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August 22, 2011

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: **Notice of *Ex Parte* Presentation in LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component, IB Docket No. 11-109; IBFS File No. SAT-MOD-20101118-00239**

Dear Ms. Dortch:

On August 18th, 2011, Deere & Company ("Deere") met with Julius Knapp, Chief of the Office of Engineering and Technology ("OET"), as well as senior staff identified in **Exhibit I** from OET, the Public Safety and Homeland Security Bureau ("PSHS"), International Bureau ("IB") and Wireless Telecommunications Bureau ("WTB") to discuss the above-referenced docket number and application. Attending this meeting on behalf of Deere was Paul Galyean, Director, System Engineering and IME/Robotics, along with Catherine Wang and Tim Bransford of Bingham McCutchen LLP, outside counsel to Deere.

During this meeting Deere discussed the Technical Working Group ("TWG") test methodologies and conclusions, as well as the evolution of high precision Global Positioning System ("GPS") receiver design. Specifically, Deere discussed:

> Why LightSquared's proposed "Low 10 MHz"[1] network configuration is not a viable interference solution, and how virtually all high precision receivers under test during the TWG experienced severe, harmful interference while in the presence of a Low 10 MHz signal.

> How 1 dB of degradation in signal to noise ratio can disrupt high precision receivers in the real world, and, as discussed in greater detail in Deere's comments and reply comments in IB Docket No. 11-109, why 1 dB of loss should be considered the appropriate interference threshold for GPS receivers.

[1] LightSquared's "Low 10 MHz" network configuration consists of a single 10 MHz LTE base station signal centered at 1531 MHz.

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Hong Kong
London
Los Angeles
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> Why the use of a free space model is the best available technique for estimating LTE base station signal propagation in real-world environments, and how simulated LTE signals during live sky tests in Las Vegas were measured at levels that exceeded free space projections due to the combination of multipath signals.

> The need to examine harmful interference from out-of-band emissions from LightSquared handsets.

> The evolution of high precision GPS receivers, including why new receivers must capture wideband signals and employ sharp code edges to achieve the accuracy required for extremely precise agricultural, construction, scientific and surveying applications, among other high precision uses.

> The universal adoption of wideband signal architectures by existing and planned GNSS systems, including GPS, Galileo, GLONASS, and Compass, and why all GNSS systems in the future will push their signals to the edge of the 1559-1610 MHz band to improve accuracy.

The attached PowerPoint was presented to staff in attendance. If you have any questions regarding this meeting, please do not hesitate to contact the undersigned.

Very truly yours,

/s/

Catherine Wang
Tim Bransford

Exhibit I – FCC Meeting Attendees

Julius Knapp	Chief, OET
Ronald Repasi	Deputy Chief, OET
Walter Johnston	Chief, Electromagnetic Compatibility Division, OET
Robert Weller	Chief, Technical Analysis Branch, ECD, OET
John Kennedy	Chief, Spectrum Coordination Branch, P&RD, OET
Michael Ha	Engineer, OET
Brian Butler	Engineer, OET
John Leibovitz	Deputy Bureau Chief
Paul Murray	Assistant Bureau Chief, Wireless Telecommunication Bureau
Darryl Smith	Public Safety & Homeland Security Bureau
Robert Nelson	Chief, Satellite Division, IB
Sankar Persaud	Engineer, IB
Chip Fleming	Engineer, IB

LightSquared Interference to GPS and StarFire

August 18, 2011

Executive Summary

LightSquared harmfully interferes with GPS and Augmentation systems

- The new LightSquared rollout plan and Recommendations do not resolve the problems
- We do not know any feasible mitigations for existing Deere receivers
- There are serious concerns about handsets that have not been addressed
- The FCC/NTIA/LightSquared should explore other spectrum

Testing to Date

Testing is conclusive: LightSquared harmfully interferes with GPS - LightSquared's assertions to the contrary are wrong

- Government testing in New Mexico
- RTCA report
- National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum (NPEF)
- Technical Working Group
- FAA report

The harmful interference:

- is not limited to High Precision receivers
- is not limited to short ranges
- is not limited to High 10 MHz
  - Low 10 MHz alone also causes harmful interference
- affects Augmentation signals as well as GPS

Interference Impact

The installed base of GPS receivers in the US is massive

LightSquared interference creates:

- Severe harm to critical high precision applications (agriculture, construction, surveying, aviation, science, etc.)
  - Loss of GPS = $14-$30 billion annual loss in agriculture alone
  - LightSquared estimates 200K – 1,000K high precision receivers in US
- Unacceptable risk to public health and safety in aviation, emergency vehicles, first responders
- Severe harm to commercial operations in many sectors
- Severe harm to consumer uses (automotive, personal location, etc.)

Major Issues

From the beginning, there have been two major issues:

- GPS receiver overload
  - Primary focus has been on base stations
  - Handsets can also overload GPS receivers
- Co-channel interference with Deere's FCC licensed StarFire augmentation network
  - LightSquared signal is >90 dB (a billion times) stronger than StarFire signal near base stations
  - LightSquared also interferes with other augmentation systems (OmniSTAR, WAAS)

These problems remain unresolved under original rollout plans or new LightSquared rollout plan and Recommendations

