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March 18, 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, IBFS File No. SAT-MOD-20101118-00239**

Dear Ms. Dortch:

On March 17th, 2011, Deere & Company ("Deere") met with Julius Knapp, Geraldine Matise, Mark Settle, Walter Johnston, Robert Weller, Brett Greenwalt and Brian Butler of the Commission's Office of Engineering and Technology, with Gene Fullano and Clifford Gonsalves of the Public Safety and Homeland Security Bureau, and with Robert Nelson and Sankar Persaud of the International Bureau to discuss the above-referenced application. Attending this meeting on behalf of Deere were Barry Schaffter, Senior Vice President, Intelligent Solutions Group and Chief Information Officer, Patricia Harris, Assistant General Counsel, Paul Galyean, Director, System Engineering and IME/Robotics, and Mark Rentz, Senior Systems Engineer, along with Catherine Wang and Tim Bransford of Bingham McCutchen LLP, outside counsel to Deere.

During this meeting Deere expressed its support for a cooperative and constructive process that through technical analysis and other means, including testing, enables the Commission and all interested parties to understand the challenging interference issues presented by LightSquared's plan for operating terrestrial cellular base stations in L-band mobile satellite service ("MSS") frequencies. We provided a presentation describing high-precision, augmented Global Positioning Systems ("GPS"), including Deere's StarFire service, that use GPS and MSS signals to guide agricultural and construction equipment with accuracy as precise as two (2) inches. We explained the major role high-precision and augmented GPS technology plays in the agricultural and construction industries, and emphasized that all modern growing activities rely on this technology, which has become so ubiquitous that it is now a standard feature on Deere agricultural products.

During this meeting we discussed the three potential types of interference that LightSquared's plan may create for GPS and augmented GPS systems. Specifically, we discussed out-of-band emissions ("OOBE"), GPS receiver overload, and co-channel interference to licensed augmentation MSS signals. We also reviewed a number of issues raised in Deere's Petition for Reconsideration, including the need for an improved and strengthened process for technical evaluation of LightSquared interference into GPS and augmented GPS receivers, adequate time to analyze and test complex and varied interference issues, development of a comprehensive test plan and open and transparent test procedures, and the need for the Commission to articulate the standards it will use to evaluate work product and data generated through the technical working group.

The attached presentation was circulated 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

CC: Julius Knapp
Geraldine Matisse
Mark Settle
Walter Johnston
Robert Weller
Brett Greenwalt
Brian Butler
Gene Fullano
Clifford Gonsalves
Robert Nelson
Sankar Persaud

# LightSquared Interference to GPS and StarFire

17 March 2011

JOHN DEERE

# Agenda

- Executive Summary
- John Deere – Who We Are
- What we do with GPS and Satellite Navigation
- Major Issues
- High Precision Receivers
- Analysis
- Testing
- Additional Concerns
- Plans

# Executive Summary

Deere GPS receivers will be very adversely affected in and near areas served by LightSquared

- Degradation starts at 11 - 85 miles, severe at 4 - 21 miles

StarFire differential GPS will be very adversely affected in and near areas served by LightSquared

- Degradation starts at 6 - 85 miles, severe at 4-21 miles

Deere customers in agriculture, construction, and other applications will lose high accuracy navigation in and near areas served by LightSquared

There are major economic consequences (not just for Deere)

We do not know any feasible mitigations at this time



JOHN DEERE

# Deere & Company: Quick Facts

- Founded in 1837
- Operations in 35 countries
- Headquartered in Moline, IL
- FY2010 Annual Net Sales and Revenues: $26.0 billion
- Number of Employees: more than 50,000 worldwide

# Committed to Those Linked to the Land

# Agriculture

A world leader in providing advanced products and services for agriculture



JOHN DEERE

# Construction

A leading equipment producer for a wide range of construction projects





JOHN DEERE

# Global Navigation Satellite Systems (GNSS)

Deere has been using satellite navigation on its platforms for 15 years – pioneer in precision agriculture.

Deere designs and manufactures its own GPS receivers

Many Deere applications require accuracies of a few inches

GPS alone can’t provide the necessary accuracy – differential GPS augmentation is needed:

- StarFire – global network – 4-10 inch accuracy
- RTK (Real Time Kinematic) – dealer and customer networks - 1-2 inch accuracy

# GPS Receivers

We are delivering our 4th generation GPS receiver: SF-3000


Deere receivers are specifically designed for our customers:

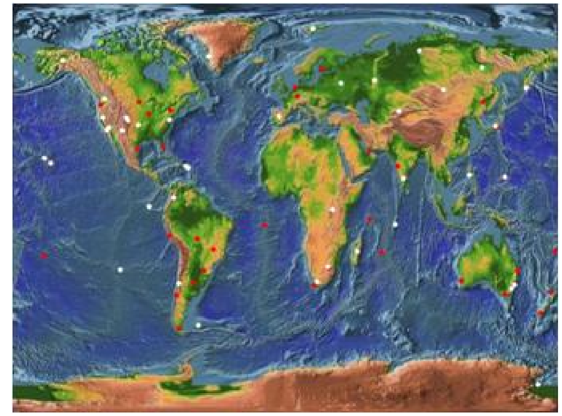
- Very high accuracy (precision measurement quality)
- StarFire and RTK are integral capabilities
- Extremely rugged/reliable (required for Ag and Construction)
- Uses GPS and GLONASS (Russian GNSS), will use Galileo (EU GNSS) and COMPASS (China) when they are available

# Deere StarFire$^{TM}$ Network

Distributes differential GPS corrections via six Inmarsat L-band satellites to Deere customers worldwide

- Owned and operated by Deere
- Corrections derived from real time data collected at over 50 worldwide GPS reference stations
- Computations at two Deere Processing Centers are sent to Uplink sites for the satellites
- Deere GPS receivers use the corrections to achieve high accuracy real time navigation

All six satellite downlinks are in the MSS band (1525-1559 MHz)

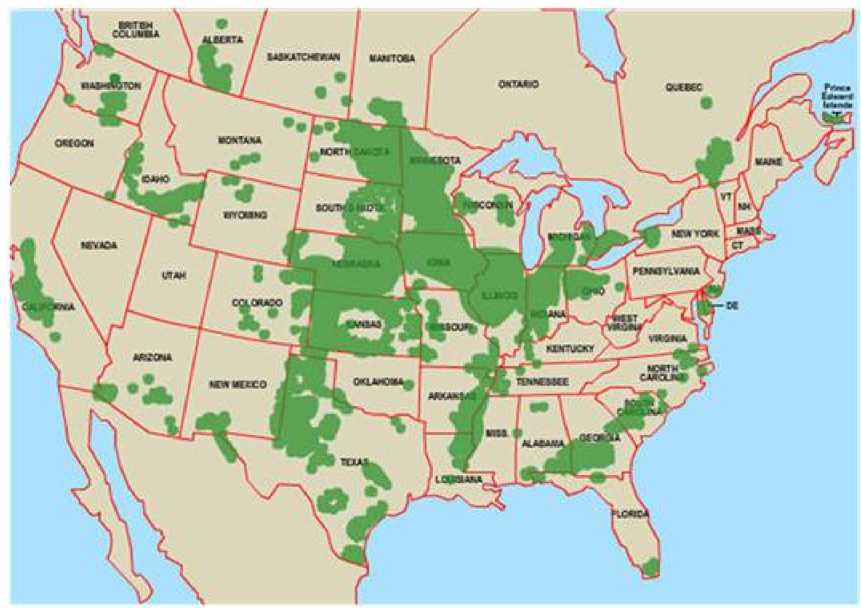


# RTK

RTK is a form of differential GPS

A stationary GPS receiver sends corrections to local mobile GPS receivers

- Accuracies of two inches over ranges of 15 miles are normal
- Deere dealers operate many RTK networks in the US




JOHN DEERE

# Major Issues

There are three issues:

- LightSquared Out of Band Emissions
- GPS receiver overload
- LightSquared MSS co-channel interference with Deere StarFire network

# Out of Band Emissions – Issue 1

LightSquared base stations will operate in the MSS band (1525 MHz–1559 MHz) just below the GPS band (1559 MHz-1591 MHz)

<u>OOBE is not a problem</u> in the GPS band if LightSquared filters their signals as they have committed

- -100 dBW/MHz is below the thermal noise floor; no GPS impact

# GPS Receiver Overload – Issue 2

Very serious problem affecting all GPS receivers near a LightSquared base station, not just Deere receivers

