



SPACE-BASED POSITIONING
NAVIGATION & TIMING
NATIONAL COORDINATION OFFICE

LightSquared Update

**Federal Geodetic Control Subcommittee Meeting
July 11, 2011**

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National Coordination Office for Space Based PNT**



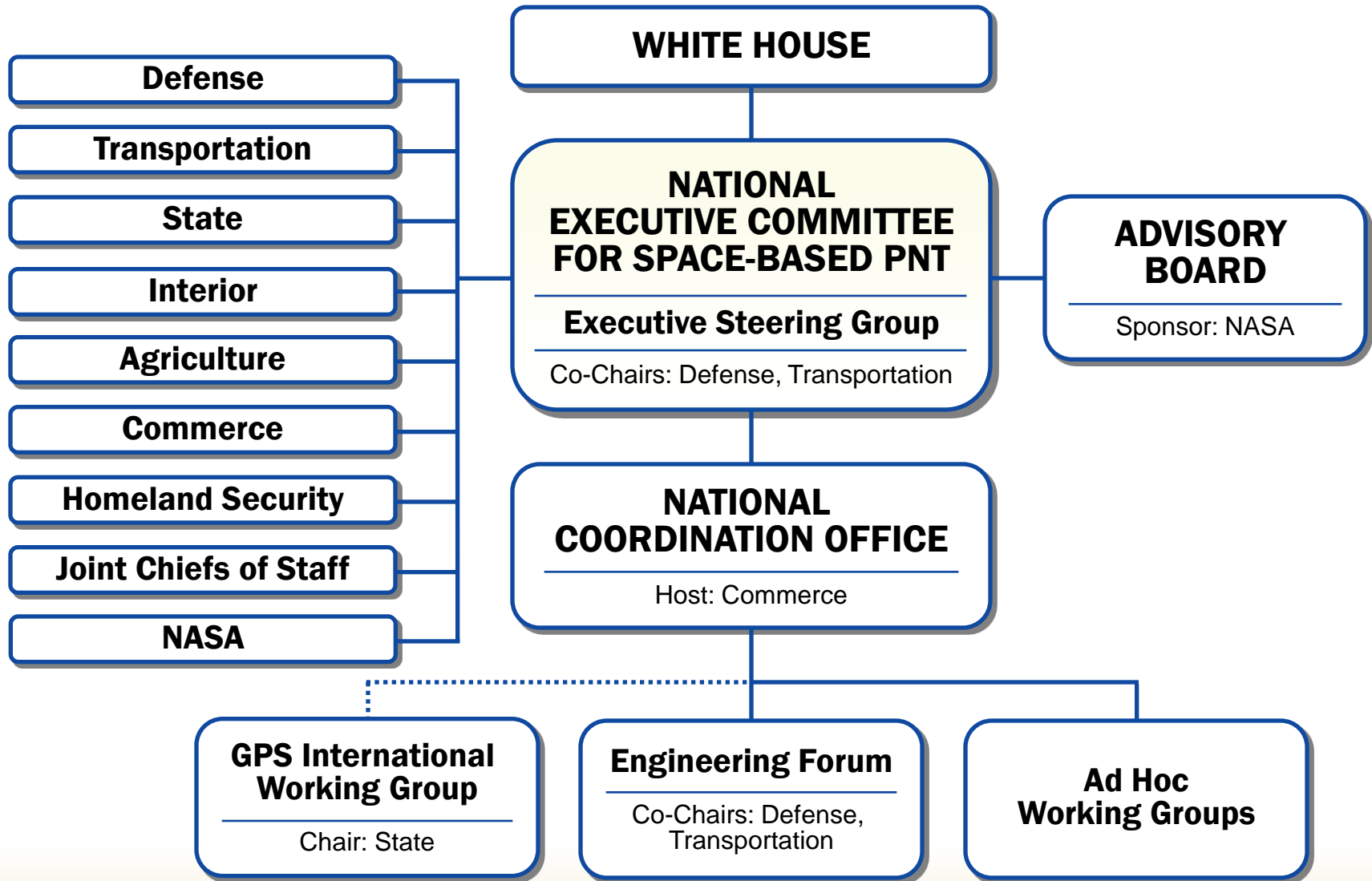
Background



- **FCC grants LightSquared a waiver on January 26, 2011 to establish a high density terrestrial network in the MSS band adjacent to the GPS L1 band.**
- **The waiver also requires that LightSquared establish a Technical Working Group (TWG) to evaluate potential interference to GPS.**
- **Other federal organizations also establish working groups to assess the impact of LightSquared's Ancillary Terrestrial Component (ATC) base stations and mobile handsets on GPS receiver desensitization and possible receiver overload**