<u>There is a new, potentially major issue that has not been evaluated</u>

- LightSquared handset OOBE

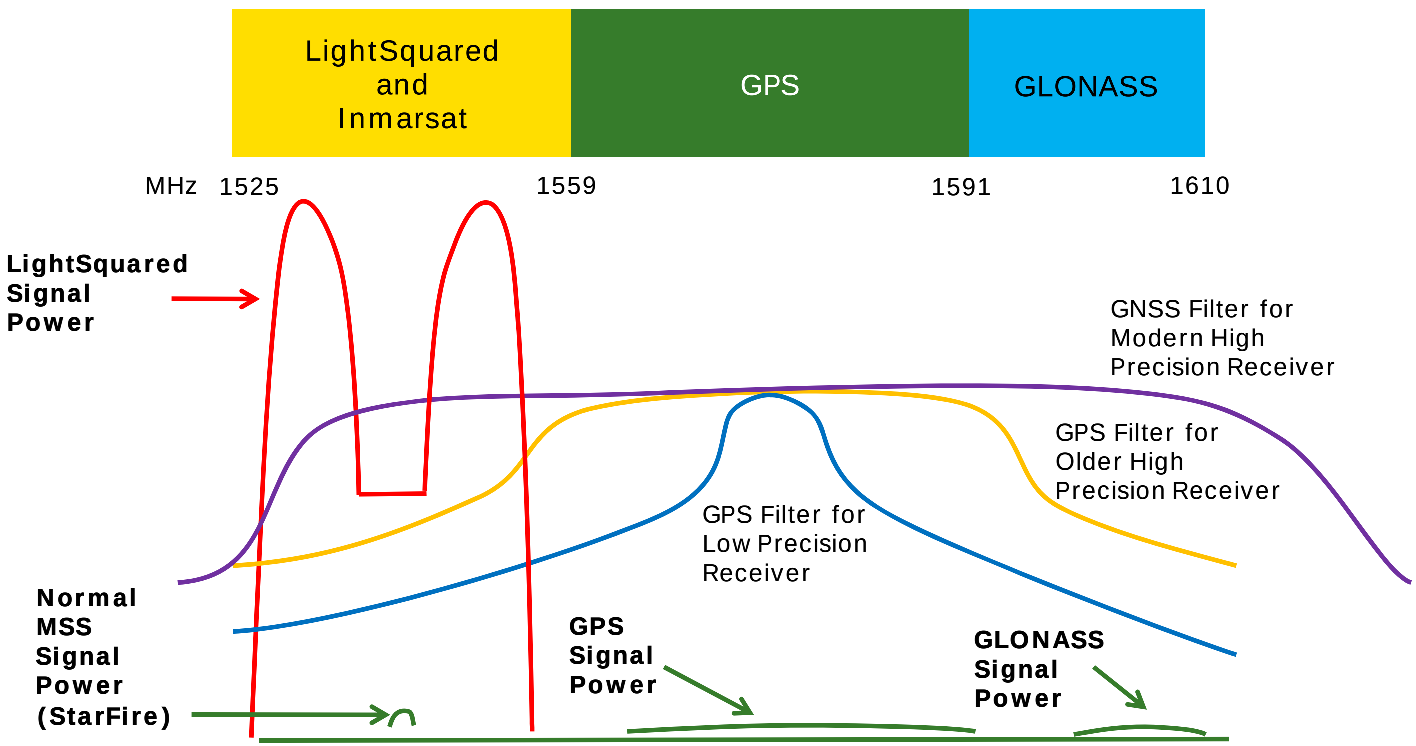
High Precision and Augmented Receivers

All modern high precision receivers are wideband and use filters that cover GPS + GLONASS bands, and if Augmented, MSS also

All Deere receivers are High Precision and Augmented

- So are many from Trimble, NovAtel, Hemisphere, Leica, etc.

Other High Precision receivers are not Augmented



Communication vs. Navigation Systems

GPS is a navigation system, not a communication system

- LightSquared wants GPS receivers to use narrow bandwidths and accept high levels of signal degradation (6 dB)
- If GPS were a communications system:
  - 1 dB of degradation might be acceptable, though undesirable
  - 6 dB would be unacceptable
  - Filtering would be to the minimum information bandwidth (e.g., 2 MHz for L1 C/A)

However, GPS is not a communication system and needs wider bandwidths and tolerates less signal degradation

See Stansell Consulting Comments:

http://fjallfoss.fcc.gov/ecfs/document/view?id=7021700936

High Precision GPS Receivers

What is required for a high precision receiver?

- Wideband signals
- Multiple frequencies
- Carrier phase tracking

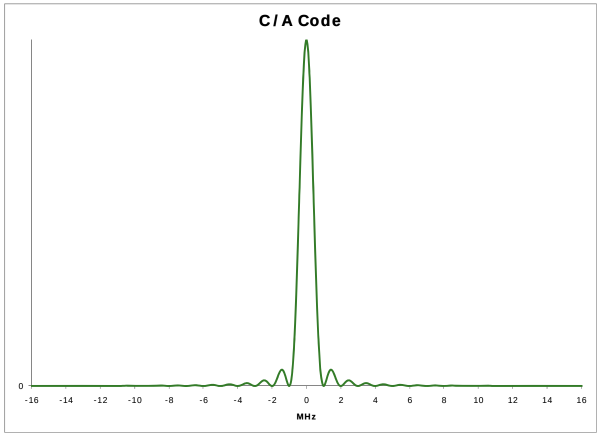
Why Wideband?

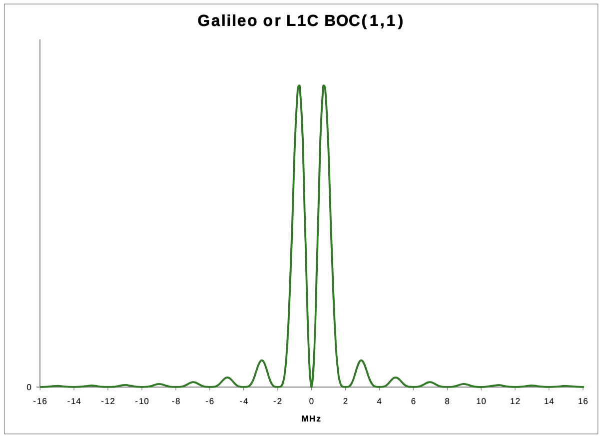
There are three reasons:

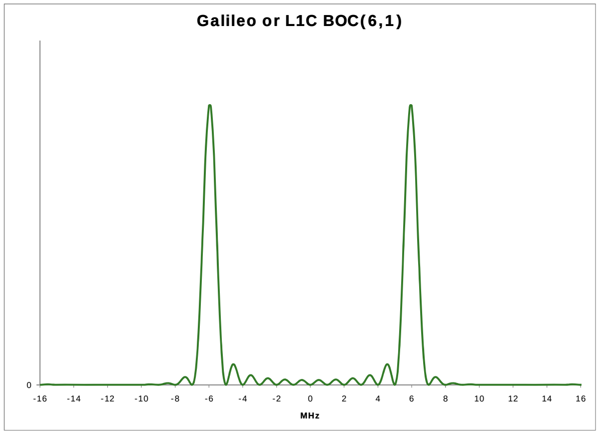
- Many GPS (and GNSS) signals are wideband
- Wideband signals are required to make accurate measurements
- Wideband signals enable multipath mitigation

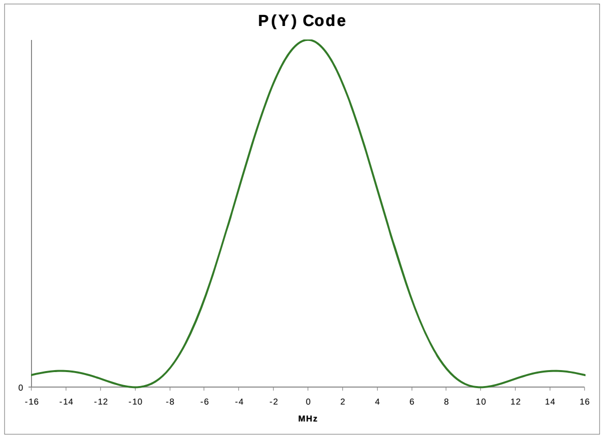
Wideband Signals

- 2+ MHz is sufficient for current consumer receivers using C/A Code
- Current High Precision receivers need 20+ MHz for GPS P(Y) code (Deere uses 32 MHz)
- GPS is being modernized with new wideband signals and satellites (L1C, L2C, L5)
- Other GNSS signals are also wideband