- All GPS receivers assume MSS contains low powered signals
- All GPS receivers use filters that overlap in the MSS band
- GPS filters are overwhelmed by LightSquared base station power
- It is not feasible to use filters that could eliminate the high powered LightSquared signals
  - >45 dB attenuation required from GNSS band at 1559 MHz and LightSquared LTE at 1555 MHz
  - Cost, power, size, weight, degraded performance

Overload may also be a problem for GPS receivers near LightSquared handsets

# MSS Co-Channel Interference – Issue 3

StarFire (and Omnistar, other major augmentation provider) signals are broadcast from satellites in the MSS band to be used by LightSquared

- Many agriculture, machine control, survey, and high precision GPS receivers receive these augmentation signals

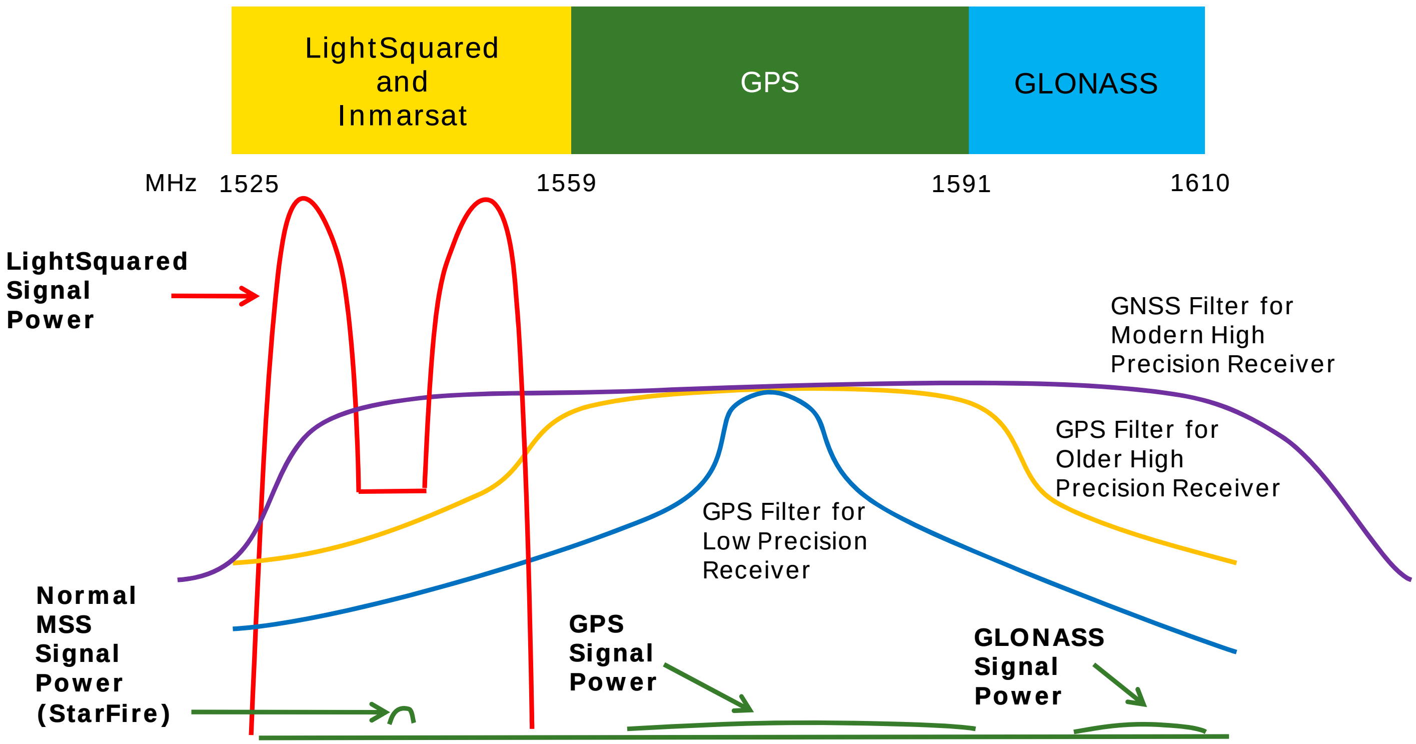
LightSquared signal is >90 dB stronger than StarFire signal near base stations

- Exceeds the capability of the filters to reject LightSquared power at considerable distances from the base stations
- Augmentation signal cannot be received when near a base station

# High Precision Receivers are More Affected

High precision receivers are more affected than are consumer grade receivers

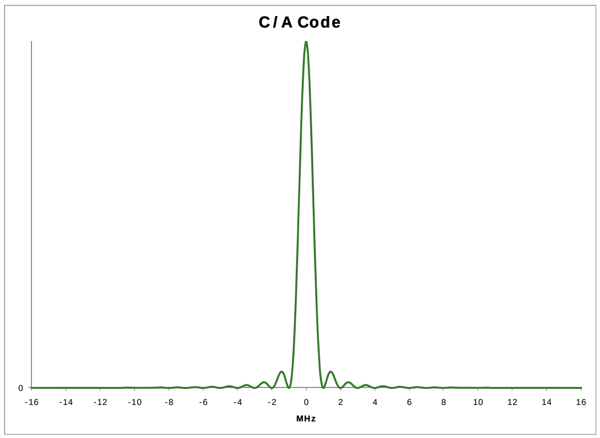
- Modern high precision receivers use filters that cover MSS, GPS, and GLONASS bands
- Wideband filters are required for higher rate, precision codes

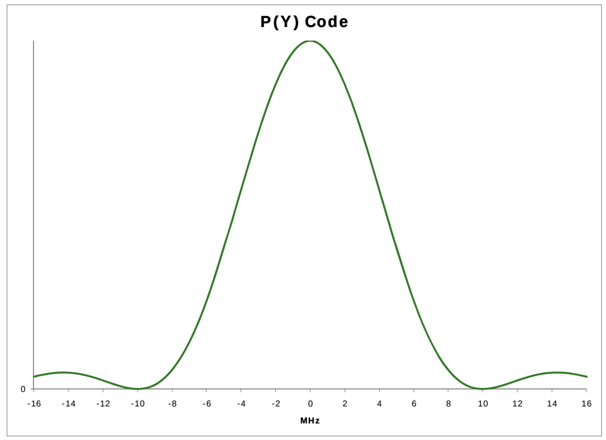


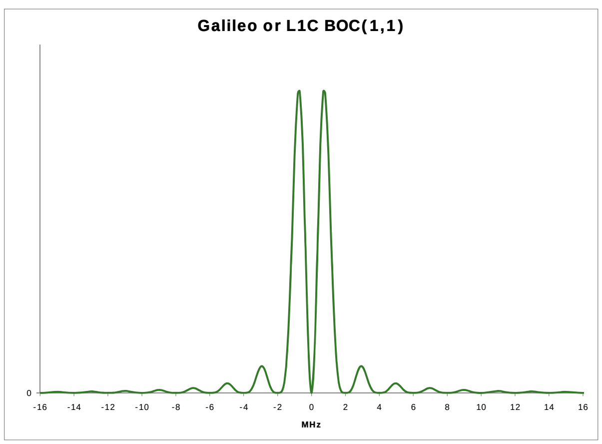
# GNSS Code Structures

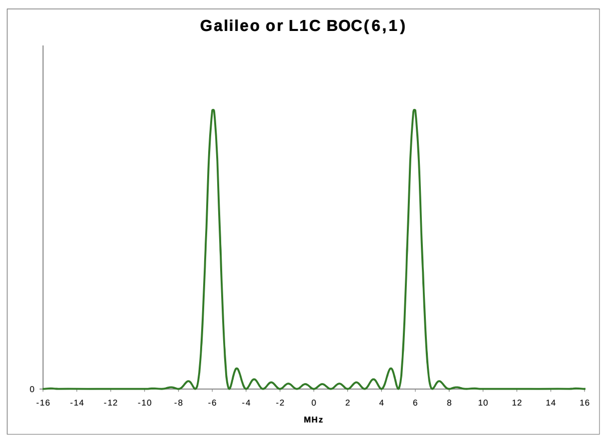
2+ MHz is sufficient
for consumer receivers
using C/A Code