US Space-Based PNT Organization Structure





LightSquared & Federal Working Groups



- **On February 9 the National Coordination Office (NCO) tasked the National Space-Based PNT Engineering Forum (NPEF) working group to conduct an assessment of the LightSquared potential interference effects.**
- **On February 10 RTCA, Inc. (an advisory group for the FAA operating under the Federal Advisory Committee Act) tasked its Special Committee 159 Working Group 6 ("GPS interference") to conduct an assessment of LightSquared potential interference effects on aviation. This task was requested by the FAA.**
- **On March 3, LightSquared and the GPS Industry Council (co-chairs of the Technical Working Group) held its first meeting in Washington, DC.**
 - **TWG has 10 federal representatives participating and providing technical input.**



NPEF Interim Update



- **Core group of 25 civil and DoD participants including contractors. Additional telecom participants.**
- **Activities:**
 - **First telecom February 24**
 - **Candidate GPS receiver list for chamber and live sky testing submitted to NPEF test group on March 9.**
 - **Eight Federal organizations participating.**
 - **Radiated chamber tests – April 4 – 7 at White Sands Missile Range (WSMR)**
 - **Live Sky tests at Holloman AFB – April 15 -17**
 - **NOAA /NGS participates one day on April 15**
- **Some conducted lab testing by Zeta associates (aviation receivers) and NASA /JPL (space – based receivers)**



NOAA /NGS Configuration



- **Four high precision geodetic / survey GPS receivers connected through an eight way splitter to a geodetic antenna using magnetic mounts on the vehicle roof.**
- **Another antenna similarly mounted was connected to a single survey receiver with the manufacturer recommended geodetic antenna.**
- **Due to high wind conditions on April 15th, the LightSquared Ancillary Terrestrial Component (ATC) reference station could only be raised to 32 ft. (9.8 m.) instead of the 100 ft. (30.48 m.) specified operational height.**
- **The NOAA vehicle was approximately positioned 315 m. from the LightSquared transmitter for Tests #2, Test #3, and Test #4.**

