the VOLPE center

National Position Navigation and Timing Architecture

APEC GNSS Innovation Summit

Karen Van Dyke, DOT/RITA/Volpe Center

May 26-28, 2008

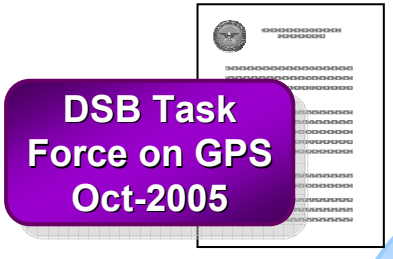
Overview

- PNT Architecture Background
- Architecture Development
- Vision, Strategy, and Vectors
- Way Forward

PNT Architecture Background

- Study requested by
  - Assistant Secretary of Defense for Networks and Information Integration
  - Under Secretary of Transportation for Policy
  - National Space-based PNT Executive Committee
- Justification - PNT Strategic Landscape is Changing
  - Gaps in current capabilities
  - Insufficient unity of effort towards future PNT capabilities
- Products
  - 20 year strategic outlook to guide near and mid-term decisions on PNT capabilities

Origins

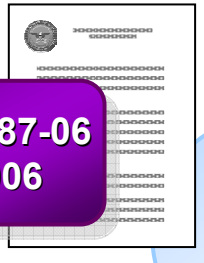


DSB Task Force on GPS Oct-2005

"Develop a Comprehensive National PNT Architecture"

"Conduct a Comprehensive Analysis of GPS Backup Navigation & Precision Timing Options"

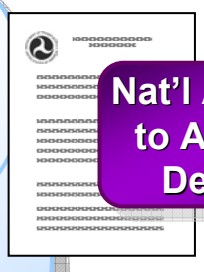
Volpe GPS Vulnerability Sep-2001



JROCM 187-06 Sep-2006

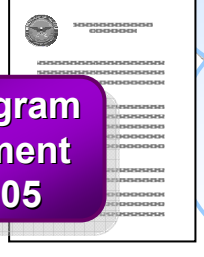
"JROC Approves the PNT JCD & Validates the Five Gaps Identified"

"Determine the optimal integrated system for meeting requirements of Federal users"



Nat'l Approach to Aug. GPS Dec-1994

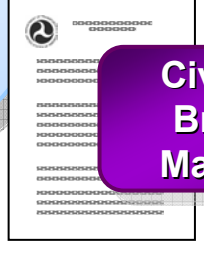
National PNT Strategy Needed



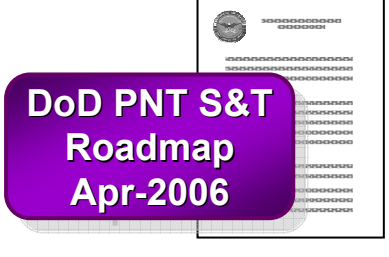
NSS Program Assessment Mar-2005

"Develop a Comprehensive PNT Architecture"

"Validate GPS Requirements vs. PNT Requirements"



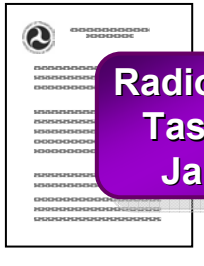
Civil AoA Briefing May-2005



DoD PNT S&T Roadmap Apr-2006

"Develop a DoD Timing Architecture"

"Periodically Evaluate Radionavigation System Contributions to the Overall Mix"

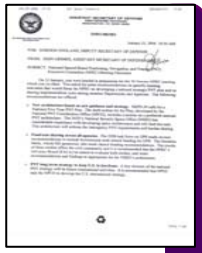


Radionav Sys. Task Force Jan-2004

Foundations

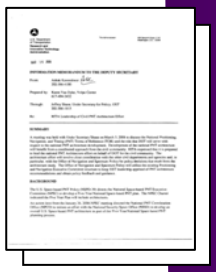
RITA
FAA
JPDO
FHWA
FRA
DOC
NIST
DHS
USCG
DOI
State
NASA
NCO

ASD/NII Memo 23-Jan-2006



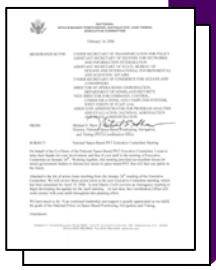
"NSSO develop a National PNT Architecture"

DOT/RITA Memo 14-Mar-2006



"RITA will lead effort on behalf of DOT for the civil community"

NPEC Action Items 26-Jan-2006



"NPCO will initiate an effort with NSSO"

PNT Architecture TOR 11-Jul-2006

NII
S&T
PBFA
JS
USA
USN
USMC
USAF
SAF/US
NGA
NSA
STRAT
SMDC
AFSPC
USNO
NRL
SMC
NSSO

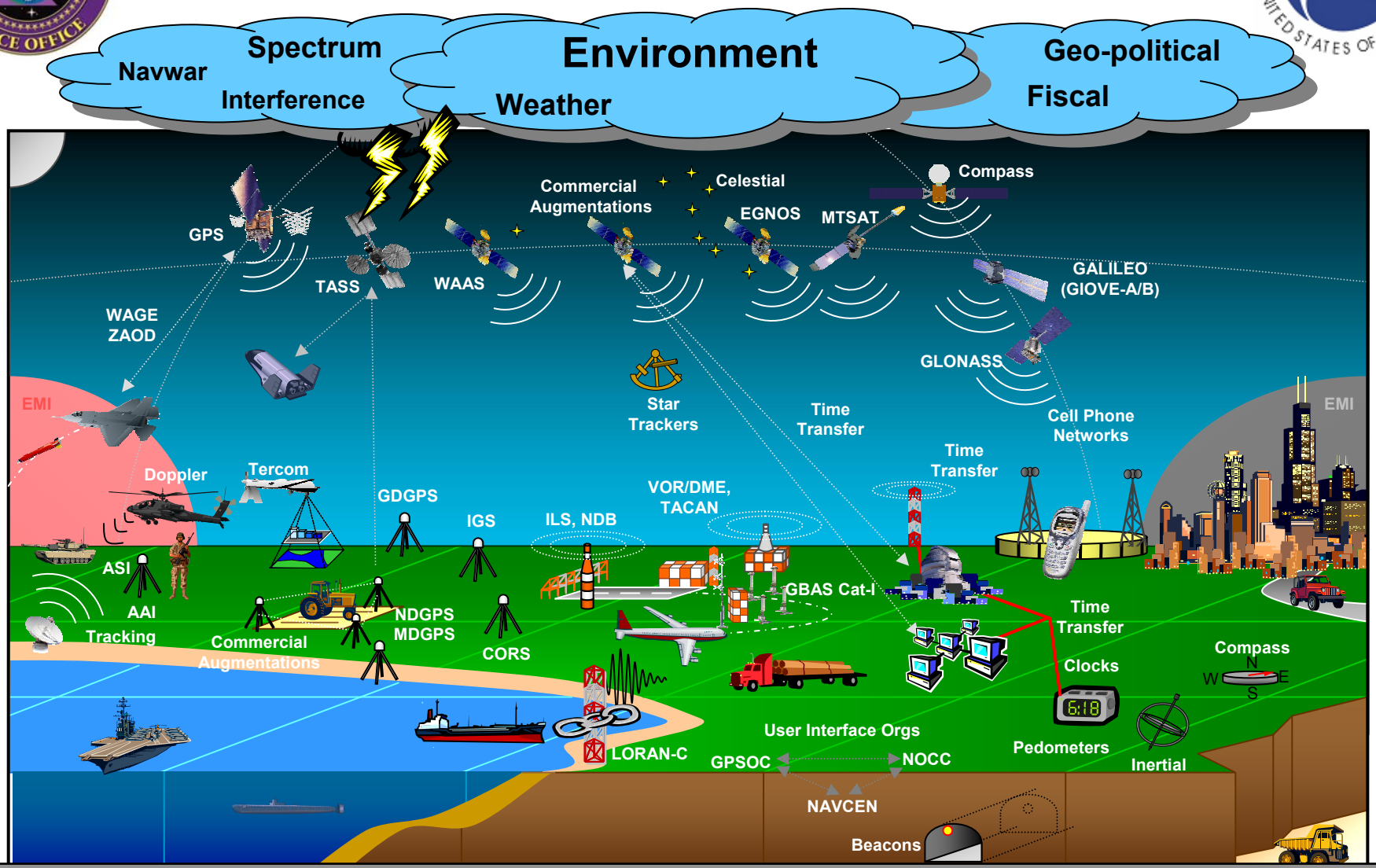
More Effective & Efficient PNT and an Evolutionary Path for Government Provided Systems & Services

