



# PNTAB

## Our Purpose:

*To Ensure PNT Is Available  
For All Users.*

*Intro to theme 2:  
Improving International GNSS Capabilities -  
Governance, Costs & Services*

December 2024

# Current PNTAB Assessment:

"No current or foreseeable alternative to GNSS (Primarily GPS) can deliver equivalent PNT accuracy (to millimeters, 3D) and world-wide 24/7 availability."

# The PNTAB Strategy:

PTA

"We must Protect, Toughen, and Augment GPS to ensure that it continues to provide Economic and Societal Benefits"

## Three Strategy Areas:

# PTA - Protect, Toughen, Augment

- Protect the Clear & Truthful Signal-3 steps
  1. Advocacy - vigorously oppose any FCC repurposing that would jeopardize current and future GPS uses
  2. Pre-actions - even before interference occurs -  
Legal/Law Enforcement/FCC:
    - Protect Spectrum/Enact strong Penalties/suppress Jammer sales
  3. Re-actions - when interference/spoofing occurs:
    - Quick Knowledge of Jamming Area/Pinpoint Location/Shutdown Source/Apprehend Perpetrator/Prosecute as Appropriate

## Three Action Areas:

### PTA - Protect, Toughen, Augment

- Toughen Users' Receivers to use GNSS
  - Employ multiple, well-known techniques to ensure spoofing can never create HMI
  - Increase Jam resistance - use well established techniques - multi-element antennas, deep inertial integration
  - Diversify - Use All integrity-certified GNSS signals to determine P&T (with vector feature)

## Three Action Areas:

PTA - Protect, Toughen, Augment

- Augment or substitute PNT sources
  - **Densify and Diversify** satellites -  
Signals/constellations
    - **Worldwide Integrity Monitoring**
  - **Use Complementary PNT Sources** -  
e.g. DME, eLoran, LEOs

# National Power Elements Typically Include:

- Population,
- Geography,
- Natural Resources,
- Political Stability,
- Leadership,
- Diplomacy,
- Cultural Influence.

GPS

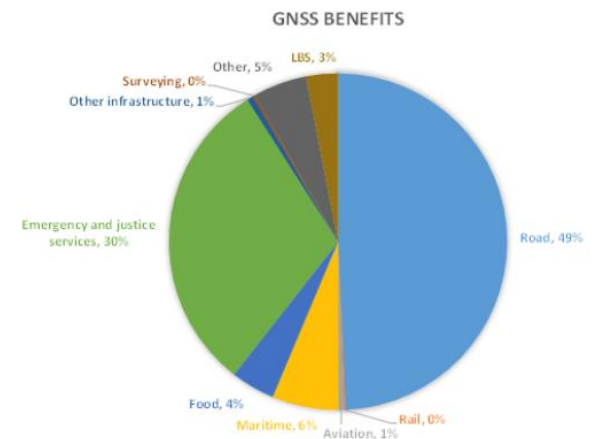
- Infrastructure,
- Military Capability,
- Technology,
- Economic Strength,
  - Direct Benefits
  - Impacts when not available



# Economic Benefits study UK only

- Quantified **economic benefits** to the UK of GNSS have been monetised at **£6.7bn per annum**, comprised of £1.2bn in Gross Value-Added (GVA) benefits and £5.5bn in utility benefits (efficiency, safety, etc.)

- Conservative estimates
- Cannot monetise all benefits
- Consider this a **LOWER BOUND**



# From Study by RTI International

## The Private-Sector Value of the Global Positioning System (GPS)

- Historical Benefits: \$1.4 trillion in economic benefits since 1984 for 10 sectors
  - Productivity, efficiency gains
  - Enjoyment of location features of personal devices
  - Lower environmental emissions, improved public health and safety
- Most benefits have accrued since 2010, from innovation initiated in the 1950s and 1960s
- GPS Outage: >\$1 billion per day in losses in the event of a GPS interruption
- Study offers insights into the relationships between public investments, private-sector innovation, and time