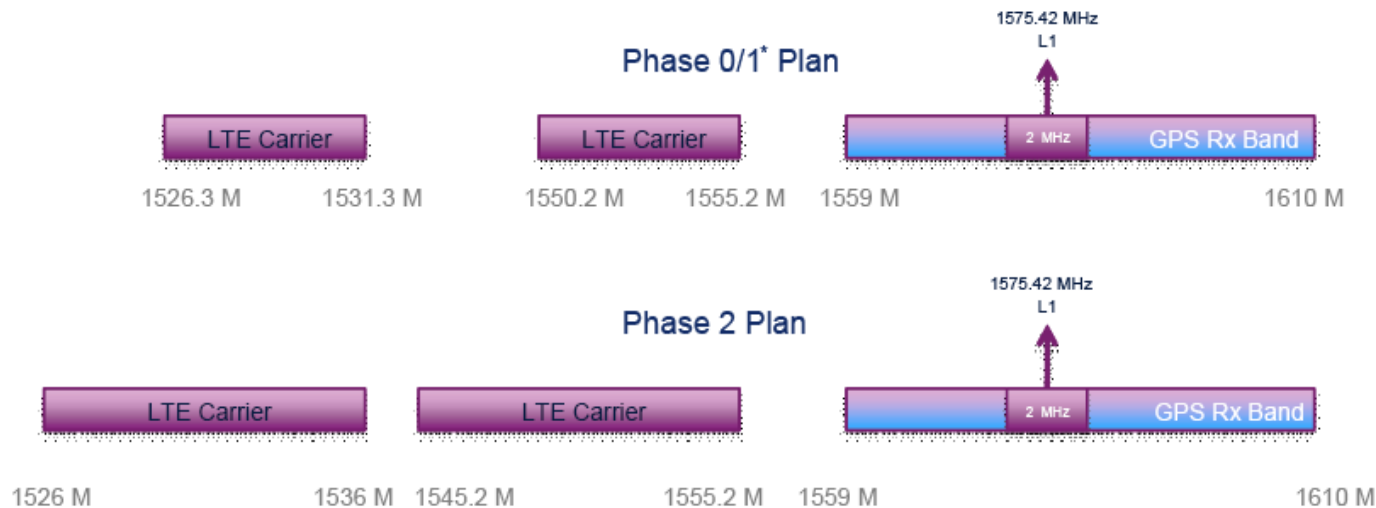


LightSquared Terrestrial Service



2.1. L-band ATC Frequency Plans GPS

Figure 1 describes the LightSquared’s present ATC frequency plans by deployment phase. These plans are subject to coordination with other satellite operators and may change in the future. However, a change in the frequency plans would not change LightSquared’s obligations to protect other services in adjacent bands, such as GPS.



* Only upper 5-MHz LTE carrier is used in Phase-0. Both 5-MHz carriers are used in Phase-1

Figure 1: Lightsquared Downlink LTE L-Band and GPS Band