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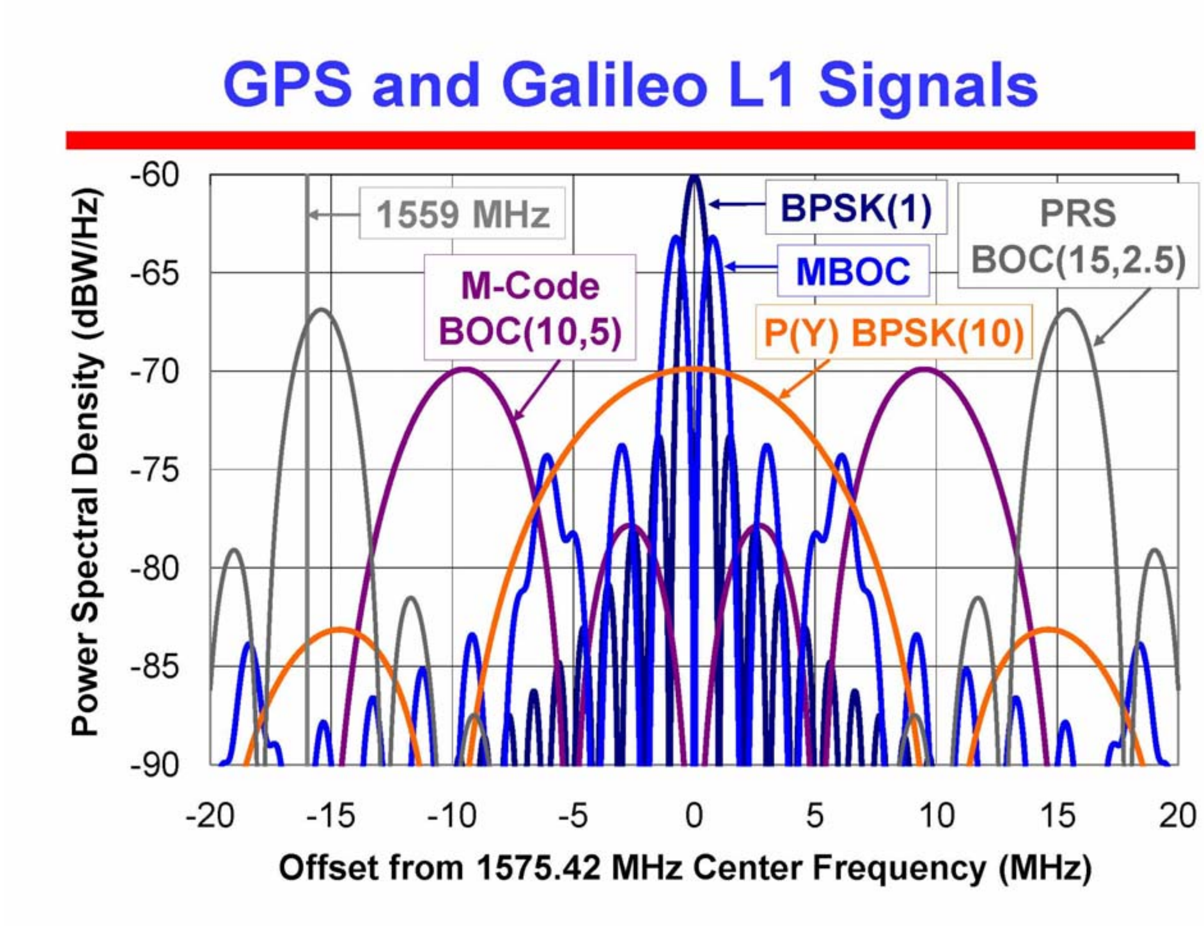
The Future

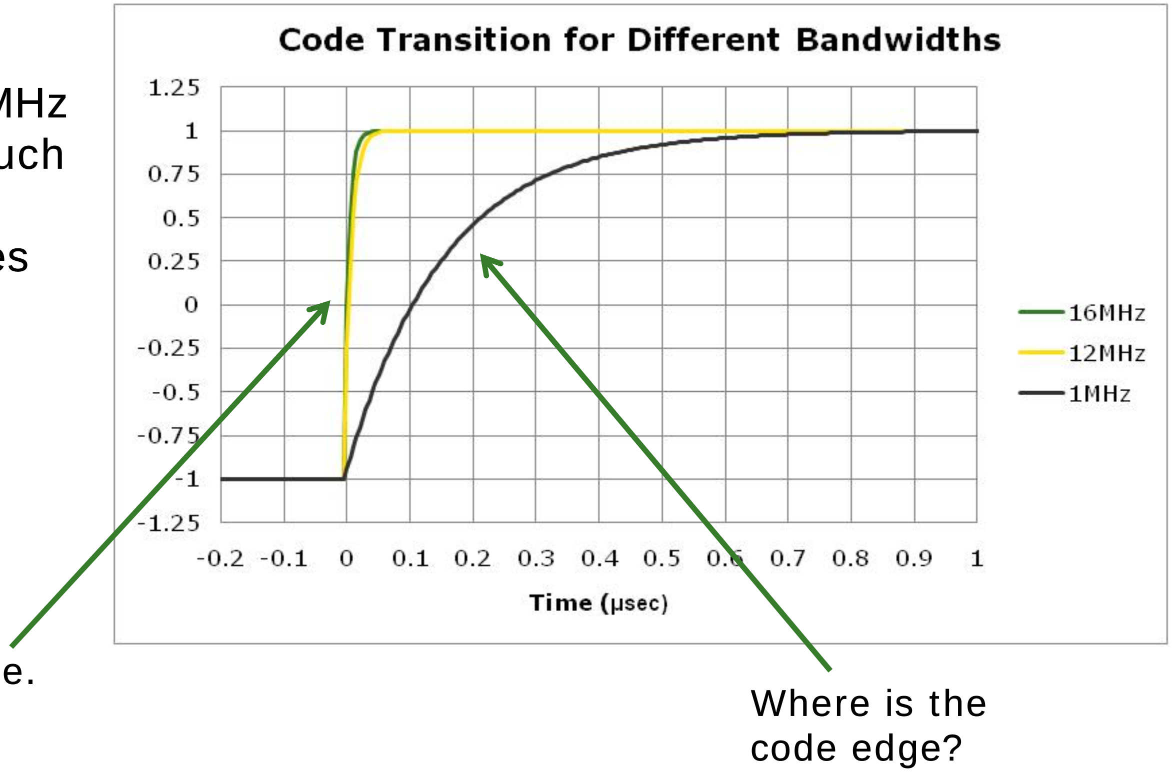
In the future, many more GNSS receivers will be wideband



Accurate GPS Measurements

GPS is based on range measurements to the satellites (pseudoranges)

