

Toughening and ITAR

Observations

PNTAB

November 2022

Brad Parkinson*

*Conclusions and recommendations that have not been made previously by PNTAB are my own.

Primary Advisory Board Objective:

Assured PNT for all Users

and

to encourage/exploit system improvements and new techniques

to advance PNT for all applications

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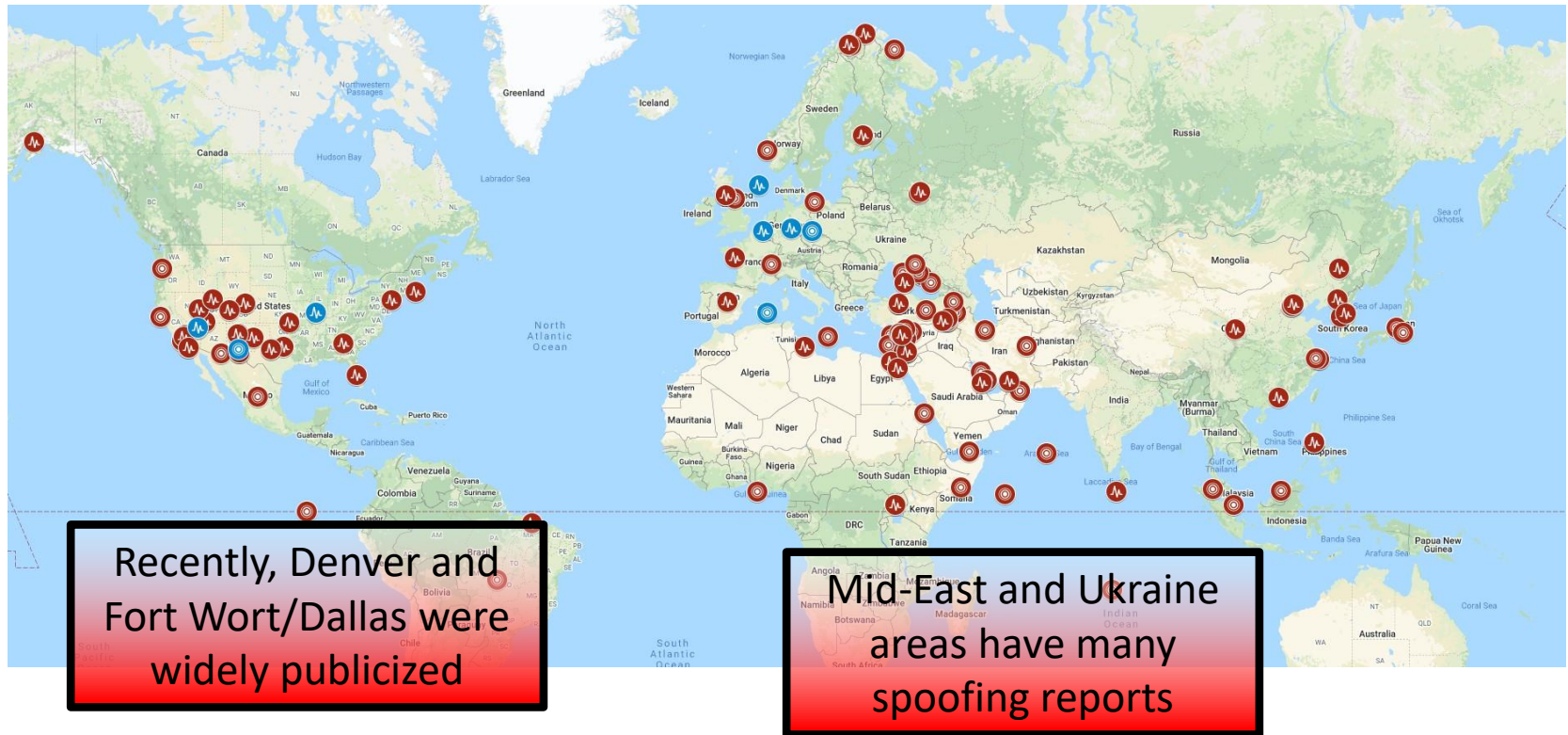
Worldwide GNSS interference incidents reported