Source: Motorola. Note that C/A-code useful energy extends beyond the 2 MHz indicated. C/A-code is defined as having a 20 MHz band in IS-GPS-200D.



Live Sky Tests w/ NGS Vehicle @ 315 m. From LightSquared ATC Transmitter



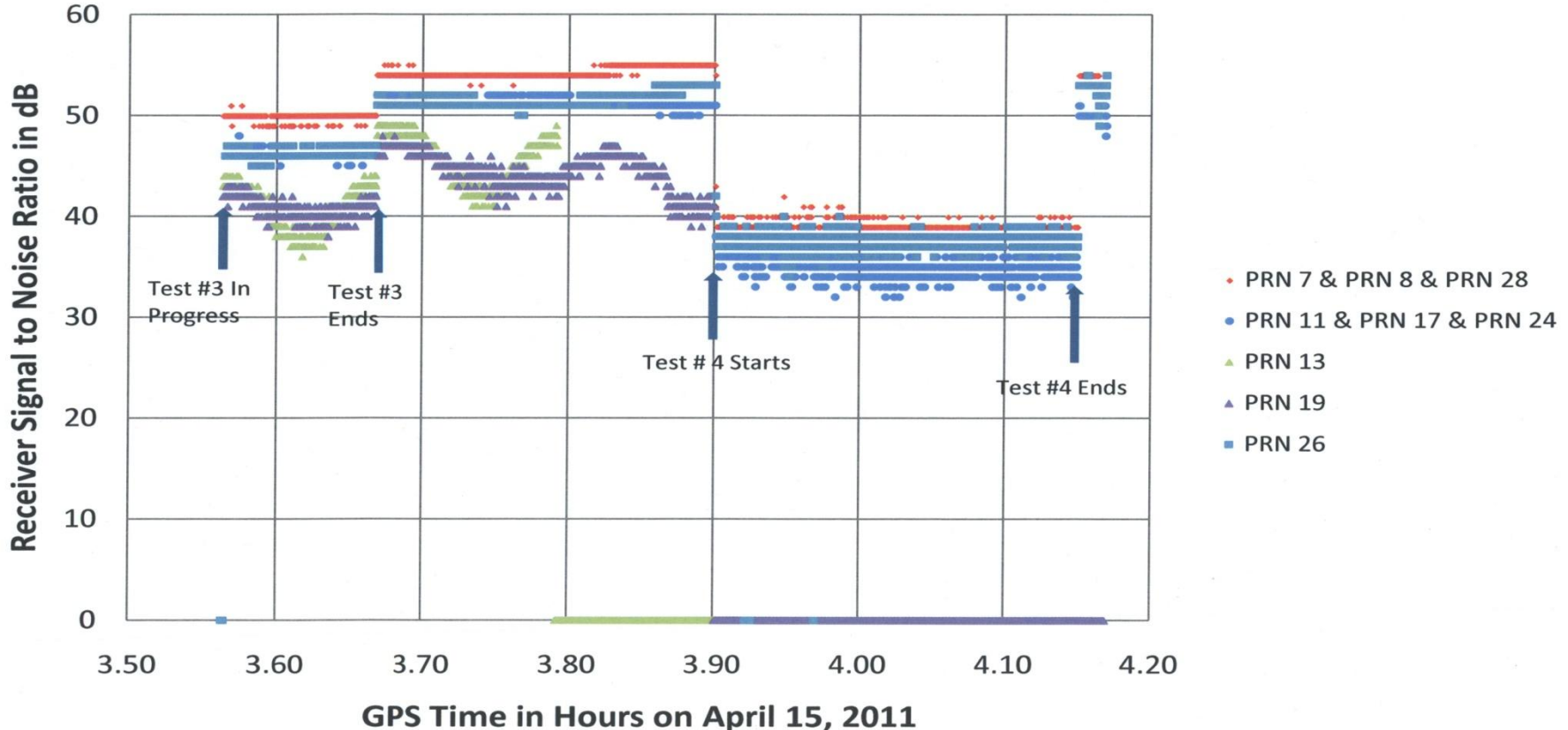
Test #2 – 5 Mhz – High Band- Full Power	Event time (GPS)	Transmitted Power EIRP –Total (dBm)
Start Test	2:39:00	54.1
Added + 3dB to each port	2:42:00	57.1
End Test	3:09:00	57.1
<i>Test #3 – 5 Mhz – Low Band – Full Power</i>		
<i>Start Test</i>	<i>3:25:00</i>	<i>57.2</i>
<i>End Test</i>	<i>3:40:00</i>	<i>57.2</i>
<i>Test #4 – 10 Mhz – Low Band – Full Power</i>		
<i>Start Test</i>	<i>3:54:00</i>	<i>57.2</i>
<i>End Test</i>	<i>4:09:00</i>	<i>57.2</i>



