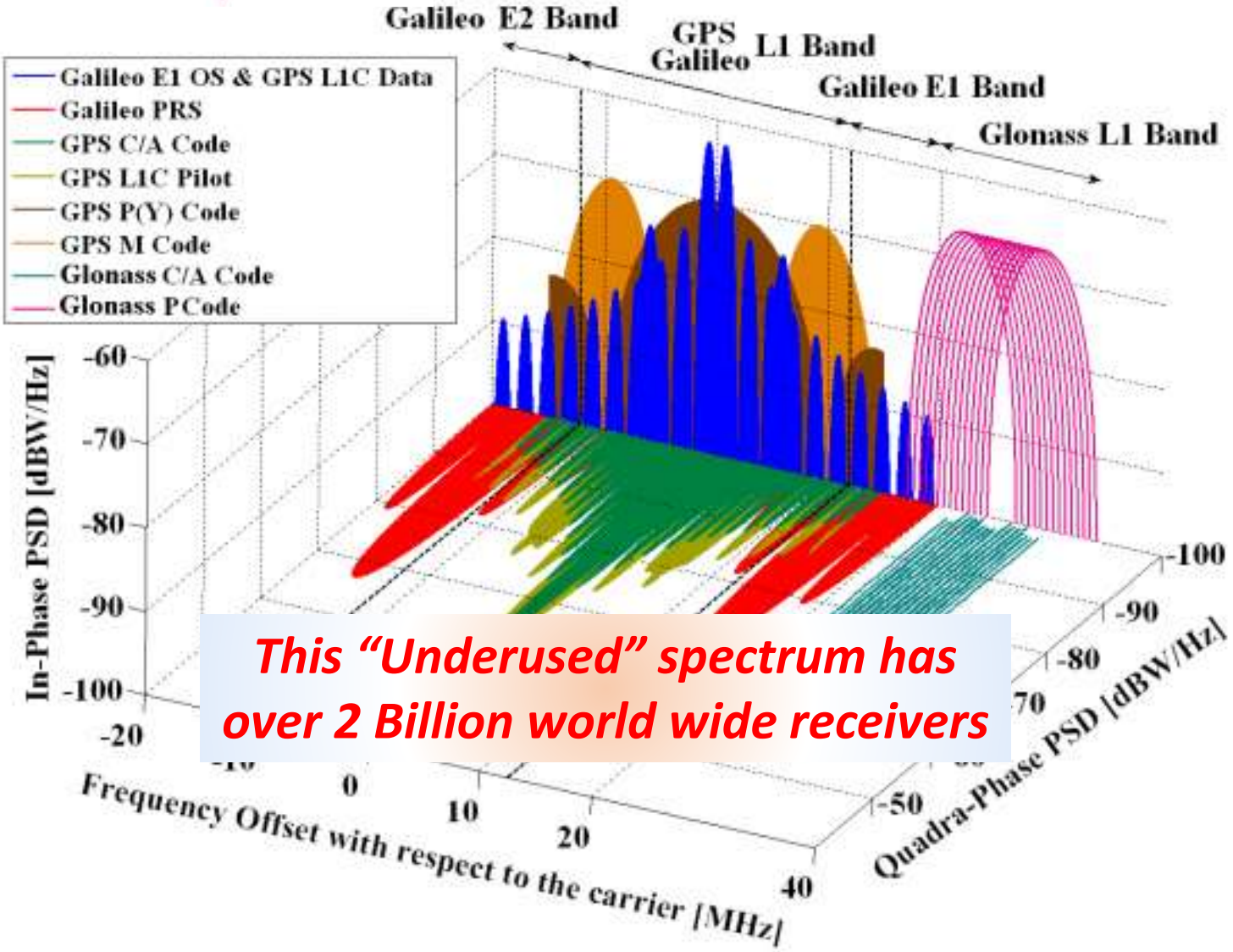
Very Crowded Primary GNSS Frequency Band