- Measure time of arrival (TOA) of spreading code transitions
- Accuracy of TOA measurement depends on sharp code edges
- Sharpness of code edges depends on bandwidth
  - Most of energy is in 2 MHz for L1 C/A code, but much of the information on sharpness is in the lobes
- Navigation accuracy depends on wide bandwidth



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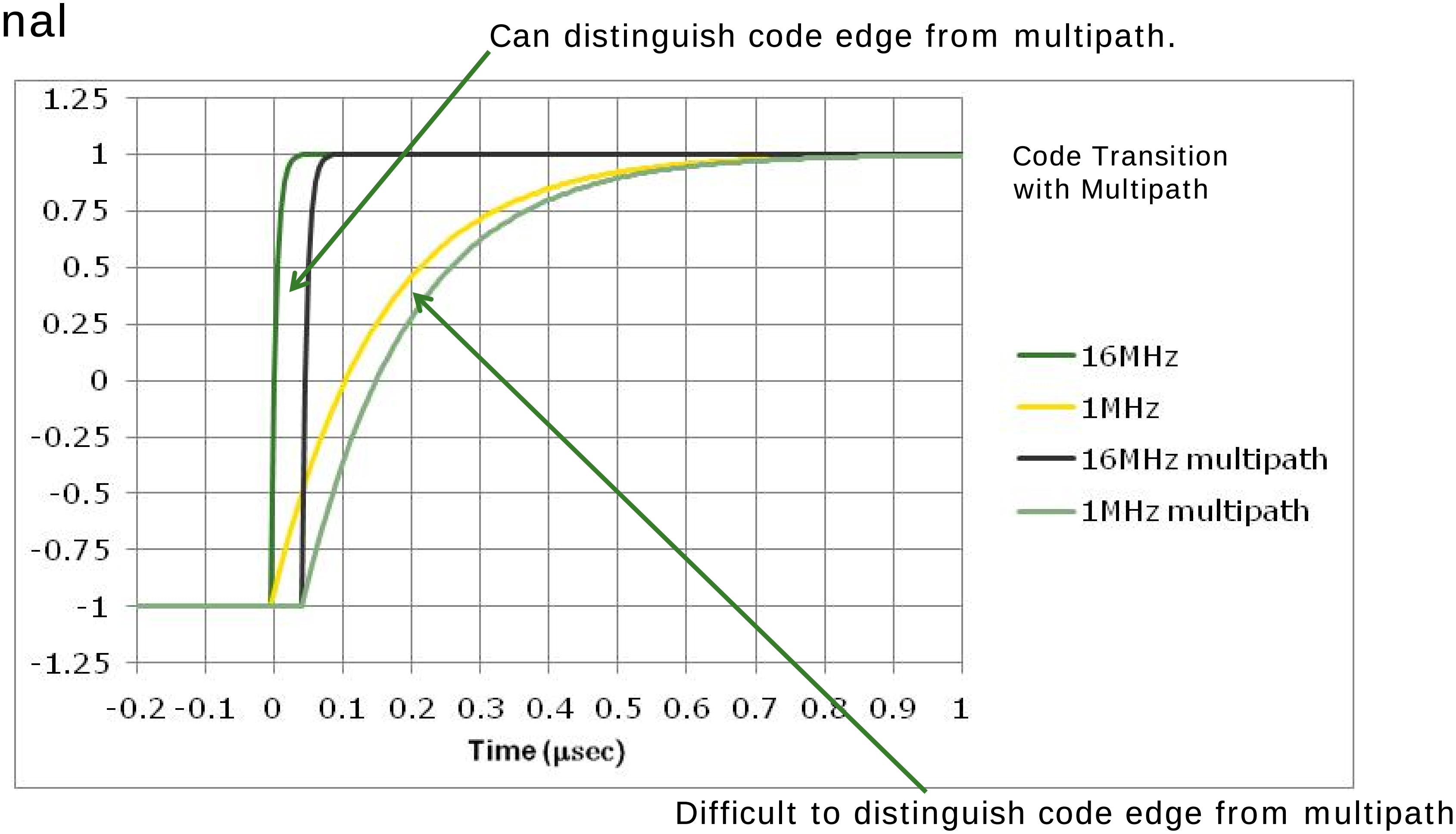
Multipath Mitigation

Difficult to find code edge in multipath-distorted signal

Need sharp code edges to see direct signal before multipath signal



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Why Multiple Frequencies?

Removal of Ionospheric Errors required for accuracy

- GPS code and carrier phase are altered as the signals pass through the ionosphere
- The alterations vary with the frequency of the signal in a known manner
- With multiple frequencies, the signal distortions can be measured and removed

Why Carrier Phase Tracking?

High accuracy depends on carrier phase tracking of GPS signals

•Code tracking is necessary, but the highest accuracy comes from carrier phase tracking

- Carrier measurements are accurate to cm, while code measurements are accurate to meters

•Carrier phase tracking must be done with a Costas loop (squaring loop), not a phase lock loop, since the GPS signal is a suppressed carrier signal

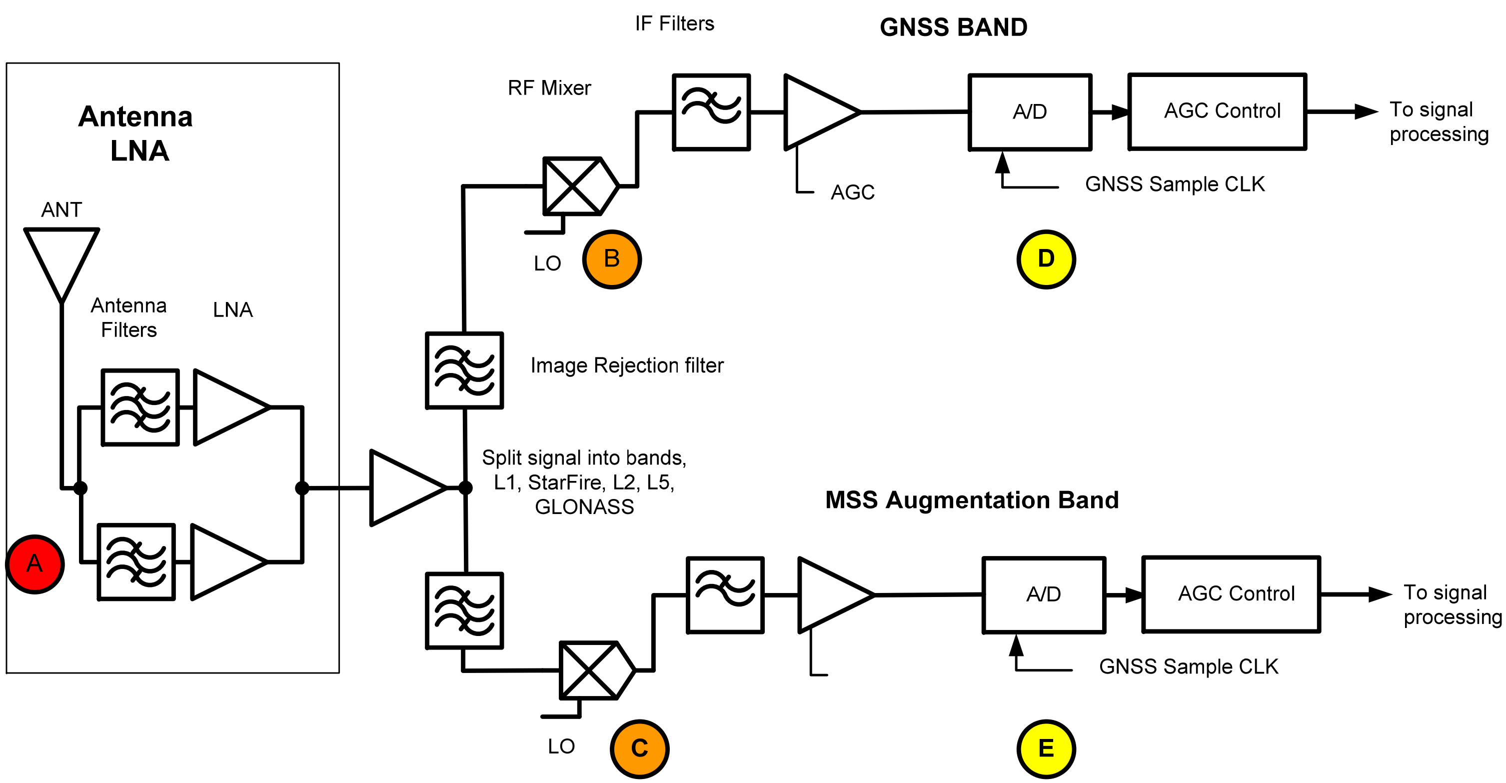
•Costas loops require higher thresholds than phase lock loops and are therefore more sensitive to degradation in C/N_0