Receiver H07007A C/N₀ (Signal-to-Noise Ratio) During Tests #3 and #4



Receiver H07007A with Geodetic Antenna C
L1 C/A PRN 7, 8, 11, 13, 17, 19, 24, 26 & 28
NOAA Vehicle Approximately 315 m. from LightSquared ATC
Reference Station (Tower at 9.8 m. Elevation)

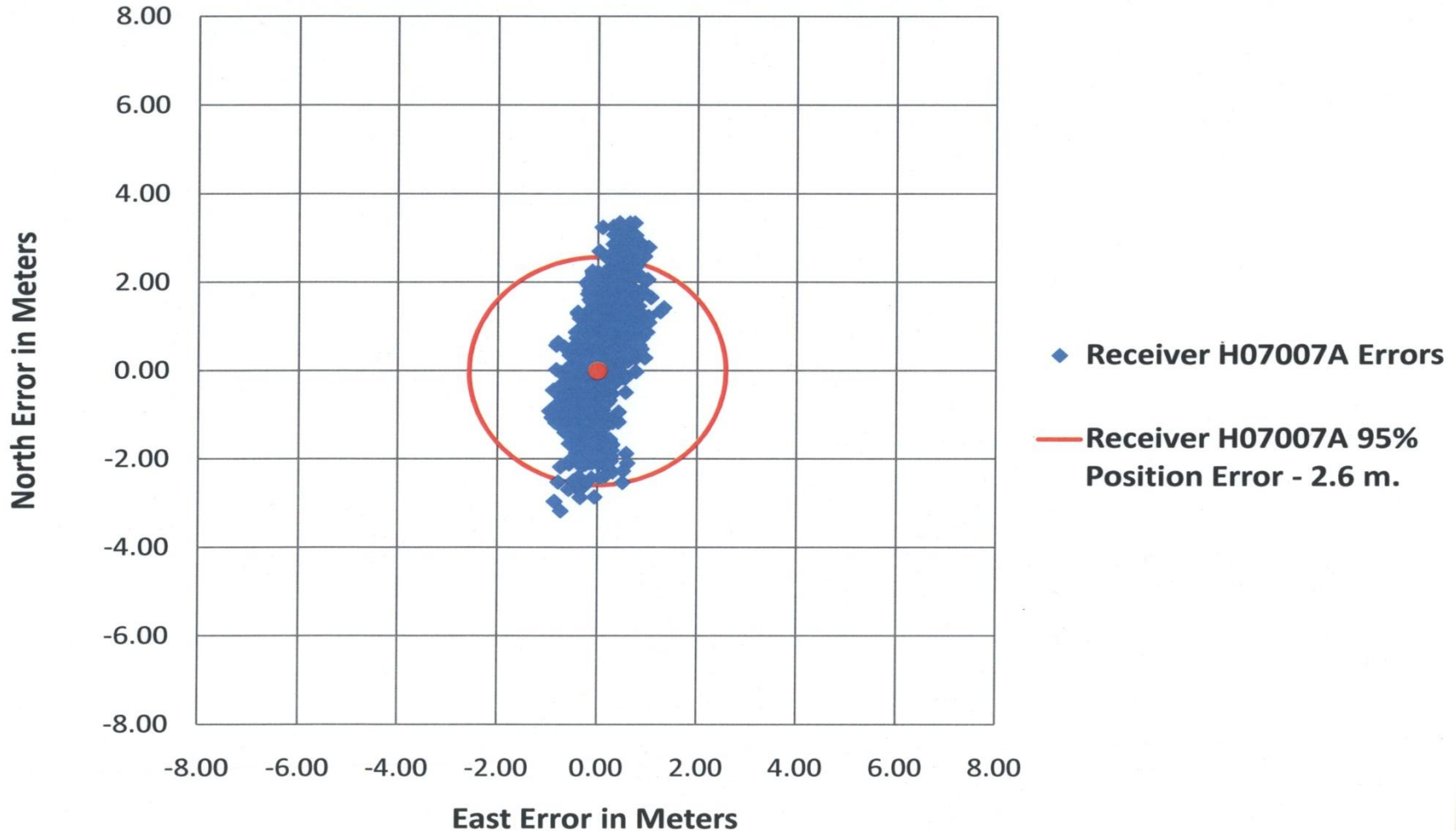




Receiver H07007A Post Processed Accuracy with LightSquared Transmitter Off



**Receiver H07007A / Antenna C - Position Error
With LightSquared Transmitter Off**

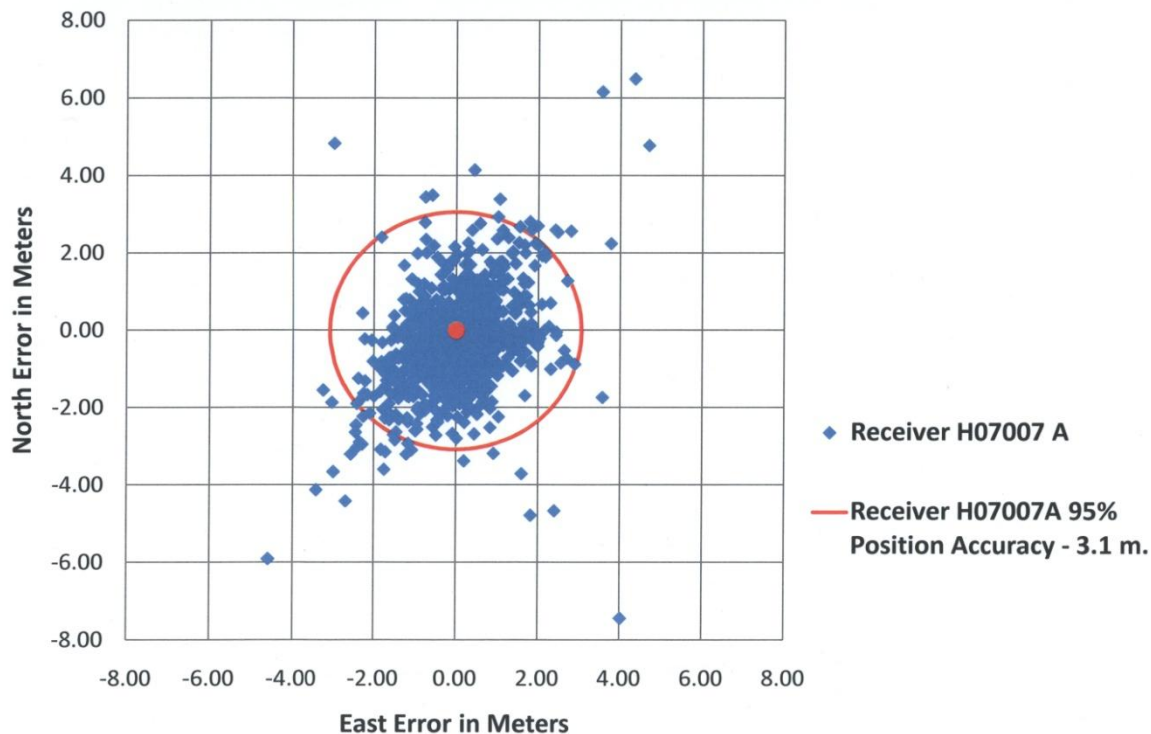




Post Processed Pseudorange and Carrier Phase Accuracy with LightSquared Transmitter On



Receiver H07007A / Antenna C - Position Error During LightSquared Transmitter Test #4 (10 Mhz Low Band 57.2 dBm)



	95% Predicted Position Accuracy	95% Measured Position Accuracy
Receiver H07007A/C-ant. Test site #1	2 cm.	1.2 cm Test # 4 (898 Data Points)



Survey Receiver Results for Ramp Test @230 m. 5 MHz High Band



Receiver ID	Test #9 (Ramp)
Receiver H07007A/C-ant.	Tracking until 5:12:03 @42.4 dBm - then less than 4 PRNs tracked – no position solution for remainder of test
Receiver H07007B/A-ant.	Tracking until 5:26:37 @57.5 dBm - Max Power then less than 4 PRNs tracked – no position solution until 5:35:13 @51.5 dBm when tracking resumes with 4 PRNs