National PNT Architecture Scope

USERS	DOMAIN	MISSIONS	SOURCES	PROVIDERS
Military	Space	Location Based Services	GNSS	Military
Homeland Security	Air	Tracking	GNSS Augmentation	Civil
Civil	Surface	Survey	Terrestrial NAVAIDS	Commercial
Commercial	Sub-Surface	Scientific	Onboard / User Equip	International
Individual		Recreation	Networks	
		Transportation		
		Machine Control		
		Agriculture		
		Weapons		
		Orientation		
		Communications and Timing		

Broad Scope Requires Innovative Approaches and Focused Analysis Efforts

“As-Is” PNT Architecture Graphic (2008)



ENABLERS & INFRASTRUCTURE

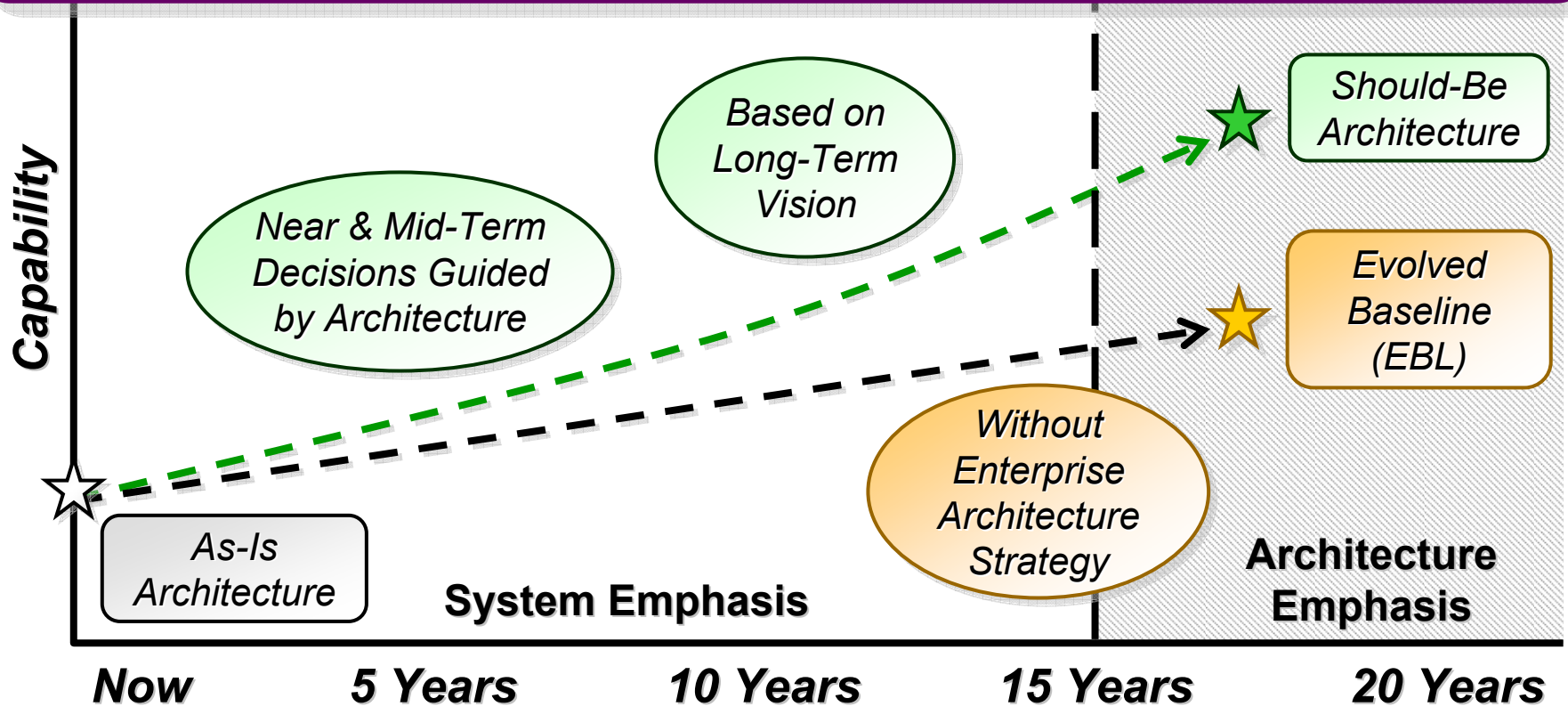
Standards · Reference Frames · Cryptography · Science & Technology · USNO · NIST · NGA · NGS · Star Catalogs · Launch · NSA · Industrial Base · Electro Optical Info. · Modeling · Mapping/Charting/Geodesy · Laser Ranging Network · Policies · Testing