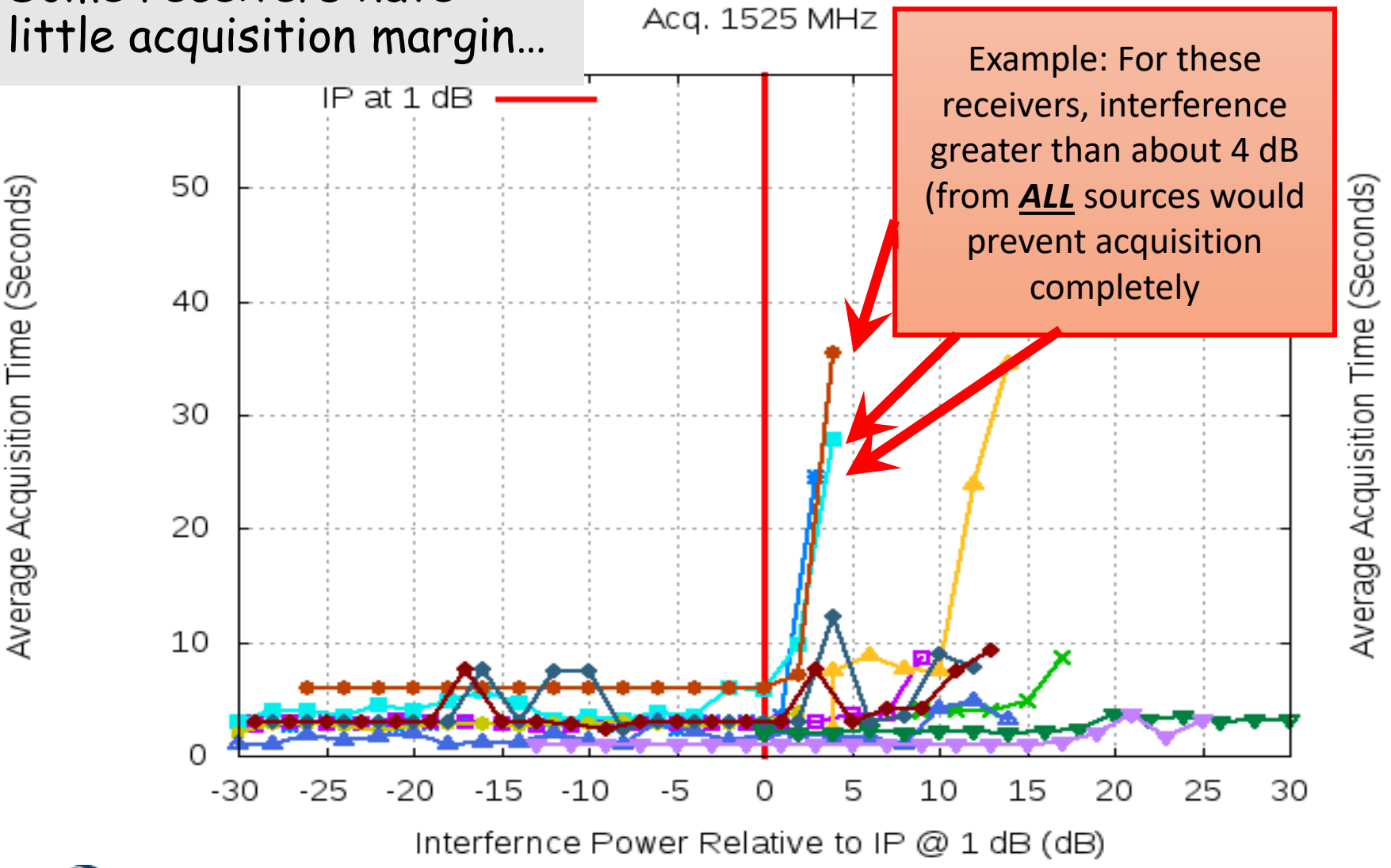
This "Underused" spectrum has over 2 Billion world wide receivers

The 1 dB Criterion:

Non-GNSS Transmitters should not raise the effective noise floor more than 1 dB (12.2%)

- Well established National and International Standard (Just reaffirmed internationally)
- Avoids having to test every application/operation
- Susceptibility varies depending on Precision of receiver - **Generally Precision is (1/Bandwidth) for Position/timing applications**
- Susceptibility of newer GNSS signal receivers must be included (e.g. consider new Qualcom chip)
- Must consider multiple transmitters, spacing, antenna patterns, and "Space Loss"

