDA PNT SIGNAL SERVICE SERVICE**

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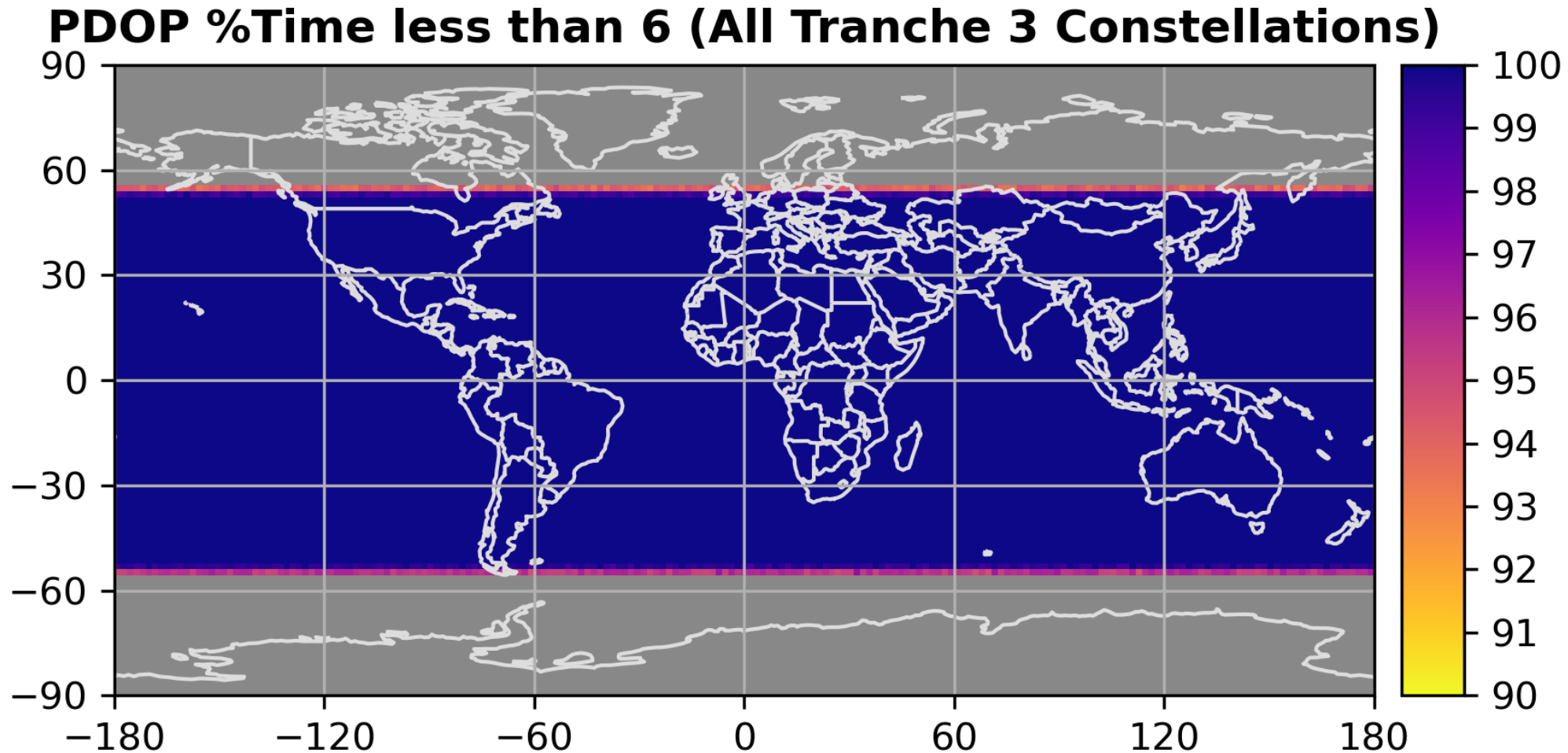
- With the timing and ranging provided by the optical mesh, SDA may complement and/or augment GPS baselined systems and enable assured PNT for a new class of lightweight systems.
- SDA is engaged with various Service PNT user community representatives to define use cases, demonstrations, and experiments for PNT service signals.
- Impact to use case receiver fielding is a significant consideration:
  - Military services could leverage MGUE Inc 2 and open-architecture PNT platform systems
  - Dedicated low-cost ASIC for LWS and ALTNAV are needed for IoT and lightweight military applications
- Current use cases considered by Services and COCOMS:
  - Under resilient navigation “PACE” plans, GPS = “Primary”, SDA = “Alternate”,
  - Enhance signal coverage for Army mobile and dismounted ALTNAV systems,
  - Aid MGUE acquisition by providing augmentation message and time transfer,
  - Provide secure PNT to lightweight platform receivers (SWAP constrained) that cannot incorporate MGUE integration, e.g. small UAVs, precision guided munitions.

