Assistant Secretary of the Air Force
for Space Acquisition and Integration

Alt PNT – The Gateway to PNT Resilience

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What is Alternate PNT (Alt PNT)?

- There is no universal definition for Alternate PNT
  - For this presentation, “Alt PNT” refers to PNT from any source other than GNSS

- Misconceptions:
  - PNT is “what GNSS gives me”
  - Alt PNT should seek to replace GNSS
  - GNSS is the only source of PNT
  - PNT should give me a 3D point position

- Paradigm Shift
  - GNSS is not the only source of PNT – legacy approach is self-limiting
  - Focus should be on specific PNT needs for each application and what technologies and sources meet those needs
    - The goal is to find a Complementary source of PNT, not a replacement for GNSS
  - Not all applications need what GNSS provides
    - E.g., timing does not necessarily require a point-position solution
  - To increase resiliency, ubiquitous PNT sources should be considered when appropriate

Systems should consider Alt PNT to meet resiliency needs — and not rely solely on GNSS

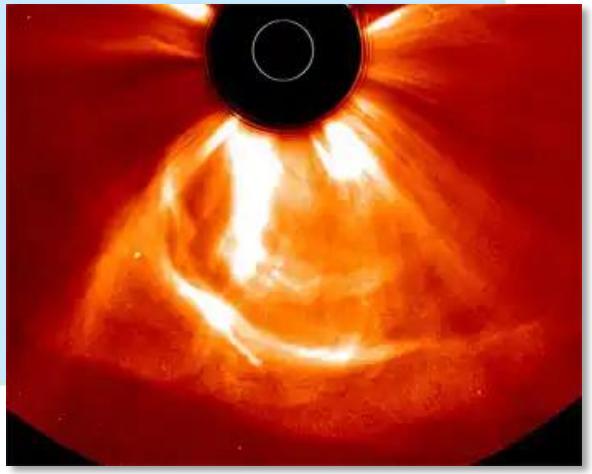
What problem is Alt PNT attempting to solve?

Interference

- Regional loss of GPS for a finite interval of time
  - e.g., “Personal Privacy Devices”

Catastrophic Failure

- Complete loss of GNSS systems
  - e.g., Carrington-like event disrupts ionosphere



Non-Traditional Domains

- Domains where GPS is not available
  - e.g., undersea, underground, cislunar, indoor environments

PNT Sources: Space-Based PNT

Attributes	Risks/Challenges	Examples

• Can provide cm-level accuracy
• Low-power RF signals
• May use encryption
• Low cost to users
• Low SWAP
• Requires global network of monitor stations
	• Jamming
	• Spoofing
	• Cyber
	• Kinetic
	• Terrain Masking
		• GNSS
		  • GPS
		  • Galileo
		  • Beidou
		  • GLONASS
		• Regional
		  • QZSS
		  • NavIC
		  • KPS
		• Commercial
		  • Satelles
		  • Xona
		• TWSTT

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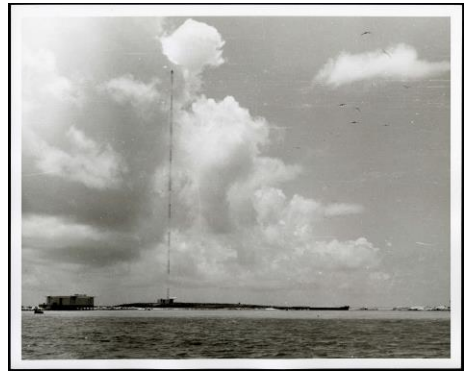
List of examples is not exhaustive

PNT Sources: Non-Space-Based PNT

Attributes	Risks/Challenges	Examples

• 10 to 100 meter accuracy
• High-power RF signals or hard wired
• Usually unencrypted
• Low cost to users
• Low SWAP
• Traditionally broadcast from fixed sites
• Can provide relative positioning
	• Jamming
	• Spoofing
	• Cyber
	• Kinetic
	• Terrain Masking
	• Site ownership and maintenance
	• Global Coverage
		• Aviation Navaids
		  • VHF Omnidirectional Range (VOR)
		  • Non-Directional Beacons (NDB)
		  • Distance Measuring Equipment (DME)
		  • Instrument Landing Systems (ILS)
		• eLORAN
		• Network time protocol
		• Two-Way Fiber Time Transfer



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PNT Sources: Signals of Opportunity

