LightSquared GPS Update

AFC Fall 2015 – Montreal

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Overview

- Summary of the LightSquared saga
- DoT GPS Study
- FCC LightSquared Filings

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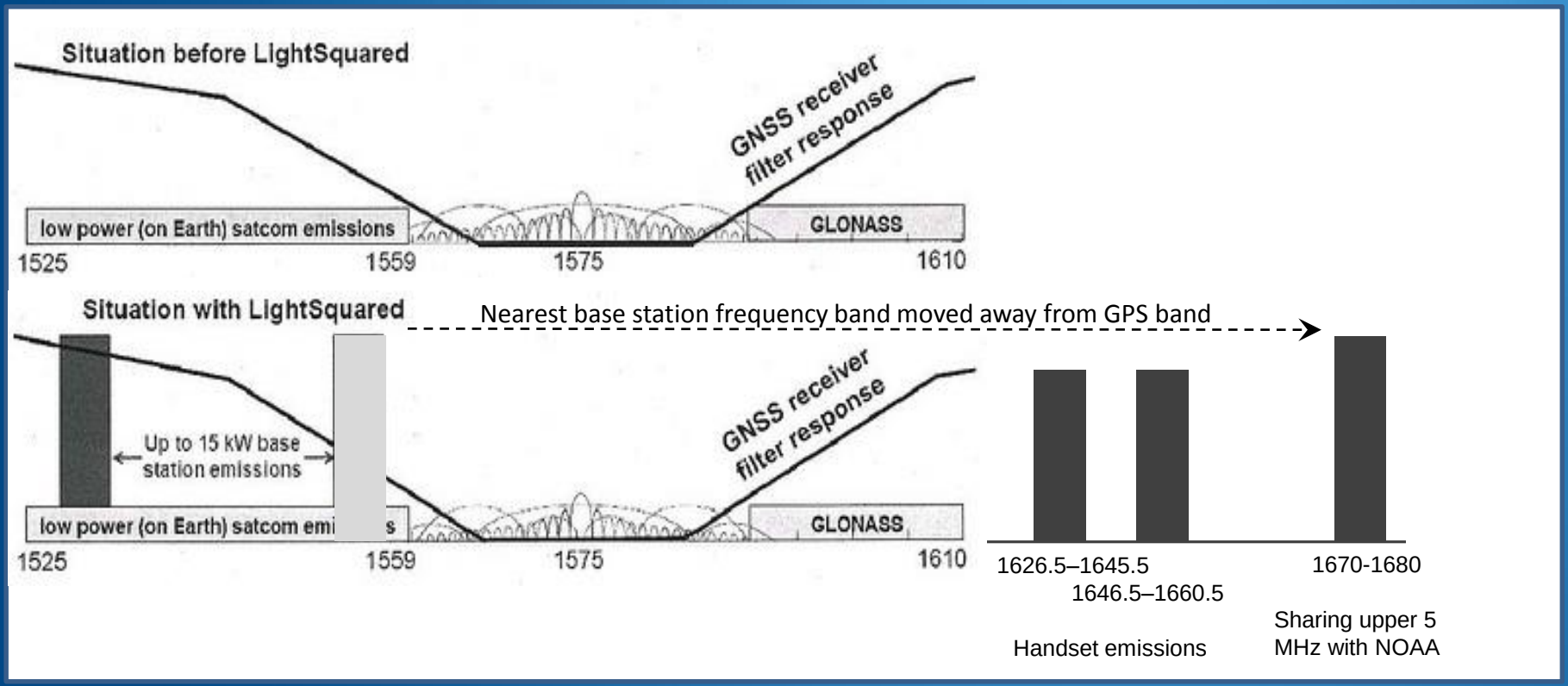
The LightSquared Problem



- Basestation down links overload GPS receiver AGC
  - Residual power also detected inside the GPS band from BS and UEs