Receiver H91389/B-ant.	Tracking until 5:16:54 @47.5 dBm - less than 4 PRNs tracked – no data until 5:40:37 @45.4 dBm when tracking resumes with 4 PRNs
Receiver H92053/B-ant	Tracking until 5:25:46 @56.5 dBm - then less than 4 PRNs tracked – no position solution until 5:41:26 @45.4 dBm when tracking resumes
Receiver H80708/B-ant.	Tracking until 5:14:09 @44.4 dBm - then no PRNs tracked – no position solution for remainder of test



LightSquared and the GPS Industry Council Technical Working Group (TWG) Testing Activities



- **Technical Working Group (TWG) sub-groups:**
 - Aviation
 - Cellular
 - General Location / Navigation
 - High Precision (Scientific & Surveying)
 - Timing
 - Reference Networks
 - Space-Based GPS Receivers.
- **Testing primarily focused on Radiated Chamber testing.**
 - Cellular sub-team tested **41** mobile phones in three labs.
 - General Location and Navigation sub-team tested **29** devices.



TWG Testing Activities (Cont.)



- **Radiated Chamber testing (Continued)**
 - **High Precision combined sub-team tested 44 high-precision and network devices and 13 timing devices**
 - **Test facility at the Naval Air Systems (NAVAIR) in Pax River, MD**
- **Aviation sub-team tested 4 receivers using conducted testing**
- **NASA / JPL tested two space-based receivers using conducted testing**



