Resilient Positioning, Navigation, and Timing

International Technical Symposium on Navigation and Timing

November 2018

Resiliency – PNT Risk Management

- **From Presidential Policy Directive (PPD-21):** The term **"resilience"** means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents

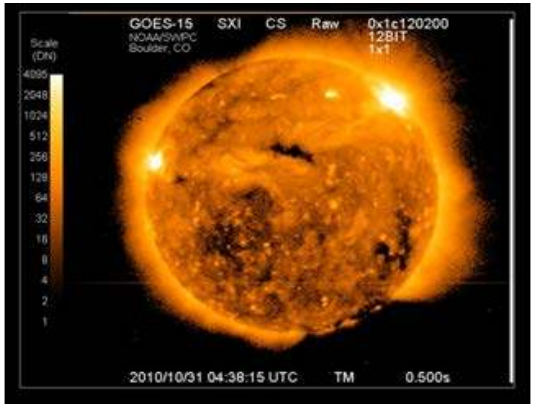
  https://www.dhs.gov/what-security-and-resilience

PPD-21 RM Examples	PNT Specific RM Examples
Developing a business continuity plan	Operations contingency planning – practices and procedures for GPS disruptions
Having a generator for back-up power	Alternate PVT sources – Clocks, inertial, GNSS, vision-aided, communication systems, RADAR, compass, etc.
Using building materials that are more durable	Antennas, protection algorithms, security engineering (IA), Cyber protections, adaptable system architectures

Courtesy of DHS

GPS/GNSS Challenged Environments

Ionospheric Disturbances



High Accuracy with Integrity

Timely Notification of Misleading Information

Underground/Indoors

Urban Canyons

Signal Interference Jamming/Spoofing)

Inaccurate/Out-of-Date Maps

Disruptions to GPS/GNSS Service

Characteristic	Example
Unintentional vs. Intentional	Is the disruption caused by a piece of space debris that disabled a GPS satellite or is it due to an intentional act by a disgruntled employee or terrorist?
Predictable vs. Unpredictable	Was the disruption due to an anticipated increase in solar flare activity or the sudden activation of a jamming device?
Environmental vs. Manmade	Is the disruption due to increased solar weather activity or due to an improperly configured radio transmitter operating in an adjacent frequency band?
Crude vs. Sophisticated	Is the disruption caused by a $50 GPS jammer purchased on-line, or by a hacker precisely manipulating a GPS signal to deceive shipping or highway traffic?
Local vs. Widespread	Is the disruption a targeted spoofing attack against a single cargo terminal, or does it cover a large geographic area (e.g., due to a significant solar weather phenomenon)?

Source: Volpe Center

Disruptions in GPS/GNSS Service (Cont'd)

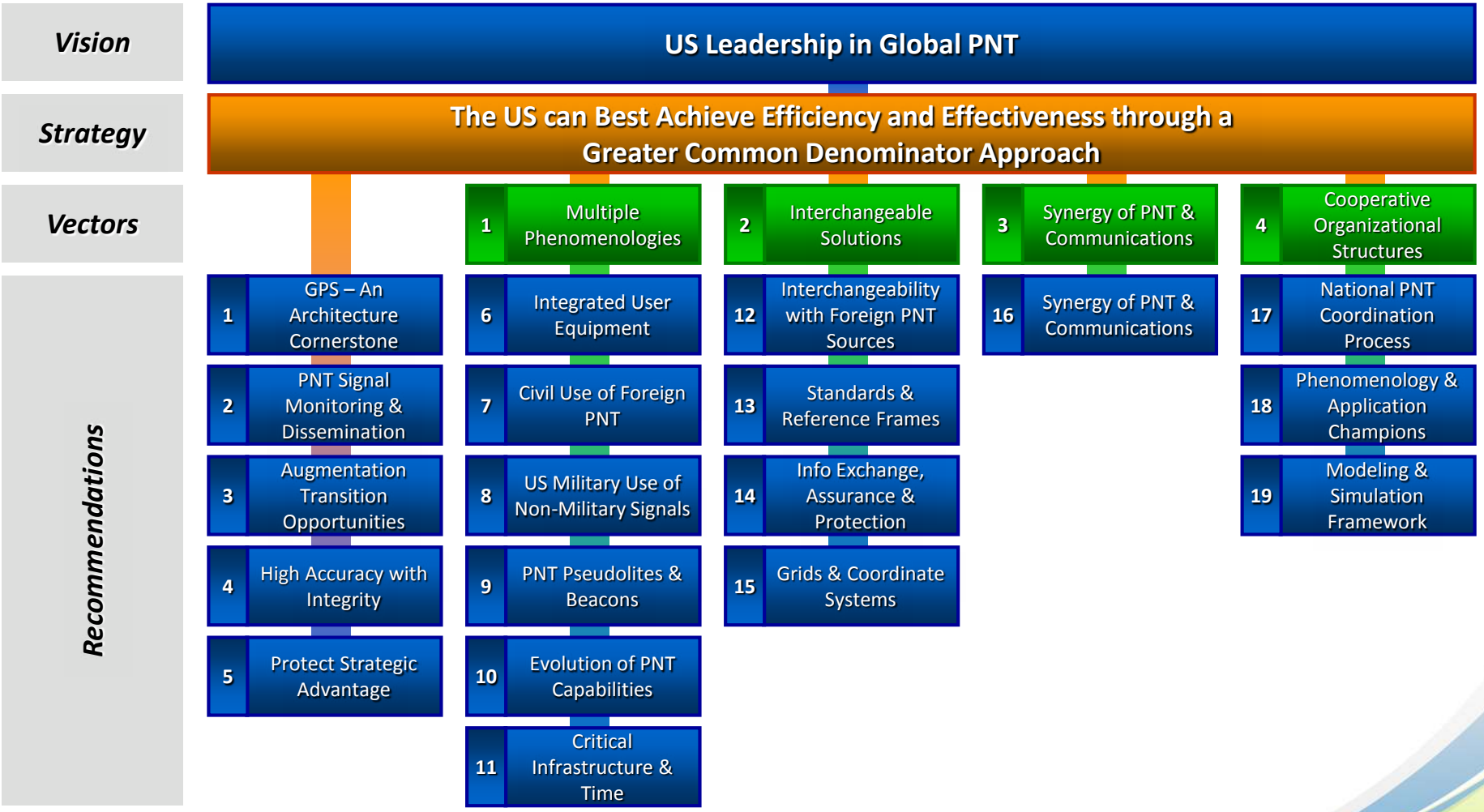
	Spectrum Encroachment	Solar Weather	GPS Infrastructure	Jamming	Spoofing
Unintentional or Intentional	UNINTENTIONAL				
			INTENTIONAL		
Predictable or Unpredictable	PREDICTABLE				
	UNPREDICTABLE				
Environmental or Manmade		ENVIRONMENTAL			
	MANMADE		MANMADE		
Crude or Sophisticated	CRUDE				
			SOPHISTICATED		
Local or Widespread	LOCAL		LOCAL		
	WIDESPREAD				