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The Legal Chapter

- LightSquared struggling after FCC delays
  - Went into bankruptcy on $1.7bn of debt
  - Power struggle between shareholders
  - Financially supported in Q1 2015 to exit bankruptcy
    - End of 2015 deadline to meet funding conditions
- Harbinger' legal action
  - Tried to sue GPS IC for $1.9bn
    - Judge rejected most claims on 5 Feb 2015, but still left open negligent misrepresentation and constructive fraud
  - Also suing US government for FCC actions
    - Claims FCC did not live up to their part of the agreement
    - Could be problematic if judgment goes against FCC

DOT GPS adjacent band compatibility assessment

- Initiated after NTIA And FCC discussions following LS process
- Intended to:
  - *'Provide a framework to define the processes and assumptions for development of GPS spectrum protection criteria on behalf of GPS civil users'*
- Deriving adjacent-band power limits to create Interference Tolerance Mask (ITM)
  - Assessing AGC overload for adjacent bands
  - Measures when 1 dB degradation in C/N is recorded from devices
    - Current GPS industry metric

Devices to be tested

- Manufacturers supporting with the following devices:
  - Aviation (non-certified)
  - Cellular
  - General location/navigation
  - High precision
  - Timing
  - Networks
  - Space-based receivers
- NDAs will be signed with manufacturers
  - Uncertain how data will be released at this time
  - May only be a summary (unlikely to be all)

Test Setup

- Test chamber to generate simulated GPS satellites and interference source
  - GPS receivers arranged in large array below
  - Orientated to interfering signal emitter
  - Simulating 10 satellites in full view, 1 partial, 1 obscured
- Interferer power slowly raised until 1dB degradation in C/N seen
  - Also assessing 3rd order IM formed within receivers

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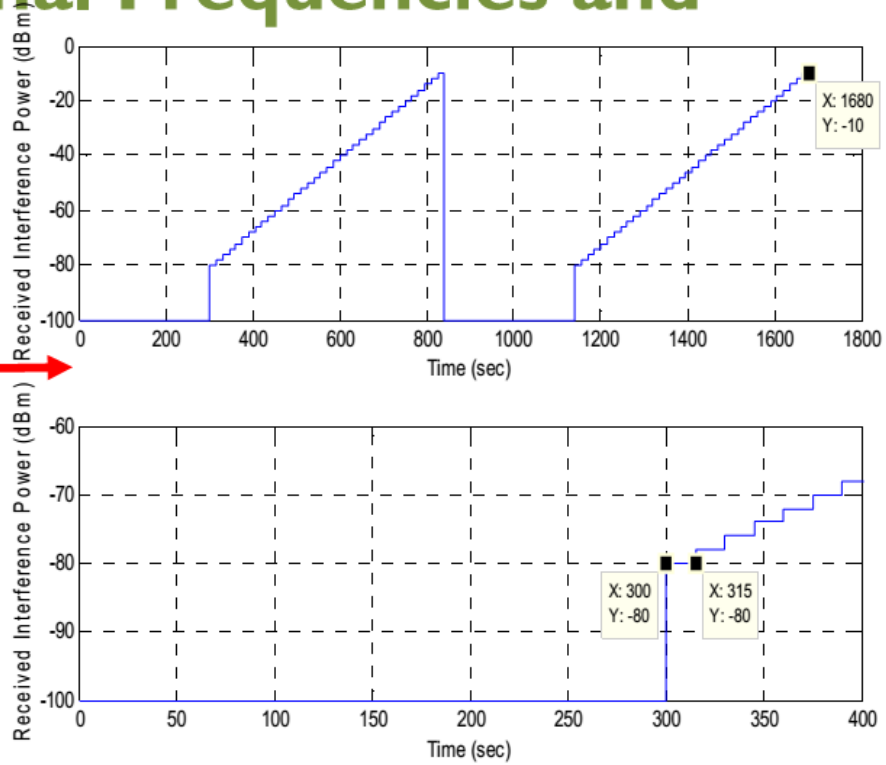
DoT Test Plan