- Key is Service use case development, AF SDUE, Army flexible receiver programs, NAVY GPNTS and AF LWS ASIC
  - Deployment of receivers in the 2030-time frame to coordinate with SDA space segment.
  - LWS intended for new use case not served by M-code.
  - Provide complementary PNT alternative service
- ALTNAV already has initial receiver production run for Army.
- Both LWS and ALTNAV services are complementary and can be used together to provide better geometry.
- T3/T4 operational transition could occur in the 2029/2031-timeframe but requires military service commitment to develop/deploy compatible receivers.

- Lightweight PNT payload proliferated on all T3 and T4 satellites with low SWAP (peak power less than 40 watts, 20 watts steady state).
- Midscale PNT payload proliferated on all T3 and T4 satellites with mid SWAP (peak power less than 100 watts, 20 watts steady state).
- Dedicated NAV satellite layer proliferated in sub-constellation of 50 SV (5 planes at 45 degree) capable of generating high powered ALTNAV and strong LWS, with transmit phase array.

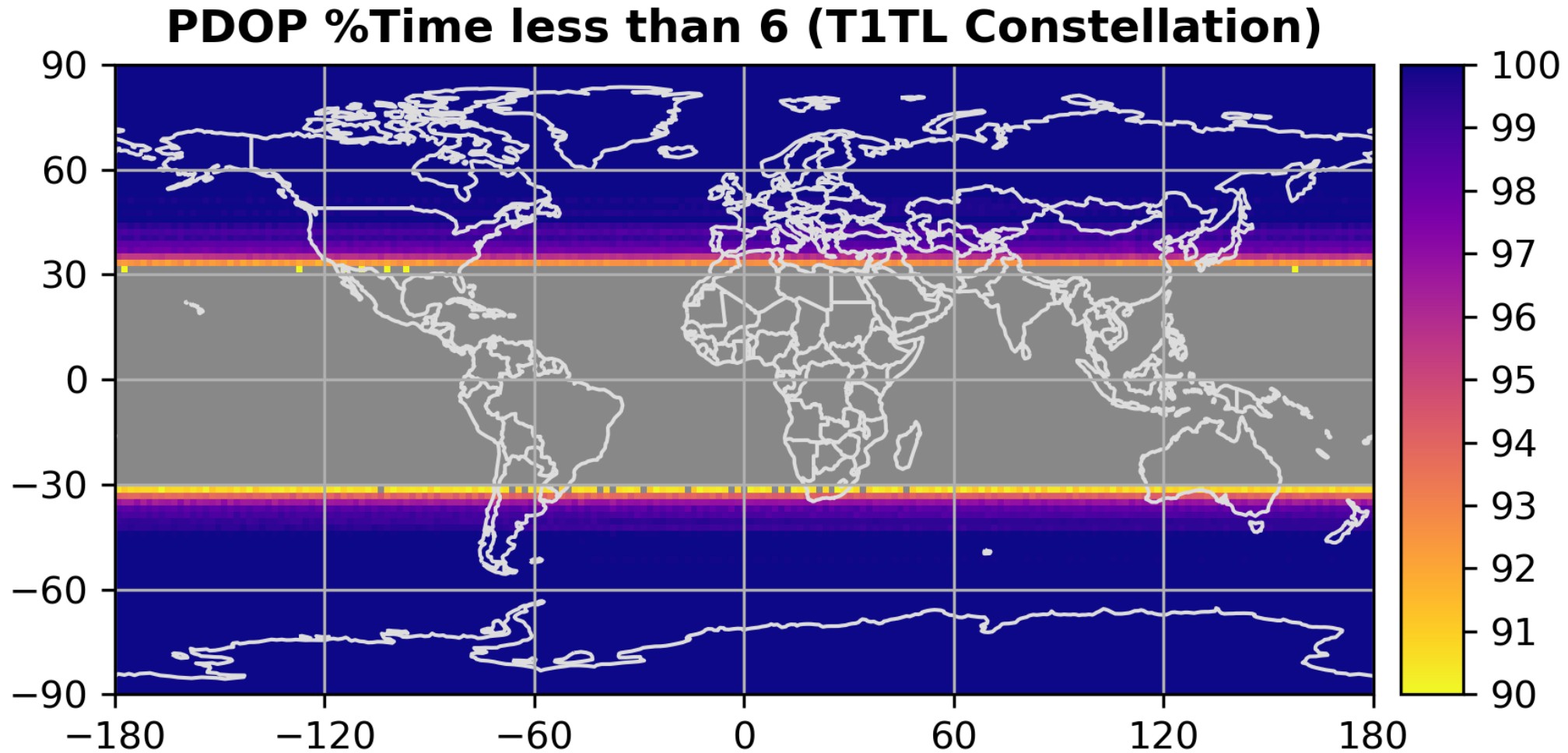
# ALL TRANCHE 3 CONSTELLATIONS (196 TOTAL SV)