[https://www.rti.org/files/analyses/gps\\_benefits.pdf](https://www.rti.org/files/analyses/gps_benefits.pdf)

# National Power

- In the last 20 years, GPS has become a major and essential element of National Power
- Other major Space-faring nations appear to completely grasp and embrace this.
  - Beidou is a concrete example
- Not clear this is understood by USG

# GPS Challenges

- GPS has not launched for about 2 years. The next launch will bring the number of L5 satellites to 18, which is a necessary (but not sufficient) condition for full operation of the L5 signal.
- The next GPS control system (OCX) has experienced extreme development challenges leading to large slips and overruns. This has impacted activation of new capabilities.
- ITAR has continued to be a massive deterrent to civil use of multi-element GPS antennas. Such antennas can reduce the effective area of jamming/interference by factors of up to 100,000.

**Some good news:** The Deputy Secretaries of Defense and Transportation (co-chairs of EXCOM) have recently re-engaged with PNT and the Advisory Board. Their ongoing personal attention (including the transition replacements) is essential for GPS to regain a leadership position among GNSS providers.

Where is the GPS Capability  
relative to other GNSS?

Major issue for this PNTAB  
(E.G. - Have we slipped to the Bronze Standard?)

**Initial Conceptual Comparison of Outcomes**- either current or projected  
 - Initial assessment to be refined.  
 Russian GLONASS intentional omitted

Color Key to this assessment	
Apparently Most Capable	Blue
Capable- Meets modern Expectations	Green
Behind expectations	Yellow
Inadequate	Red

Global Metric	GPS	Galileo	Bediou
Global Availability of Accuracy	<ul style="list-style-type: none"> <li>• 12 Hour update – being modified by need (2hr?)</li> <li>• No Retro-reflectors</li> <li>• L5 not Opnl. (FOC Jan '29)</li> <li>• No High-accuracy service</li> </ul>	<ul style="list-style-type: none"> <li>• 2 Hour Update</li> <li>• Retro-reflectors</li> <li>• E5 Being Deployed</li> <li>• High accuracy Service being deployed</li> </ul>	<ul style="list-style-type: none"> <li>• Wideband Intersatellite updates</li> <li>• Retroreflectors</li> <li>• B2 operational</li> </ul>
Global Robustness/resistance to Jamming and spoofing	<ul style="list-style-type: none"> <li>• ITAR restricts use of Digital nulling antennas in US</li> <li>• No plan for authentication Message</li> <li>• Use of all GNSS if Integrity is assured</li> <li>• Not Operational</li> </ul>	<ul style="list-style-type: none"> <li>• Apparently, no User Antenna restrictions in Europe</li> <li>• Operational Integrity Message</li> <li>• PRS service available for public safety</li> </ul>	<ul style="list-style-type: none"> <li>• Antenna restrictions unknown</li> <li>• 3 Opnl. Civil signals at 3 frequencies</li> </ul>
Global Integrity	<ul style="list-style-type: none"> <li>• GLAS Provides rapid integrity Updates in US</li> <li>• No System Integrity Message</li> </ul>	<ul style="list-style-type: none"> <li>• EGNOS provides rapid integrity updates in Europe</li> <li>• Imbedded authentication message</li> </ul>	<ul style="list-style-type: none"> <li>• Rapid short messaging Capability</li> </ul>
# of Operational Civil Signals or # of Civil Frequencies	<ul style="list-style-type: none"> <li>• 31 Opnl. Satellites</li> <li>• 1 Signal at 1 Frequency</li> <li>• 2 new signals at 2 new freq. have begun but not Opnl.</li> </ul>	<ul style="list-style-type: none"> <li>• 24 Opnl Satellites</li> <li>• 3 Signals at 3 Frequencies Opnl.</li> </ul>	<ul style="list-style-type: none"> <li>• 35 Opnl Satellites (46?)</li> <li>• 3 Signals at 3 Frequencies Opnl.</li> </ul>
Other Measures and Features	<ul style="list-style-type: none"> <li>• Search and Rescue Support has begun</li> </ul>	<ul style="list-style-type: none"> <li>• Search and Rescue Support Operational</li> <li>• SAR return Link service</li> </ul>	<ul style="list-style-type: none"> <li>• Search and Rescue Support Operational</li> <li>• SAR return link service</li> <li>• Regional Geo. overlay</li> </ul>