Some receivers have little acquisition margin…



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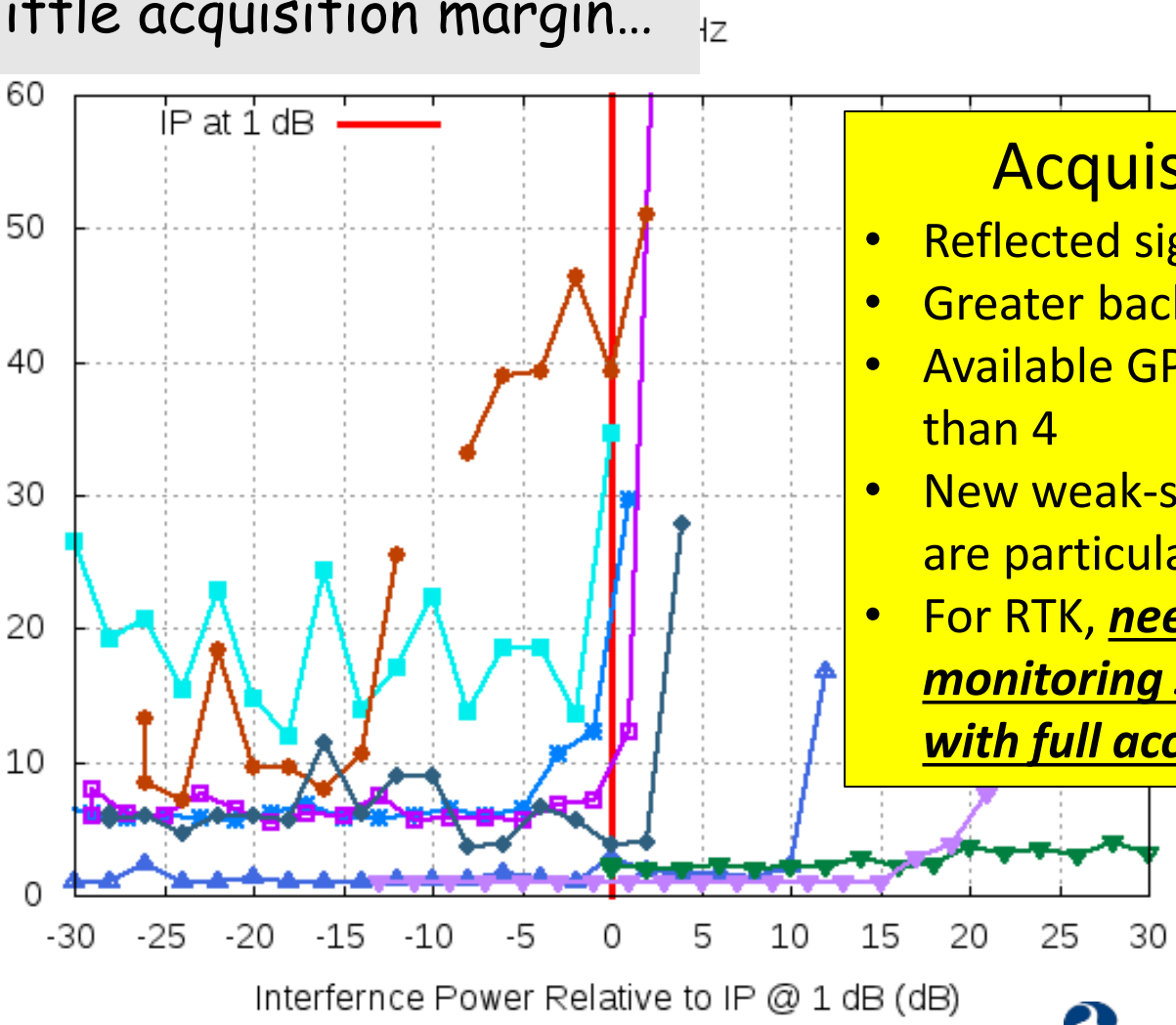
ICD Min. Power

Some receivers have little acquisition margin…



Acquisition in cities

- Reflected signal weaker and LHCP
- Greater background interference
- Available GPS signals frequently less than 4
- New weak-signal (indoor) receiver are particularly susceptible – (911?)
- For RTK, ***need both user and monitoring station to be operating with full accuracy***

Low Elevation

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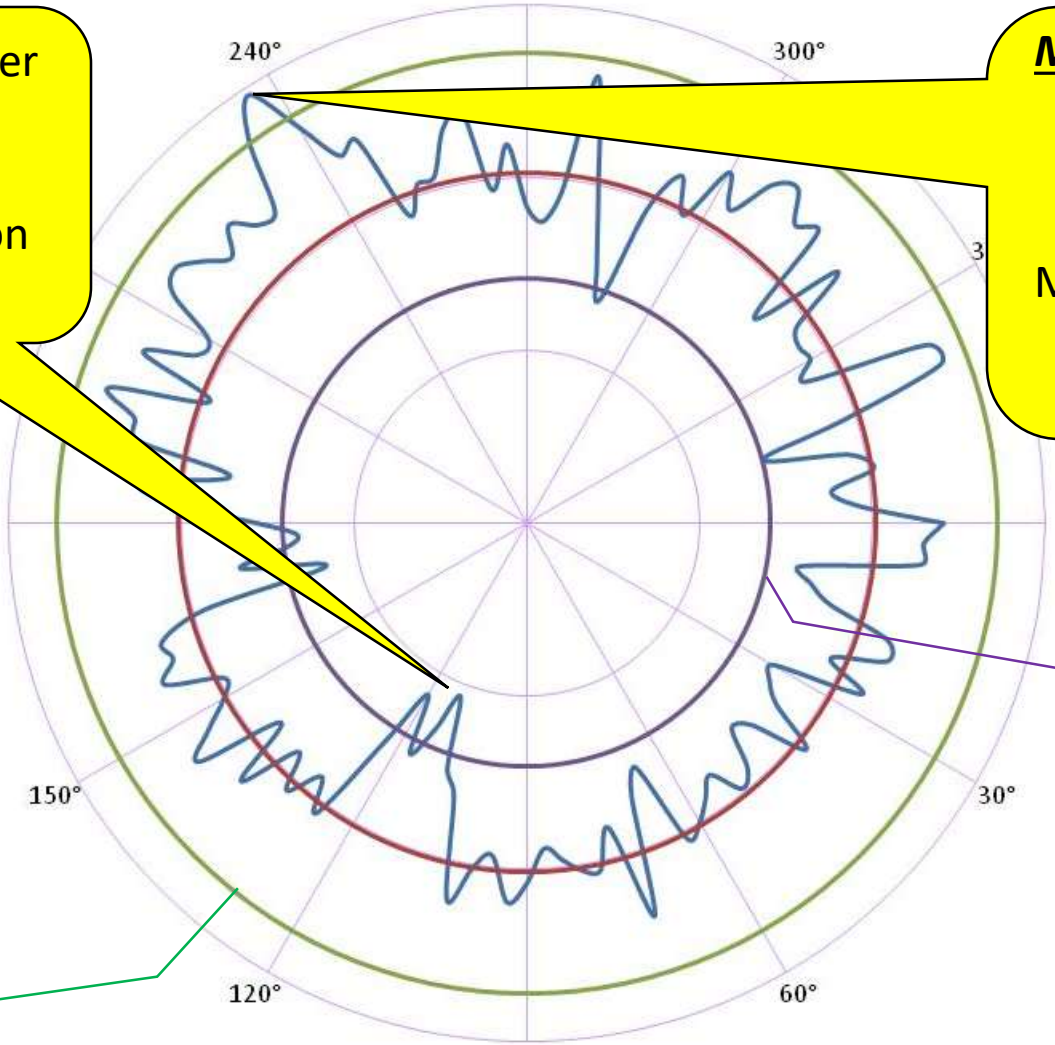
Typical Urban Antenna Power Pattern