Source: Volpe Center

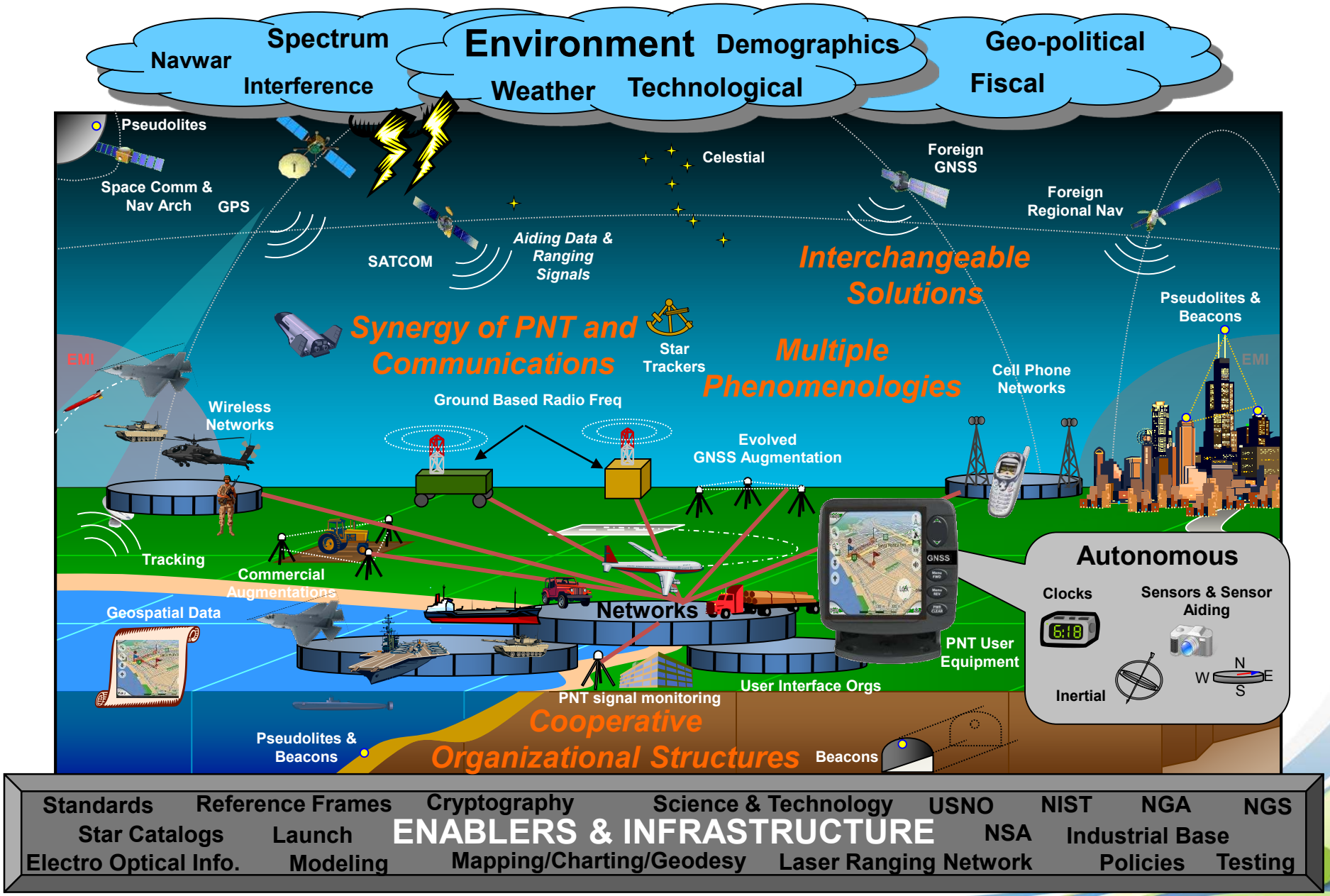
Advanced Navigation and Timing Strategy for Robustness and Resilience