Interference Test Signal Frequencies and Power Profiles

Name	Value	Unit
f_{start}	1475	MHz
f_{end}	1675	MHz
$[p_{min_1}, p_{max_1}]$ (1475 to 1505 MHz)	[-75,-5]	dBm
$[p_{min_2}, p_{max_2}]$ (1520 to 1555 MHz)	[-80,-10]	dBm
$[p_{min_3}, p_{max_3}]$ (1575 and 1595 MHz)	[-130,-60]	dBm
$[p_{min_4}, p_{max_4}]$ (1615 to 1640 MHz)	[-80,-10]	dBm
$[p_{min_5}, p_{max_5}]$ (1645 to 1675 MHz)	[-75,-5]	dBm
Δf_1 (1475 to 1505 MHz)	15	MHz
Δf_2 (1520 to 1555 MHz)	5	MHz
Δf_3 (1575 and 1595 MHz)	N/A	MHz
Δf_4 (1615 to 1640 MHz)	5	MHz
Δf_5 (1645 to 1675 MHz)	15	MHz
ΔP	2	dB
Startup Time	15	min
T_{BL}	5	min
T_{step}	15	s
N_{cycle}	2	N/A



Nominal receive interference power profiles at GNSS antenna location for the (1520 to 1555 MHz) and (1645 to 1675 MHz) frequency ranges.

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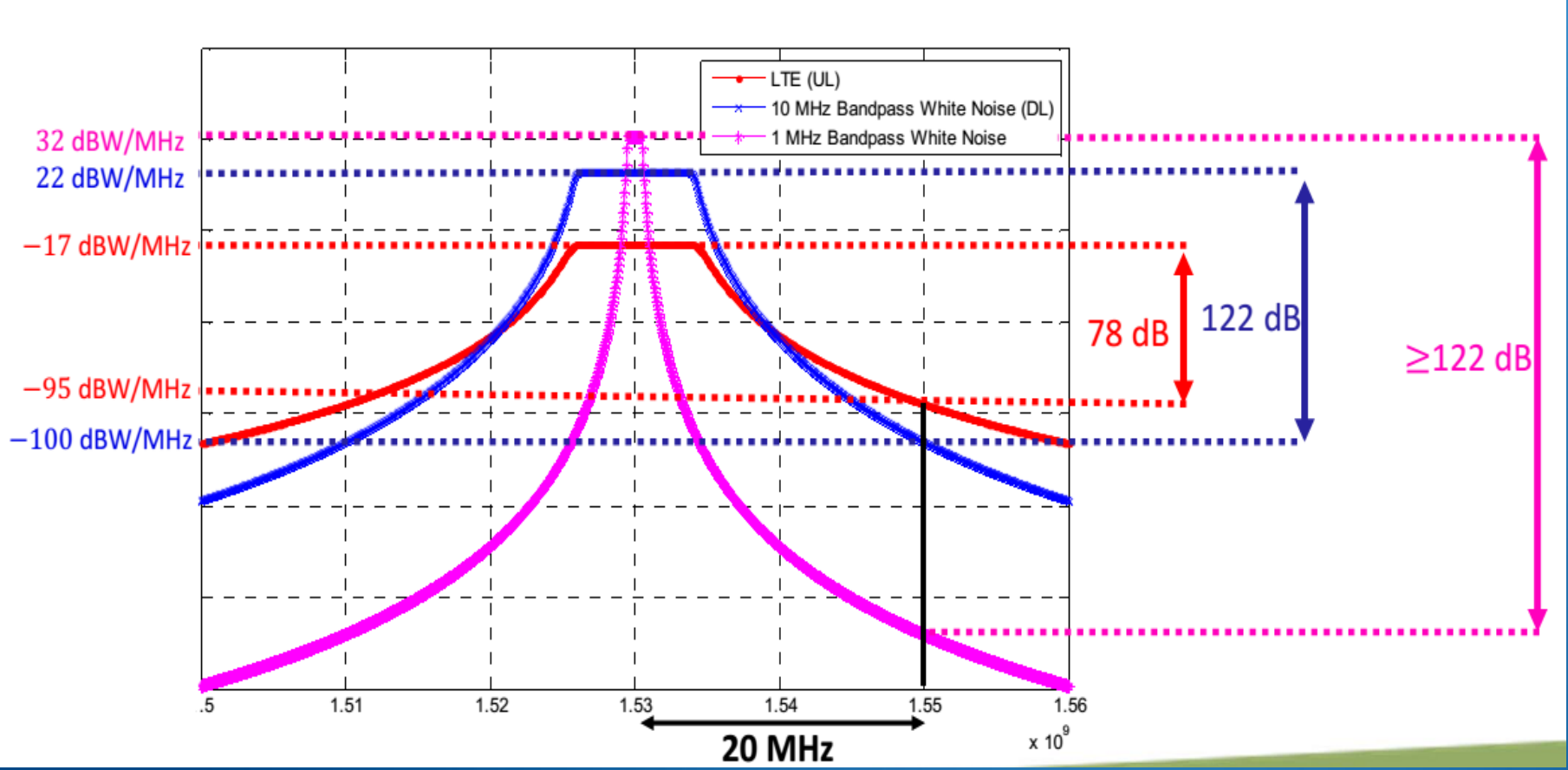
Interfering signal