Plotted around 360 degrees of Azimuth

Minimum Power and Most Challenging Communication Link Problem

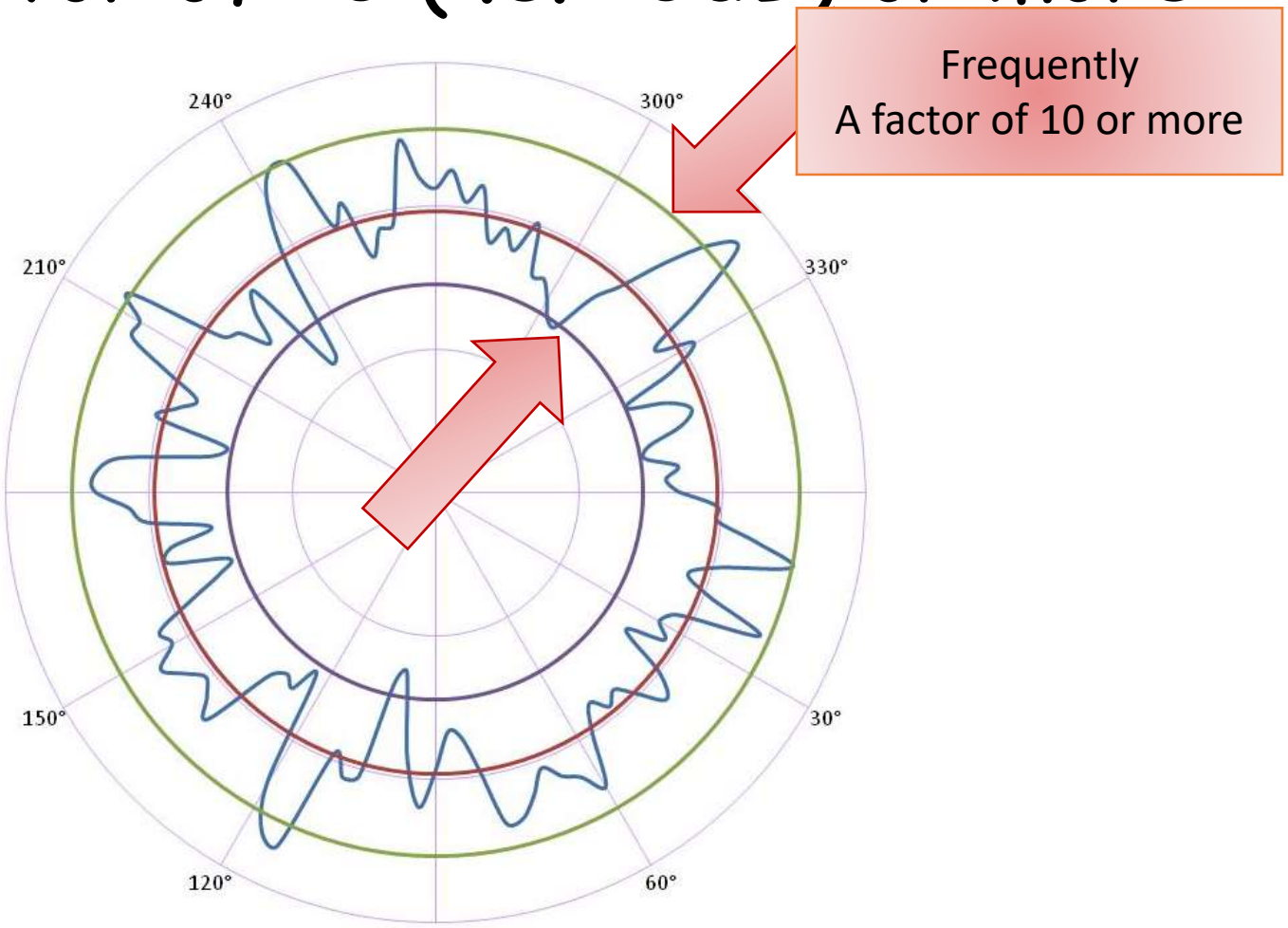
Maximum Power -Maximum Interference Levels Most Challenging for Navigation Systems