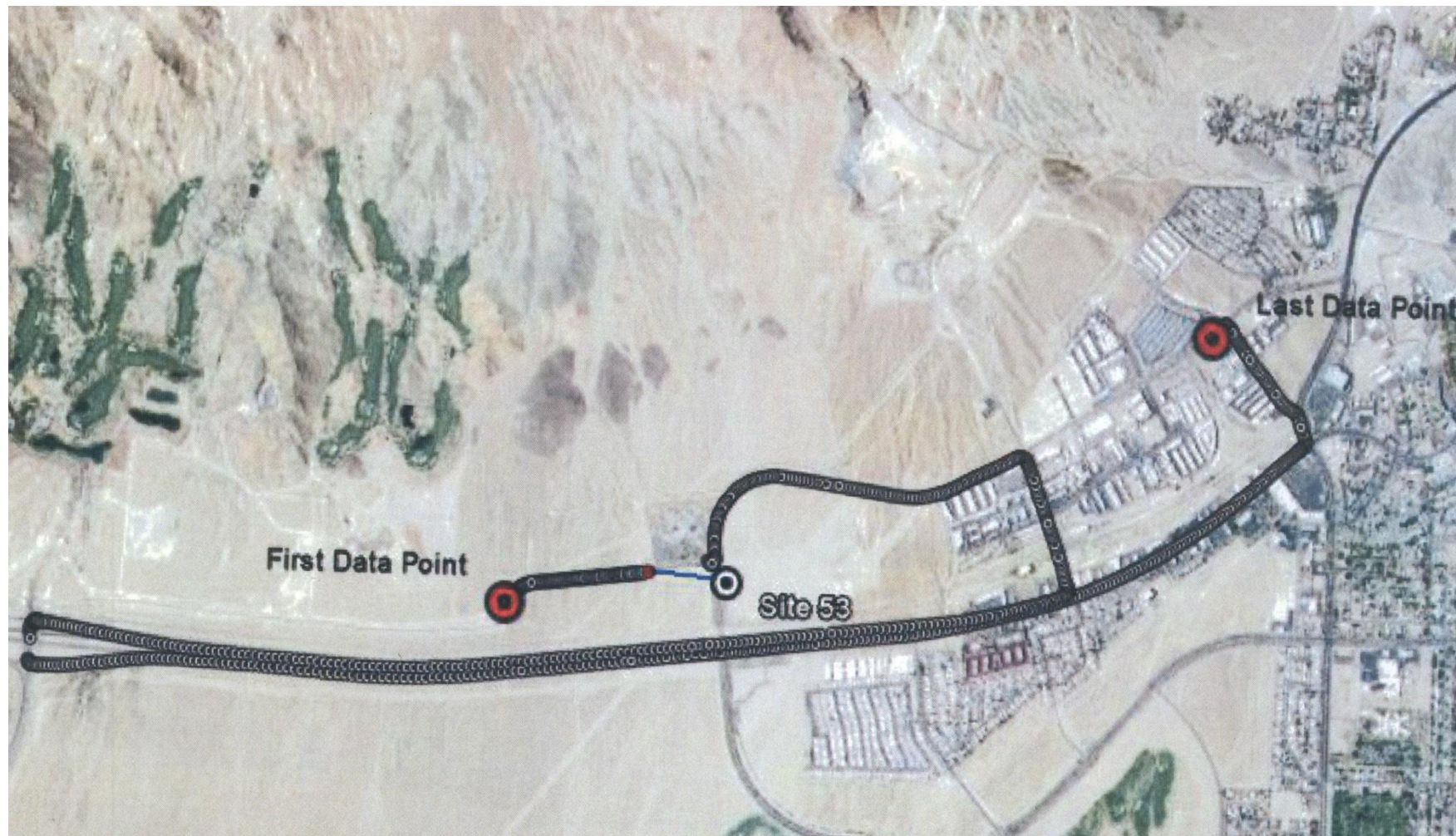
TWG Live Sky Testing in Las Vegas



LightSquared Site ID	Latitude	Longitude	Antenna Height AGL (ft)	Number of Sectors	Azimuths (degrees)	City
LVGS0053-C1	35.9697	-114.8681	60	2	30, 270	Rural
LVGS0068-C1	36.1245	-115.2244	55	3	0, 120, 240	Suburban
LVGS0160-C1	36.127	-115.189	50	3	0, 120, 240	Urban
LVGS0217-C1	36.1065	-115.1705	235	2	0, 240	Dense Urban