Primary PNT Gaps

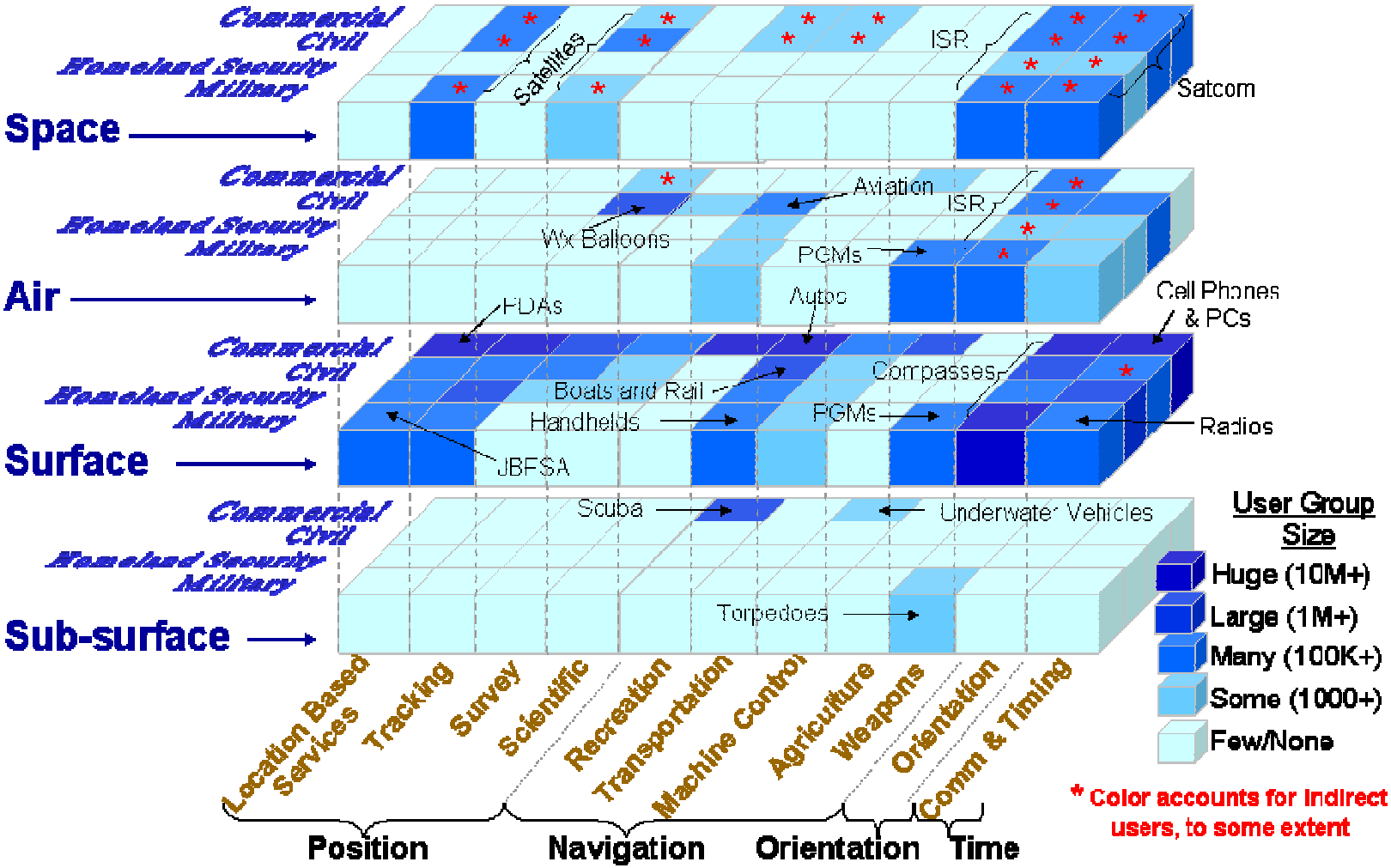
- Gaps primarily drawn from military's PNT Joint Capabilities Document, with additions and modifications from parallel civil community documents and discussions
  - Physically Impeded Environments
  - Electromagnetically Impeded Environments
  - Higher accuracy with integrity
  - Hazardously Misleading Info (Integrity)
  - High Altitude/Space Position and Orientation
  - Geospatial information - access to improved GIS data (regarding intended path of travel)
  - Insufficient modeling capability

Primary Objective of the Architecture

"…provide more effective and efficient PNT capabilities focused on the 2025 timeframe and an evolutionary path for government provided systems and services." -- Terms of Reference



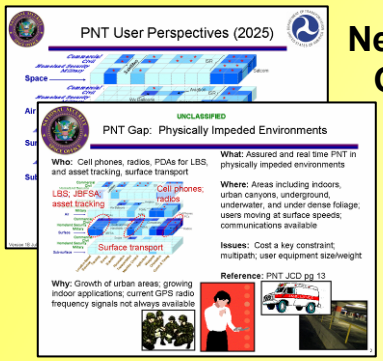
PNT User Perspectives (2025)



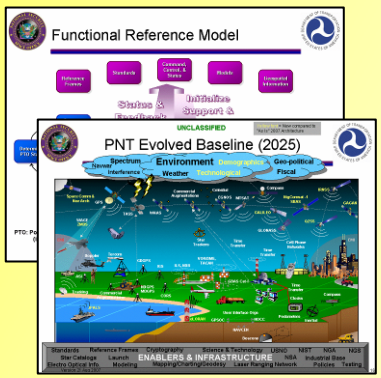
Framework to describe user needs & environments, and which users are affected by each capability gap

Cumulative Process

Data Gathering

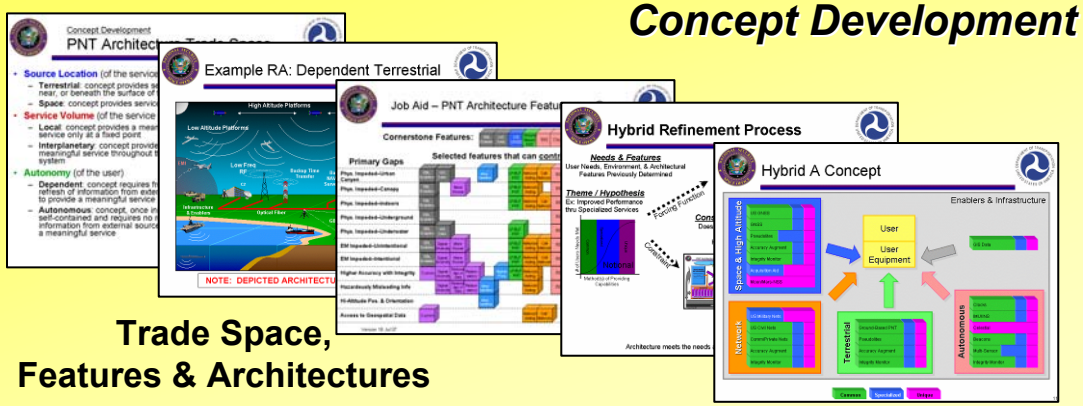


Needs & Gaps



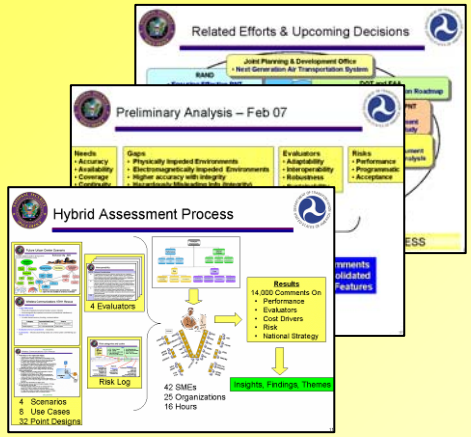
Environment, Technology & Evolved Baseline