99th Percentile – only exceeded 1% of the full azimuth circle – Prudent for a ***Navigation Interference*** Model

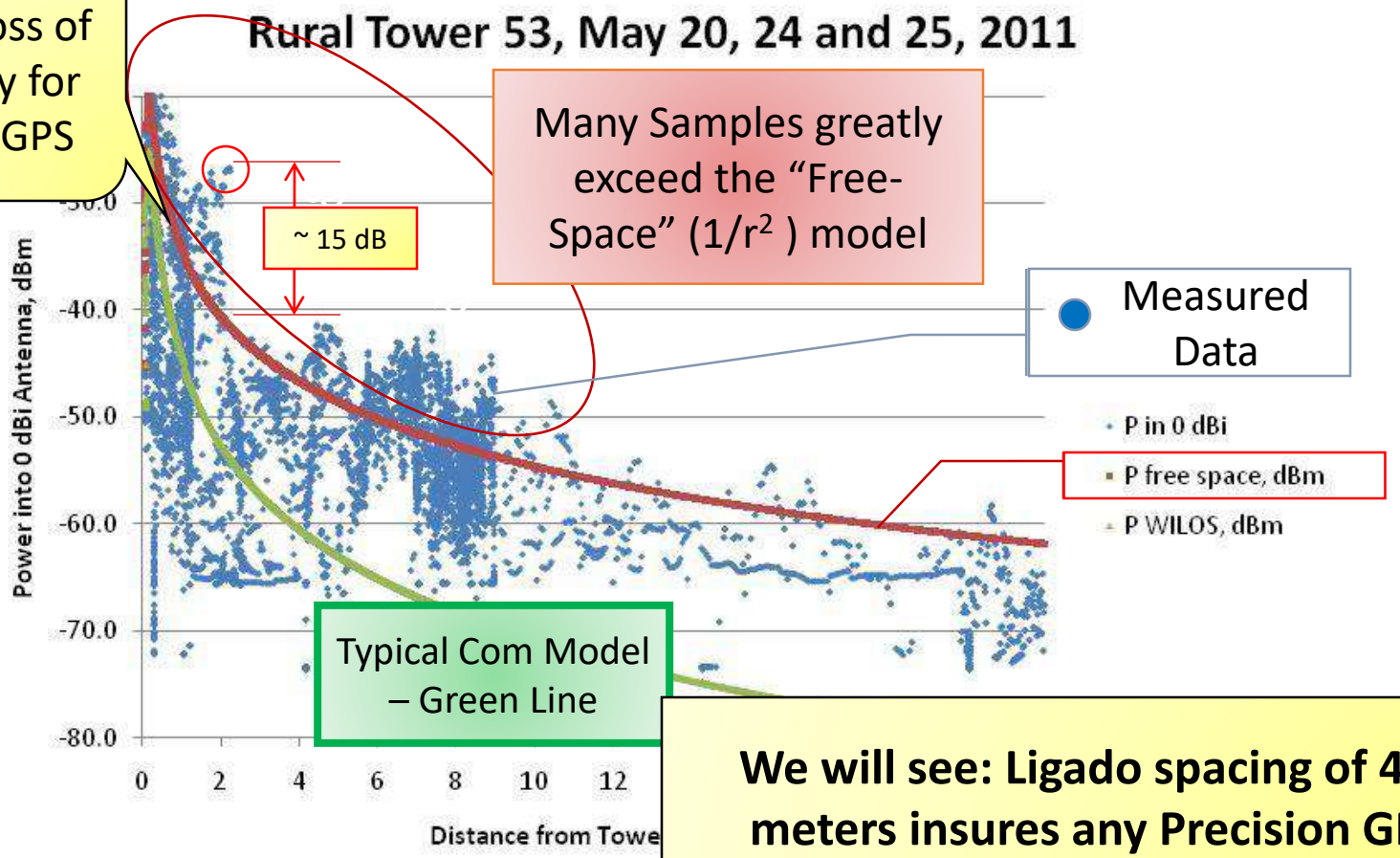
5th Percentile – Less signal in only 5% of the full azimuth circle Useful as a ***Com*** model