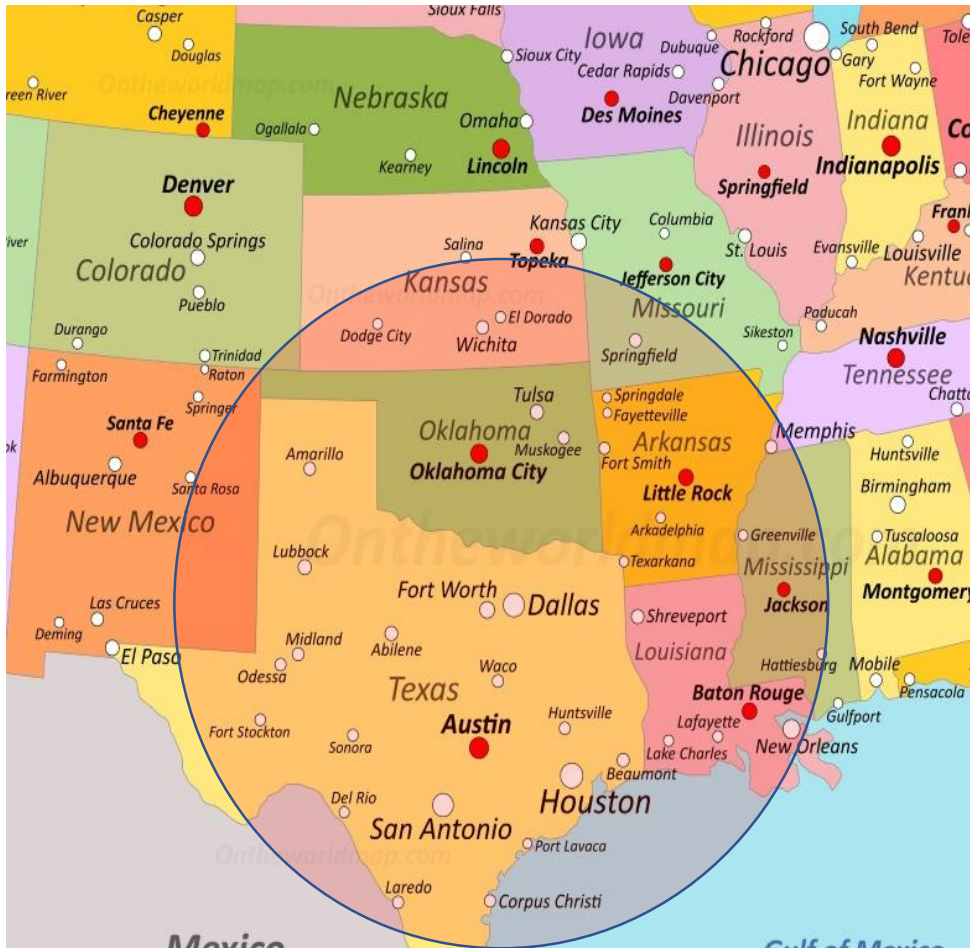
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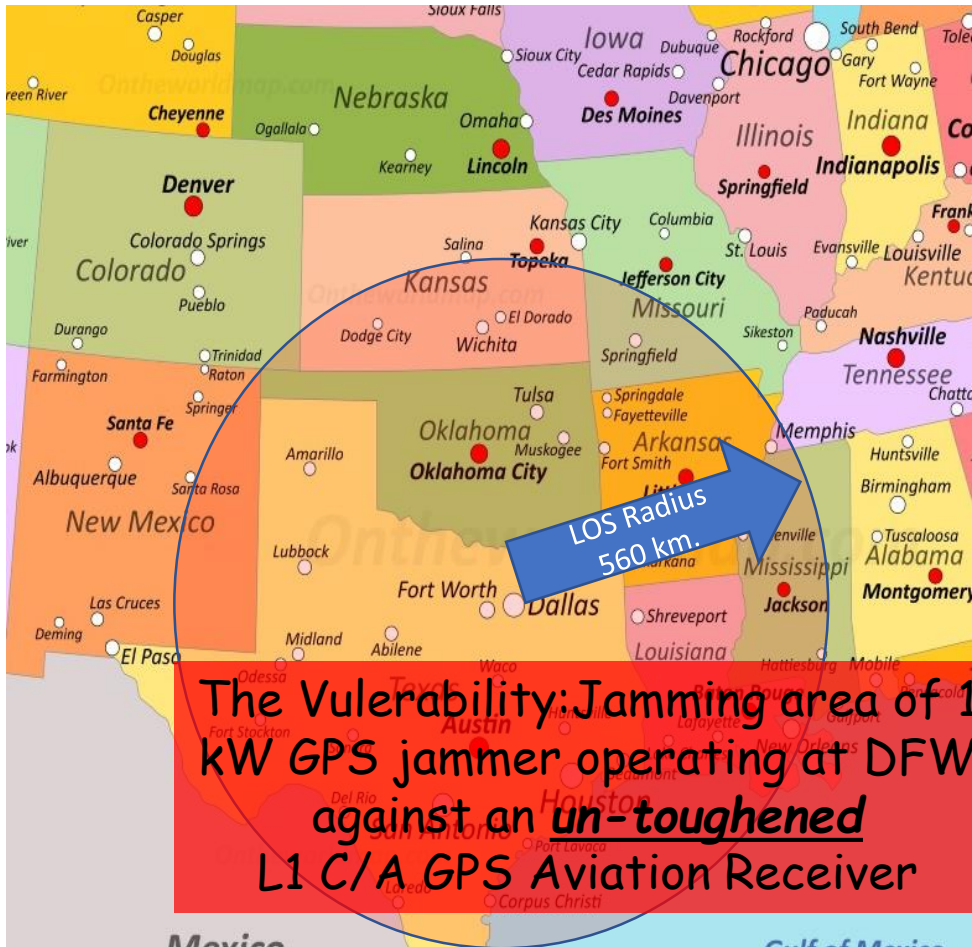
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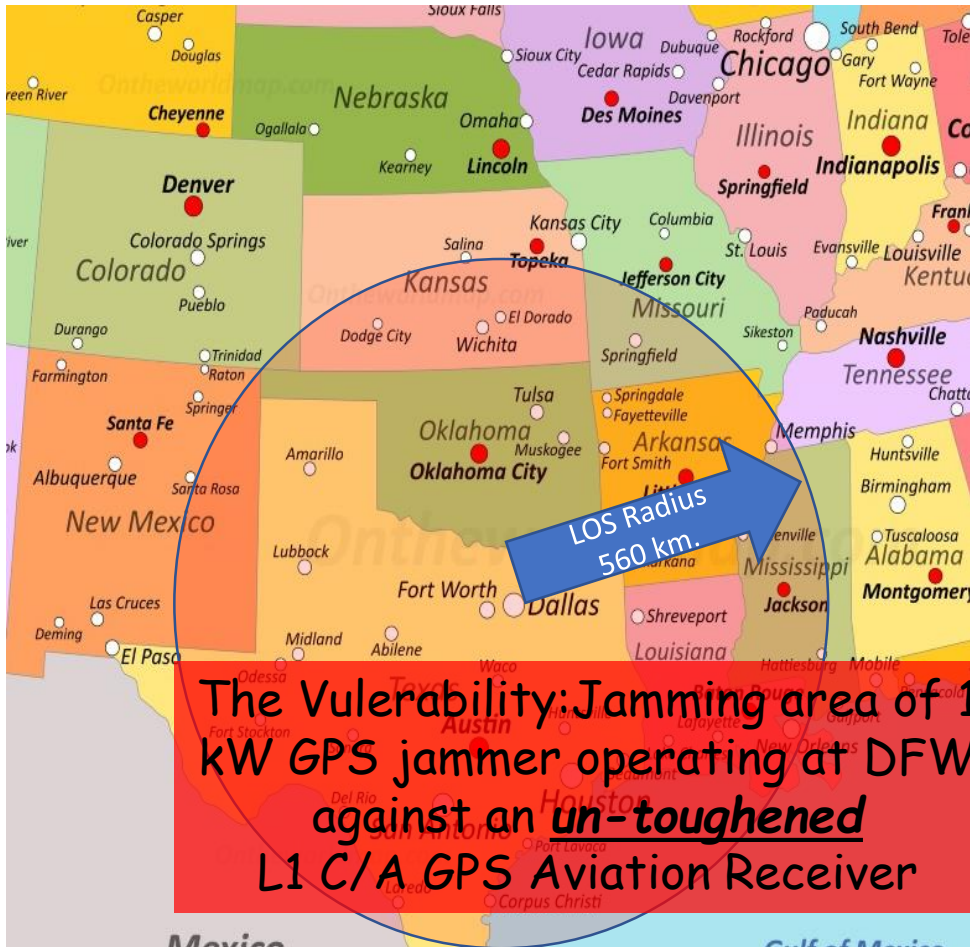
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Such Beam steering design also obviates the Spoofing threat.



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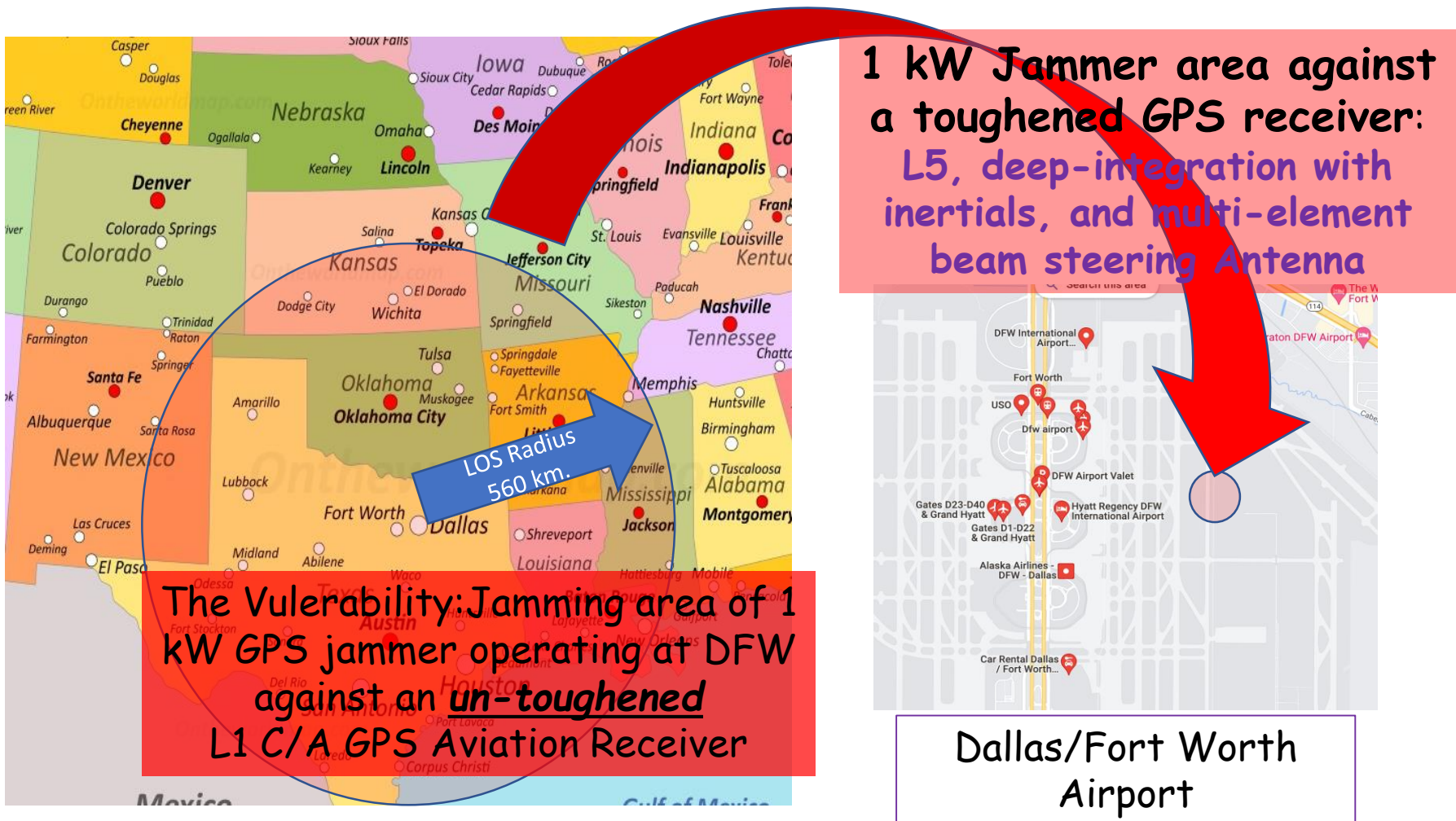