- Transition from GPS User Equipment to Assured Navigation and Timing (NT) User Equipment
- Implement Satnav User Equipment Competency
- Enhance and Develop Satnav Infrastructure
- Recognize and Remove Threats
- Take Complementary Actions to Address Policies, Processes, Legislation, etc.

National PNT Architecture Recommendations



Future of Positioning, Navigation, and Timing



GPS Backup/Complementary PNT

In December 2016, Section 1618 of the 2017 National Defense Authorization Act (NDAA), "Backup and Complementary Positioning, Navigation and Timing Capabilities of Global Positioning System" required the Secretaries of Transportation, Defense, and Homeland Security to:

1) Identify PNT requirements to backup and complement PNT capabilities dependent on GPS for national security and critical infrastructure;
2) Conduct an analysis of appropriate technology options;
3) Conduct an analysis of the viability of a public-private partnership to establish a complementary PNT system;
4) Conduct an analysis of the viability of service level agreements to operate a complementary PNT system;
5) Determine the estimated costs, schedule, and system level technical considerations, including end user equipment and integration considerations; and
6) Identify appropriate resourcing for each such Department in accordance with the respective requirements of the Department, including domestic or international requirements.

GPS Backup/Complementary PNT (Cont.)

In December 2017, Section 1606 of the 2018 National Defense Authorization Act (NDAA), "Demonstration of Backup and Complementary Positioning, Navigation, and Timing Capabilities of Global Positioning System" additionally required the Secretaries of Transportation, Defense, and Homeland Security to:

1) Jointly develop a plan for carrying out a backup GPS capability demonstration for critical infrastructure sectors

2) Subject to appropriations, carry out the GPS backup demonstration within 18 months (June 2019)

$10M appropriated in DoD's budget to carry out GPS backup demonstration
- Plans underway by DHS and DOT to conduct demonstration

GPS Dependencies in the Transportation Sector

In 2016 the Volpe Center conducted an inventory of Global Positioning System Dependencies in the Transportation Sector, Best Practices for Improved Robustness of GPS Devices, and Potential Alternative Solutions for Positioning, Navigation and Timing

https://rosap.ntl.bts.gov/view/dot/12386

Senate Version of 2018 U.S. Coast Guard Reauthorization

SEC. 514. BACKUP NATIONAL TIMING SYSTEM.

(a) SHORT TITLE.—This section may be cited as the "National Timing Resilience and Security Act of 2018".

(b) IN GENERAL.—Chapter 30 of title 49, United States Code, is amended by adding at the end the following:

"§ 312. Alternative timing system

"(a) IN GENERAL.—Subject to the availability of appropriations, the Secretary of Transportation shall provide for the establishment, sustainment, and operation of a land-based, resilient, and reliable alternative timing system—

"(1) to reduce critical dependencies and provide a complement to and backup for the timing component of the Global Positioning System (referred to in this section as 'GPS'); and

"(2) to ensure the availability of uncorrupted and non-degraded timing signals for military and civilian users in the event that GPS timing signals are corrupted, degraded, unreliable, or otherwise unavailable."

Senate Version of 2018 U.S. Coast Guard Reauthorization (Summarized)

Backup GPS

- The measure would direct the Transportation Department (subject to appropriations) to establish a backup system for the timing component of GPS that would begin operation within two years of the measure's enactment. It would have to be designed to operate for at least 20 years and be available for government use at no net cost to the federal government within 10 years of initiating operation.
- The system would be developed by a competitively selected nonfederal entity. The entity could sell timing and other services to third parties, but would have to share 25 percent of the proceeds with the Transportation Department for at least 10 years.
- The Coast Guard would transfer its Long-Range Navigation System (LORAN) infrastructure to the Transportation Department for use with the system as needed.

Considerations for Provision of PNT

"The vital need for efficient methods of navigation is as universal and ancient as the requirement to travel. Each era of navigation history has necessarily been marked by the particular situation of mankind at the time, including use of the available tools."

"At issue on a continuing basis are questions of geographic coverage, the particular types of radionavigation systems which are needed and who must bear the responsibility and expense of providing the signals."

- DOT National Plan for Navigation, November 1977