High precision
GPS receivers
need 20+ MHz for
GPS P(Y) code



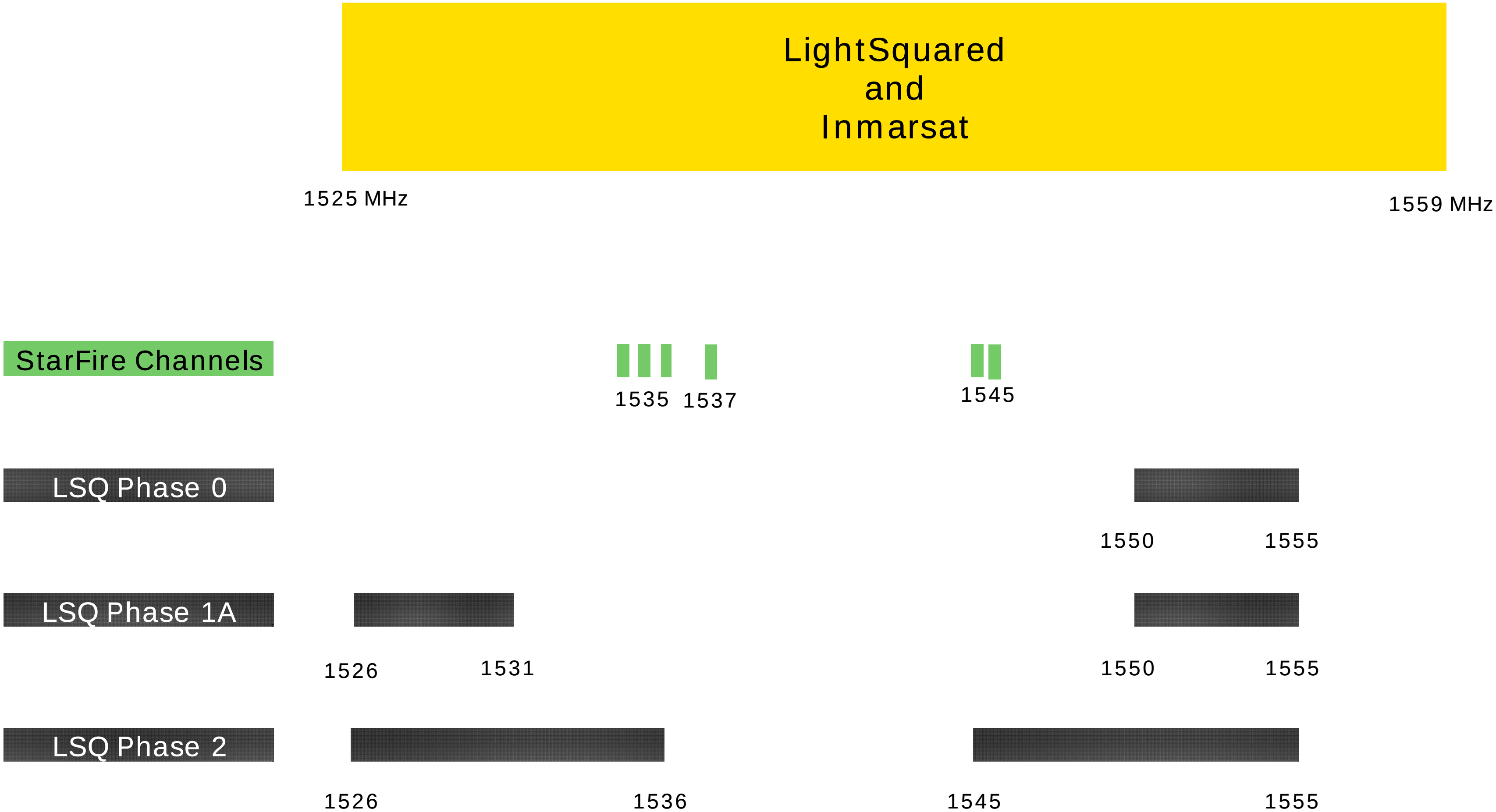

- Legacy GPS satellite signals are 24 MHz bandwidth
- GPS is being modernized with new signals and satellites
- Future GPS satellite signals will be 32 MHz bandwidth
- Other GNSS signals are also wideband
- <u>In the future, many more GNSS receivers will be wideband</u>

# Analysis

We have analyzed the response of some of our receivers to LightSquared signals

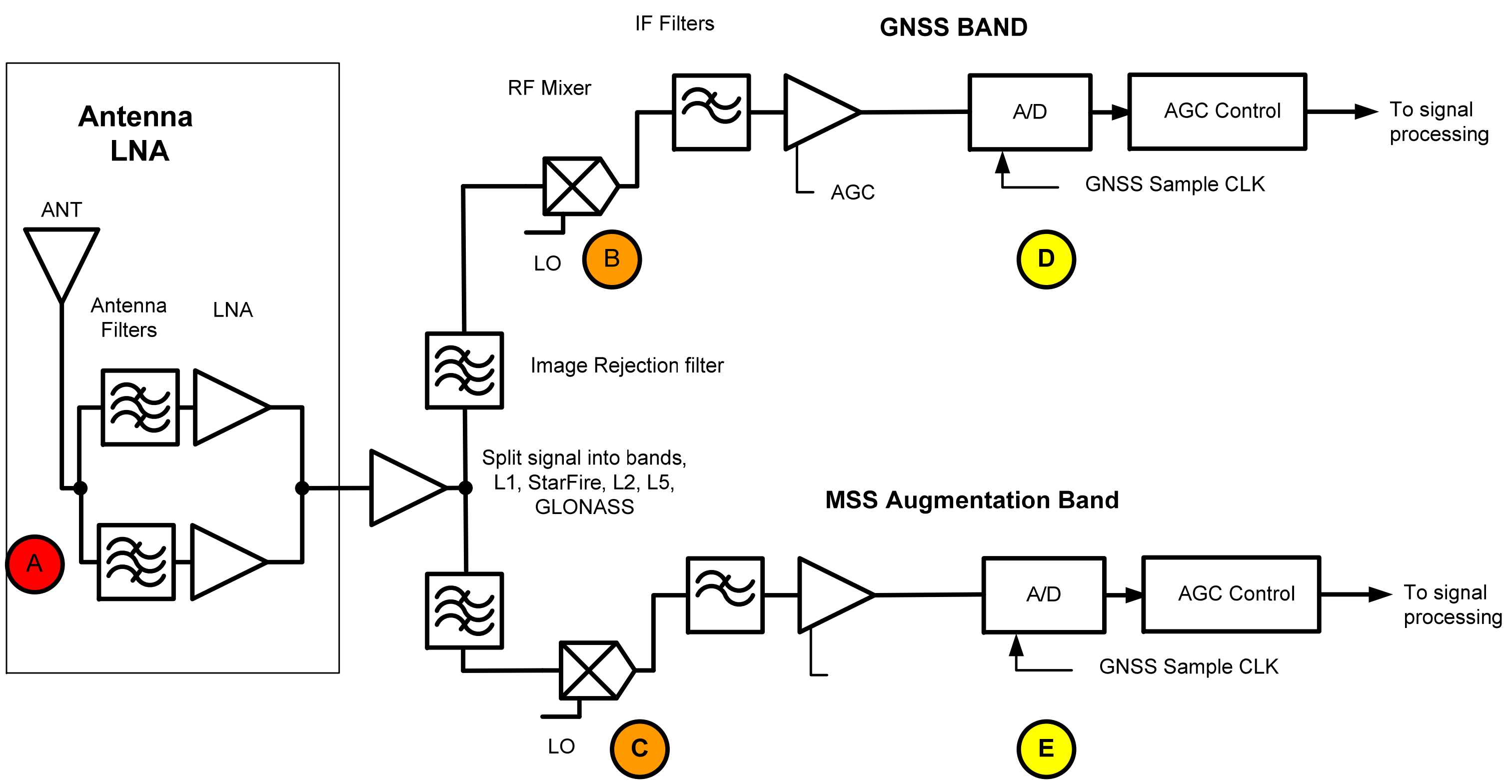
- GPS and StarFire reception considered
- LightSquared power mask and signal structure used
- Particularized to the architecture of our receivers
- Considers propagation models:
  - The $1/d^2$ model is for free space, does not account for horizon effects, and overestimates ranges in the Deere environment
  - The HATA Open model is for urban environments ($1/d^{4.5}$), drops off very rapidly at the horizon, and underestimates ranges in the Deere environment
  - These two estimates bound the range of the interference effects

# LightSquared Terrestrial Service



# GNSS Receiver Architecture

## TYPICAL GNSS RECEIVER WITH MSS-BAND AUGMENTATION



# LightSquared GPS Interference Effects

**Red Zone**: No satellites are tracked (A)

- LTE[1] causes significant compression in the antenna/LNA

**Orange Zone**: Some satellites lost, all measurements degraded (B)

- LTE weaker than antenna/LNA maximum, but stronger than 1 dB compression point of GPS mixer