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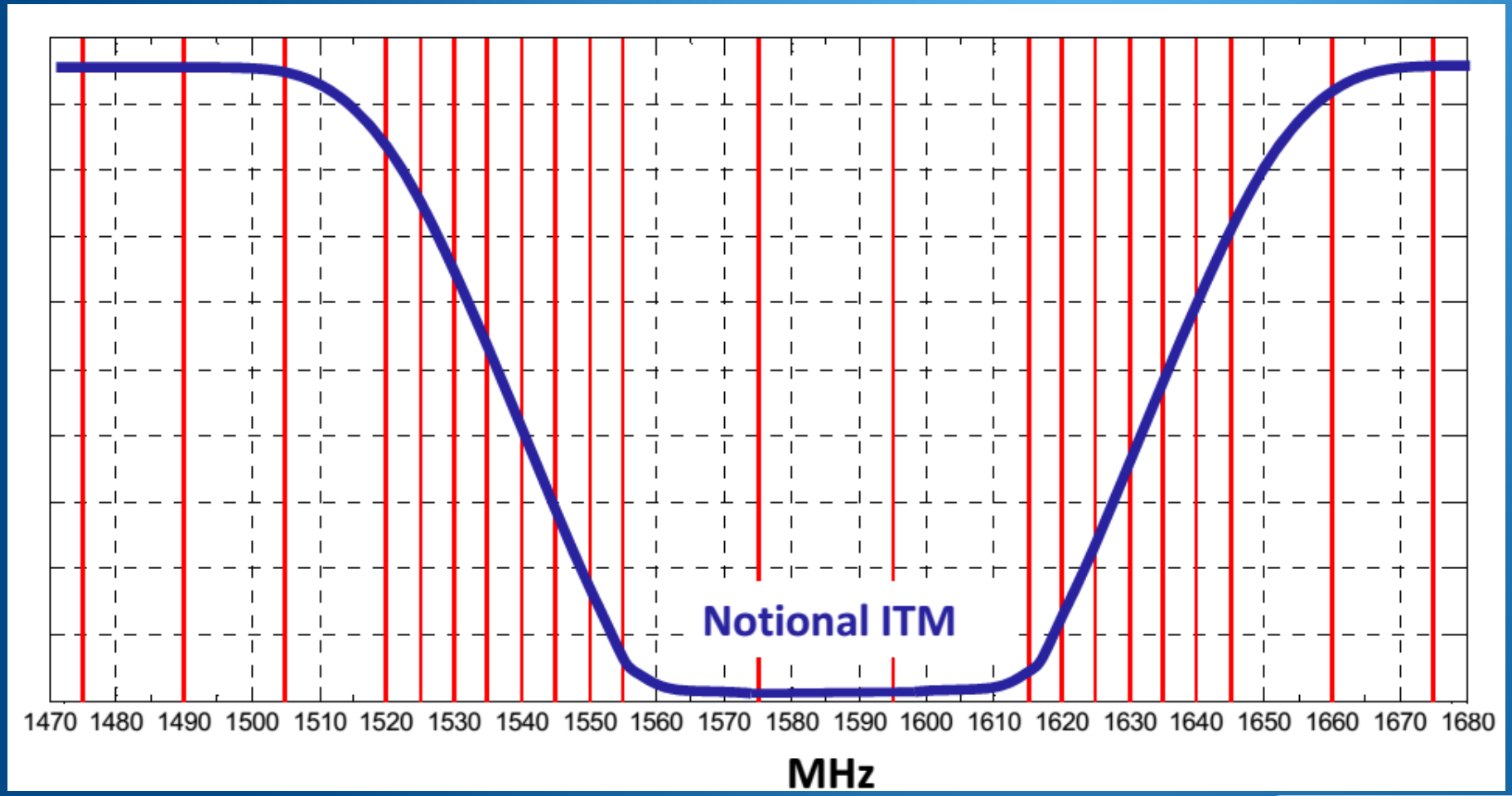
DoT Test Frequencies