In urban areas the differences can be a factor of 10 (i.e. 10dB) or more



Real Data - One Azimuth in Las Vegas

Massive Loss of Availability for Precision GPS



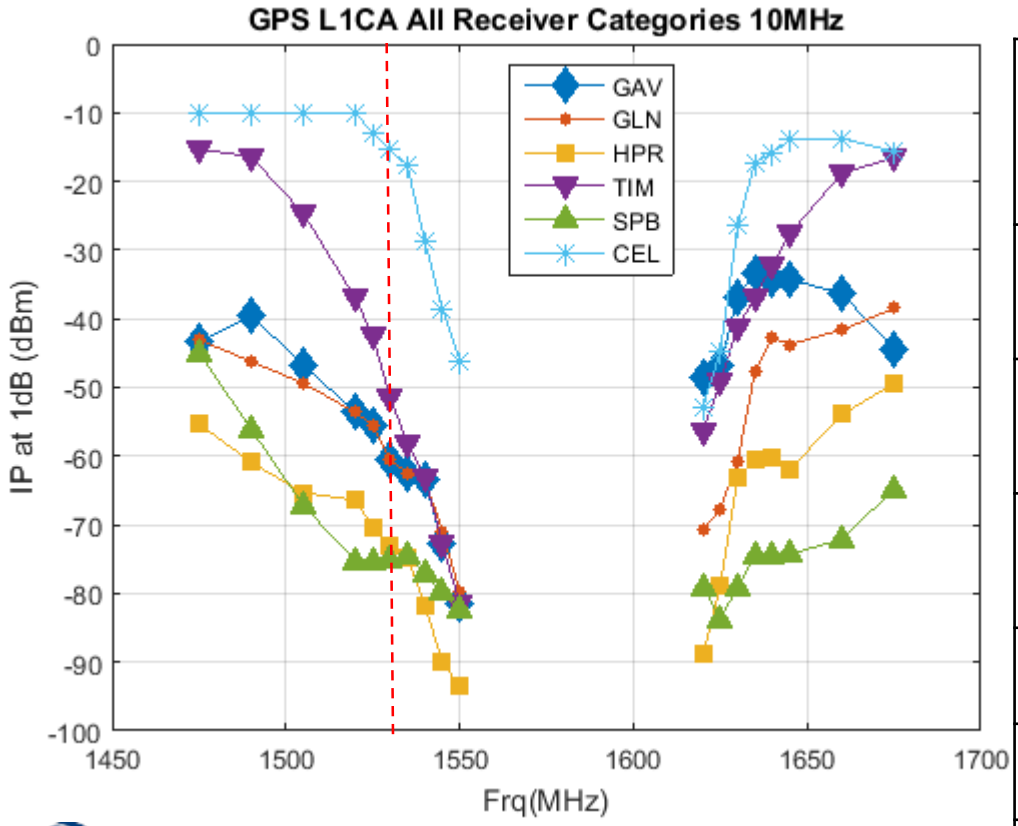
We will see: Ligado spacing of 400 meters insures any Precision GPS receiver is well within Jamming Range

Summary: Why are there Different Views of Propagation* Models?

- Propagation in the real world:
  - Does not fall off as $1/r^2$ (free-space) would suggest
  - There are peaks and valleys reflecting reinforcing reflections or attenuation – **and they change with rain, passing trucks and urban construction**
- As an ***Assured Communications System***
  - Must insure connectivity - use largest attenuation
  - Tend to model as "worst case" (Perhaps the 5 percentile low "tail")
- As ***Interference to a Navigation Signal***
  - Must consider "least attenuation" (An envelope of the highest signal)
  - In Urban areas signal can be larger than "free-space", $1/r^2$, model due to reflections (multipath)

* A **Propagation Model** is a mathematical description of how the transmitted Radio Signal varies with distance and angle to the transmitter

DOT measurement of 10 MHz Bounding Masks Most Sensitive GPS L1 C/A Receivers



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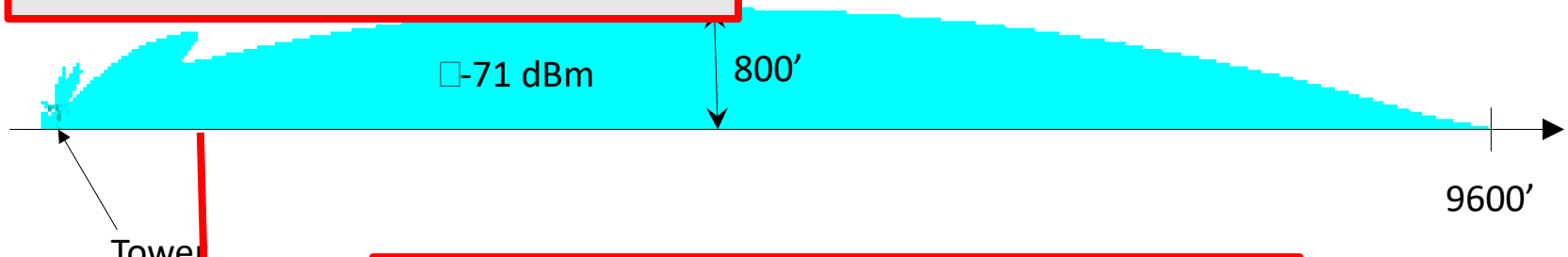
Category	ITM at 1530 MHz (dBm)
GAV - General Aviation (non certified)	**-61.0**
GLN - General Location/Navigation	**-60.5**
HPR - High Precision & Networks	**-73.0**
TIM - Timing	-59.4
SPB - Space Based	**-73.5**
CEL - Cellular	-15.3