•L2 carrier phase tracking requires robust L1 C/A carrier phase tracking

- Access to L2 is only possible with aiding from L1
- P(Y) code on L2 is 6 dB lower power than C/A code on L1
- Squaring process degrades L2 P(Y) C/N_0 relative to L1 C/A

GNSS Receiver Architecture

TYPICAL GNSS RECEIVER WITH MSS-BAND AUGMENTATION



Receiver Effects & Range Modeling

GPS L1 Signals Processing	dBm	Effect	Range 1/D² Model (miles)*	Affected Area (sq miles)	Range WILOS Model (miles)	Affected Area (sq miles)
Saturation of Antenna LNA	-40	Inoperative	1.2	4.5	0.7	1.5
Saturation of Mixer	-65	Heavily degraded sensitivity, not GPS usable	22	1520	3.6	43
Degraded A/D and Baseband	-80	Reduced accuracy, weak satellites lost	22	1520	14	614

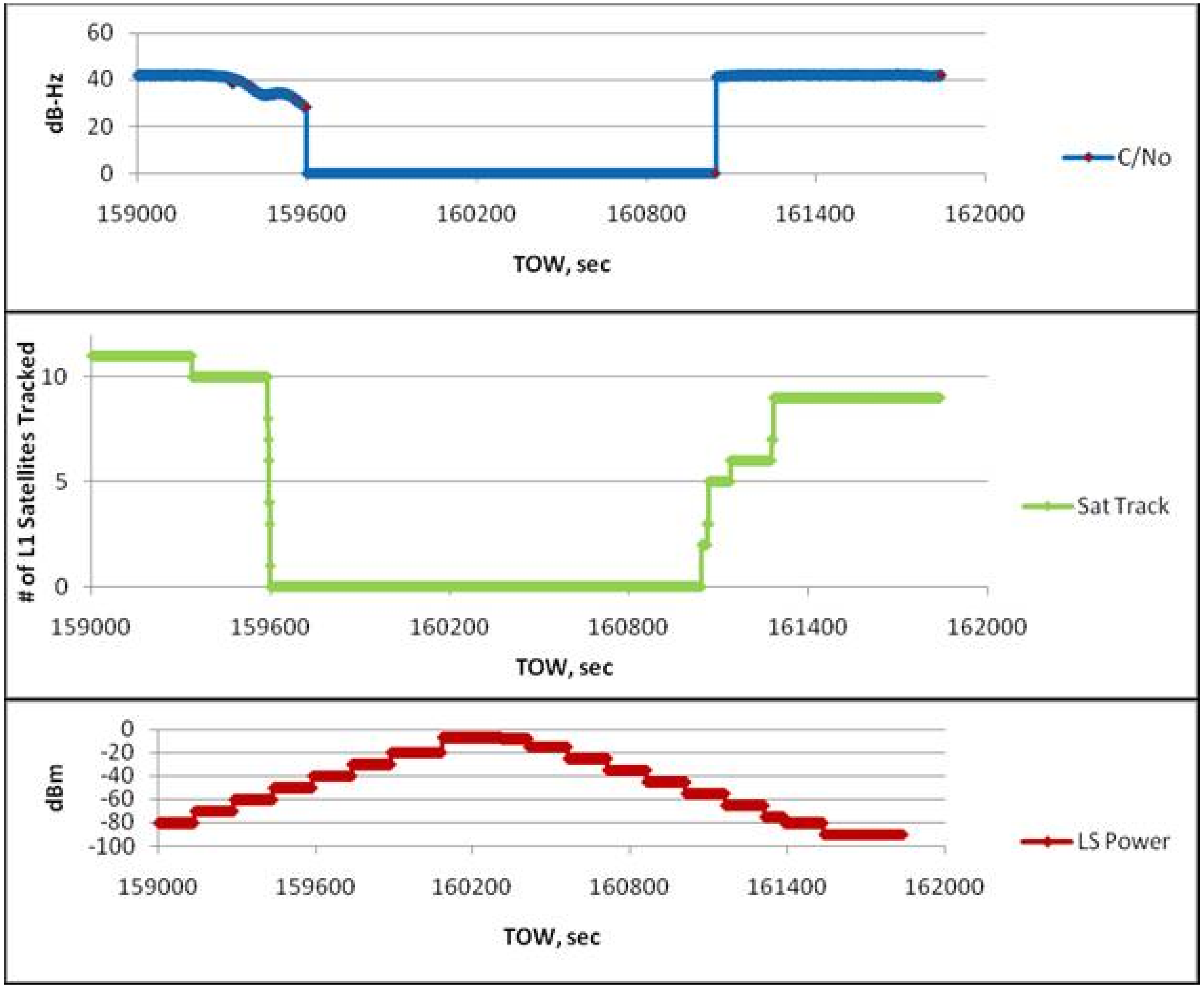
StarFire Signals Processing	dBm	Effect	Range 1/D² Model (miles)*	Affected Area (sq miles)	Range WILOS Model (miles)	Affected Area (sq miles)
Saturation of Antenna LNA	-40	Inoperative	1.2	4.5	0.7	1.5
Saturation of Mixer	-65	Strongly degraded tracking, very high BER	22	1520	3.6	43
LTE OOBE power equals StarFire power	-70	3 dB degraded tracking, minor to significant BER	22	1520	6	113
Degraded A/D and Baseband	-80	Degraded tracking, minor to significant BER (depending on channel)	22	1520	14	614

* Assumes 100m tower; horizon is at 22 miles.

