



DOT Briefing to FCC

Concerns Over Ligado Order & Authorization

June 2020

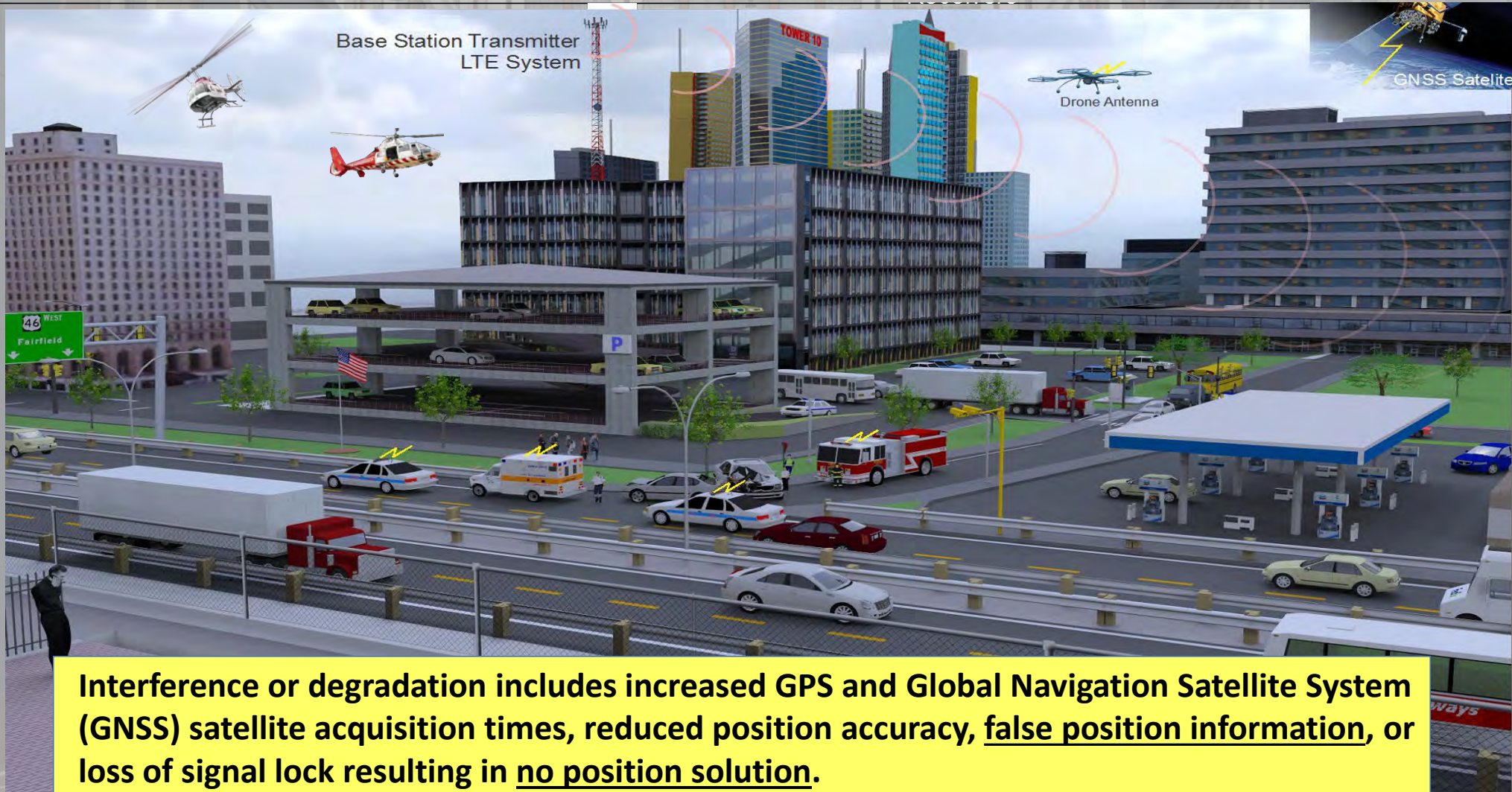


FCC Identified Benefits, Neglected Costs

- ❖ Costs to Federal Users—Tens of Billions of Dollars
- ❖ Costs to Private Users—Tens of Billions of Dollars
- ❖ Lives Lost
- ❖ People Injured