Preliminary Results

Impact of Single 12.2 dBW Tower on High Precision Receivers

Transmitter Power is
16.6 Watts
- Most Sensitive Receiver Tested

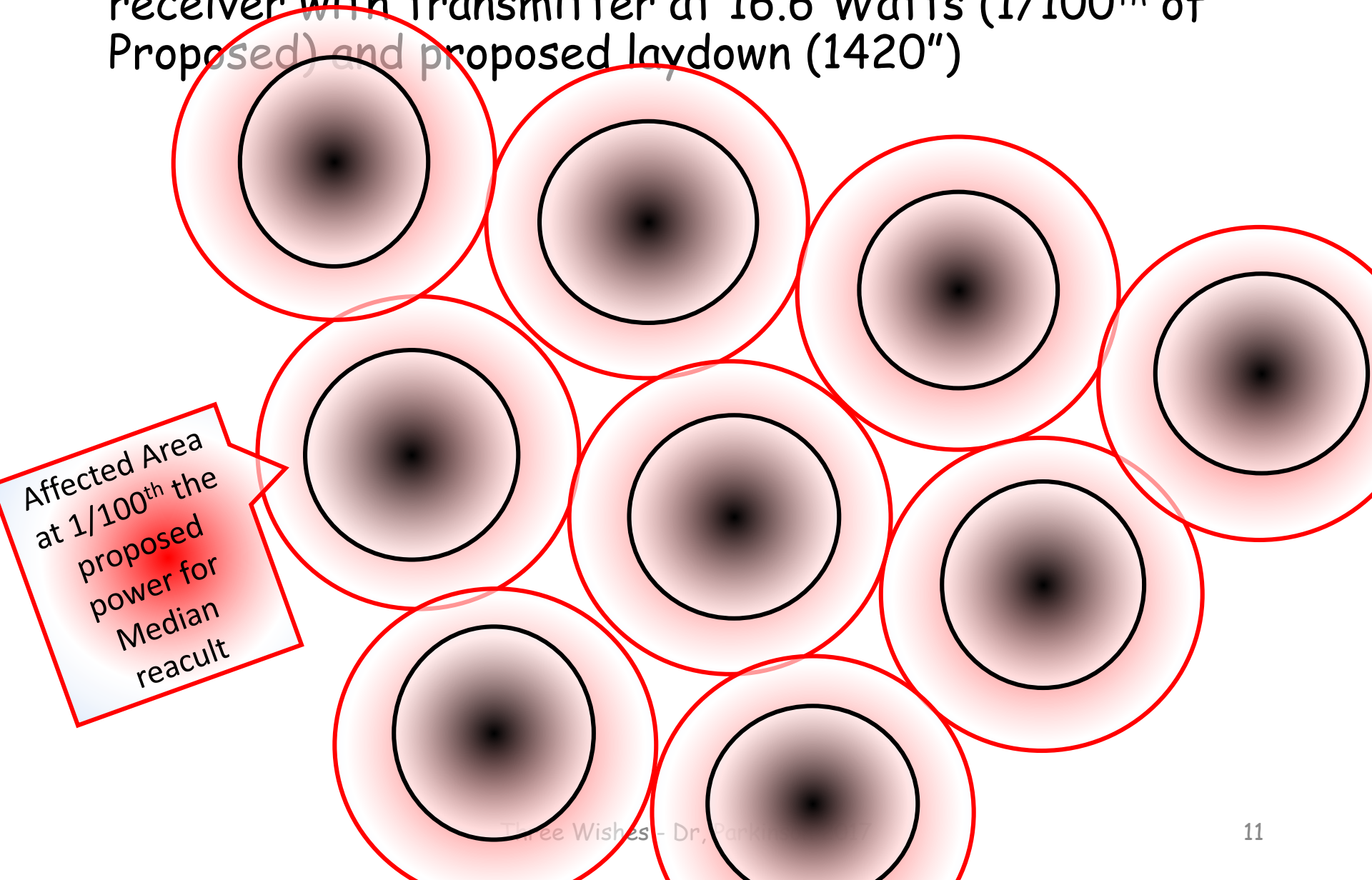
- EIRP = 12.2 dBW
- Tower height = 25 m (82')
- Downtilt = 6 degrees
- Frequency = 1530 MHz



Median Sensitivity, Hi Performance receiver might improve by 25 dB -
Impact Radius would still be 9600/(316)^1/2
or over 525 feet for 17 Watt Transmitter

6

Consider the ***Median*** High Precision GPS L1 C/A receiver with transmitter at 16.6 Watts (1/100th of Proposed) and proposed laydown (1420")



So What?