Center Frequency (MHz)	Type-1 (1 MHz) OOBE Level	Type-2 (10 MHz) OOBE Level
1475	Max rejection	Downlink (-100 dBW/MHz)
1490	Max rejection	Downlink (-100 dBW/MHz)
1505	Max rejection	Downlink (-100 dBW/MHz)
1520	Max rejection	Downlink (-100 dBW/MHz)
1525	Max rejection	Downlink (-100 dBW/MHz)
1530	Max rejection	Downlink (-100 dBW/MHz)
1535	Max rejection	Downlink (-100 dBW/MHz)
1540	Max rejection	Downlink (-100 dBW/MHz)
1545	Max rejection	Downlink (-100 dBW/MHz)
1550	Max rejection	Downlink (-100 dBW/MHz)
1555	Max rejection	N/A (Eliminated for Type-2 signal)
1575	Max rejection	N/A (Frequency is inside L1 Band)
1595	Max rejection	N/A (Frequency is inside L1 Band)
1615	Max rejection	N/A (Eliminated for Type-2 signal)
1620	Max rejection	Uplink (-95 dBW/MHz)
1625	Max rejection	Uplink (-95 dBW/MHz)
1630	Max rejection	Uplink (-95 dBW/MHz)
1635	Max rejection	Uplink (-95 dBW/MHz)
1640	Max rejection	Uplink (-95 dBW/MHz)
1645	Max rejection	Uplink (-95 dBW/MHz)
1660	Max rejection	Uplink (-95 dBW/MHz)
1675	Max rejection	Downlink (-100 dBW/MHz)

Expected ITM Output Example



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DoT Timeline

- Final Test Plan released: Nov 6, 2015
- NDA execution: Dec 1, 2015
- Finalize list of GPS receivers to be tested: Jan 16, 2016
- Test Procedure Presentation (workshop): Late 2015 or Early 2016
- Workshop –V : Late 2015 or Early 2016
- GPS/GNSS receiver testing: Mar 2016

Points to note on DoT Test

- Does not include certified aviation systems
  - FAA has stated that these follow the required MOPS interference mask
  - Not just the interference levels required to certify
- Spectral masks/spurious levels not realistic
  - Approx. 30-35 dB down on IMT-A levels agreed in 3GPP and ITU-R
  - BS can be filtered, but unlikely for handset
  - These can be added in calculations later if needed
- Does not include potential 3rd order IM in LTE Txs
  - Only looks at IM generated in GPS Rx
- Does not include signal acquisition by GPS receivers
  - More complex testing

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DoT Test Plan Summary

- Generally supported by manufacturers and GPS industry
  - 1 dB degradation to C/N is already standard industry practice
  - NDA's providing assurance
- Could be more precise
  - Simplified to AGC to prevent in depth discussions
  - 3rd order IM at Tx missing
- Comments required from AFC?