Attributes

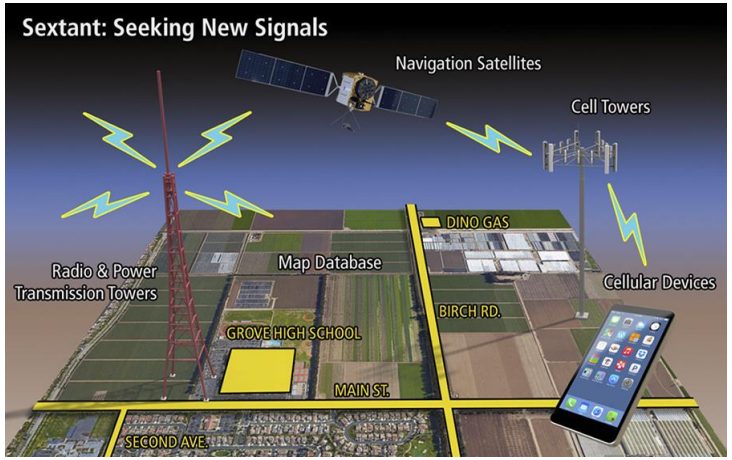
- Uses ambient radio signals for navigation
- Typically uncooperative transmitters
- 10 to 100 meter accuracy possible
- May require out-of-band data of sites
- Can use ground-based or space-based transmitters
  - e.g. TV stations, HD radio, comm sats

Risks/Challenges

- Jamming
- Cyber
- Kinetic
- Terrain Masking
- Complex/expensive user equipment
- Reliability, accuracy, and coverage of transmitters not guaranteed and not optimized for PNT
- Location of transmitters may be unknown

Examples

- Mostly research systems
  - Aerospace SEXTANT (TV and Radio)
  - UCI STAN (Starlink)
  - VT "Transit on Steriods" (Many Comm Sats)
- Arguably code-less use of encrypted GNSS



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PNT Sources: Natural

Attributes

- Uses external natural phenomena for navigation
- 10 m to 1 km accuracy (depending on source)
- Can provide absolute or relative PNT information

Risks/Challenges

- Clouds/weather
- Collecting and distributing data
- Maintaining databases
- Requires features to monitor (oceans/deserts)
- Typically, expensive or complex hardware

Examples

- Celestial
- Vision Navigation
- Terrain Following
- Bathymetry
- Radar Odometry
- Barometers
- Compasses

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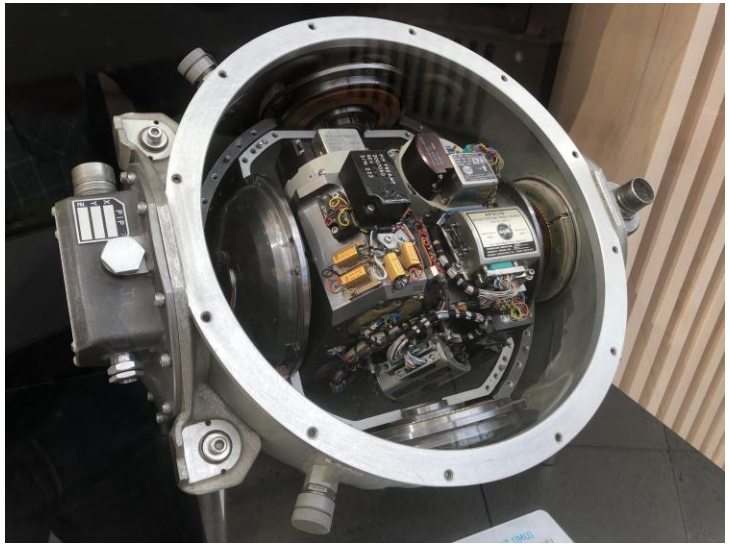
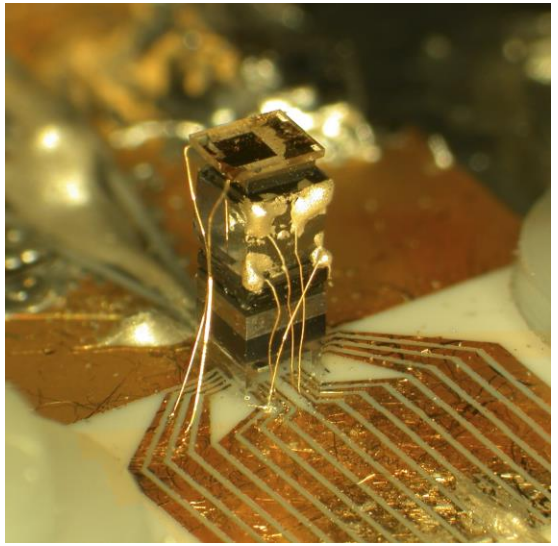
Alt PNT Sources: Internal

Attributes	Risks/Challenges	Examples
• Uses internal devices to derive PNT information • Can only provide relative PNT information • Effectively invulnerable to external threats	• Cyber • No absolute position – drift • Accuracy related to cost and SWAP	• Accelerometers • Gryoscopes • Quantum INS • Atomic Clocks • Crystal/MEMS Oscillators





