White Paper

Ligado and GPS Interference: **What You Need to Know Now**

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The Global Leader in Resilient PNT

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Executive Summary

Recent news about the FCC granting Ligado Networks new licenses to broadcast in the band adjacent to GPS has raised concern among many in the GPS community about the possibility of interference. Will GPS operations near Ligado ground transmitters be interrupted?

At Orolia, we support the position of the DOT, DHS and DOD and the measures they are taking to protect the GNSS band. However, interference is a fact of life in this band. GNSS signals are very weak, so additional measures must be taken for resiliency, especially for critical infrastructure.

Adversarial interference can be much worse than this, so a range of solutions are possible: From the simple – for example, a horizon blocking antenna that shields energy from a nearby tower – to full multi-layer defenses that include RF filtering, advanced DSP filtering/detection, alternative PNT from STL signals, atomic clock and IMU backup, and CRPA antennas. No one solution covers every case, but the problem can be managed.

Background

Several years ago, a company called Lightsquared proposed a new communications network comprising both satellite and terrestrial transmitters to cover most of the USA. Concern was raised then about the potential for GPS interference, and the Dept. of Transportation (DOT) commissioned a study to understand the effects. The graph shown below is from that study.

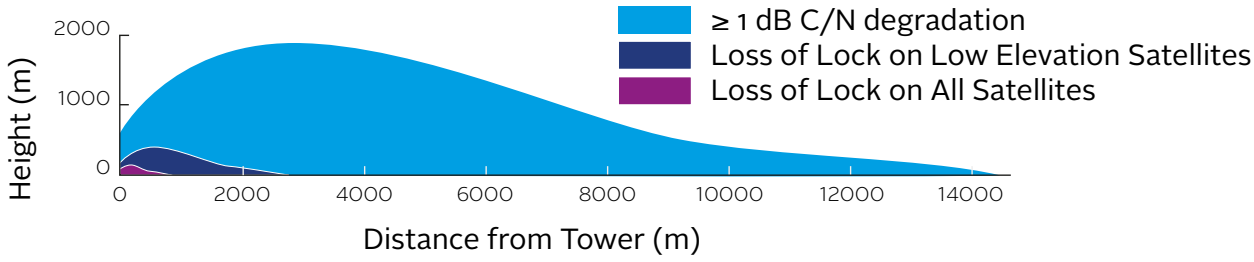


Figure ES-3: Impact of a 29 dBW Cellural Base Station Transmitting at 1530 MHz on a High Precision GPS/GNSS Receiver

The three colored regions show the points at which a typical GPS receiver reacts to the interference:

Cyan – 1 dB or more of signal strength indication is lost, but the receiver continues to track all the satellites

Violet – receiver begins to lose some satellites

Magenta – receiver loses all satellites

Obviously, the closer you are to the transmitter tower, the worse the interference becomes. Also, the relative height of your GPS antenna to the transmitting tower is a factor. If you are in an aircraft at 2000 meters above a nearby transmitter, you will get less interference, because the transmitting antennas send most of their energy horizontally vs. vertically. But for medium distant transmitters, you are now in their horizontal plane. As distances further increase, the interference goes down with the R^2 law of radio propagation.

For ground-based systems, we can see from the graph that, starting at ~10 km from the tower, you will begin to see interference effects and that within 2 km, a loss of satellites will definitely become a problem. That is why the deployment of Lightsquared transmitters was halted.

Current Situation

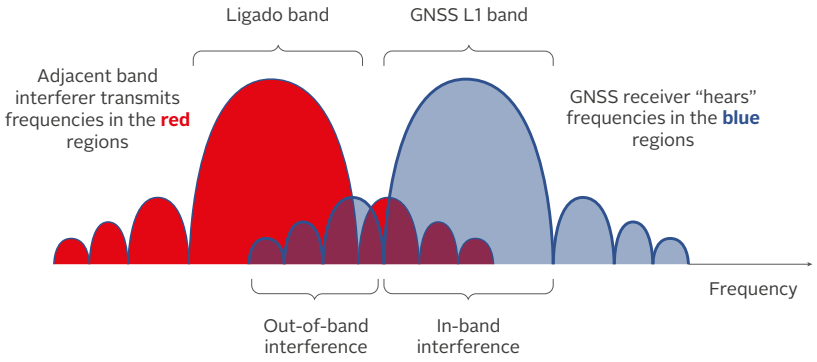
Today, the new company Ligado has responded to this problem by proposing to reduce their transmit power level by 20 dB, from 29dBW to 9 dBW. Using the old graph, we can account for this reduced power by just dividing the x-axis by 10 to get the new range values. [The R^2 law of radio propagation states a decrease of power by a factor of 100 (20 dB) will result in a reduction of range by a factor of 10.] So now, the situation is:

- Within **~ 1 km**: some noticeable interference seen
- Within **200 m**: loss of satellites

Without knowing the deployment plan or density of the terrestrial transmitters, it is difficult to predict how often one will encounter interference, but it would be prudent to take precautions if a Ligado transmitter is located within a few hundreds of meters of your site.

How the Interference Hurts

The interference enters the GNSS receiver in two possible ways, as shown in the figure below:



1. In-band interference – No transmitter is perfect. Some energy "spills" into the GNSS band from small bits of energy coming from the high-power transmitter. This can be reduced by better filtering at the transmitter.