Emergency Response Scenario








Effect of One Ligado Base Station on GPS (Loss of Lock) Based on DOT ABC Testing



- FCC O&A Statement that DOT only looked at 1 dB Criteria is not accurate
- 9.8 dBW base station placed on National Mall

-  High precision GPS receivers (used, e.g., for surveying, construction)
-  Timing GPS receivers (used, e.g., by cell towers, Communications/ IT, finance, energy, Federal mission systems)
-  General-purpose GPS receivers (used, e.g., by personal navigation, emergency response, UAVs)

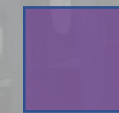
The loss-of-lock results indicate that there will be widespread interference issues under any definition of harmful interference.



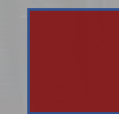
Effect of Many Ligado Base Stations on GPS (Loss of Lock) Based on DOT ABC Testing



- FCC O&A Statement that DOT only looked at 1 dB Criteria is not accurate
- 9.8 dBW base stations separated by 433 m in hexagonal grid on National Mall



High precision GPS receivers (used, e.g., for surveying, construction)



Timing GPS receivers (used, e.g., by cell towers, Communications/ IT, finance, energy, Federal mission systems)

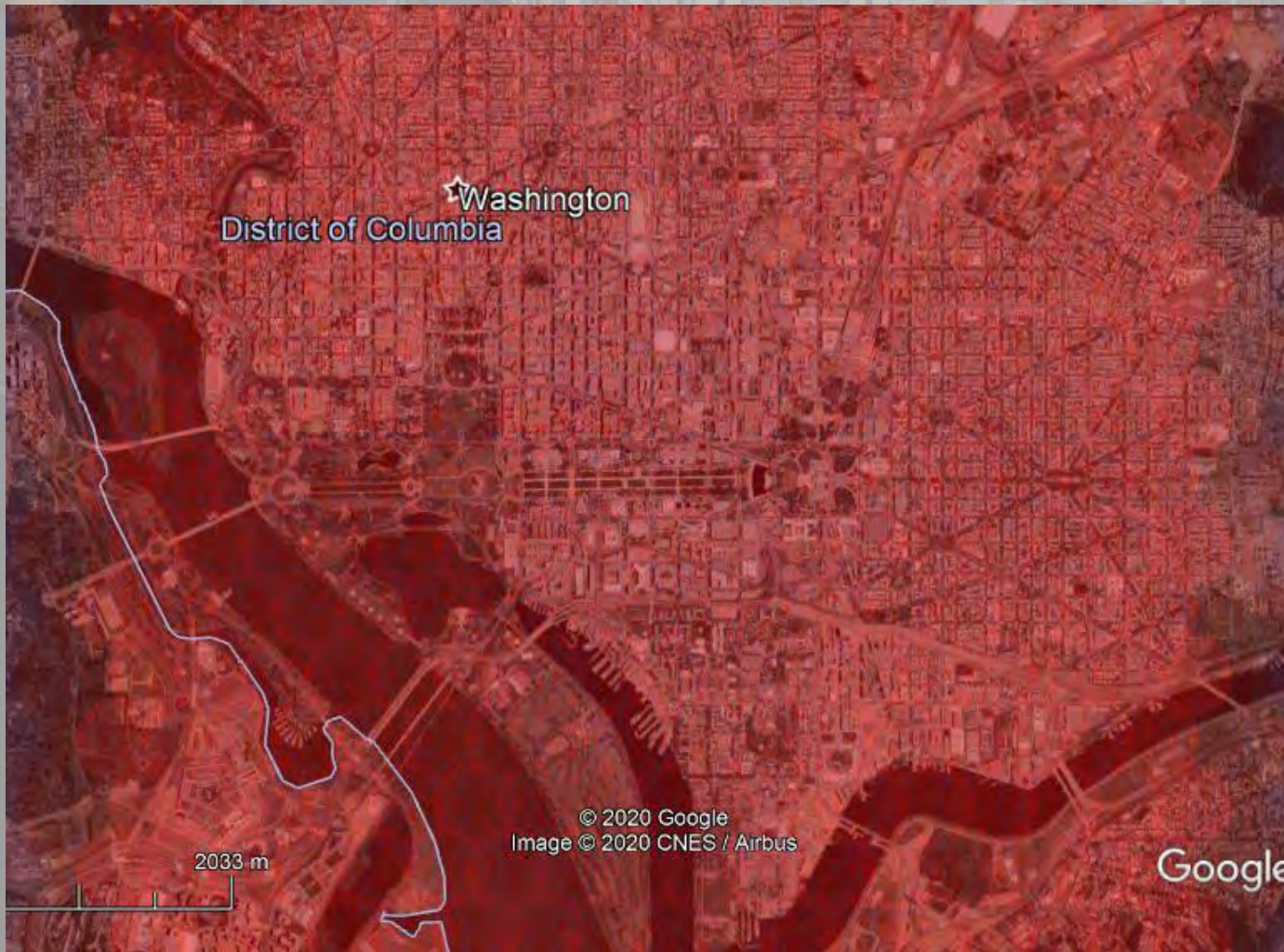


General-purpose GPS receivers (used, e.g., by personal navigation, emergency response, UAVs)




The loss-of-lock results indicate that there will be widespread interference issues under any definition of harmful interference.



Effect On GPS of Many Ligado Base Stations (1 dB)



- 9.8 dBW base stations separated by 433 m in hexagonal grid
- Blanketed Impact for All Receiver Categories

-  High precision GPS receivers degraded (used, e.g., for surveying, construction)
-  General-purpose GPS receivers degraded (used, e.g., by personal navigation, emergency response, UAVs)
-  Timing GPS receivers degraded (used, e.g., by cell towers, Communications/ IT, finance, energy, Federal mission systems)