Concept Development



Trade Space, Features & Architectures

Analysis & Assessment

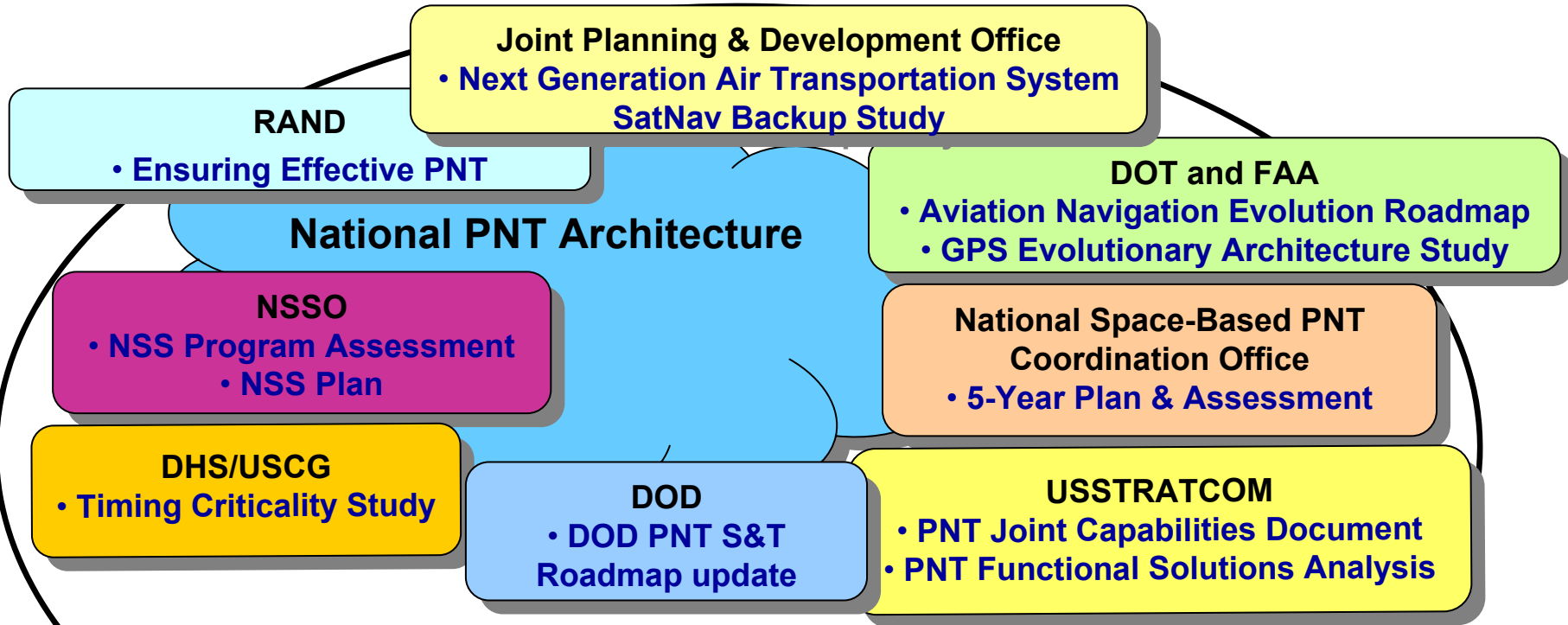


Analytical Framework

Community Involvement

Architecture Development Team, Subject Matter Experts, Small Working Groups & Industry

Related Efforts & National Decisions



- Recent & Upcoming Decisions
  - Future of eLORAN
  - Future of NDGPS and High Accuracy NDGPS
  - Backup SATNAV Tasking
  - Backup PNT Needs (ADS-B, NGATS, Timing Infrastructure)
  - GPS III and OCX Acquisition Strategies