**Yellow Zone**: Only weakest satellites lost, minor to significant measurement degradation (D)

- LTE signals do not cause mixer compression, but stronger than filtered thermal noise, affects A/D

**Green Zone**: No satellites lost, little loss of measurement accuracy

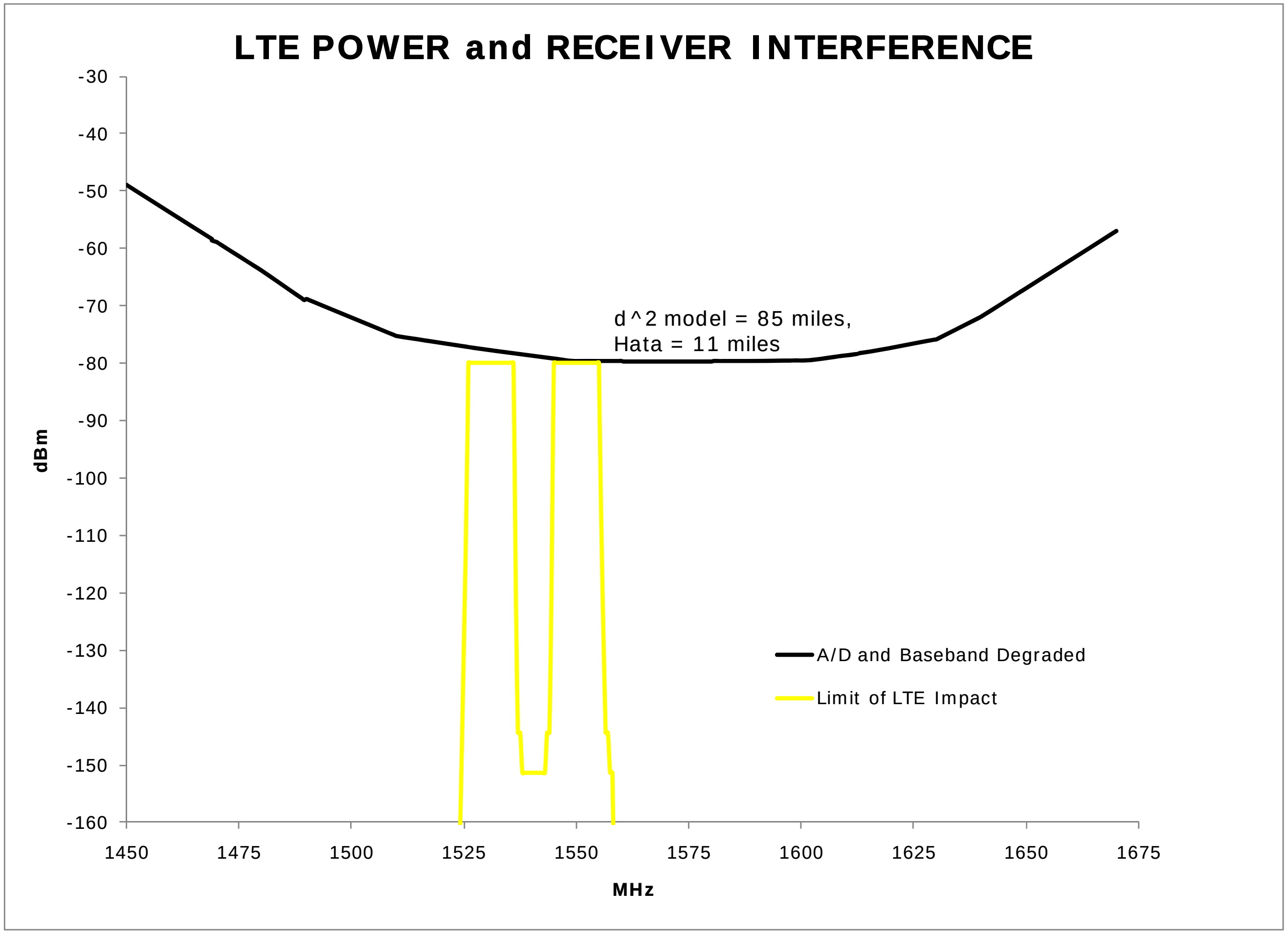
- LTE signals weaker than thermal noise floor

(1) Long Term Evolution, the standard 4G signal structure used by LightSquared



JOHN DEERE

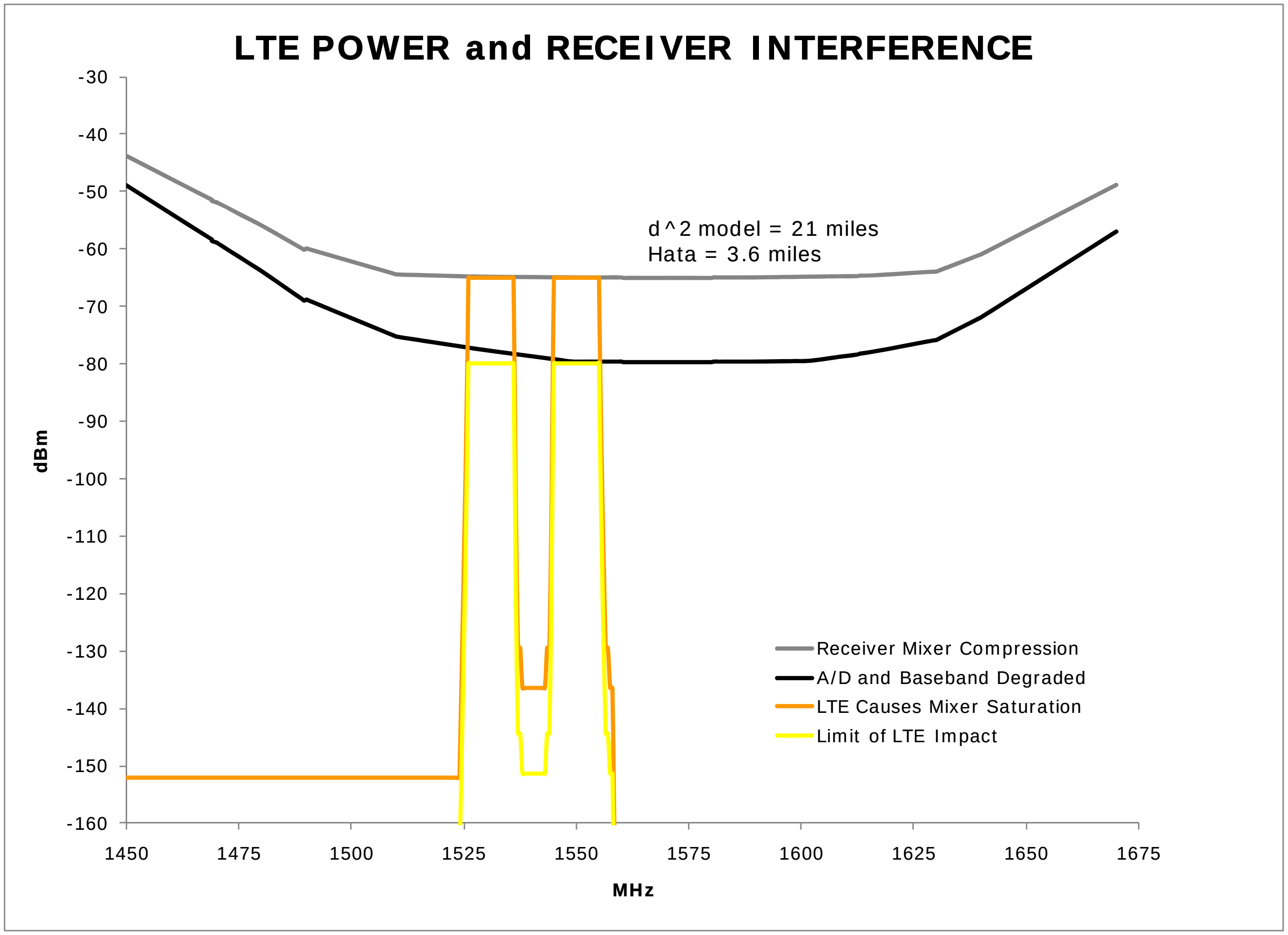
# LTE Interference in Wide Band GNSS Receivers