# From PTA subcommittee at this Meeting

Comparison of PNT Services Available to Civil Users						
System or Capability	United States				China	
	Timing		Positioning		Timing	Positioning
	Government-Provided	Commercial-Provided	Government-Provided	Commercial-Provided		
Global Navigation Satellite System	GPS [1], Galileo	[1]	GPS [1], Galileo	[1]	BeiDou, Galileo(?)	BeiDou, Galileo (?)
LEO Satellites		Iridium STL [2]		TrustPoint, Xona, NAL, Parsons	[3]	[3]
Terrestrial Broadcast	WWV, WWVB	ATSC 3.0 BPS [4], [8]		ATSC 3.0 BPS, mobile phones [4], [8]	eLoran Infrastructure Installed [5]	Mobile phones
Fiber-Based Timing		Major Telecoms, [8]	Not Applicable	Not Applicable	Comprehensive Government Program Being Implemented [6]	Not Applicable
Authentication/Integration of Timing		Unknown What Iridium STL and Major Telecoms Offer and Plan	Not Applicable	Not Applicable	Comprehensive Architecture Being Developed [7]	Not Applicable

Notes and references in Notes page and final slide

# Comparing GNSS Capabilities and Plans

## *Draft for discussion at April PNTAB Meeting*

### Estimated Current Status

Dates are estimated year of earliest FOC, or actual FOC	Not planned/funded
	Being "studied"
	currently funded
	currently being fielded
	fully operational
	Unknown

Estimated Dates are driven by earliest fully funded project start and Satellite launch rates, currently about an average of 2 per year

	Capability or Policy	Description	GPS	Galileo	BDS
1	Activate L5 (and L2C and L1C)	L5 more capable civil signal - both accuracy and anti-jamming. Is not currently planned for US Military receivers	2025 for L5 IOC 2028 for Certification?		
2	Laser Retroreflectors	Enhanced ranging accuracy- enabling better long distance predictions of satellite position and satellite clock errors	2035? Constrained by two a year launch rate.		
3	Remove all ITAR restrictions on multi-element antennas and on deeply integrated GPS-Inertial receiver designs	US restricts to a few states the art in Resistant Signal antennas/Receivers being sold in Turkey	2024	UNK	UNK
4	Free Broadcast PPP data ("High Accuracy Service") also on the internet	Provides worldwide ranging error corrections either through data message or over the internet	2030?		
5	Rapid (2 hour) Updates and Reduce Vulnerability of Upload stations	May be coupled with inter-satellite ranging and High Speed Comm.Reduces Ranging errors by 50% compared to 12 hour updates	2035?		
6	Search and Rescue (SAR) Support	Distress Receiver on GNSS, monitoring location and notifying rescue authorities	Started Fielding		
7	Embedded authentication	Well studied technique to defeat spoofing attack	Studies by FAA - 2040?		UNK



# Comparing Advanced GNSS Capabilities and Plans

Draft for discussion at April PNTAB

Meeting

Estimated Current Status

Dates are estimated year of earliest FOC, or actual FOC	Not planned/funded
	Being "studied"
	currently funded
	currently being fielded
	fully operational
	Unknown