FCC and LightSquared

- LS proposing its own test plan
  - Focuses on KPIs for devices
  - Increase interference until KPI is affected
    - Will then define interference limit for each device
  - Will test certified aviation devices
- Roberson and associates working on LS' behalf
  - Not part of DoT plan, only in FCC
  - No support from manufacturers, but will go ahead anyway
- Heavily referencing the FCC TAC's harm claim threshold
  - Could be seen as a test case for the concept
    - Note that concept still not approved in the FCC

LS Test Plan Devices and Parameters (LS provided info)

	Aviation (Cert)	Aviation (Uncert.)	HP (High Precision)	Timing	Cellular	General Nav
KPI	1) 3D Position Error	1) 3D Position Error	1) 3D Position Error 2) Loss of RTK	1) Timing Error	1) 3GPP KPIs 2) 2D Position Error	1) 2D Position Error
System Data	1) C/N_0 2) WAAS message error rate 3) DOP	1) Satellites in view 2) C/N_0 3) DOP 4) WAAS message error rate	1) Augmentation Signal Quality 2) Satellites in View 3) C/N_0 4) DOP	1) Frequency Error 2) Satellites in view 3) C/N_0 4) DOP	1) Satellites in View 2) C/N_0 3) DOP	1) Satellites in View 2) C/N_0 3) DOP

DoT vs LS Test Plans (LS provided info)

Category	DOT Volpe Test Plan	Roberson and Associates Test Plan
Overall Goal	Identify tolerance profile for existing GPS receivers	Identify joint GPS receiver design, and LTE deployment , compatibility solutions
Compatibility Metric	C/N_0, an RF metric	Position Error /User KPI, a functional metric
Test Frequencies	1475MHz to 1675MHz	Focused on LightSquared LTE deployment 1526 - 1536MHz; 1670 - 1680MHz 1627 - 1637MHz; 1647 - 1657MHz
GNSS Test Signals	Generate all GNSS signal as practical (GPS SBAS, GLONASS, Galileo, QZSS, BeiDou)	Generate GPS sgnals and augmentation only (Include devices with other GNSS capability)
Stressed GPS Condition	No plans to test	Real-World, stressed GPS simulated (reduced SVs and Power)
Adjacent Band Signal	Bandlimited 10MHz and 1MHz narrowband noise signals.	Testing with typical commercial 10MHz LTE signal
Time to First Fix	No plans to test	Testing Time to First Fix for public safety units Per NPSTC request
3rd Order Intermodulation	Injecting two signals (such as 1530 and 1550MHz) to measure the 3rd order IM	No plans to test 3rd order IM, since planned deployments do not have this problem

LightSquared FCC Filings

- LS pushing the plan heavily in the FCC
  - Selling it as more realistic than DoT plan
  - Will cloud the issue in a public manner
- Several statements made concerning aviation use of GPS
- More LS lobbying expected
  - Expected that ASRI will need to file
  - If LS not successful be end of year, bigger corporation may buy the spectrum

Going forward

- DoT test plan comments deadline of 9 Oct
- FCC process ongoing
- AFC should prepare to file in the FCC
  - Counter LS claims on GPS performance
    - KPI not an appropriate metric
  - Support DoT test plan as the definitive version
  - Question of LS' ability to lower OOBE for handsets
- Single filing with supporting signature?
  - ASRI will begin coordination in next few weeks
  - AFC members requested to forewarn their management of possibility

Questions?

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