MAINTAIN SHARED SITUATIONAL AWARENESS

Guiding Principles

VISION
US Leadership in Global PNT

STRATEGY
Greater Common Denominator

PRIMARY VECTOR
Multiple Phenomenologies

PRIMARY VECTOR
Interchangeable Solutions

SUPPORTING VECTOR
Synergy of PNT with Communications

SUPPORTING VECTOR
Cooperative Organizational Structures

National PNT Architecture Vision

US Leadership in Global PNT

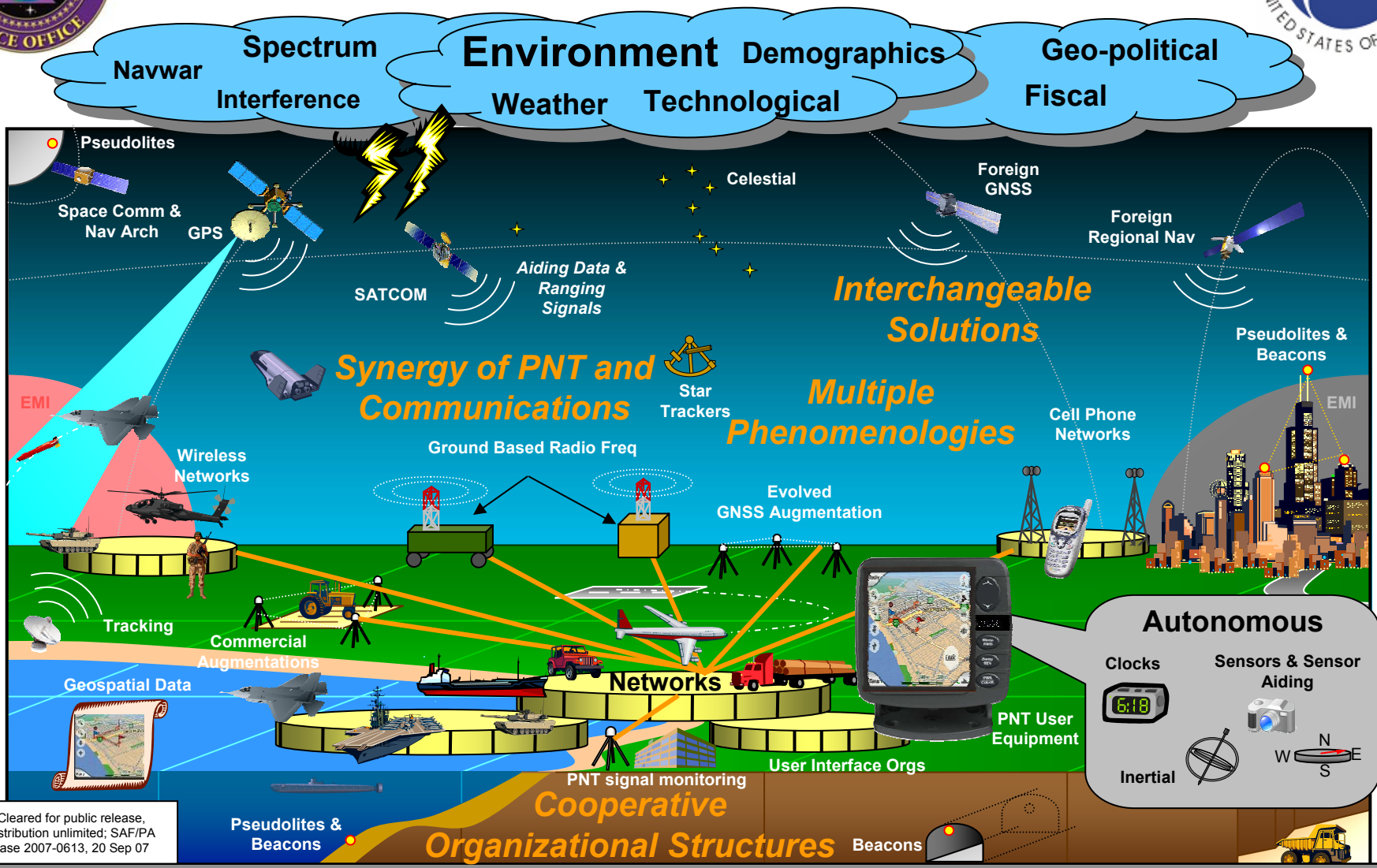
- National PNT Architecture based on policy foundation set by 2004 Presidential Policy Directive on Space-Based PNT
- Efficiently (cost, schedule, acceptable risks, user impact) develop and field the best technologies and systems
- Promulgate stable policies (commitment to funding, commitment to performance, advanced notice of change, etc)
- Foster innovation through competition within the commercial sector
- Ensure robust and enduring inter-agency coordination and cooperation
- Maximize the practical use of military, civil, commercial and foreign systems and technologies
- Judiciously develop and apply standards and best practices

National PNT Architecture Strategy

The US can Best Achieve Efficiency and Effectiveness through a Greater Common Denominator Approach

- Satisfy common needs with common solutions
- Promulgate a predominantly “dependent” architecture where users rely upon external sources
- Leverage ongoing US GNSS modernization to assure global service and support national interests
- Promote adoption of low-burden “autonomous” features for robustness
- Specialized needs still require specialized solutions
- Balance provided or enabled capabilities with the need for a military PNT advantage

“Should-Be” PNT Architecture Graphic (2025)



Cleared for public release, distribution unlimited; SAF/PA case 2007-0613, 20 Sep 07

Standards Reference Frames Cryptography Science & Technology USNO NIST NGA NGS
Star Catalogs Launch **ENABLERS & INFRASTRUCTURE** NSA Industrial Base
Electro Optical Info. Modeling Mapping/Charting/Geodesy Laser Ranging Network Policies Testing

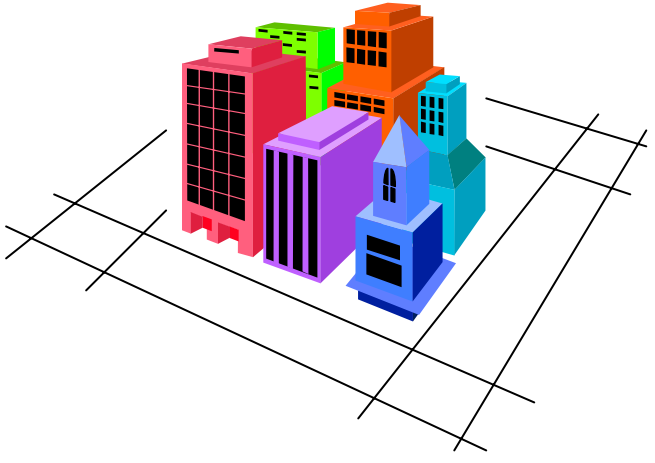
Next Steps

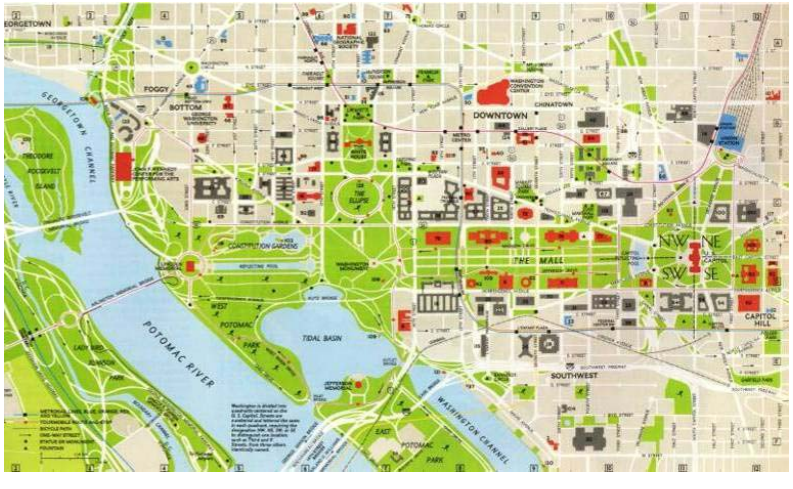
- NSSO, RITA & NII oversee development of detailed transition and implementation planning
- Hold Workshop to Obtain Industry Feedback on Recommendations When Publicly Released
- Architecture Implementation Memorandum
  - Approved event-based implementation timeline
- Influence update to PNT planning documents
  - Federal Radionavigation Plan
  - Five-Year National Space-Based PNT Plan