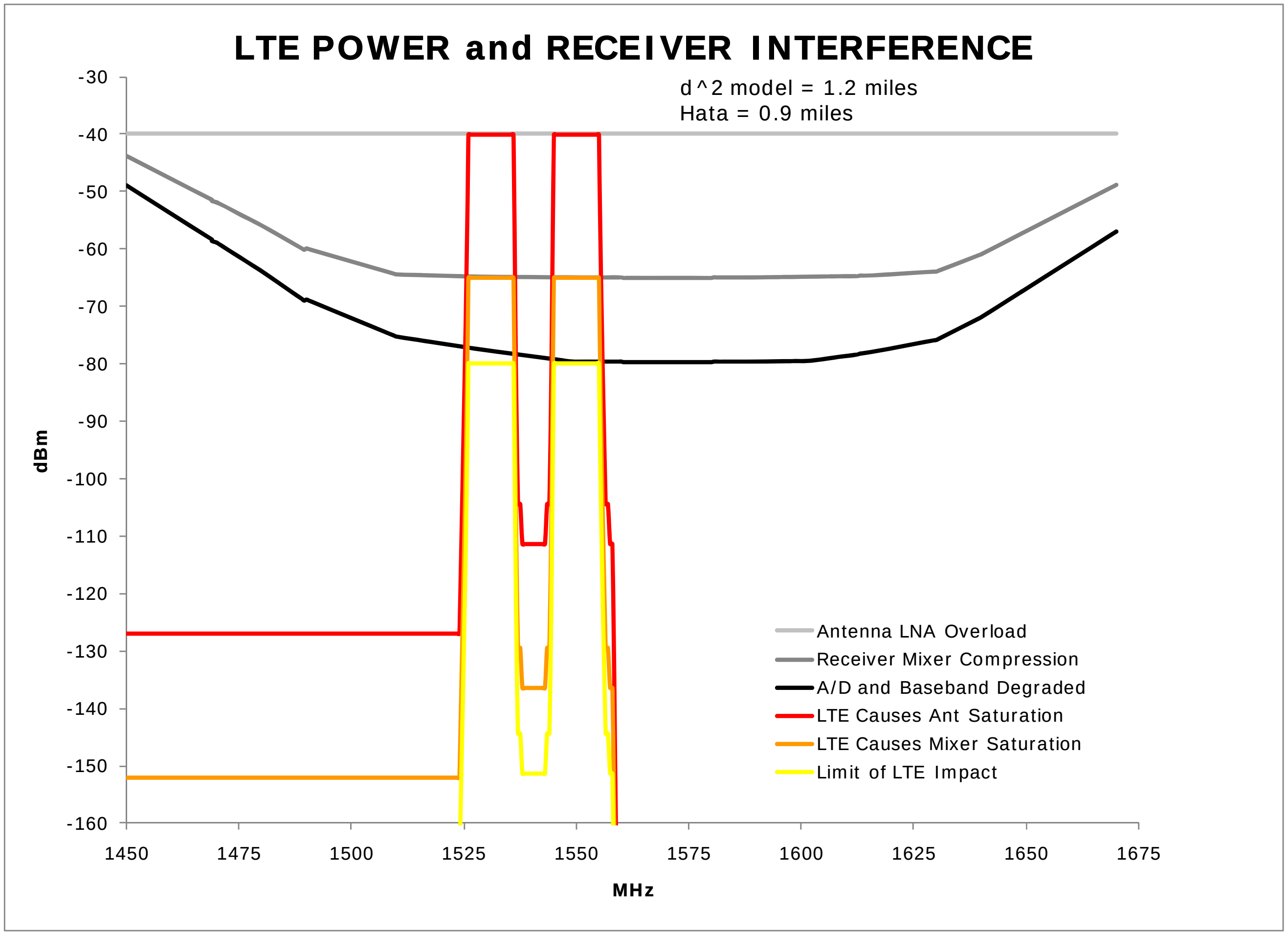



JOHN DEERE

# LTE Interference in Wide Band GNSS Receivers



# LTE Interference in Wide Band GNSS Receivers



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# LightSquared StarFire Interference Effects

**Red Zone**: No StarFire signal tracked (A)

- LTE[1] causes significant compression in the antenna/LNA

**Orange Zone**: Strongly degraded StarFire tracking, very high bit error rates (C)

- LTE weaker than antenna/LNA maximum, but stronger than 1 dB compression point of StarFire mixer

**Yellow Zone**: Degraded StarFire tracking, minor to significant bit error rates (E)

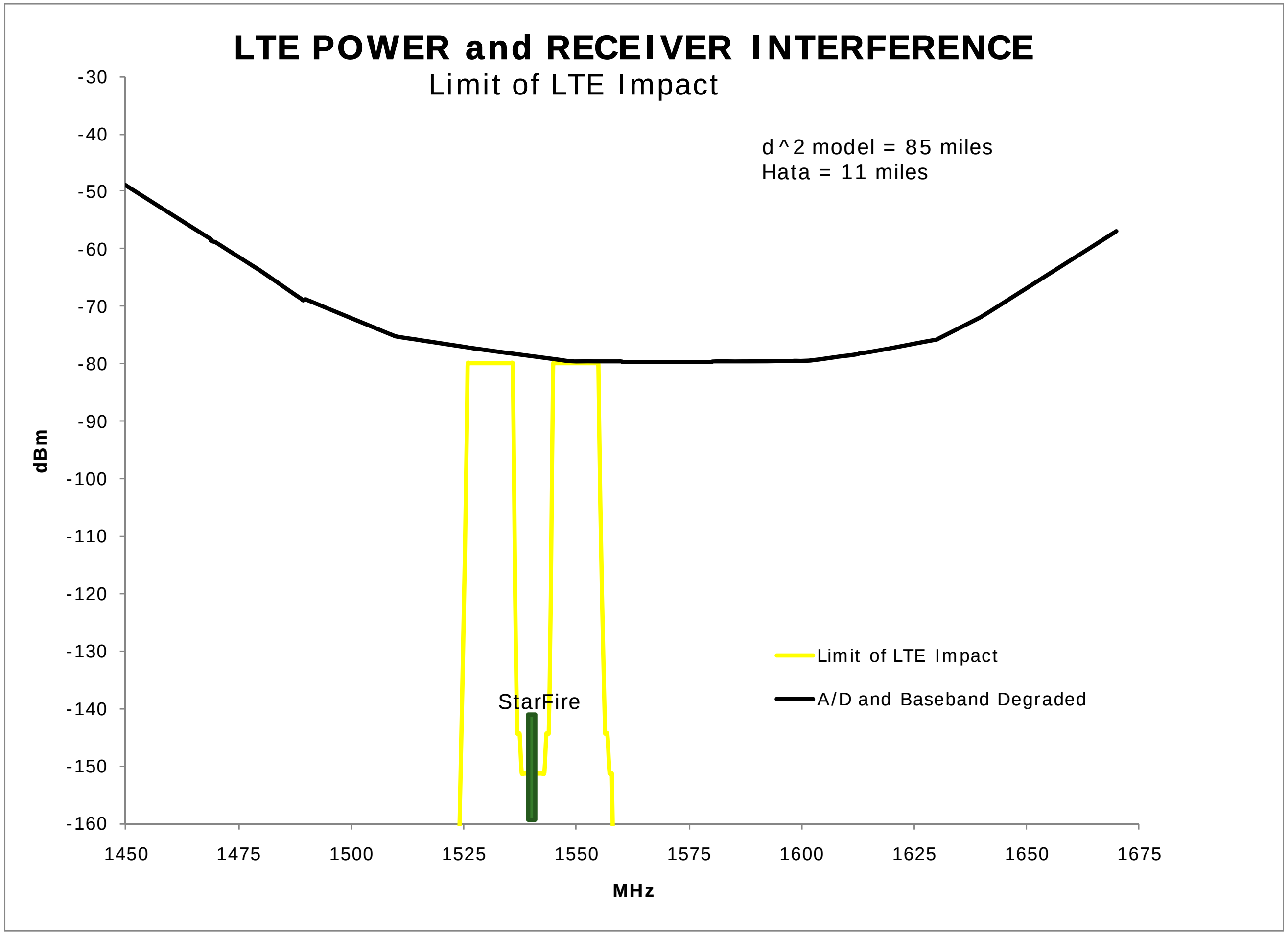
- LTE signals do not cause mixer compression, but stronger than filtered thermal noise, affects A/D