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Dallas/Fort Worth Airport

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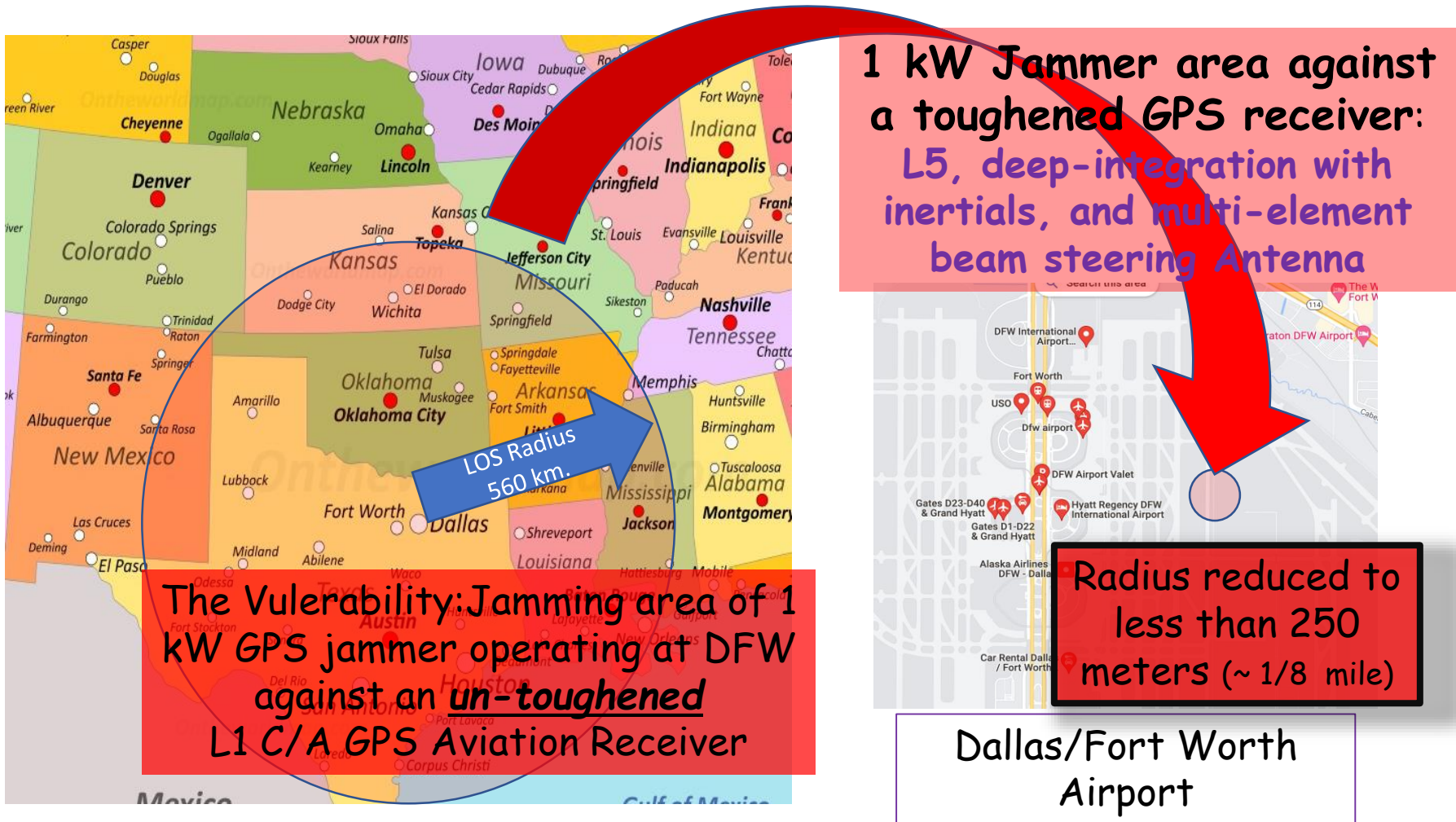


1 kW Jammer area against a toughened GPS receiver: L5, deep-integration with inertials, and multi-element beam steering Antenna

The Vulnerability: Jamming area of 1 kW GPS jammer operating at DFW against an un-toughened L1 C/A GPS Aviation Receiver

Dallas/Fort Worth Airport

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But Receiver Toughening is clearly the quickest solution to threats of J&S and can preserve full 3D accuracy and 24/7 worldwide availability

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5. Based on the answers above, are restrictions on GNSS CRPAs effective at preventing such systems being used by potential enemies?

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Vladimir Alekseevich Varyukhin, (1921 - 2007) was a Soviet and Ukrainian scientist, Professor, Doctor of Technical Sciences. Founder of the theory of multichannel analysis. Creator of the scientific school on digital antenna arrays (DAAs)



Example Publication : V.A. Varyukhin, Fundamental Theory of Multichannel Analysis (VA PVO SV, Kyiv, 1993) [in Russian].

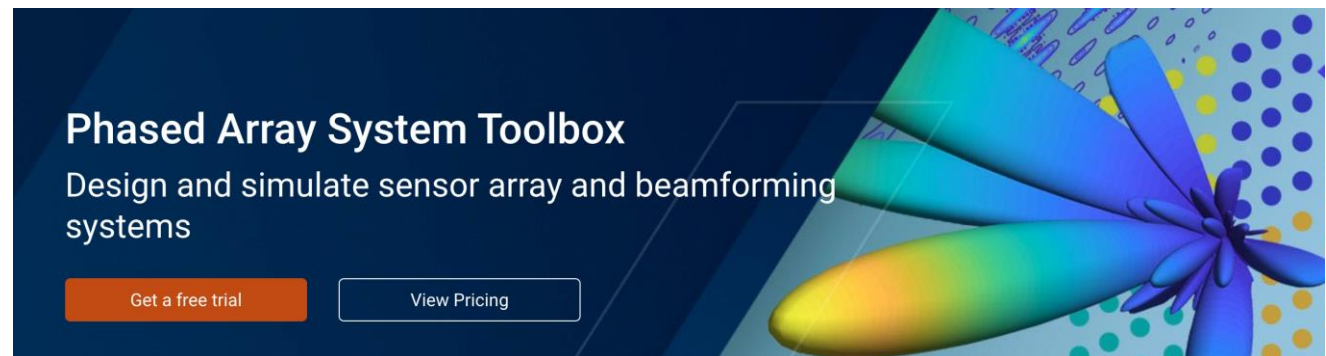
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MATLAB has the tools for complete a design and analysis



Phased Array System Toolbox
Design and simulate sensor array and beamforming systems

[Get a free trial](#) [View Pricing](#)

The advertisement features a dark blue background with a 3D visualization of a beamforming system. The visualization shows a central blue antenna-like structure with several colored beams (yellow, green, blue) extending outwards. The background is decorated with a pattern of blue and yellow dots.

General world knowledge:
Literature search for GNSS A/J or
antennas

- Literally hundreds of conference and journal articles on these subjects in English
- There are reasons to believe there are even more articles in Chinese only (i.e. almost 1000 untranslated to date)

2. Have Phased Arrays been extensively deployed? For how long?

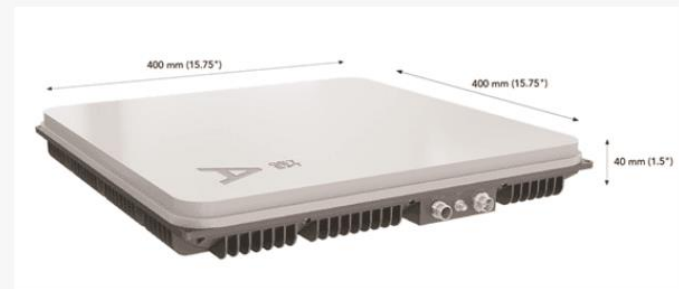
Example: Phased-
array technology
(since ~1970)
AN/TPS -59/77



L-band pencil beam
in the 44-by-32 antenna
array.