BACKUPS

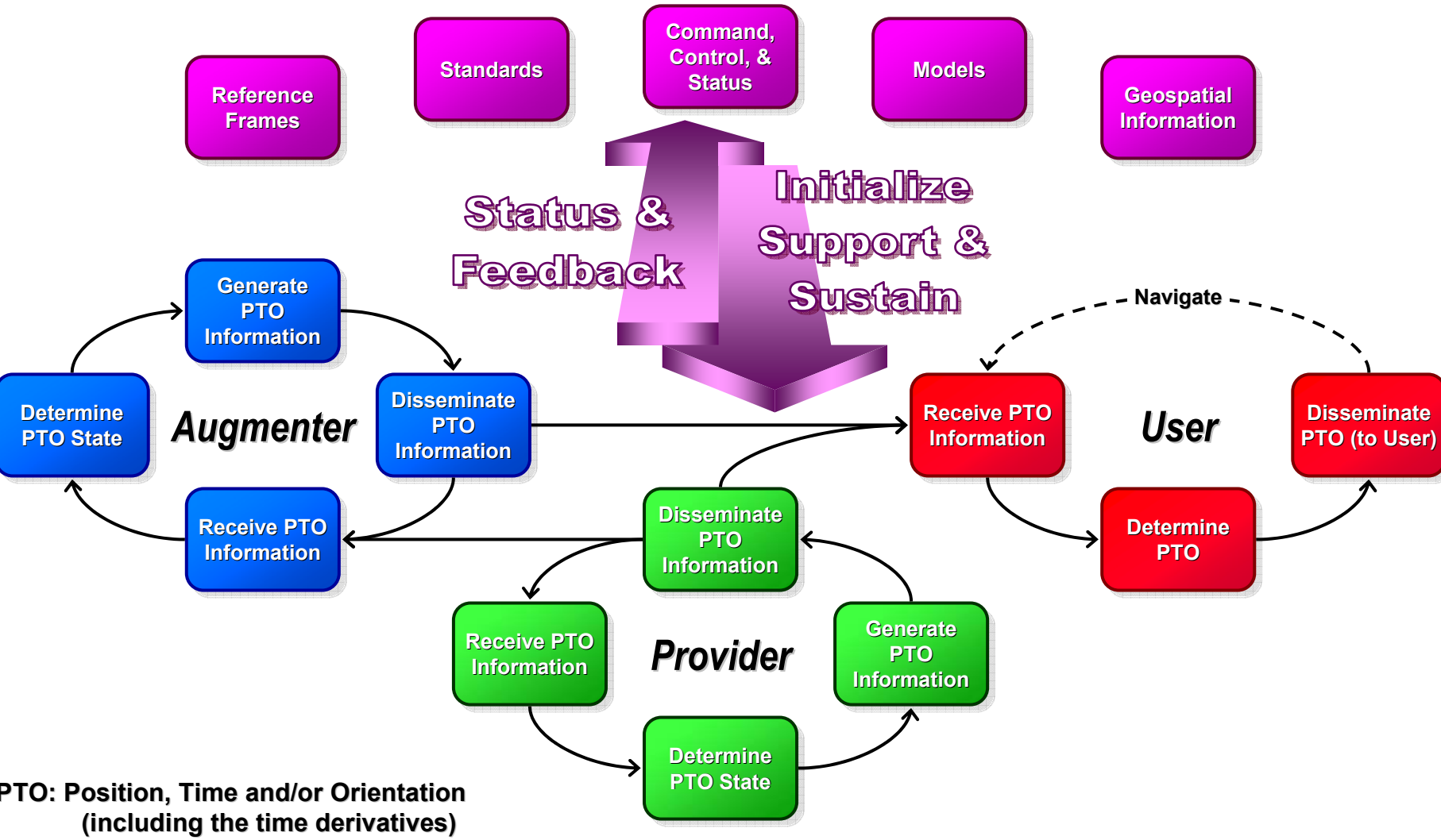
Purpose of NSSO Architectures

- Enterprise Level Guidance
  - High Level Capabilities
  - Fundamental Processes
  - Organizations
  - Infrastructure
- Similar to City Planning
  - Considerations for how people, buildings, transportation, utilities work together
  - Effect of External Factors (e.g., weather, state jurisdiction, etc.)
  - Objective is not to design all the buildings
  - May conduct detailed design of some elements, primarily to gain understanding of higher level issues





Functional Reference Model



PTO: Position, Time and/or Orientation (including the time derivatives)

Concept Development

PNT Architecture Trade Space

Source Location (of the service provider)

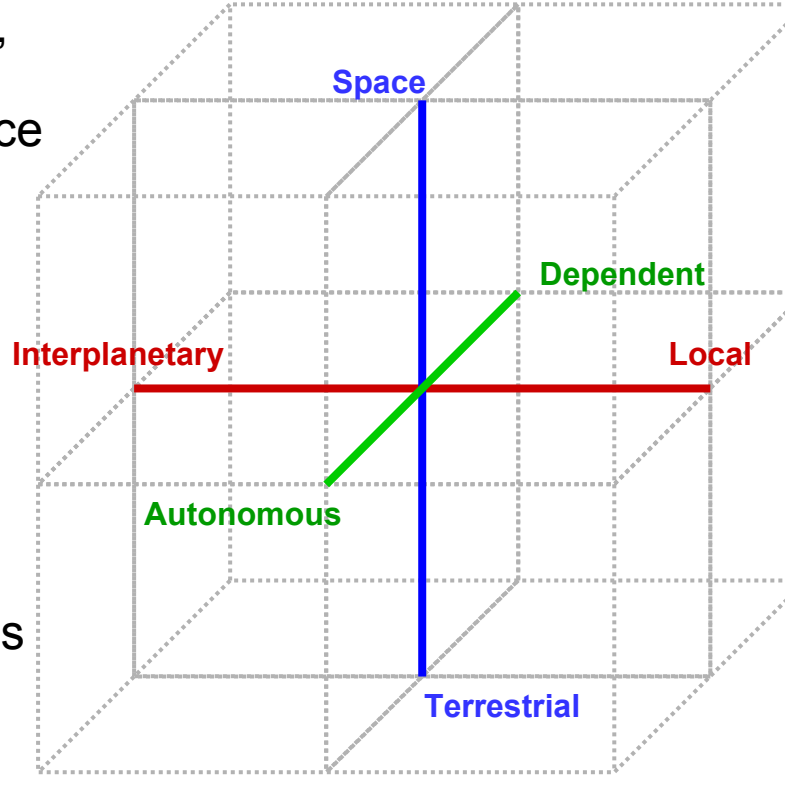
- **Terrestrial**: concept provides service from, near, or beneath the surface of the earth
- **Space**: concept provides service from space

Service Volume (of the service provided)

- **Local**: concept provides a meaningful service only at a fixed point
- **Interplanetary**: concept provides a meaningful service throughout the solar system

Autonomy (of the user)

- **Dependent**: concept requires frequent refresh of information from external sources to provide a meaningful service
- **Autonomous**: concept, once initialized, is self-contained and requires no refresh of information from external sources to provide a meaningful service



PNT Representative Architectures (RA)