Urban Applications at Risk

Taxiway and Runway Navigation

Emergency Vehicle Control and Monitoring Plus 3D victim location

Control and Monitoring of UAVs – Delivery and Reconnaissance

Precision control of Construction Vehicles

Also Possibly in the interference pattern

GNSS Precision Survey in construction of High-Rise Buildings

Self Piloted Cargo Airplanes

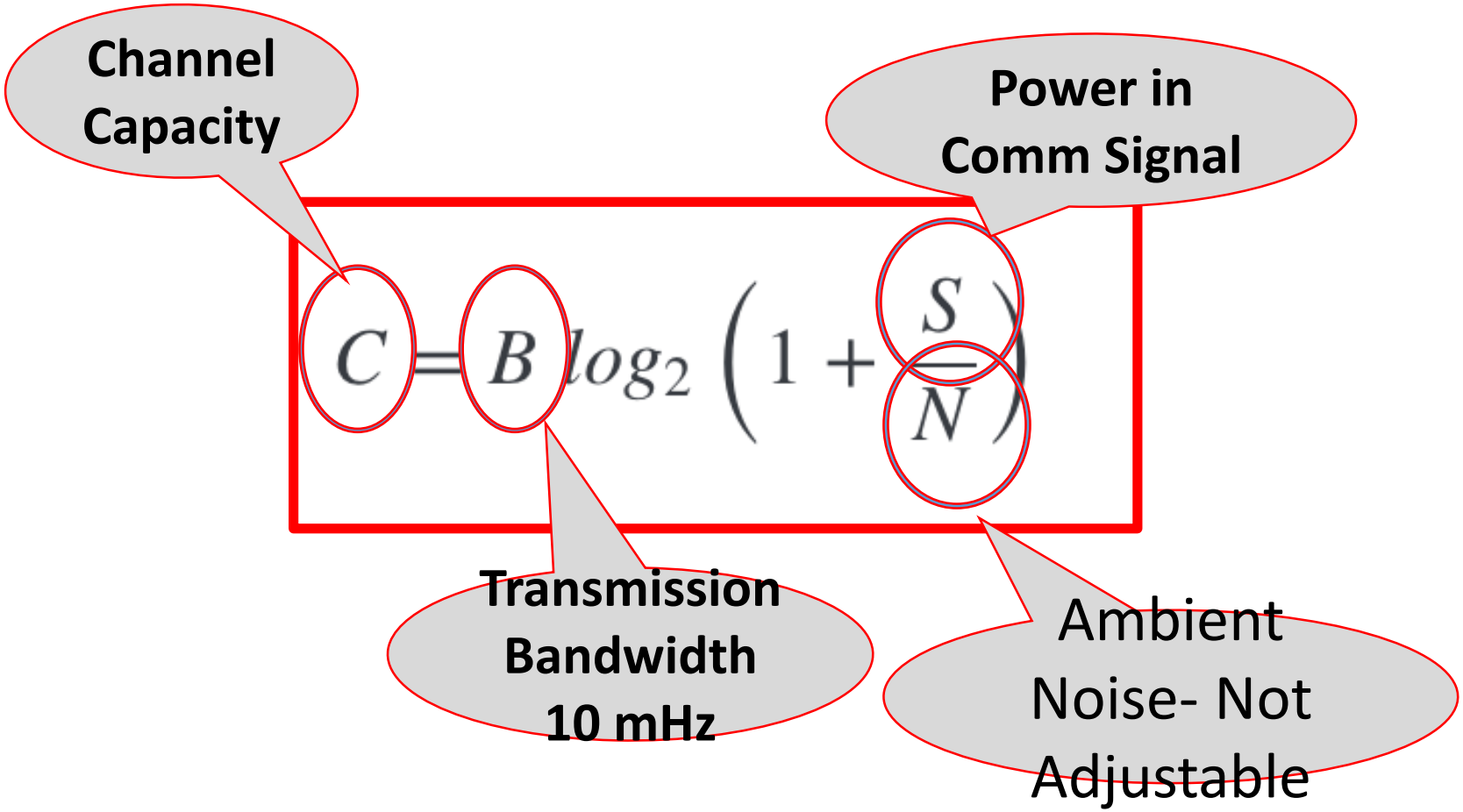
Flying Car/Robotic Taxi

GNSS Track Safety Discernment

Wish 3: *FCC: Does not approve repurposing of Adjacent Spectrum until proposal passes realistic evaluation of all current and future GNSS signals, applications and techniques*

- Must honor international "1 dB" criterion
- Tests and analysis are incomplete
  - Excellent work by DOT
  - NASTCN did not explore many critical aspects
  - Critical current Applications and installed base apt to be in Harms way
  - Future Applications and techniques are in jeopardy

The Fundamental Problem: The Shannon Limit



Recap: The 3 Wishes

P

Wish 3: That *FCC does not approve repurposing of Adjacent Spectrum until/unless proposal passes realistic evaluation of all current and future GNSS signals, applications and techniques*

T

Wish 2: *That low-cost Very Jam-resistant GNSS receivers are Commercially available*

A

Wish 1: *Begin deployment of eLoran Immediately*

Important Takeaway: ***A Real Concern***–

- A US commercial company has argued that ***"precise" GNSS applications*** should not be frequency-protected, since they were not originally "authorized"
- Tests show this is very harmful to precision GPS **At 1/100th** the current proposal power (16 W):
  - The most Sensitive receivers affected everywhere
  - Half the Receivers affected at ½ the transmitter operating radius
  - Many future applications/techniques potentially at risk…
- Let's support both existing Base and the Future

Are you our Genii?


Questions?
Third Floor in High Sierras 2017
Drought is over?