3. Are the key L-band technical components available and affordable?

GetSAT, a provider of small, lightweight satellite communication terminals for airborne, ground, and maritime applications, introduced its Ultra Blade L-Band antenna, which is compatible with any L-Band satellite. According to the release, Ultra Blade is the market's first complete, all-planes, Electronically Steerable Array (ESA) antenna.



4. Are there "existence proofs"
of worldwide GNSS A/J
receivers for sale?

Ancient (very?) History

- Apparent to me in 1973 that signal strength and susceptibility to Jamming was an important issue
- We sponsored and encouraged AFAL to build a demonstrator Hi-A/J receiver with cooperation from my Program Office (JPO)
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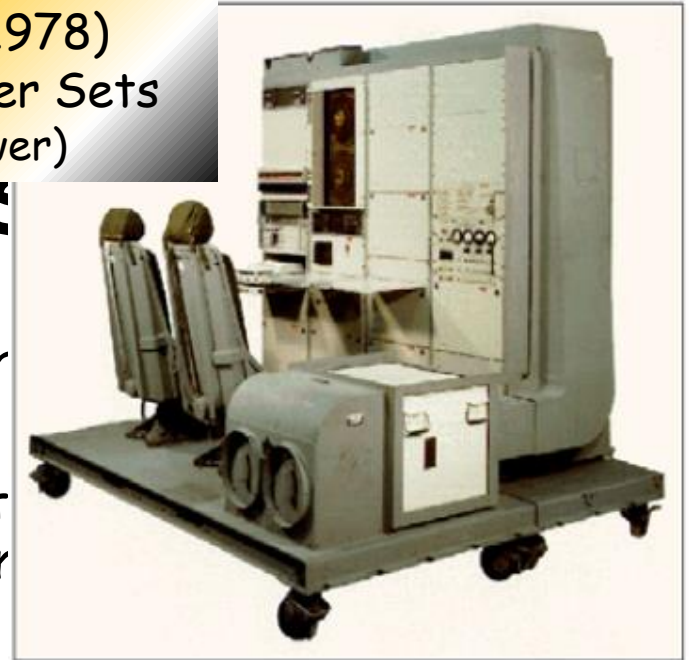
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Rockwell Collins GDM (1978)
One of the Phase One User Sets
(used over 10 kW of power)

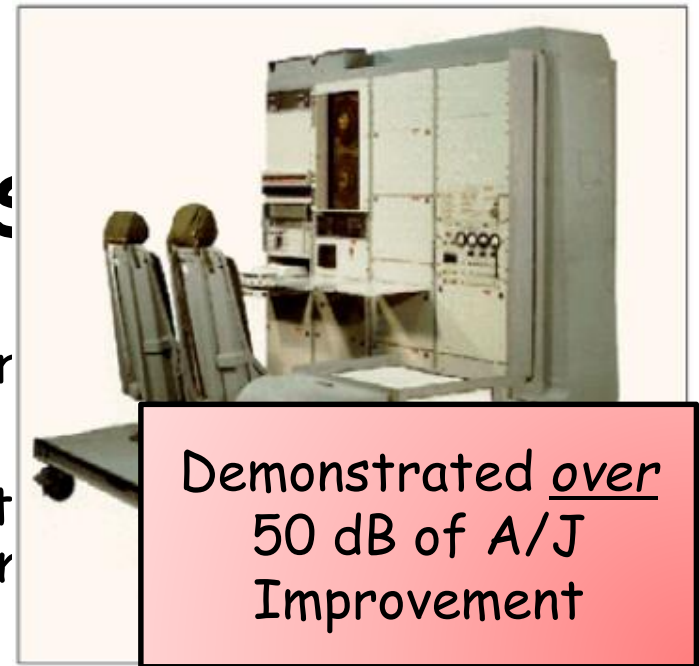
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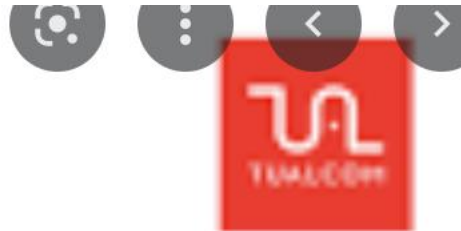


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- *Field test (1978) Showed that a Hi-A/J GPS receiver could fly directly over a 10 KW jammer with no effect*
- Results were forgotten for at least 20 years...

My Point: Much of what has been shown has been known and verified for over 40 Years - I think we need to balance the search for "GPS Replacements" with a vigorous pursuit of Toughening

Turkish company selling GNSS Jam-resistant receivers - Particularly for UAVs



The world's smallest
Anti-Jamming solution for
civilian applications

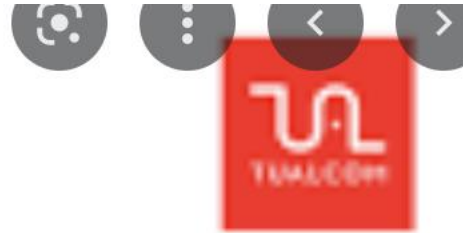


critical missions by providing jam free
GNSS signals.

The system eliminates interference by applying novel beamforming techniques. With an 8-array CRPA antenna, the system can assure the normal operation of GNSS receiver in presence of multiple jamming sources.

TUALCOM Anti-Jam GNSS CRPA System can be employed using various configurations and operates with civil and military GPS receivers for the land, sea, air platforms (including unmanned aerial systems) and fixed installations. The product has an embedded GNSS receiver that supports all satellite constellations. Wide bandwidth of the system also enables the SBAS signals to GNSS receiver.

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8 element phased array antenna
"over 2500 sold" (this and other 8 element
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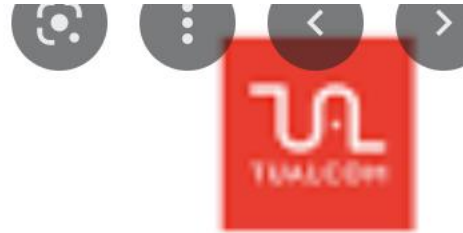
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A 16 element phased array antenna
6-10 weeks to release the product
(CEO Ahmet Erdem)

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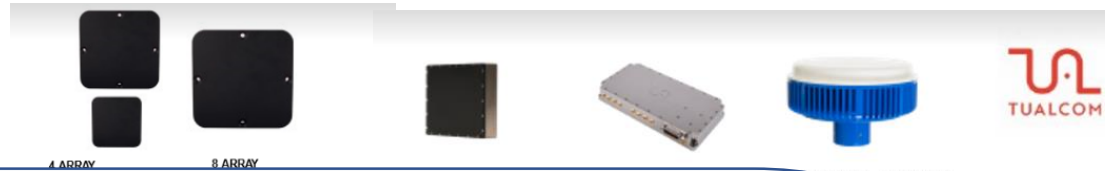
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Turkish company

CEO claims they have sold over 2500 of these 8 element antennas. Intend to release 16 element this year. Mostly in the middle east, many. For use on Iranian RPVs.

	 4 ARRAY ANTI-JAM CRPA ANTENNA	 8 ARRAY ANTI-JAM CRPA ANTENNA	 TUALAJ 8200	 TUALAJ - 8300	 TUALAJ - 8300 D	
Dimension(cm)			9 x 11 x 2.3	7 x 13,9 x 1,9	25 (Radius), 9,8 (Height)	
Weight(g)			380	380	4150	
Power Consumption (w)			< 12W	< 24W	< 24W	
Antenna Array			8	8	8	
Simultaneous Independent Nulling			7	7	7	
Simultaneous Active Bands			GPS L1, GLONASS G1, GALILEO E1, BEIDOU B1C SBAS	GPS L1, L2, GLONASS G1, G2, GALILEO E1, BEIDOU B1C SBAS	GPS L1, L2, GLONASS G1, G2, GALILEO E1, BEIDOU B1C SBAS	
Nominal Wideband Suppression			>50 dB	>50 dB	>50 dB	
Data Interfaces			Serial	Serial	Serial	
			>50 dB	>50 dB	>50 dB	
			GLONASS (L1), GPS (L1)	GLONASS (L1,L2), GPS (L1,L2), QXSS(L1)	GLONASS (L1,L2), GPS (L1,L2), QXSS(L1)	
Operating Voltage			12-28 Vdc	12-28 Vdc	12-28 Vdc	
Antenna with Your System			 INTEGRATED	 TUALAJ - 8300 +  140 x 140 CRPA Antenna	 TUALAJ - 8300 +  110 x 110 CRPA Antenna	 INTEGRATED