General Aviation Left Unprotected

- ❖ **General Aviation GPS (Non-IFR) Will Be Affected Up to One Kilometer**
- ❖ **Helicopter Terrain Awareness and Warning System (H-TAWS) Could Be Severely Harmed**
 - ❖ **Operational effects of possible loss of non TSO certified GPS H-TAWS capability over large geographic areas have not been assessed.**
- ❖ **350,000 Installed and Portable Visual Flight Rule GPS and Electronic Flight Bag Devices Would be Affected**



1 dB CNR Degradation Interference Protection Criteria

- ❖ Dispute over interference standard based on papers prepared by TAC, chaired by Ligado consultant Roberson, inconsistent with Administration standards.
- ❖ Intent of the 1 dB IPC is to preserve the accuracy and integrity of timing/ranging and position information – **Essential for safety-critical applications of GPS**
- ❖ FAA uses interference mask for certified avionics, **more restrictive than the 1 dB criteria.**
- ❖ 1dB-Criteria Supported by the GPS Receiver Manufacturers
- ❖ FCC's March 2020 C-band Report & Order includes adjacent-band interference requirement to protect satcom I/N of -6 dB (which equates to a 0.97 dB C/No degradation).
- ❖ International Standard: Recommendation ITU-R M.1903



Maximum Tolerable Power Level for GPS/GNSS Receivers at 1530 MHz

Deployment	Stand off distance (m)	Max Tolerable EIRP (dBW)			
		GLN	HPR	TIM	CEL
Macro Urban	10	-31.0	-41.9	-20.6	10.9
	100	-11.0	-21.9	-0.6	31
Micro Urban	10	-29.8	-41.2	-20.1	10.7
	100	-9.8	-21.1	-0.1	30.8

Deployment	Stand off distance (m)	Max Tolerable EIRP			
		GLN	HPR	TIM	CEL
Macro Urban	10	0.8 mW	64 μ W	8.7 mW	12.3 W
	100	79.4 mW	6.5 mW	0.9 W	1.26 kW
Micro Urban	10	1 mW	76 μ W	9.8 mW	11.7 W
	100	104 mW	7.8 mW	1 W	1.2 kW

At proposed Ligado spacing, power must be reduced from 10 Watts to about one milliwatt (factor of 10,000) to protect all existing receivers