2. Out-of-band Interference – No receiver is perfect. The very sensitive GNSS receiver will "hear" high levels of energy outside its main band because it has such high gain to receive its desired signals. This can be reduced by better filtering at the receiver.

What Can be Done?

For fixed site installations, Orolia recommends using a horizon blocking Anti-Jam (AJ) antenna or a null steering antenna system. Orolia's 8230 AJ horizon blocking antenna blocks signals below 30 degrees elevation from the ground plane of the antenna. Because most interference comes from the horizon, including the Ligado ground transmitters, the interference is eliminated. The antenna will also block low elevation angle GNSS satellites, reducing the number of satellites received. However, for the fixed site application for precision time, this is not a problem. There are many GNSS signals in view at high elevation angles, and the timing application does not need many satellites to form a reliable solution.

Additionally, antenna placement can be a factor. Simply locating the GNSS antenna away from the offending nearby transmitter, or in the shadow of its beam obstructed by some other structure, can often be the cure.

For mobile applications or fixed sites that need to receive the horizon satellites, we recommend using a null steering antenna system. The GPSdome Anti-Jammer from InfiniDome is a simple two-element system that will automatically

steer the null of the combined antenna pattern toward the interference to prevent it from entering the receiver. Two antennas are used, spaced about 20 cm apart, and their signals are intelligently combined into a single cable for connection to the receiver. The resulting null is more than sufficient to block the energy from a nearby transmitter.

Another countermeasure to this problem is to use the STL signal to augment GNSS. Even though the Ligado signal is also near the STL band, STL is 1000x stronger, so the interference is not a factor.

Frequently Asked Questions

1. **What is the probability of encountering interference from a Ligado transmitter?**
   At this point, it is difficult to know. Deployment plans have not been disclosed, but since interference only occurs within 1 km from the transmitter, even if thousands of transmitting stations are deployed, the possibility of interference for fixed site installations should remain low.

2. **Is it certain that these transmitters will be deployed?**
   No. Several US government agencies are fighting to have this FCC ruling overturned, including the DoD, DHS, and DOC. Orolia supports the measures that these agencies and others are taking to protect the GNSS band.

3. **Will Orolia's ThreatBlocker filter out this interference?**
   Possibly, but not likely. ThreatBlocker does filter out out-of-band interference, but it may not be enough. ThreatBlocker is designed to filter out narrowband and sweep jammers. This interference is broadband, corrupting most of the band, so it will not eliminate all the in-band interference.

4. **Are all GNSS constellations affected or just GPS?**
   In general, yes, all are affected. This interference is in the L1 band, which all the constellations use, so it will affect all of them, but possibly in different ways. Newer multi-frequency receivers that do not require the L1 band to operate may be unaffected, but these types of receivers are rare today. We expect that in the future, most new receivers will operate with or without L1.

5. **Are there any receivers that are not affected?**
   Yes. High-end receivers claim that they can operate through this interference, but these can be expensive. Also, out-of-band filtering is often part of the antenna, so you need to look at the antenna/receiver combination.

6. **Will there be Ligado deployments outside of the USA?**
   Unknown. To date, we have only heard about USA deployment.

7. **Can I test for this interference before I deploy?**
   Yes. If you know of or suspect a transmitter location nearby, you can test your GNSS receiving equipment's susceptibility to interference with a simulator such as the GSG-8. You enter in the transmitter's relative location, its power level, frequency band and signal characteristics, and you can simulate how your receiver will be affected under various conditions. The simplest way to test is direct cable connection from the simulator to the receiver. However, this will give you a worst-case result, because any beneficial filtering affects from the antenna would not be included. To include the antenna, use an anechoic chamber with the receiving antenna and the simulator's transmitting antenna placed inside the chamber.

Conclusion

As mentioned above, interference is a fact of life in this band. Because GNSS signals are very weak, it is prudent to take additional measures to create resiliency, especially for critical infrastructure. The first place to start is with the antenna. A horizon blocking antenna that shields energy from nearby towers is the least expensive and simplest way to protect against interference. For mobile applications, use a simple two-element CRPA antenna, or a more advanced multi-element antenna for demanding applications. For even more assurance, consider alternative signals such as those provided by Satelles' STL.

We are confident that any of our antenna solutions or STL will counter this particular threat.

About the Author

For more than 15 years, John has been part of Orolia, where he works with global navigation satellite systems (GNSS), wireless, positioning navigation and timing (PNT), and specialized systems. Prior to joining Orolia, he specialized in wireless telecom as a founding member of two startups: Aria Wireless in 1990 and Clearwire Technologies in 1997. At Clearwire, he served as Chief Technology Officer in creating wireless broadband equipment for Internet connectivity. Early in his career, John worked as a systems engineer in radar, EW and command and control systems at Sierra Research and Comptek Research. He holds Masters and Bachelor of Science degrees in electrical engineering and computing engineering from the State University of New York at Buffalo.

About Orolia

With a presence in over 100 countries, Orolia provides virtually failsafe GPS/GNSS and PNT solutions to support military and commercial applications worldwide. Orolia is the world leader in Resilient Positioning, Navigation and Timing (PNT) solutions that improve the reliability, performance and safety of critical, remote or high-risk operations.

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23 July, 2020. Ligado and GPS Interference: What You Need to Know Now