0: Evolved Baseline

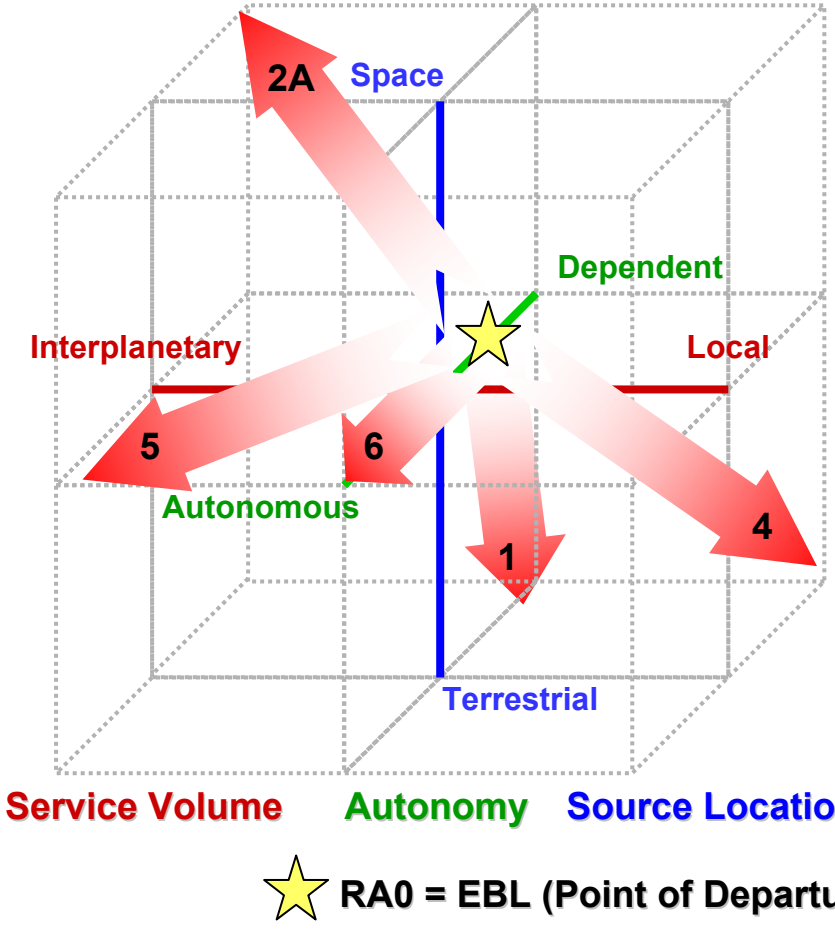
1: Dependent Terrestrial

2A: Combined GNSS Constellations

4: Network Aiding of GNSS

5: Aided Autonomous Sensors and Aiding Sources

6: Highly Autonomous

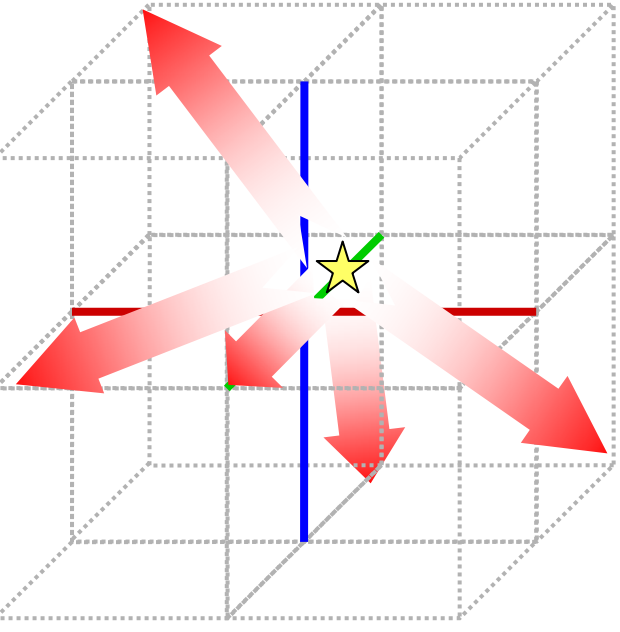


RAs ARE *NOT* FINAL SOLUTIONS – THEY *ARE* USED TO GAIN INSIGHTS TOWARDS FINAL RECOMMENDATIONS

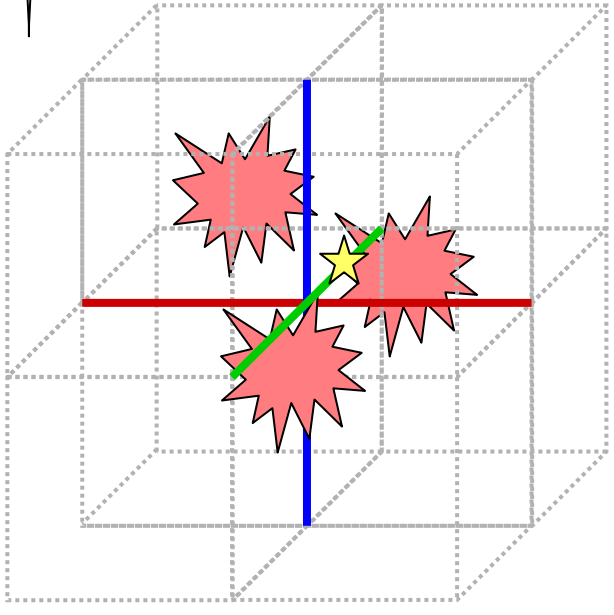
From Representative Architectures … to Recommendations

Preliminary Analysis (Feb - Mar 07)

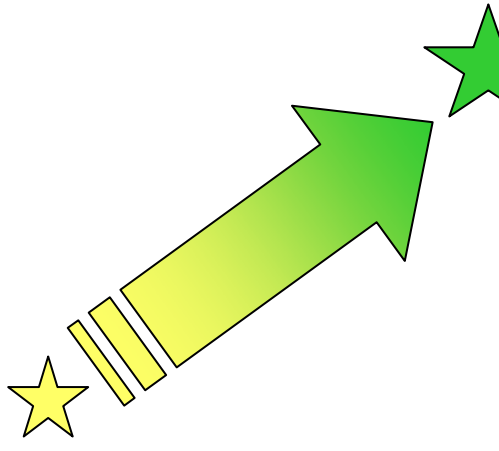
Cost and Performance Analysis (Apr - Jul 07)



Representative Architectures



Hybrid Architectures



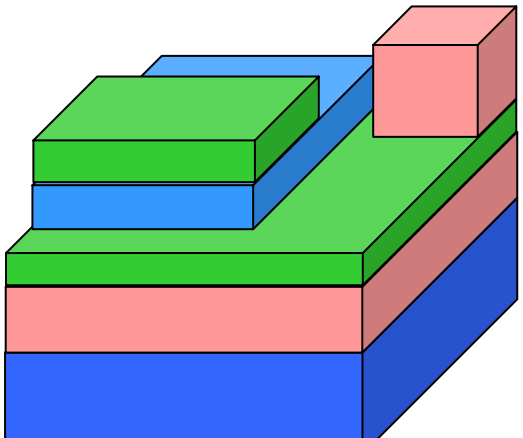
Should Be Architecture

- **Recommendations**
- **Guidance**
- **Decision Criteria**

Three Themes (Hybrid Architectures)