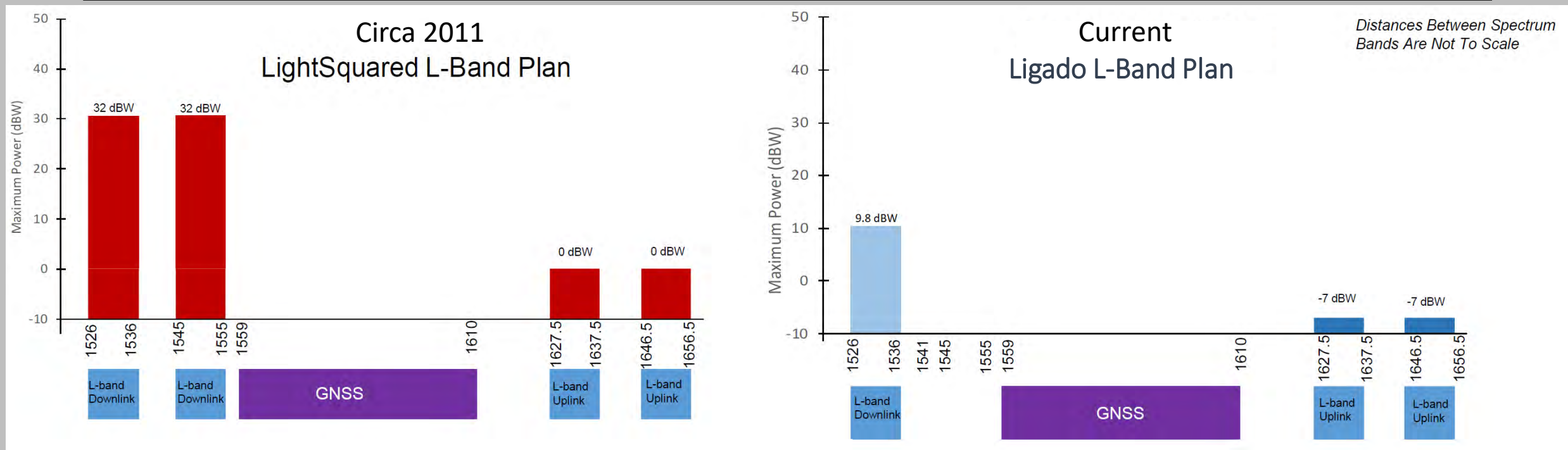


Summary of DOT Concerns

- ❖ The DOT GPS Adjacent Band Compatibility (ABC) test results clearly demonstrate there will be widespread disruption to GPS receivers.
- ❖ DOT serves as the Civil Lead for GPS and is concerned about the millions of receivers that will experience interference
 - The majority of civil GPS receivers are not U.S. Government devices and will not qualify for repair or replacement paid for by Ligado.
- ❖ FCC should thoroughly assess and account for the economic costs and burdens that will result.
 - Many GPS/GNSS receivers are hermetically sealed so it is not possible to retrofit them with new antennas.
 - Furthermore, many receivers are integrated into end-user applications making adversely affected GPS users unable to retrofit or replace their GPS receivers.