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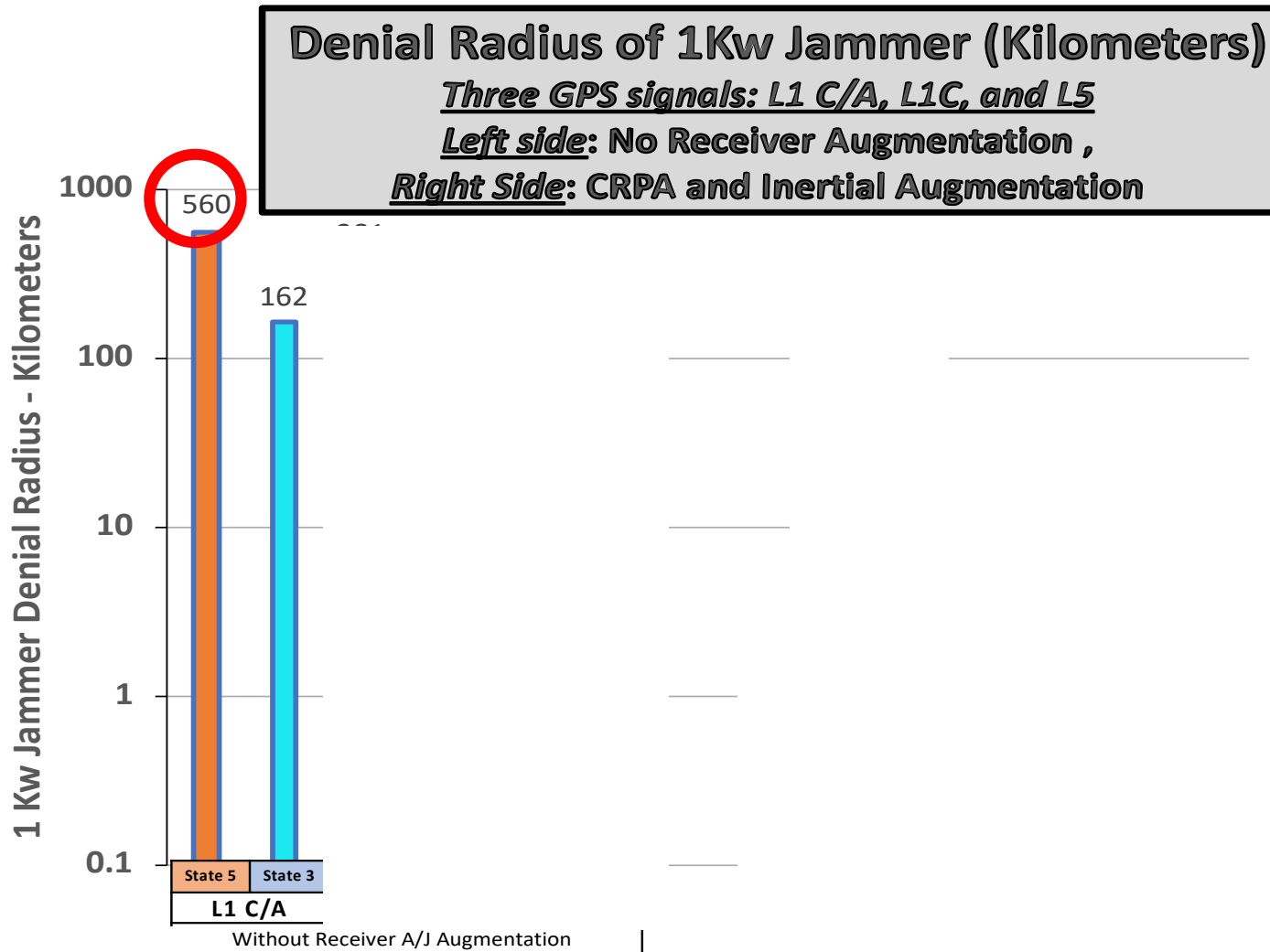
CEO
h

- So allegedly, UAVs, with 8-element GPS A/J antennas from Turkey, are flying in the Middle East
- Jamming resistance is claimed to be over 10,000 times that allowed by our government for commercial aircraft
- If our commercial aircraft were so equipped, the US concerns of GPS commercial aircraft interference (including Ligado) would nearly vanish
- Who in the US government is responsible for fixing this obviously ineffective restriction on technology?

TUALAJ - 8300 110 x 110 CRPA Antenna

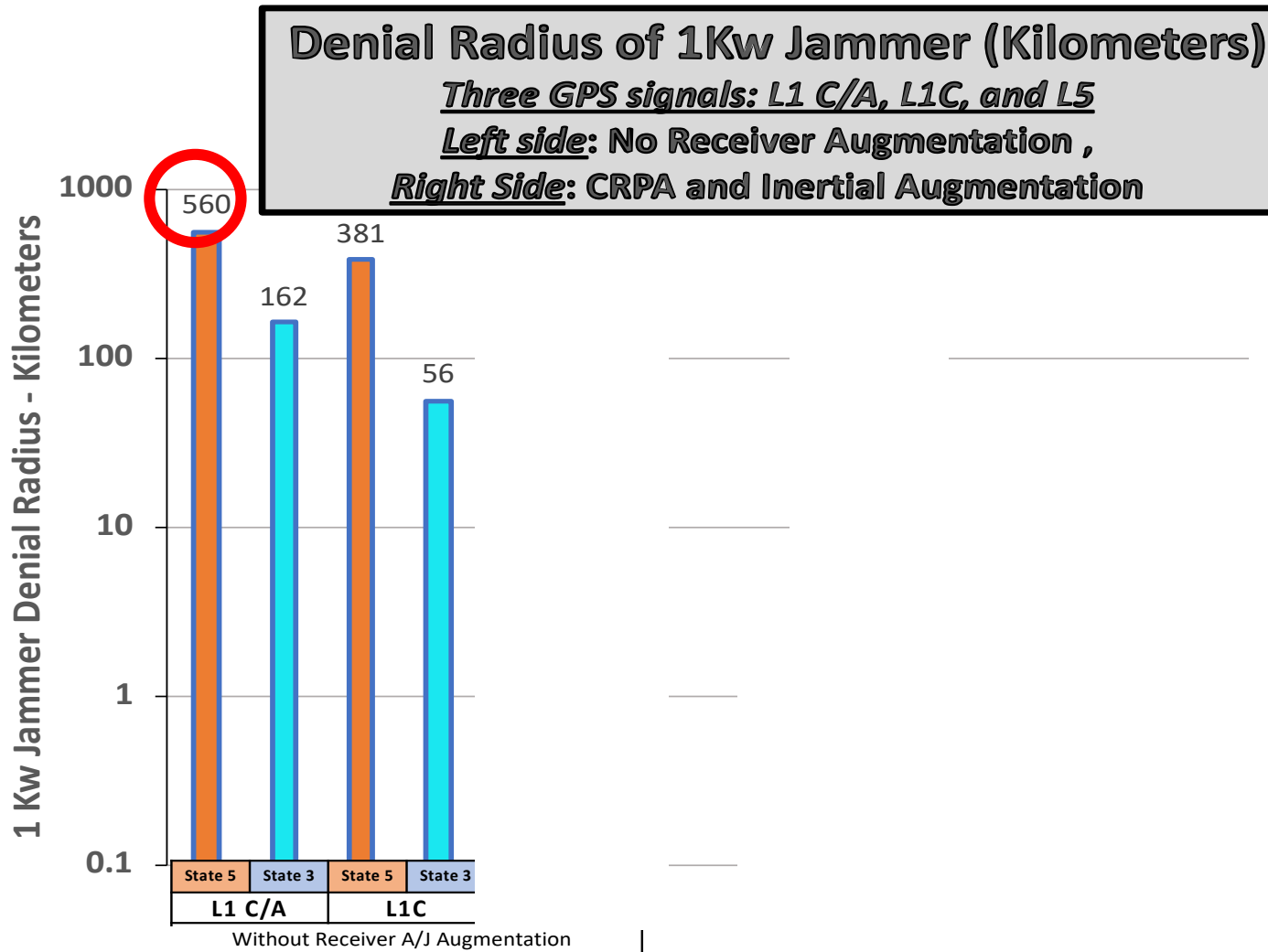
Analysis: Toughening - The big payoff

Results of 40 dB of Toughening (less than the 50 dB claimed by TUAV)