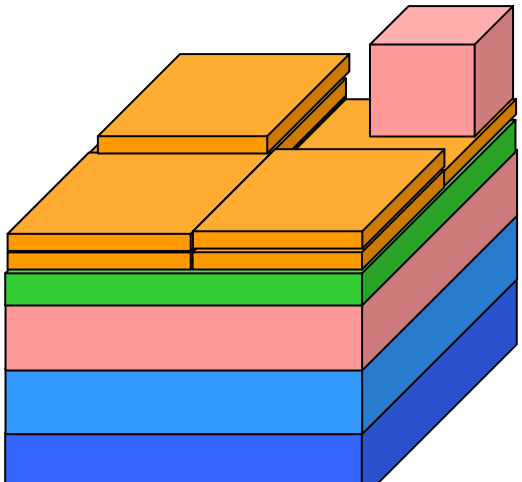
Hybrid A

- Common solutions for many users
- Horizontal integration
- Greatest common denominator
- Emphasis on global and long range broadcasts direct to users



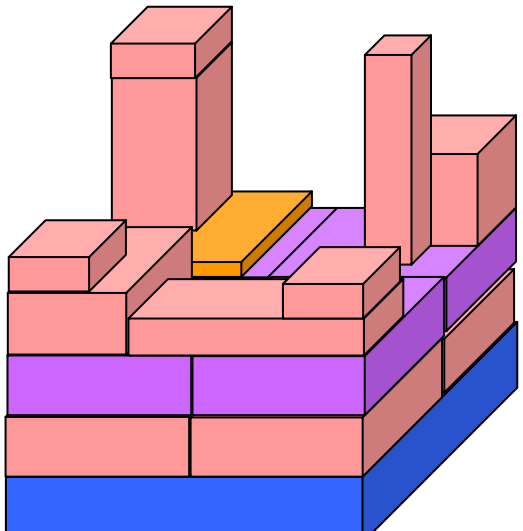
Hybrid B

- Common solutions for many users
- Horizontal integration
- Greatest common denominator
- Emphasis on networks



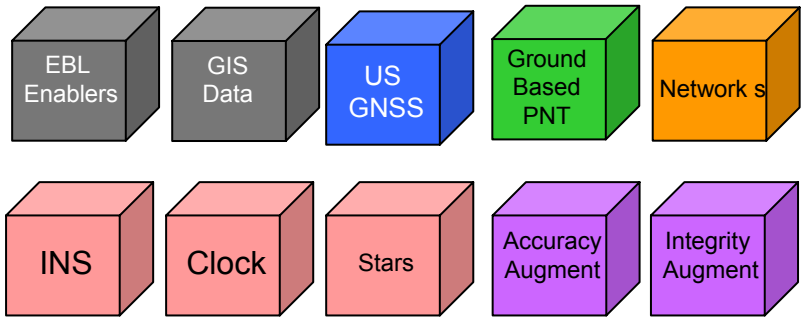
Hybrid C

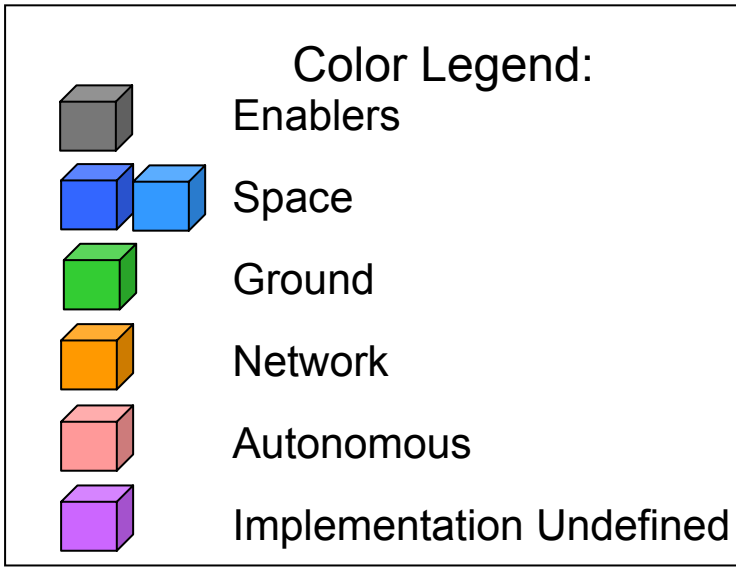
- Specialized solutions for each user group
- Vertical integration
- Least common denominator
- Emphasis on autonomous solutions



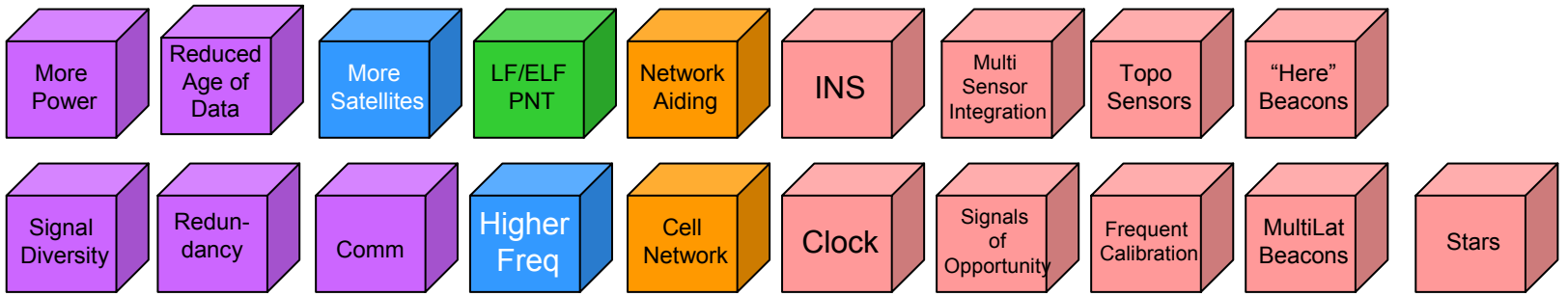
Job Aid -- Draft PNT Architecture Features

These features should be hybrid cornerstones:





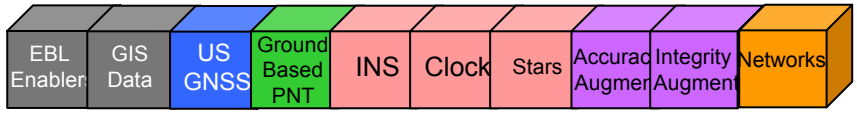
These features/systems can contribute to covering primary PNT gaps; those which help the most, or which help to cover multiple gaps, should be included in hybrids:



Version 18 Jul 07

Job Aid – PNT Architecture Features vs. Gaps

Cornerstone Features:



Selected features that can contribute to covering gaps