**Green Zone**: StarFire tracking OK

- LTE signals weaker than thermal noise floor

(1) Long Term Evolution, the standard 4G signal structure used by LightSquared

# LTE Interference in StarFire Receivers



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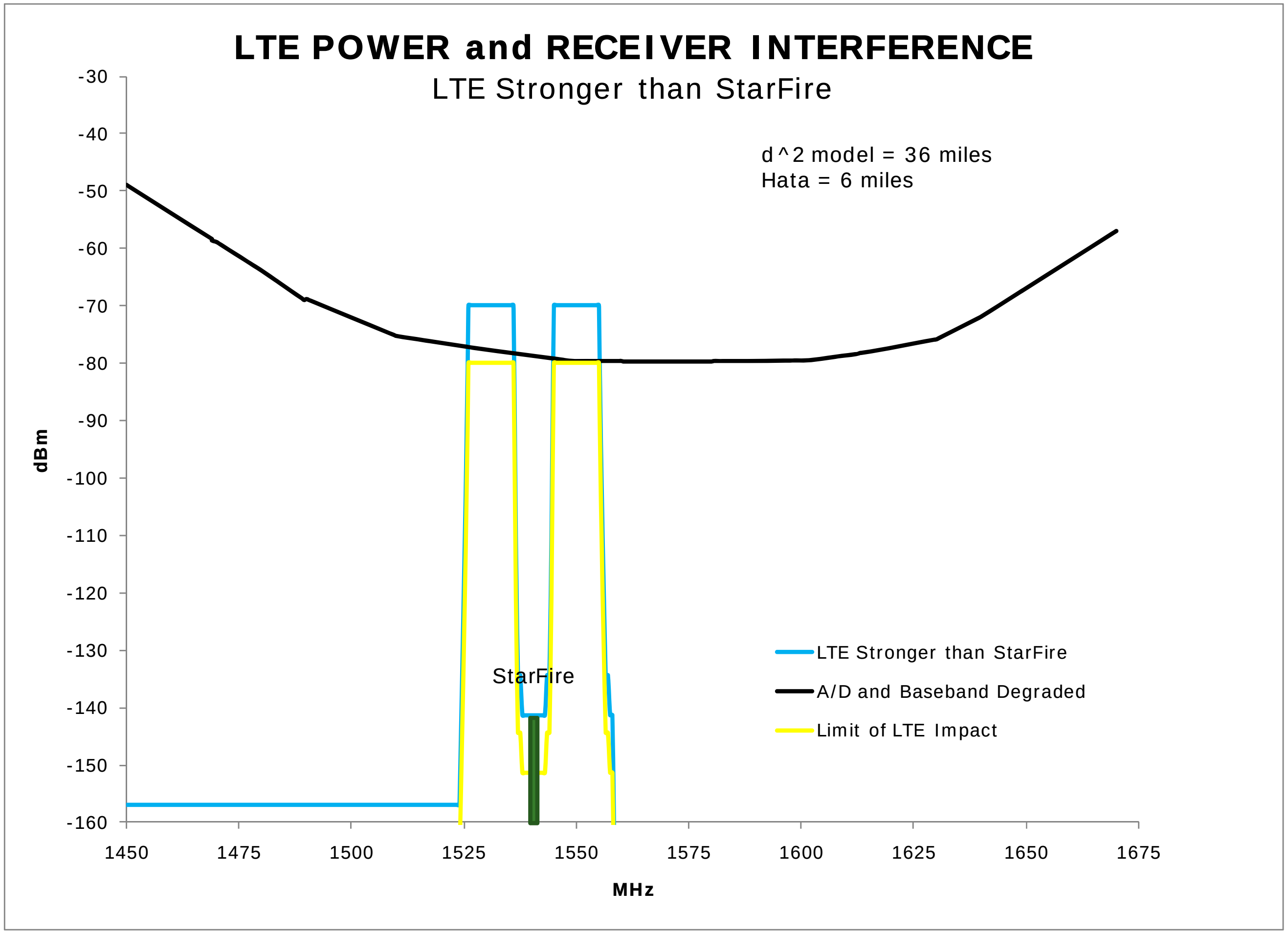
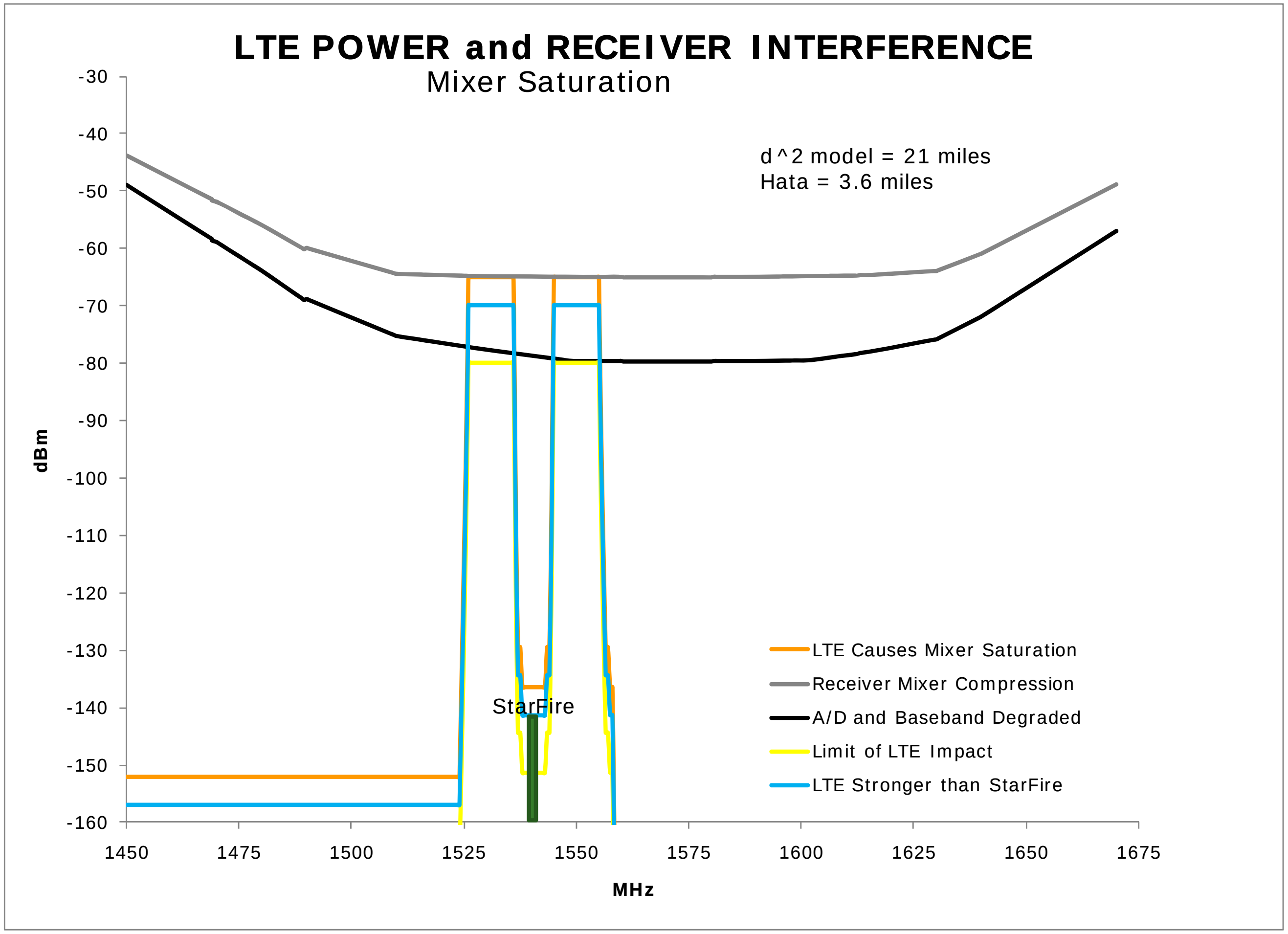
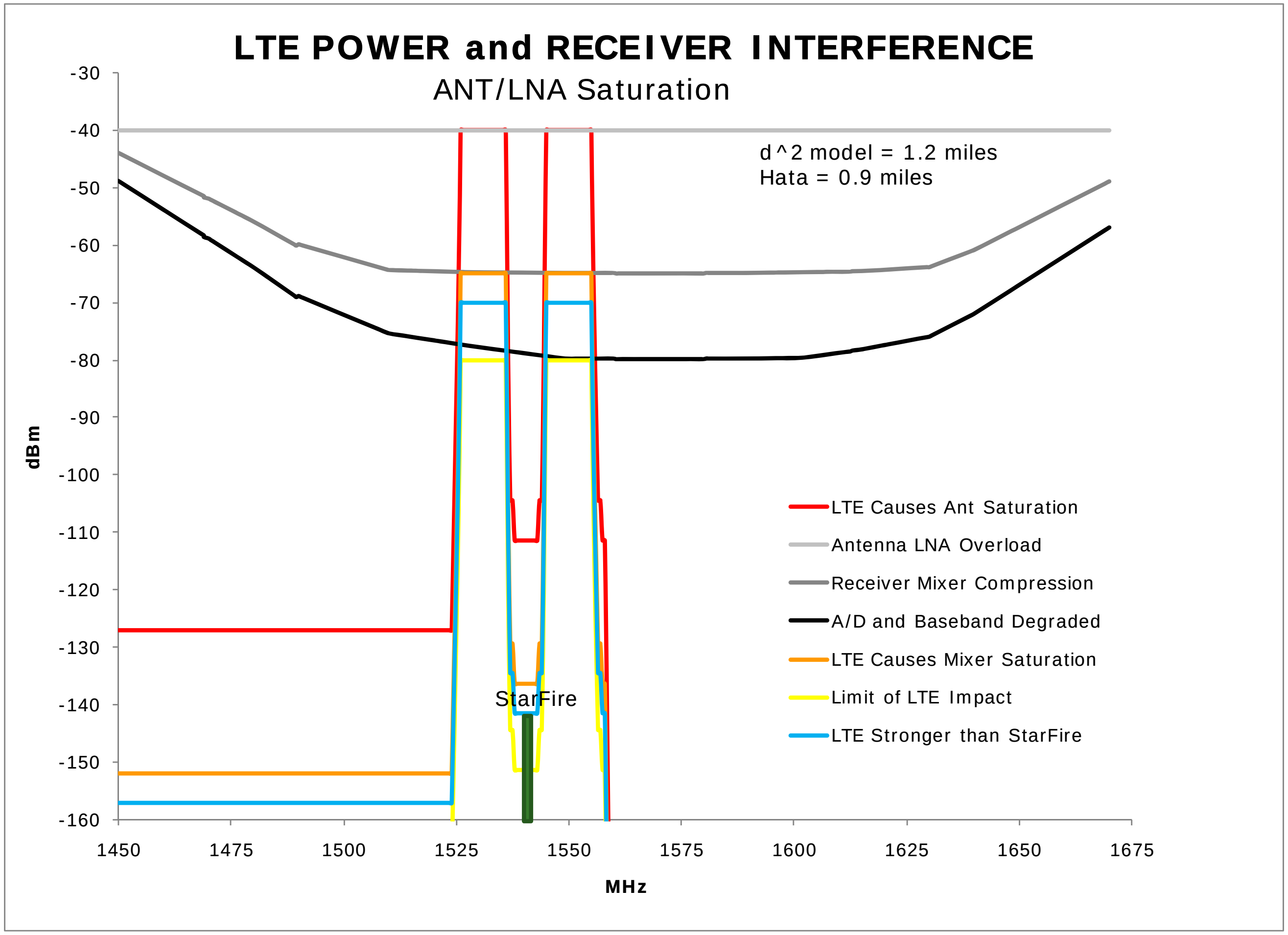
# LTE Interference in StarFire Receivers