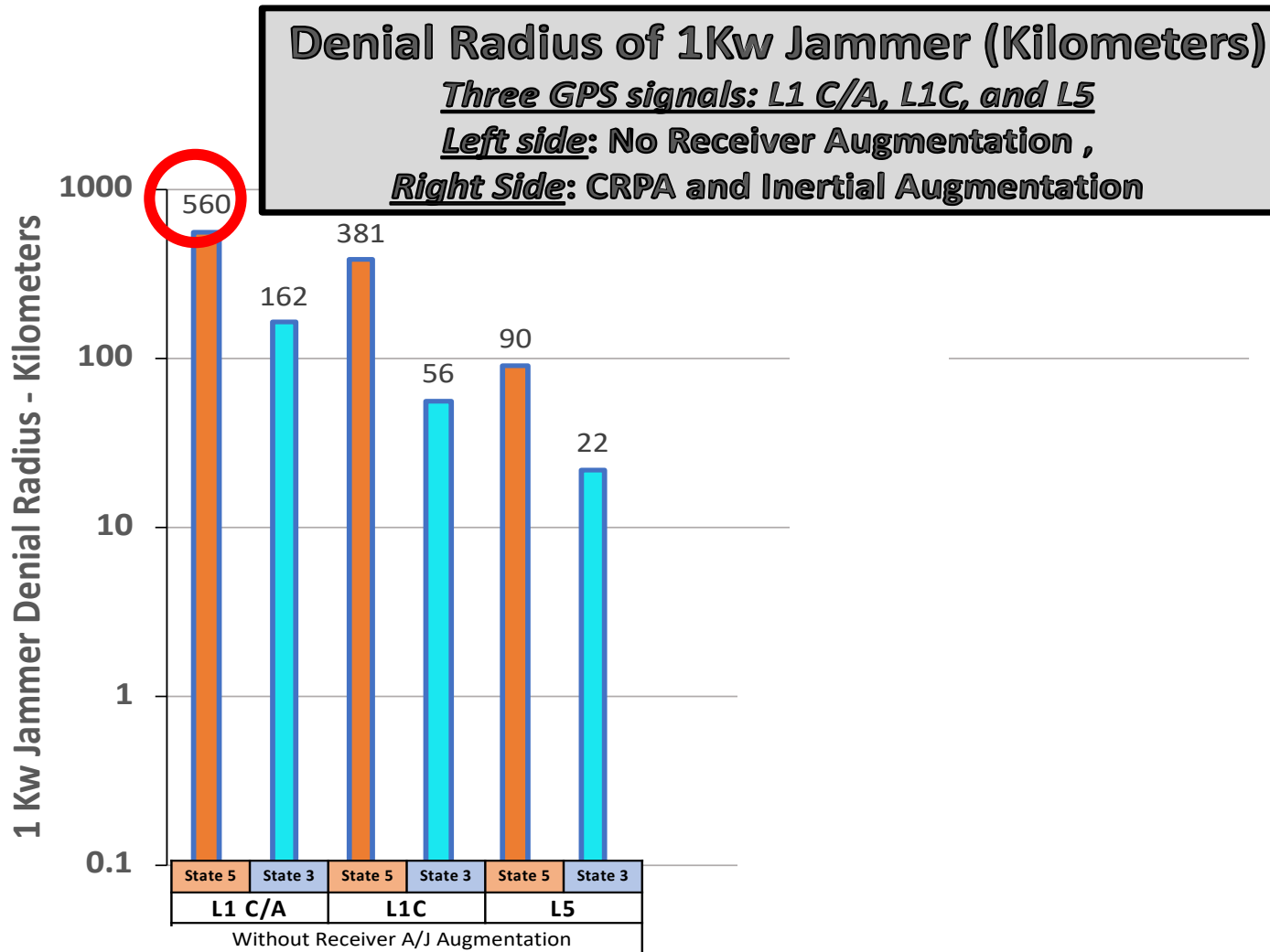
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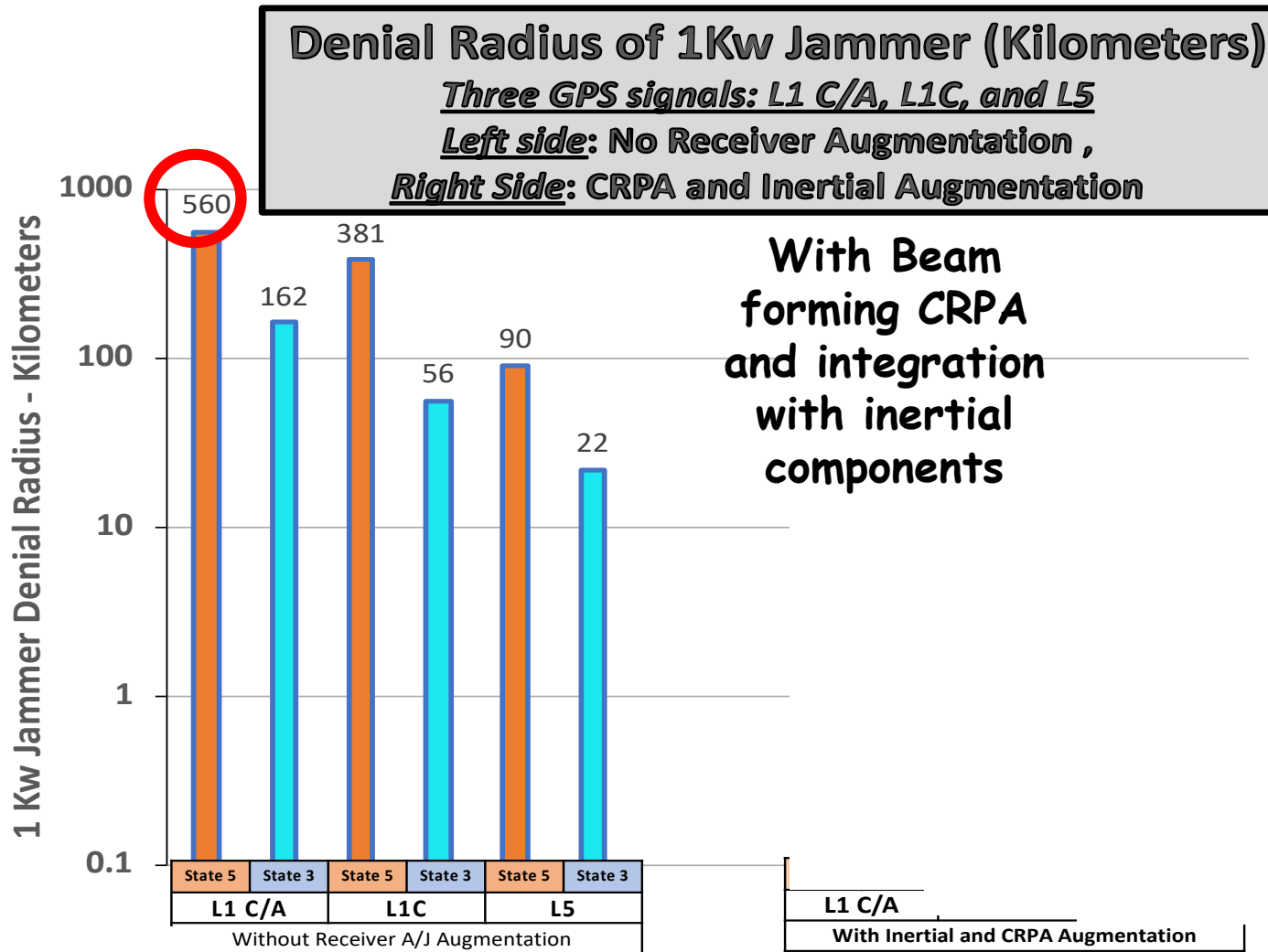
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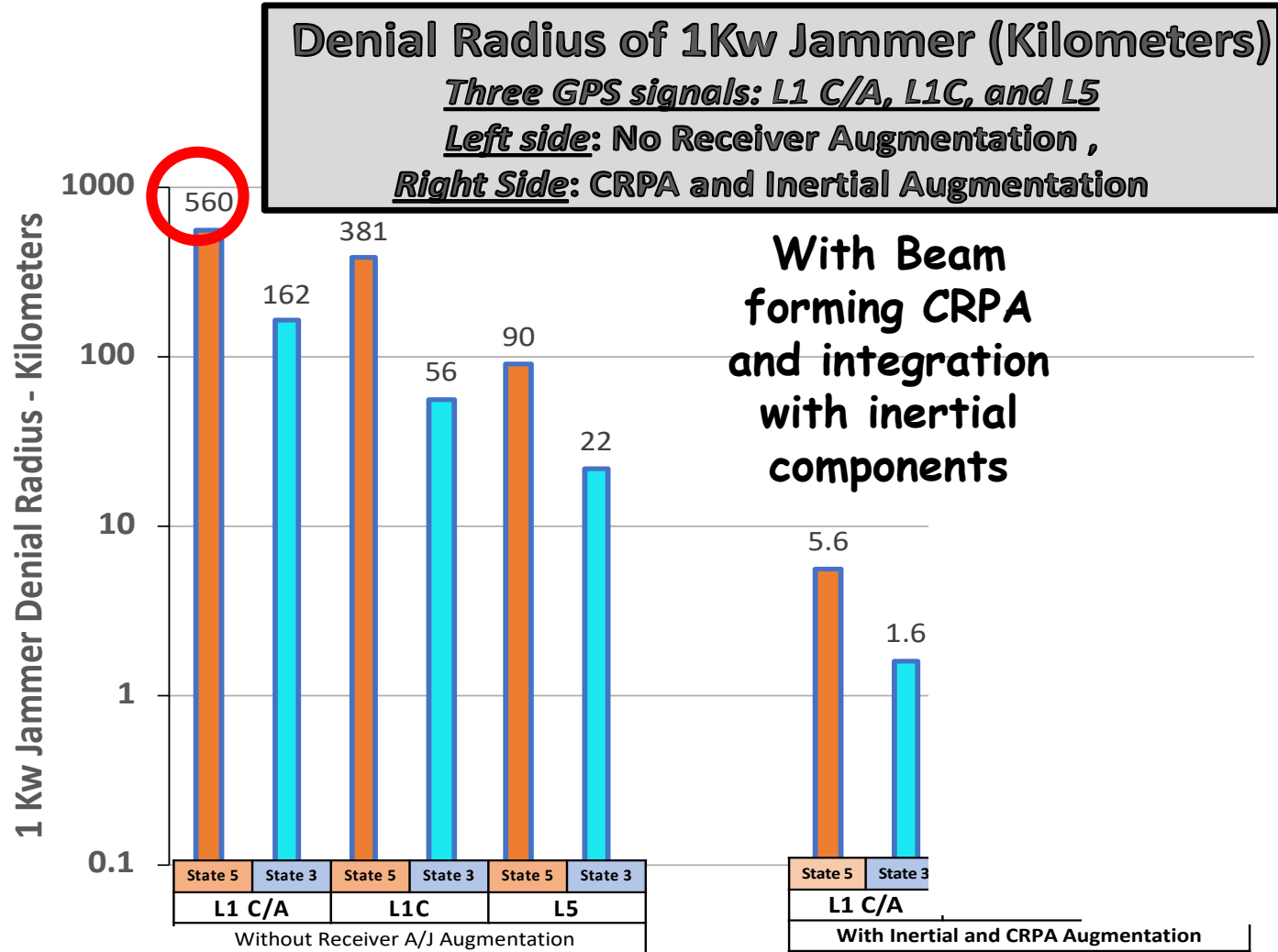
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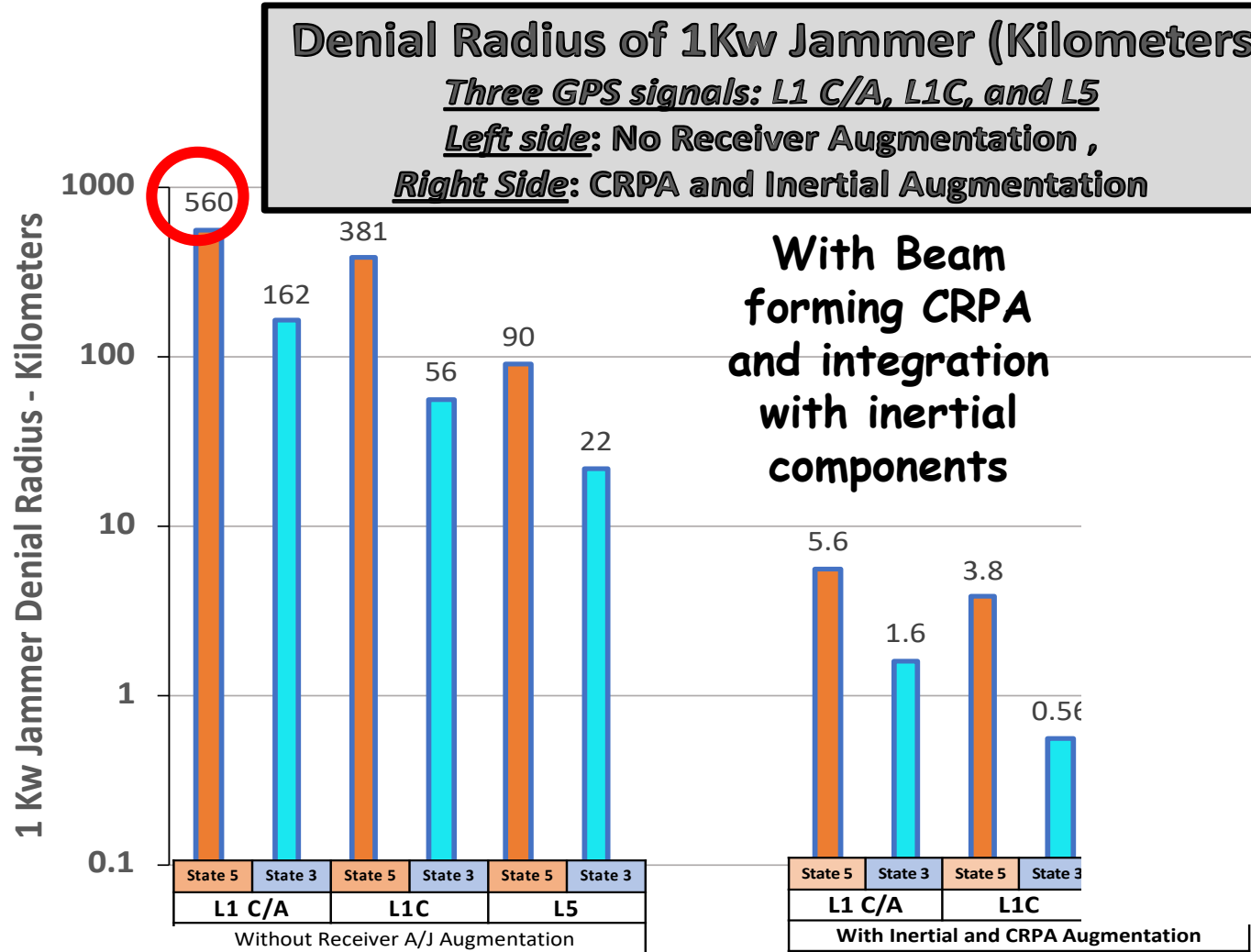
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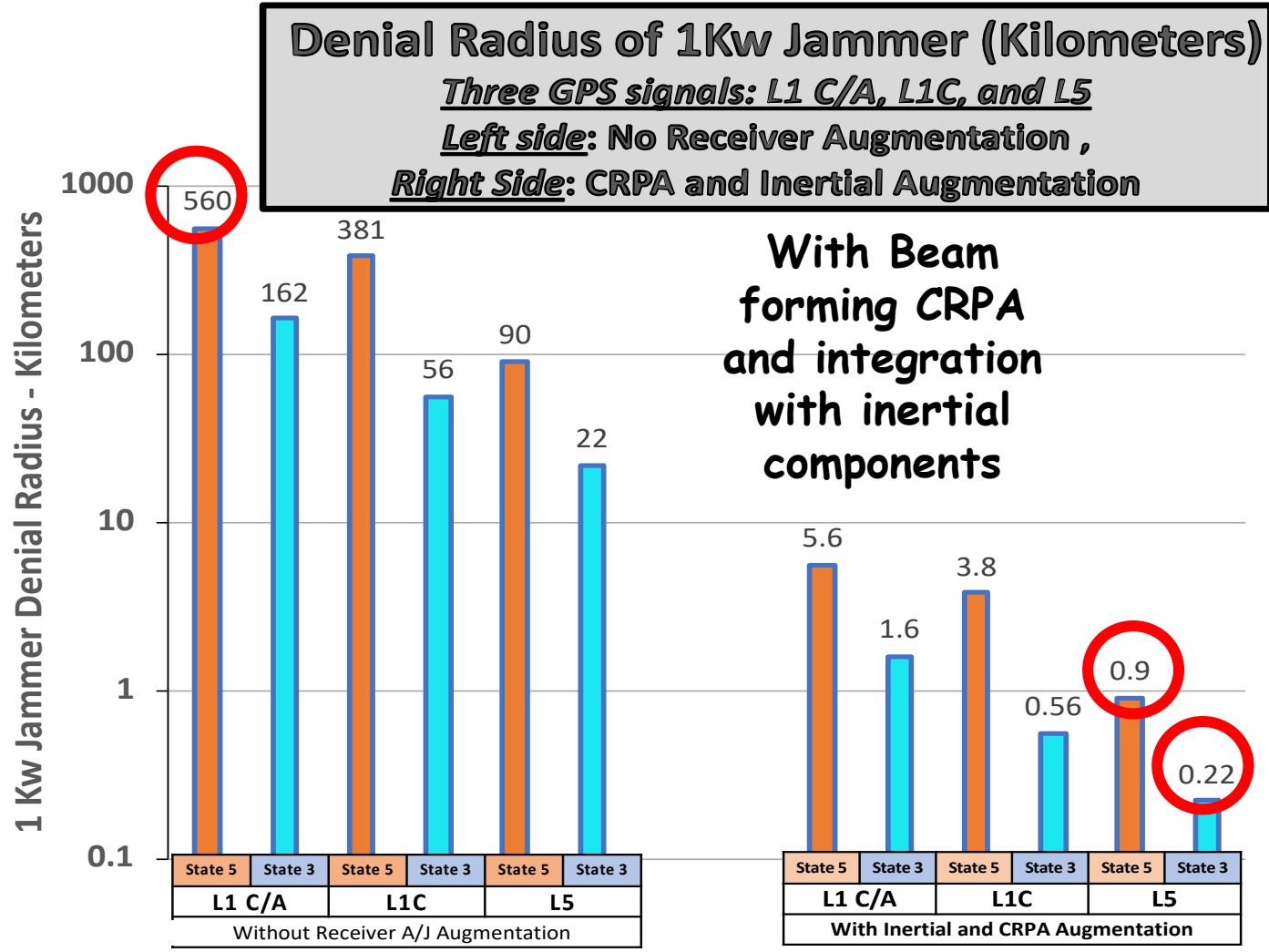
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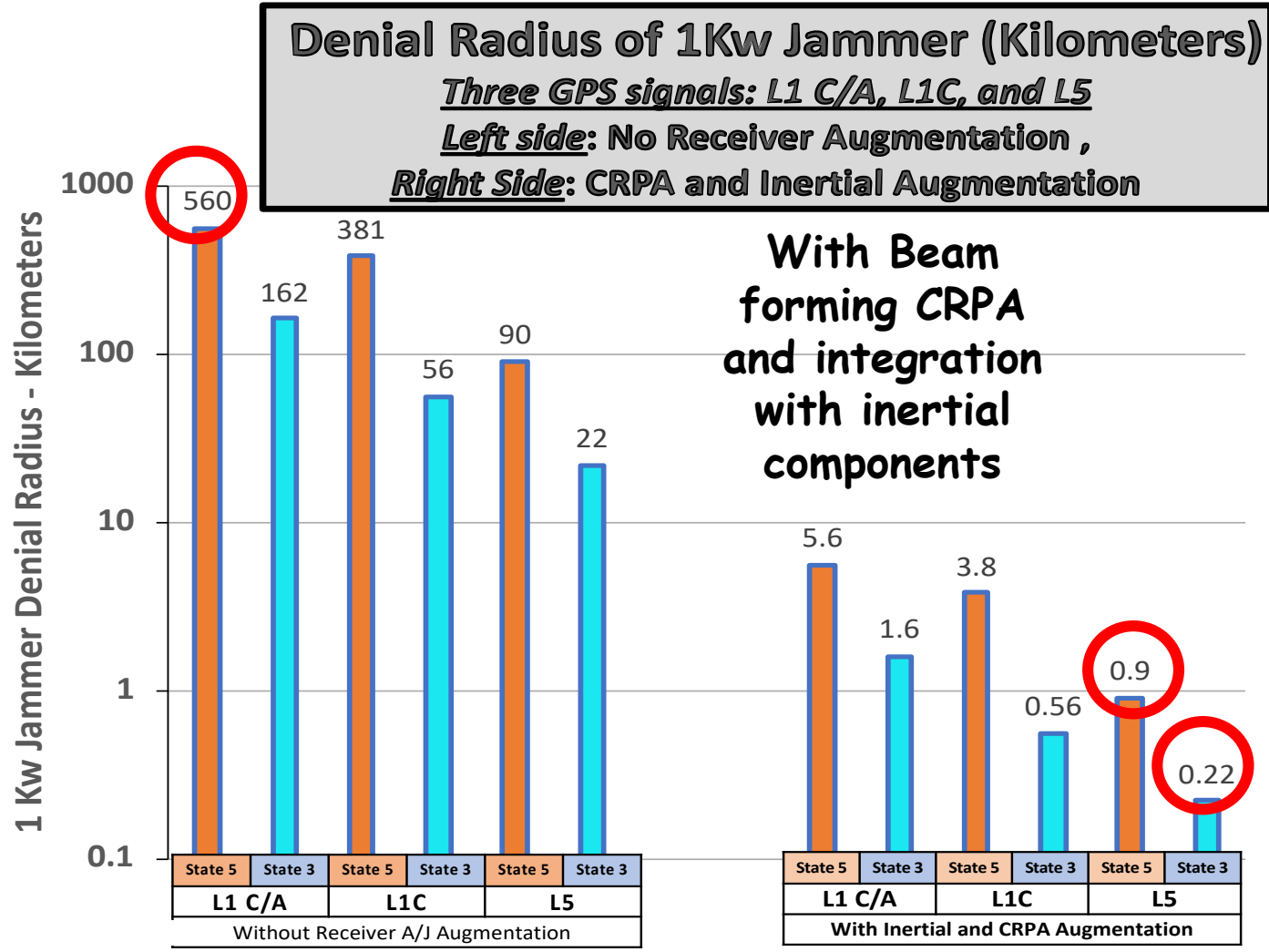
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Summary: Digital Phased array antennas - the keys to near jamming and spoofing immunity

- Technology known and deployed for at least 45 years
- More elements generally allows greater "gain" and deeper nulls against jamming and spoofing
- For GPS (with deeply integrated inertials), provides increased Jamming resistance - by factors up to 100,000 ("50 dB") or more
- US Government denies access to this technology for civil use (ITAR: must be less than 4 elements)
 - Good reasons for original prohibition, but in 2022?

Impacts of failure to remove restrictions

- Denial to US civil/commercial users of major jamming threat- mitigation techniques
- Potential safety of life/commerce implications
 - Aviation
 - Maritime
 - Intelligent Highways
 - Public Safety Users
 - UAVs and Helicopters
- Denial of design/cycle evolution of toughened receivers from US industry

Proposed PNTAB Recommendations

- CRPAs and ITAR
 - Develop white paper and highlight on the agenda at next EXCOM, a request for endorsement and support of removal of all GPS antenna constraints
- L5 Availability
 - Complete activation of signal with full data - (at user's risk),
 - Incorporate L5 into WAAS integrity alarm ASAP (underway!)

Current PNTAB Assessment:

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