- PDOP < 6 Performance, 1 day, 1.8° x 1.8° Rectangular Grid



# T1TL (as T4) CONSTELLATION (126 SV IN 6 PLANES AT 81 DEGREE INCLINATION)

- PDOP < 6 Performance, 1 day, 1.8° x 1.8° Rectangular Grid



# NAVIGATION CAPABILITIES SUMMARY AND OUTLOOK



- **SDA is providing capability to the warfighter PWSA**
  - Tranche 0 satellites are launched in FY23
    - ✓ Launch 1, 2 and 3 complete (MAR 2023, AUG 2023, FEB 2024)
  - Tranche 1 entering Test Readiness Review phase,
    - Transport and Tracking SVs executing into Assembly, Integration and Test
    - First launch expected Q4 2024
  - Tranche 2 Transport and Tracking awarded in FY24
    - ✓ Warfighter Council (WFC) T2 Transport and Tracking MVC concurrence, complete (Q3 CY 23)
    - ✓ T2 Transport Alpha, Beta awarded. T2 Tracking awarded. Transport moving toward PDR. Tracking moving to SRR.
  - Tranche 3 collecting Minimum Viable Capability
    - ✓ NAV warfighter solicitation cycle for endorsements and needs statements ends Q3 2024.
- **SDA Navigation capabilities continue to evolve**
  - Constellation exploits optical mesh network to determine ephemeris and clock (meter level, ns performance)
  - Inform PNT situational awareness of terrestrial GNSS RFI, add M-code monitoring
  - Exploit any Transport RF/optical space to ground signal as a potential PNT service to the warfighter.
  - Add PNT unique signal service starting in Tranche 3 (ALTNAV/LWS)
    - NEXT Saber PNT Service payload with (ALTNAV/LWS) completed CDR, expected on-orbit demonstrations FY25.

# SEMPER CITIUS

In Latin, it means “always faster.” SDA recognizes that good enough capabilities in the hands of the joint warfighter sooner may be better than delivering the perfect solution too late. Because of this, it means we as an agency accept a higher level of risk, employ novel business models, and move to develop and field capabilities more quickly than you might see in “traditional” government agencies. We believe this builds resiliency into our people and our product—the Proliferated Warfighter Space Architecture.

When we say “semper citius,” we mean that we are moving at or ahead of the speed of the threat because we know the joint warfighter is counting on us.

SEMPER CITIUS