Additional Information for the
PNT Advisory Board's
Consideration

Proposals for Use of Spectrum Adjacent Band to GPS L1



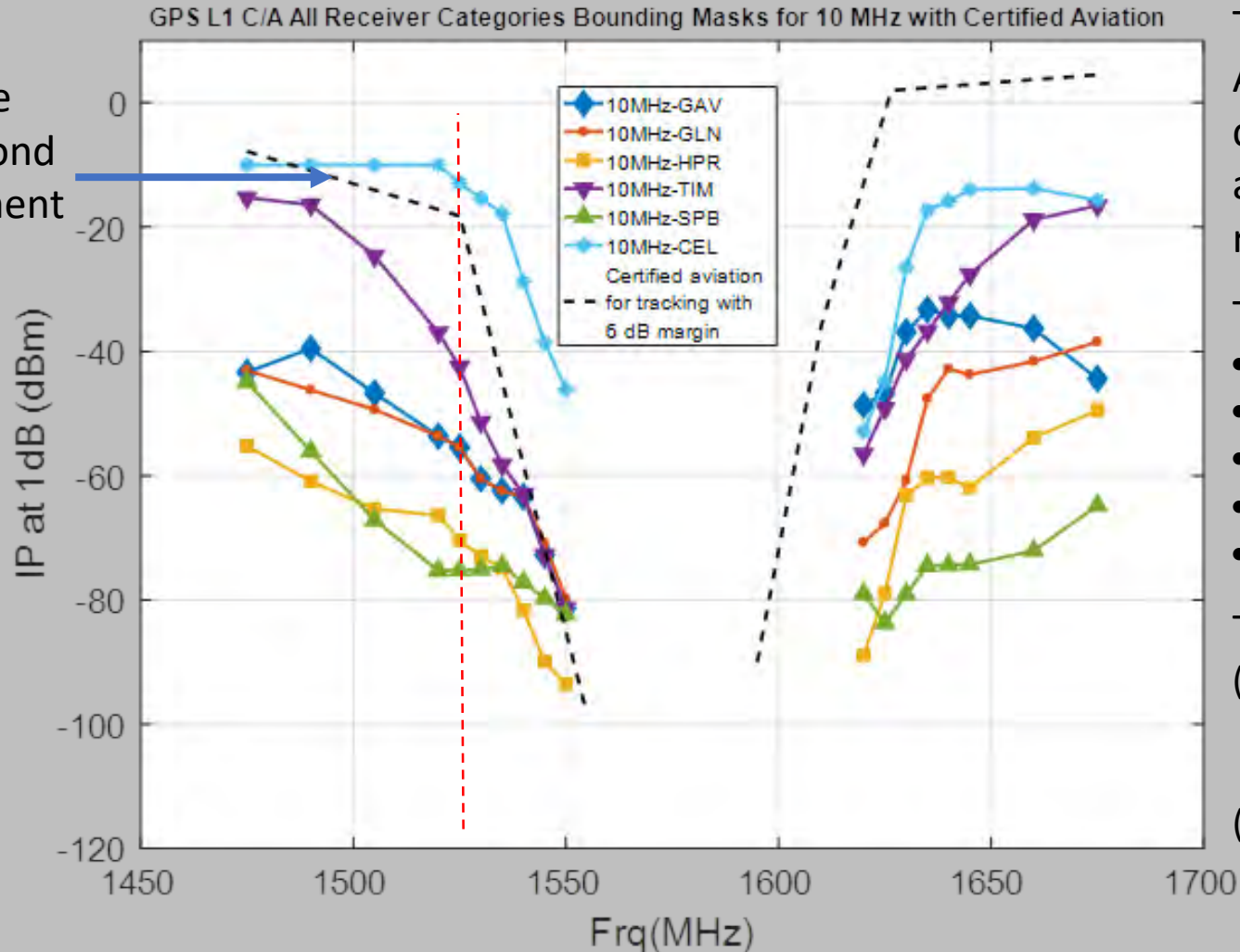
- At 9.8 dBW (~10 watts) at 100 meters from the transmitter, Ligado signals are **2 Billion times greater power** than GPS
- GPS is a faint signal – 20 watts of power from 20 million meters away

DOT ABC Testing Did Not Consider JUST the Most Sensitive Receivers

- The statement that DOT only considered “worst-case” device results at each frequency were publicly reported” is incorrect. At each frequency, the DOT Report included:
 - (1) Most sensitive receiver
 - (2) 10% receiver results
 - (3) Median receiver results
 - (4) 90% receiver results
 - (5) Most robust receiver
- All of this data was included in Appendix B of the DOT ABC report
- The “most sensitive” DOT ABC test results were used to develop a summary “bounding mask” for each category of receiver equipment to ensure protection of the most sensitive receivers in each category from adjacent band power

Summary of 10 MHz Bounding Masks GPS L1 C/A

All points/receivers below the dashed line will be impacted beyond the aviation "assessment cylinder"



The statement in the FCC Order & Authorization that DOT only considered "worst-case" device results at each frequency were publicly reported" is **not accurate**.