Low 10 MHZ Creates Harmful Interference

Graphs are from a Deere receiver in the anechoic chamber at White Sands, New Mexico during Govt. testing

All satellites lost at -50 dBm (free space range of 3.5 km)



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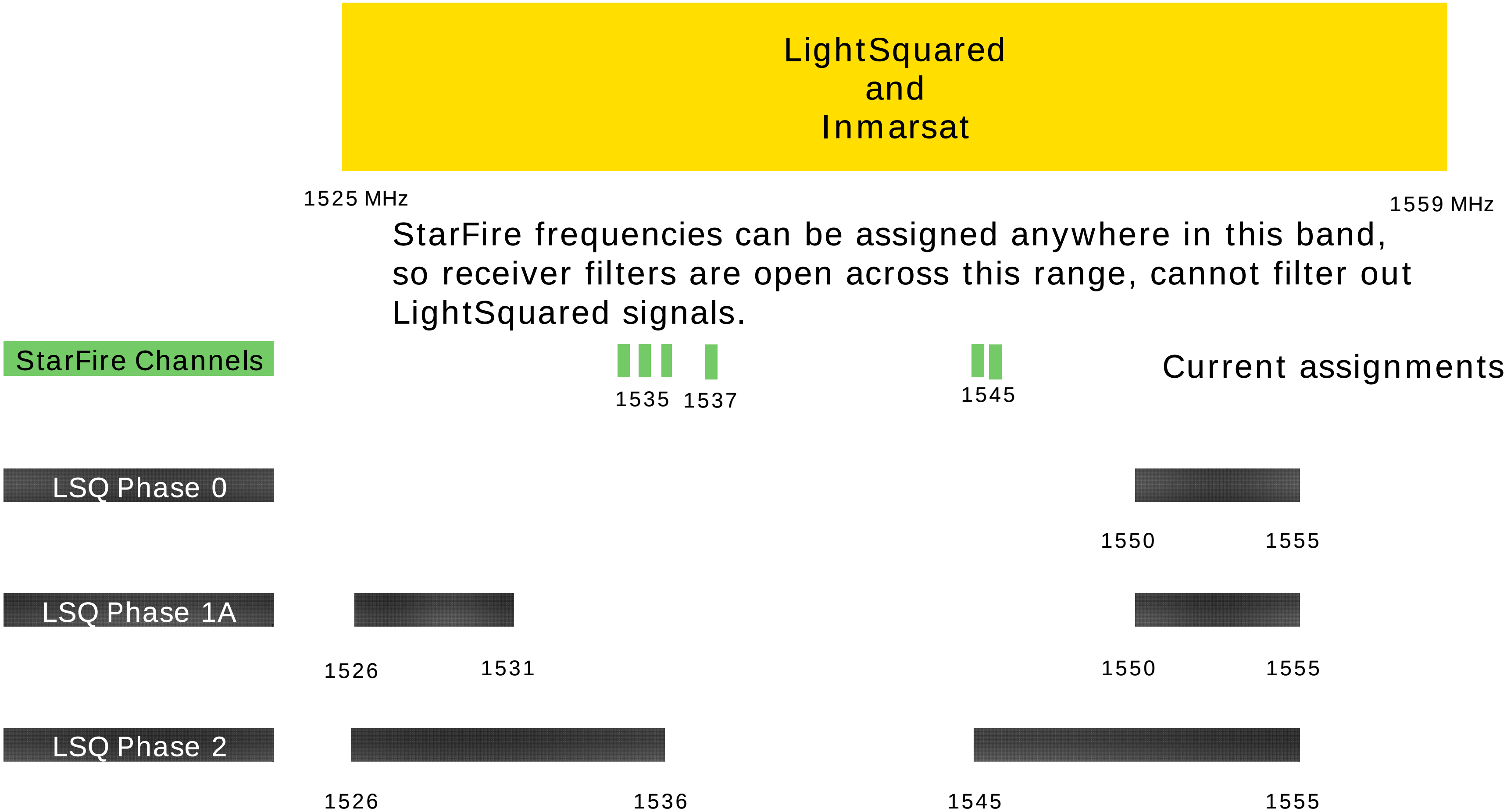
LightSquared Rollout and StarFire Frequencies



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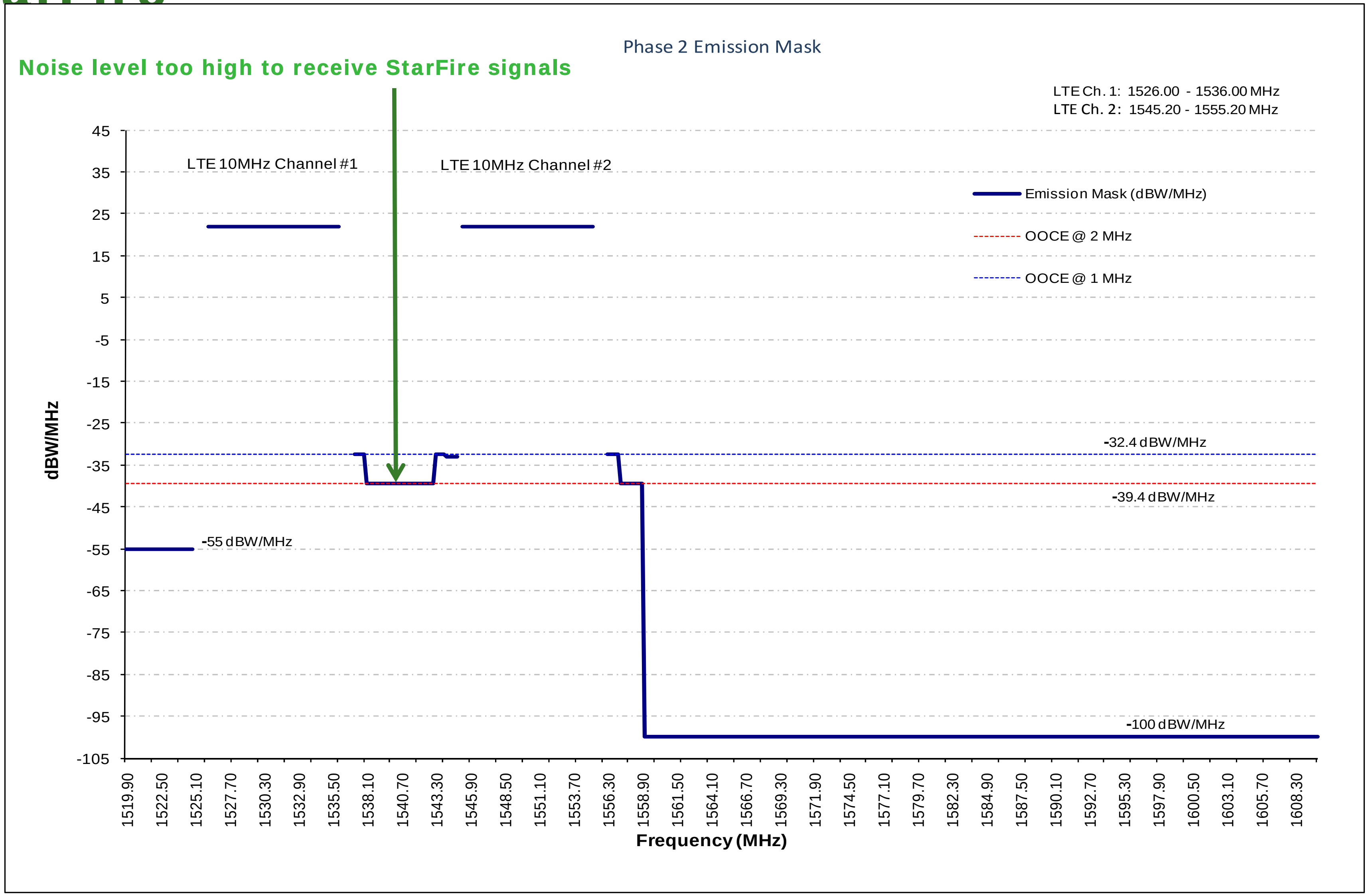
LightSquared Power Mask – No Place for StarFire