# LTE Interference in StarFire Receivers



# LTE Interference in StarFire Receivers



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# LightSquared Interference Analysis Results

| GPS L1 Signals Processing | dBm | Effect | Range 1 / D² Model (miles) | Affected Area (sq miles) | Range Hata Open Model (miles) | Affected Area (sq miles) |
|---|---|---|---|---|---|---|
| Saturation of Antenna LNA | -40 | Inoperative | 1.2 | 4.5 | 0.9 | 2.5 |
| Saturation of Mixer | -65 | Heavily degraded sensitivity | 21 | >1200 | 3.6 | 40 |
| Degraded A/D and Baseband | -80 | Reduced accuracy, weak satellites lost | >85 | >20,000 | 11 | >375 |

| StarFire Signals Processing | dBm | Effect | Range 1 / D² Model (miles) | Affected Area (sq miles) | Range Hata Open Model (miles) | Affected Area (sq miles) |
|---|---|---|---|---|---|---|
| Saturation of Antenna LNA | -40 | Inoperative | 1.2 | 4.5 | 0.9 | 2.5 |
| Saturation of Mixer | -65 | Strongly degraded tracking, very high BER | 21 | >1200 | 3.6 | 40 |
| LTE OOBE power equals StarFire power | -70 | 3 dB degraded tracking, minor to significant BER | 36 | >4000 | 6 | 110 |
| Degraded A/D and Baseband | -80 | Degraded tracking, minor to significant BER (depending on channel) | >85 | >20,000 | 11 | >375 |

# Laboratory Testing

GPS testing conducted March 2011, StarFire testing pending

- Filtering consistent with LightSquared power mask
  - Used 10-pole cavity filter which kept LTE OOBE in L1 below thermal noise floor
- Particularized to the architecture of our receivers

# LTE Jamming Test – GPS

## Test 1 Setup

- NavLabs GPS simulator
- Agilent E4438C-OPTS34 LTE source
- Signal combiner and attenuators
- UUT: SF-3000 GNSS Receiver with hard line LNA input

## Test 1

- With LTE source off, set GNSS level and $C/N_0$ to GPS ICD nominal at LNA input.
- Add LTE signal in increments of 10 dBm to LNA input.
- For each increment measure:
  - Acquisition time
  - Received $C/N_0$ for all channels


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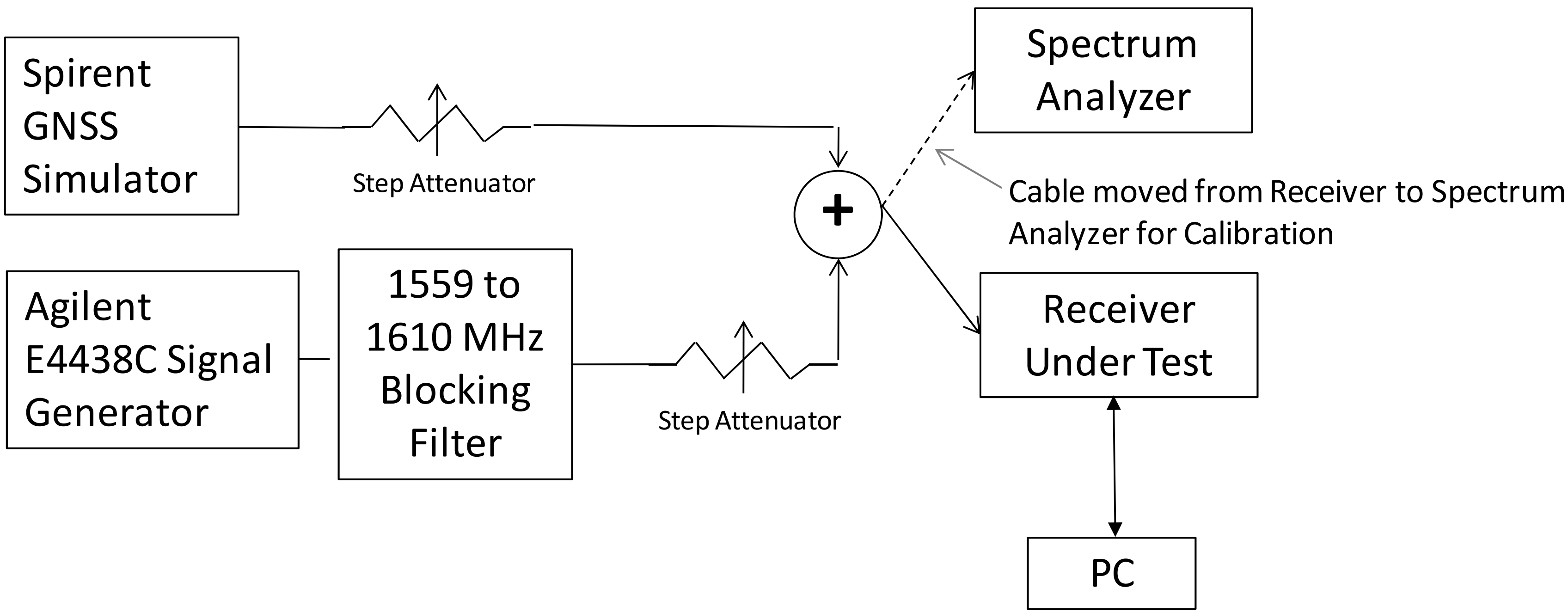
# Test 1 Setup Diagram