The DOT Report includes:

- Most sensitive receiver
- 10% receiver results
- Median receiver results
- 90% receiver results
- Most robust receiver

The DOT Report also provides:

- (1) Loss-of-lock results (low elevation satellites and complete loss of lock on all satellites)
- (2) Analysis of time-to-acquire the GPS signal

Ligado's Settlement Agreements With GPS Receiver Manufacturers Does Not Mean There Will Be No Interference

- Ligado's Settlement Agreements with the GPS Receiver Manufacturers have been misrepresented – they were business deals to have the Ligado lawsuits against the manufacturers dropped
- DOT met with engineers from all of the companies who signed settlement agreements and were told that their products would still be interfered with
- A number of the same receiver manufacturers participated in the DOT Adjacent Band testing and agree with the results from that testing
- The receiver manufacturers who signed agreements with Ligado all stand behind use of the 1-dB CNR degradation interference protection criteria and have filed on the FCC docket stating so

DOT Certified Aviation Analysis Caveat

- The DOT Adjacent Band Assessment Report notes: “there were unresolved concerns expressed by several, though not all, operators about the assessment zone and its impacts to aviation operations and safety.”
 - See 2016 RTCA Tactical Operations Committee report that was attached to RTCA’s June 2020 *ex parte* submission
- DOT Report also states: “The FAA has not completed an exhaustive evaluation of the operational scenarios in developing this assessment zone. Further, the current analyses do not include an operational assessment of the impact of the assessment zone in densely populated areas. For example, the risk posed to people and property for operations such as unmanned aircraft systems (UAS) using certified avionics may be significant as such aircraft may be required to operate within the assessment zone.”

Note: Cylinders repeat every 433 meters, adding to overall airspace complexity.

GPS Signal vs. Ligado Noise



Signal: Leaves Rustling. (0-10 dB)

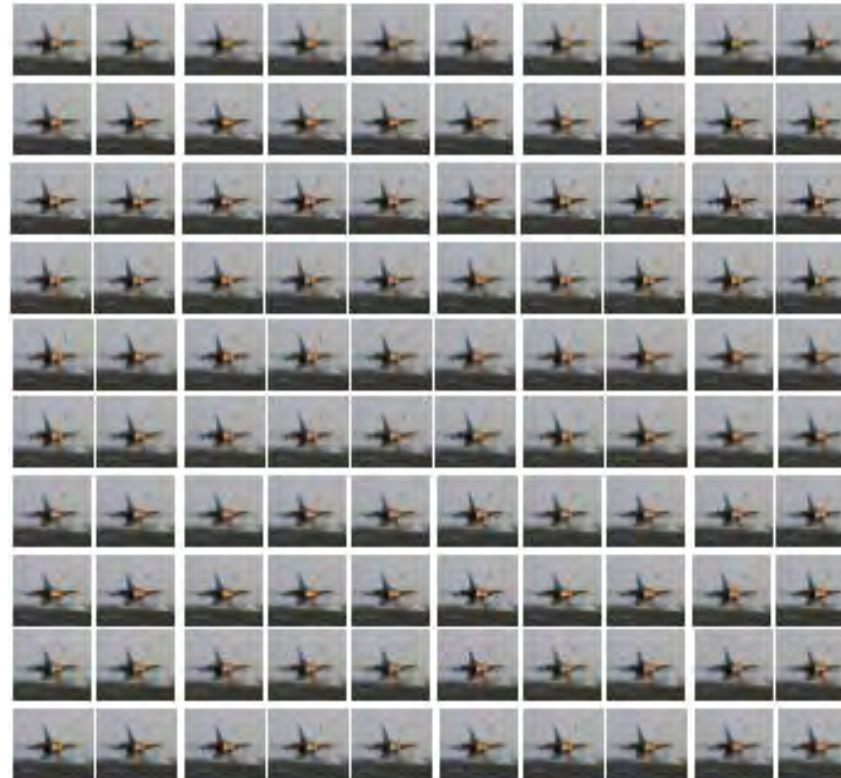


Noise: Jet Takeoff (140-150 dB)

0 dB = barely audible sound
Every 10 dB increase = factor of 10 power increase;
i.e., 20 dB = 10X the power of 10 dB, 30 dB = 100X
the power of 10 dB, etc.



With GPS, We are Trying to
Hear Rustling Leaves...



Through the Noise of 100 Jets



GPS Receiver