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What Are the Disagreements?

- Worst case test conditions
- Harmful interference
- Intermodulation effects
- Propagation range modeling
- Handsets
- Filters
- Replacing fielded receivers
- Adequacy of TWG testing
- Urban rollout
- Percentage of affected receivers
- GPS Community knew about ATC
- Frequency coordination
- GPS Signal Specification
- Rural broadband
- International obligations
- Deere engagement
- Mitigations

Worst Case Conditions

Interference testing must consider worst case conditions, not median, probabilistic, or best case conditions

- Use of such models leads to underestimation of the effects
- Satellite availability and signals
  - Cannot assume that current satellite signals will be the same in the future
  - Particularly with respect to the number of GPS satellites
- LTE propagation models
  - Cannot use propagation models that underestimate worst case power and range

Harmful Interference

LightSquared proposes 6 dB (75%) degradation in C/N_0

- Very serious degradation in GPS signal processing
- Loss of some satellites (and likely loss of service)
- Reduced measurement quality (decreased accuracy)
- GPS satellite acquisition sometimes impossible
- No engineering basis for this extreme level of degradation

GPS community believes 1 dB (20%) degradation in C/N_0 is the correct metric

- Well recognized basis in radionavigation satellite service receivers (now awaiting final approval within the ITU's Radiocommunication Sector)
- FCC has previously used 1 dB rise in noise floor in protecting the sensitivity of GPS receivers

Intermodulation

Degradation in C/N_0 caused by LightSquared signals has two causes

- Overload
  - De-sensitization caused by saturation of the receiver by out of band signals before they can be reduced sufficiently by filtering
- In-band Intermodulation (IM3)
  - The frequency bands chosen by LightSquared (10H + 10L) can create over 100 million intermodulation products within the GPS band above 1559 MHz
  - Power in these IM products caused 10L+10H to be more than twice as bad as either 10H or 10L alone in TWG testing
  - Even if the non-existent, very large, costly filters proposed by LightSquared were used, high precision GPS receivers would still suffer C/N_0 degradation caused by intermodulation interference more than a hundred meters from the transmitter

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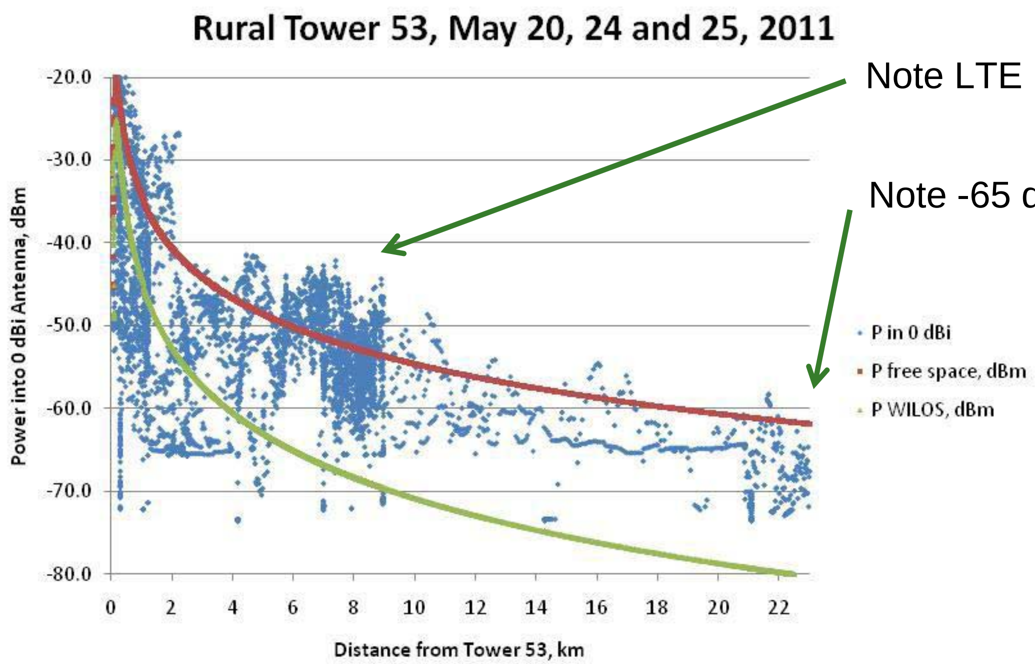
Propagation Range Modeling

- LTE propagation models
  - LightSquared network planning models optimize coverage for handsets, underestimate actual power in many locations
  - Las Vegas tests showed that signals even stronger than that that predicted by Free Space model can exist
  - Free Space is a good model for interference assessment



Note LTE power above free space model

Note -65 dBm power at 22 km

LTE power at 32 dBW, mixture of 5H and 5H+5L measurements

LightSquared Handsets

TWG testing shows that LightSquared handsets, when operated close to a GPS receiver, harmfully interfere with it.