# Test 1 Setup in Lab

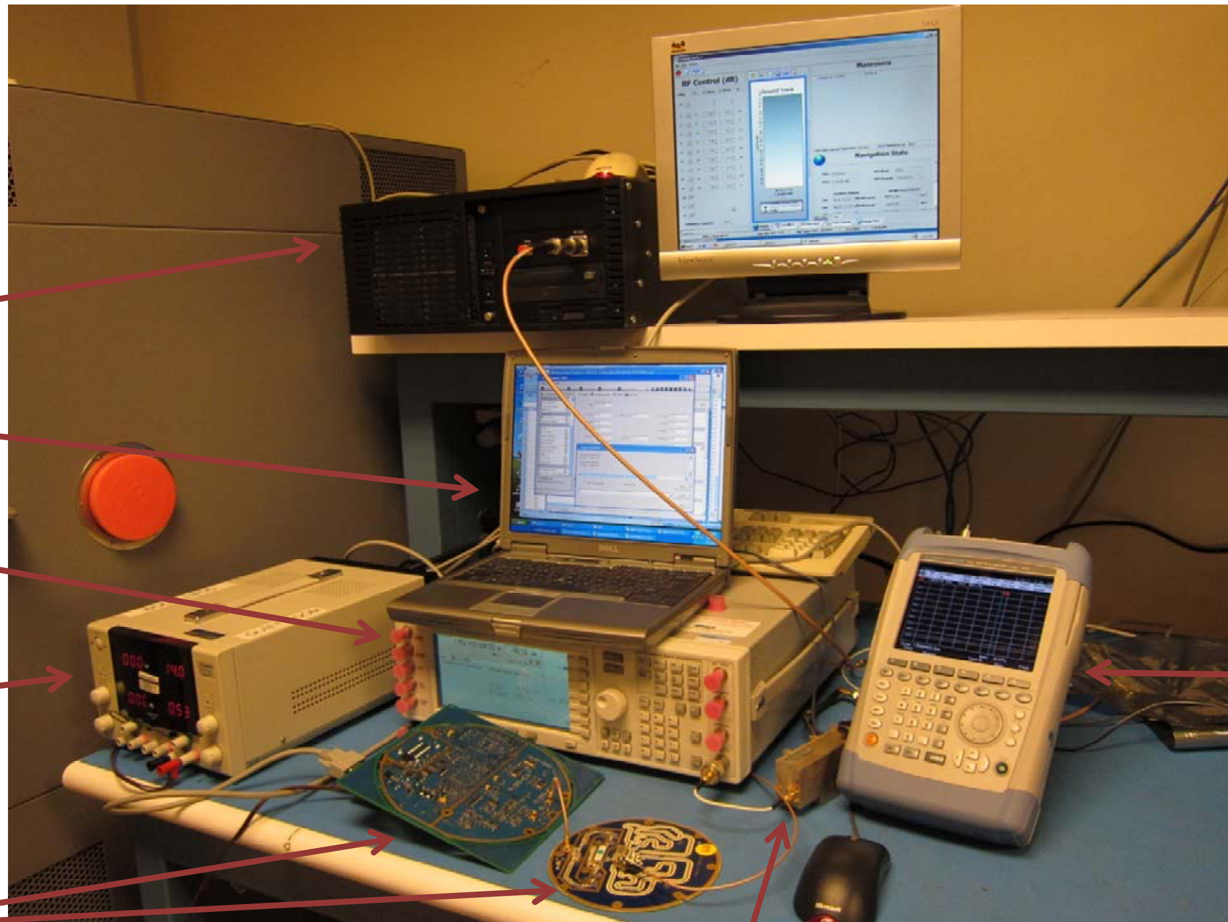
GPS Simulator

PC

LTE Generator

Power Supply

Receiver Under Test



Spectrum Analyzer

Combiner and Filter

# LTE Jamming Test – StarFire

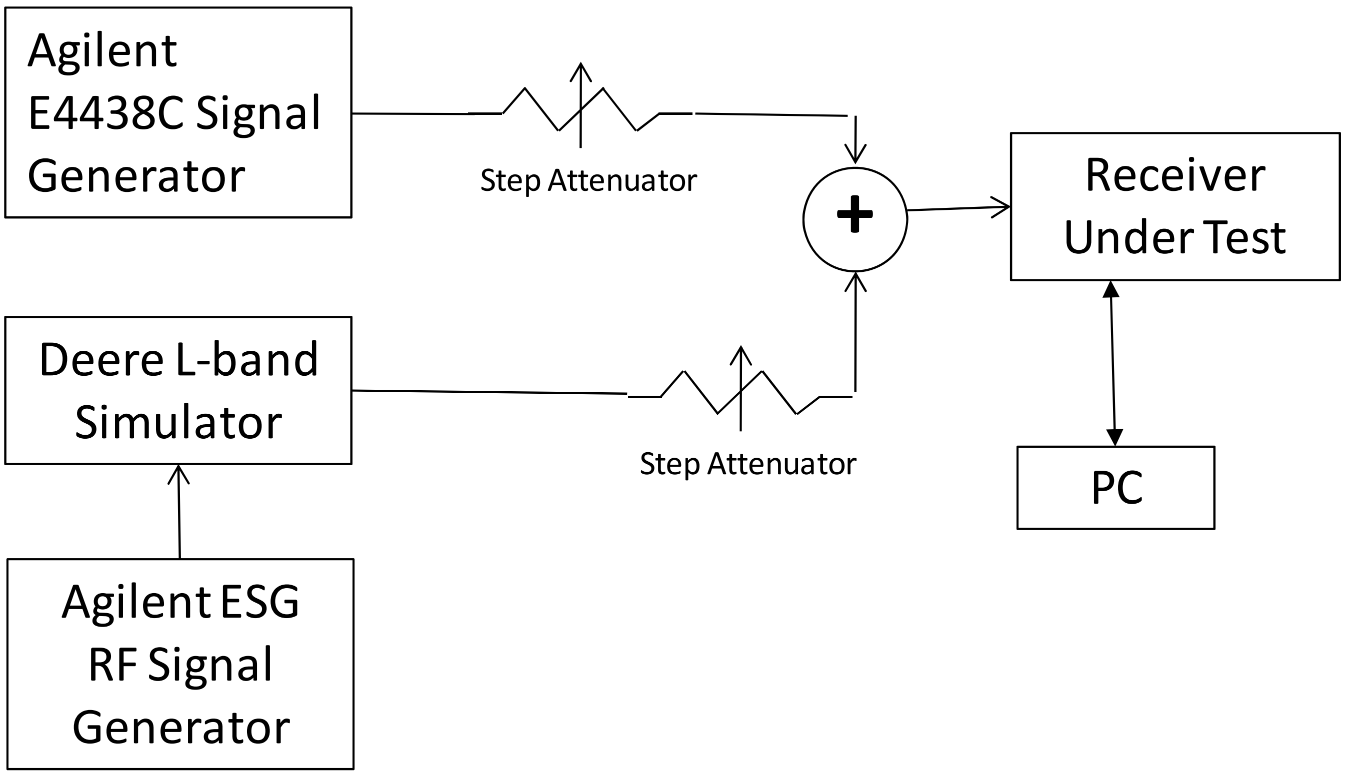
Test 2 Setup

- NavLabs GPS simulator
- Deere L-band Simulator with Agilent ESG RF Signal Generator
- Signal combiner and attenuators
- UUT: SF-3000 GNSS Receiver with hard line LNA input

Test 2 Procedure

- With LTE source off, set L-band power at LNA input such that $E_b/N_0$=10 dB (data rate = 600 BPS)
- Add LTE signal in increments of 5 dBm to LNA input.
- For each increment measure:
  - Acquisition time
  - Receiver Reported $E_b/N_0$
  - Bad Packet ratio

# Test 2 Setup Diagram



# Additional Concerns

May not be possible to receive StarFire signal in MSS band with remaining Inmarsat bandwidth and LightSquared OOBE power level in this band (-40 dBW/MHz)

While LightSquared intends to operate at 32 dBW, they are licensed to 42 dBW

•Higher powered operations would increase the range of degradation

LightSquared operations closer to GPS than 1555 MHz could be done with reduced power

•Even more difficult to address closer frequency

Handsets may be a problem when operated close to GNSS receivers

# Plans

Conduct further Deere tests, measure more parameters to determine the impact on receiver performance: $C/N_0$, code noise, carrier noise, cycle slips, bit errors, etc.

Continue to fully participate in LightSquared – USGIC Technical Working Group

Work with FCC on any evaluation it conducts, if requested

JOHN DEERE