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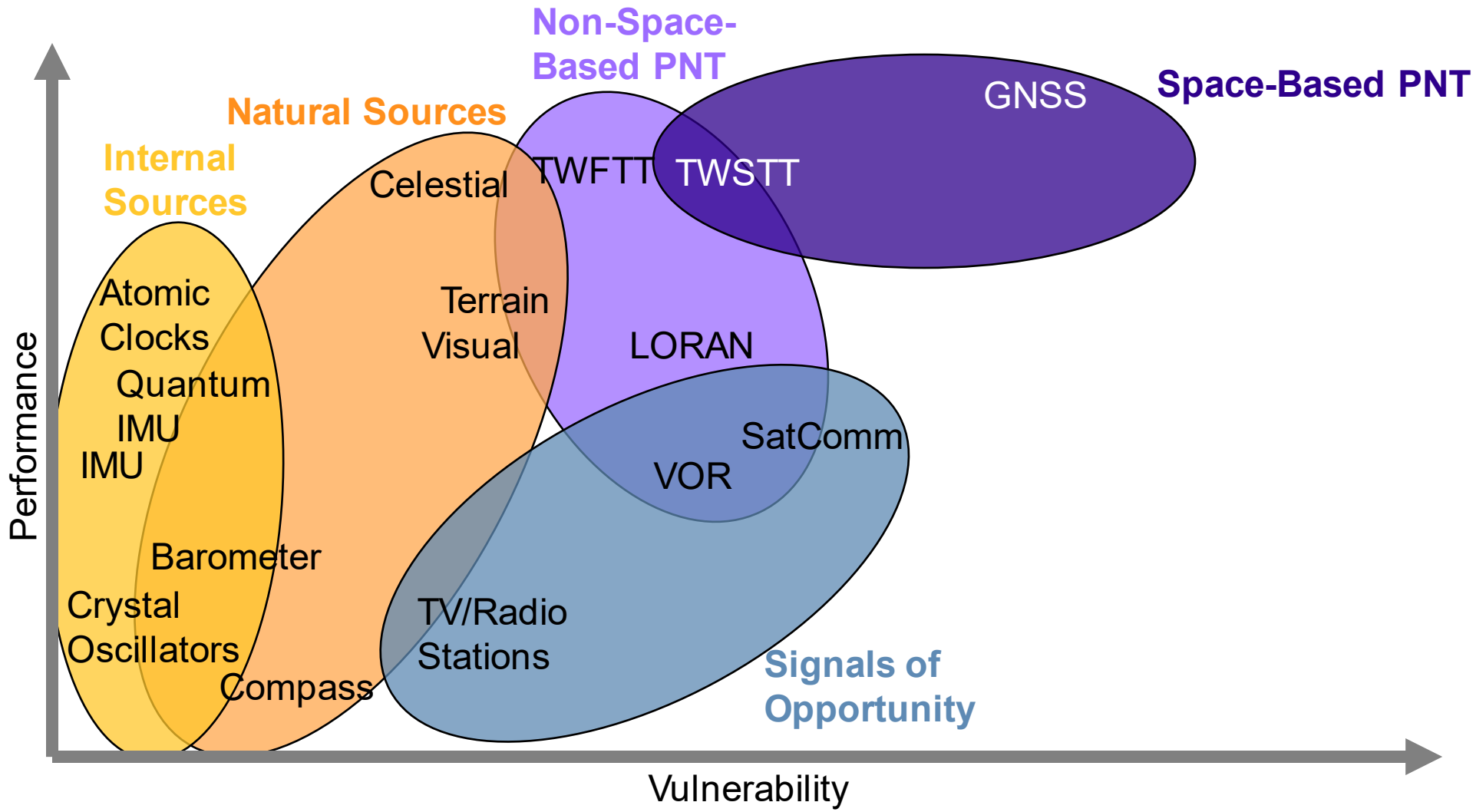
Performance vs Vulnerability



Performance does not include cost or SWAP

Challenges to Implementing Alt PNT

- Impediments
  - Costs and Hardware Refresh Cycles
    - Implementing more Alt PNT source will increase cost, size, weight, and power
    - Fielded systems typically do not have their PNT systems replaced unless it breaks
  - No “one-size-fits-all” Alt PNT solution
    - Operators need to understand their application’s PNT needs and determine the best PNT source(s) for them
    - Different applications and domains may require very different Alt PNT sources
- Alt PNT is a set of resilient complements to GNSS
  - Users need to determine which technologies meet their resiliency needs
  - Significant focus on finding a replacement for GNSS; instead, focus should be on utilizing multiple sources of PNT
- The US Department of Transportation has tested numerous Complementary PNT technologies and published reports on their performance [Link]

Alt PNT can give users a diverse set of solutions – eliminating homogenous systems with known vulnerabilities