- This is due to their uplink signal

Analysis shows that LightSquared handsets will also interfere with GPS due to their out-of–band-emissions*

- One handset at 1m causes 16 dB of GPS C/N_0 degradation
- 50 handsets at 10m causes 13 dB of GPS C/N_0 degradation
- 10 handsets at 10m causes 7 dB of GPS C/N_0 degradation
- 50 handsets at 50m causes 4 dB of GPS C/N_0 degradation

Handset OOBE may be more significant to GPS than base station interference

As no handsets yet exist, there is no way to confirm this analysis

Filters – High 10 MHz

LightSquared says filters and "innovation" can resolve the interference problem

Future filters do not do anything for the existing base of hundreds of millions of fielded receivers in the US

Any filters that could filter out High 10 MHZ while permitting wideband signals:

- Must roll off 40 - 50 dB in 2-3 MHz
- Would cause extremely serious distortion of GPS measurements
- Are far too large and expensive to be practical
- No prospect that innovation will change this

An unacceptable alternative to enable High 10 MHz:

- Operate GPS in dramatically narrowed bandwidth
- This would destroy medium-high precision capability

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Filters – Low 10 MHz Only

Future filters do not do anything for the existing base of hundreds of millions of fielded receivers in the US

Any filters that could filter out Low 10 MHZ while permitting wideband signals:

- Don't exist, would have to be developed
- Will likely impact sensitivity (insertion loss)
- May cause serious distortion of GPS measurements
- May be large and expensive

Remember that:

- More and more GPS receivers will be wideband in the future
- LightSquared offers only temporarily to refrain from High 10 MHz use
- Filter requirements for narrow band timing receivers are very different from most other GPS receivers

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Time to Replace Fielded Receivers

If it were feasible to design receivers that were compatible with LightSquared, it would take many (10 or more) years to replace fielded receivers

- Aviation, military, and high precision applications take longer than others
- For Deere:
  - Development, field testing, production setup, rollout of a new product to the field, and replacement of older receivers takes many years
  - Changing receivers can be costly and highly disruptive to customer operations (particularly if the new receivers don’t work as well as the older ones)

Adequacy of TWG Testing

TWG testing was extremely rushed

- No time to properly characterize handset interference (even if they had existed)

Cellular testing may not have been adequate

- Based on minimal standards (3GPP, 3GPP2)
- Did not look seriously at degradation, only pass/fail
- Does not account for modern cell phone applications (e.g., location based services)

Low 10 MHz concept was introduced at the end of TWG testing, could not be fully tested (but testing done showed interference)

Live Sky testing may not have been representative enough of real world conditions

- Higher downtilt increases power at close ranges
- Higher base station density needed for adequate testing
- Didn't include pico cells

Urban Rollout

LightSquared rollout will be urban initially

- LightSquared says that precision agricultural receivers will not be affected for several years
- Rollout plan is not public, but agriculture occurs near urban areas – protection for agriculture is not clear
- However, construction, survey, aviation, and other high precision receivers used in urban areas will be affected from the start

Percentage of Receivers Affected by Low 10 MHz

LightSquared maintains that 99% of GPS receivers will not be harmed by Low 10 MHz

LightSquared's numbers and conclusions (with Deere opinions):

Cell phones	(300,000K)	All OK	(not correct)
Personal Navigation	(100,000K)	All OK	(not correct)
Aviation	(200K)	All OK	(not correct)
Timing	(500K)	Most OK	(?)
High Precision	(200K-1,000K)	Most Not OK	(agree)
Space	(0K)	Not OK	(agree)

The 99% assertion is not supportable

•It includes all cell phones based on minimal pass/fail criteria that do not account for degradation

•It uses an unacceptable metric of 6 dB C/N_0 degradation to claim that Personal Navigation receivers are not affected

LightSquared acknowledges that high precision receivers are harmed by Low 10 MHz

•Does not acknowledge the critical role of high precision receivers in agriculture, construction, surveying, science, aviation, military, etc.

GPS Community and Use of L-Band by Ubiquitous, High Power, Standalone Terrestrial Networks

It is not true that the GPS Community should have predicted this

- Deere had no information that MSS L-band was to be converted to a ubiquitous, high powered, standalone terrestrial network until December 2010
- Had this been known:
  - DOD would not have designed M-code as it did
  - Other GNSS signals would not have been designed as they are
  - The many companies that design GPS receivers and chips would not all have designed receivers as they did
  - Filter manufacturers would likely have tried to develop new filters

  LightSquared says filters that could deal with their signals don't exist because GPS manufacturers chose not to develop them
- No perceived need for them – it was a satellite neighborhood

  It is not credible that everyone knew of this issue and ignored it

Frequency Coordination

LightSquared is proposing a “frequency coordination” plan

- There are no details on which to judge this
- If it means a database of LightSquared tower locations, this is not useful
- If it means that a GPS user affected by LightSquared signals can take immediate action to end the interference, it would be useful, but this seems very unlikely

GPS Signal Specifications

LightSquared asserts that the GPS signal specification* dictates how GPS receivers should be designed, and that GPS manufacturers willfully ignore its requirements

This is not true

- The spec is a specification for the L1 civil signal in space, not a specification about receiver design
- It specifically says that it does not apply to the design of receivers
- It uses receiver information only because some is needed to specify navigation GPS performance
- The idea of guard bands was never intended at all

*GLOBAL POSITIONING SYSTEM STANDARD POSITIONING SERVICE PERFORMANCE STANDARD, Sept 2008

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Rural Broadband

Rural broadband is a very worthwhile goal which Deere fully supports

- Rural broadband would be very useful to Deere
- But not if it degrades or denies GPS, which is vital for agriculture and other uses in rural America

Broadband data rates require terrestrial base stations

- Broadband can't be offered using the LightSquared satellites
- Using terrestrial base stations in rural areas means GPS interference in those areas

International Obligations

The US has international obligations to protect the signals of other GNSS. In the 2004 agreement with the European Union concerning Galileo, the US agreed to:

- ensure RF compatibility in spectrum use
- make all practical efforts to protect GNSS signals from interference
- promote harmonized use of spectrum
- cooperate with respect to identifying sources of interference and taking appropriate follow-on actions

LightSquared signals in MSS L-band are not compatible with these commitments

Deere Engagement

LightSquared has publicly complained that Deere is uncooperative

Deere has cooperated and engaged with LightSquared, both inside the TWG and outside it

- Deere headed the TWG High Precision Sub-Team
- Deere has continued to work with LightSquared to identify possible mitigations
- Several Deere-LightSquared meetings have occurred
- Confidential receiver information was provided under a NDA to help LightSquared understand receiver requirements

Deere refusal to accept wholly ineffective mitigations is not being uncooperative

- To date, no effective mitigations have been identified

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Mitigations

LightSquared's proposed mitigations are:

- New filters
- Delay (but not abandon) use of High 10 MHz
- Underestimate the number of affected receivers
- Ignore Low 10 MHz effects on GPS receivers
- Limit initial rollout to urban areas
- Frequency Coordination

As shown on the previous slides, these do not mitigate the harmful interference to GPS

- And they do not mitigate the interference to StarFire

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