Capability	Description	GPS	Galileo	BDS
		and Earliest Probable IOC (18 Satellites) on current Satellite Planning Trajectory		
Regional Geosynchronous Overlay	Enhance Geometry. Method to simply use Concentrating Antenna for signal acquisition	2030	UNK	
Two-way High Data Rate intersatellite laser (or RF?) ranging and communications	Enables better ephemeris prediction. Enables "Autonomous" ephemeris predictions. Enables remote refreshing of ephemeris predictions	2040	UNK	
Two way short messaging including SAR confirmation messaging	Emergency Warning and other brief communications	2035	<a href="https://www.eoportal.org/satellite-missions/galileo-g2#novel-capabilities-from-galileos-next-phase">https://www.eoportal.org/satellite-missions/galileo-g2#novel-capabilities-from-galileos-next-phase</a>	
Emergency warning/integrity service	Worldwide WAAS on GPS - could be part of PPP (see later item).	2030?	UNK	UNK
GPS-lite + 3 or 4 per booster	New hardware prototype to fully evaluate potential for protection and reduce on-orbit cost	2028 for 24 on orbit?	UNK	UNK
Locating and shutting down Jammers	National Authority and System			

# Major un or partially fulfilled PNTAB Recommendations

1. **ITAR.** To achieve near-immunity to jamming, remove all ITAR restrictions on civil GPS toughening measures - particularly multiple element digital antennas.
2. **L5.** Activate L5 and accelerate standards development to encourage exploitation of benefits. Promptly launch GPS IIIs with fully redundant L5 and Laser retroreflectors. Ensure L5 is a fully redundant civil signal.
3. **GNSS Signal Protection.** *Designate, fund, and give full authority* to central US government individual to detect, characterize **and remove** GNSS signal interference.
4. **Exploit all ("friendly?") GNSS Signals.** Expand authorization and encouragement of **integrity-assured** multi-frequency and multi-GNSS constellation receivers. Encourage, expand and implement concept of **multi-layered integrity assurance**. (further explanation follows)
5. **HARS.** Develop and implement a GPS High Accuracy and Robustness Service (HARS) delivered via the Internet. See white paper.
6. **Watermark.** To enhance anti-spoofing capability, develop and implement an anti-spoofing watermark component for GPS open signals. Like Galileo OSNMA (Open Service Navigation Message Authentication) or Chips Message Robust Authentication (CHIMERA)

## Use of GNSS signals from all sources - Resiliency and the "Layered Integrity Guardians" - (layered security)

- There are *At least seven major techniques* to assess the integrity of positioning signals and improve resiliency. Most of them ensure the integrity of both US and foreign GNSS transmissions. *Note: A typical cell phone is now receiving about 60 signals from at least two frequency bands, with over 30 satellites in view.*

1. **Direct Integrity Monitoring and Notification- WAAS, EGNOS, et.al.**
2. **System, Frequency, and Signal Diversity.**
3. **Differential operations.**
4. **Watermarking to prevent Spoofing**
5. **RAIM and ARAIM - Autonomous self checking.**
6. **Cell Phone Monitoring and Integrity Screening**
7. **Internet Integrity Messaging**

# An Overarching Issue

**Background:** Most measures of GNSS capabilities and plans show Civil GPS falling behind other GNSS. US Policy states that GPS should be second to none.

**Recommendation:** Relook at organization of PNT governance, authorities, and resources with a purpose of:

- Developing and publishing a ***funded*** National PNT strategy (update to DOT version)
  - Strategy architecture should build a future-oriented, national, resilient PNT strategy architecture, implementation, and action plan
- Ensure Coordination directly with all executive branch departments, independent agencies (including the FCC), and Congress.

**Speaker's thought provoker (follow-on to Chair Comment):**

- Is it time to ***disaggregate*** civil and military GPS satellite systems:
  - GPS Civ-sat - All civil signals only
  - Separate Control System (without military grade security)
  - Separate funding (Say a \$10/year US cellphone tax)
  - Drive to multi-launched, simplified satellites
- Should PNTAB do an initial study of ***How*** and ***Advantages/Disadvantages?***

Let's re-emphasize "Toughening"  
and get multi-element antennas into all Military Platforms  
And remove them from the ITAR List so Commercial airplanes can  
exploit and the COTS prices drop.