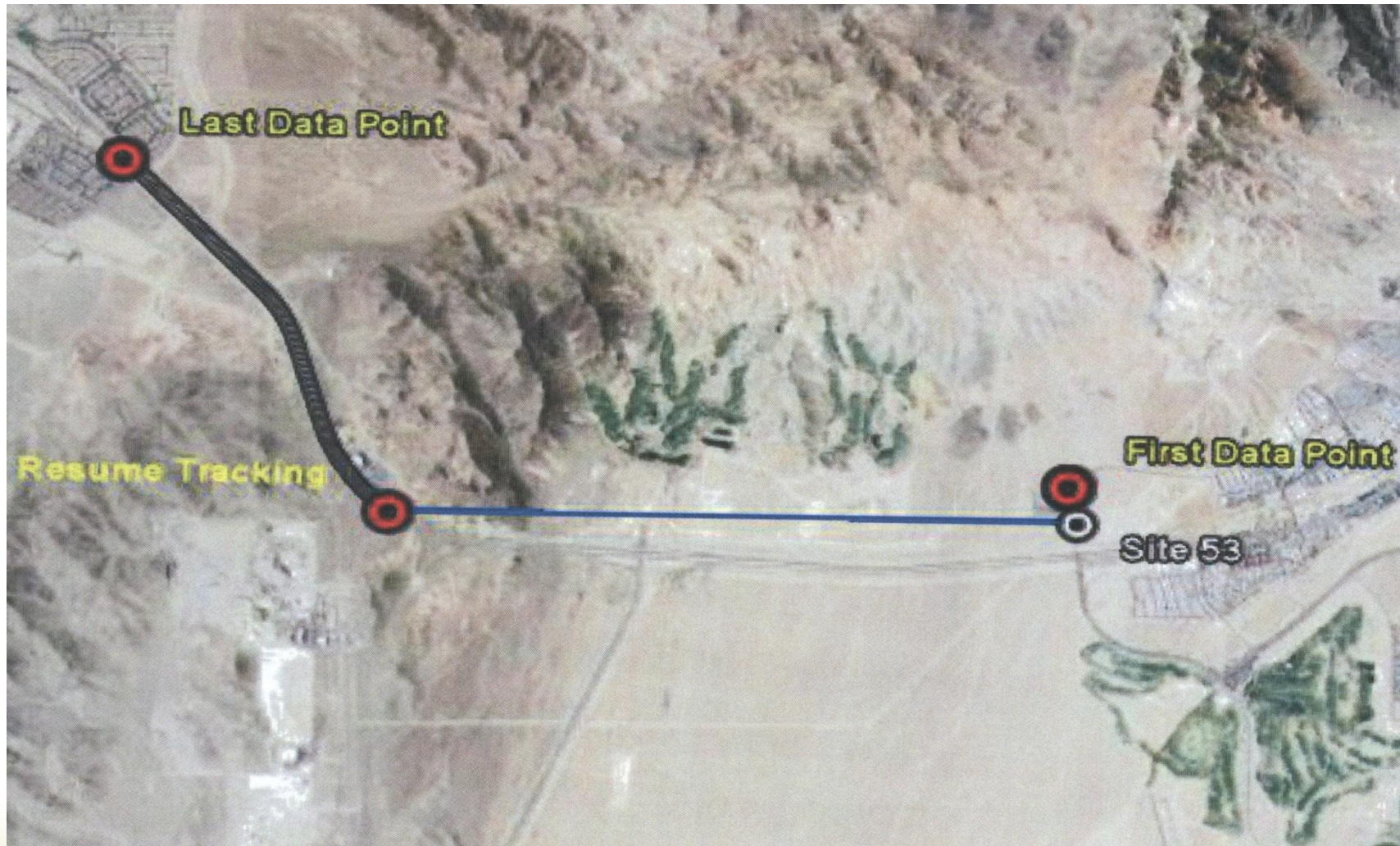


Typical East - West NOAA / NGS Vehicle Test Track May 19 -20, 2011





High Percentage Tracking Loss - GPS Receiver H33451 - Resume Tracking @ 3753 m. LightSquared Transmitter





East – West Maximum GPS Receiver Tracking Loss Distances



Receiver ID	Tracking Loss Range - East	Tracking Loss Range - West
H07007 w/ Antenna 2	1101 m.	1339 m.
H41591 w/ Antenna 5	1025 m.	1303 m.
H80708 w/ Antenna 5	No Tracking Loss	775 m.
H33451 w/ Antenna 5	1125 m.	3753 m.
H84576 w/ Antenna 5	<u>2012 m.</u>	<u>3995 m.</u>

May 19, 2011

Receiver ID	Tracking Loss Range - East	Tracking Loss Range - West
H07007 w/ Antenna 5	520 m.	362 m.
H41591 w/ Antenna 1	1868 m.	2981 m.
H33451 w/ Antenna 1	1886 m.	3133 m.
H84576 w/ Antenna 1	2015 m.	<u>3151 m.</u>
H47596 w/ Antenna 1	1153 m.	2094 m.
H91389 w/ Antenna 1	<u>2027 m.</u>	2119 m.

May 20, 2011

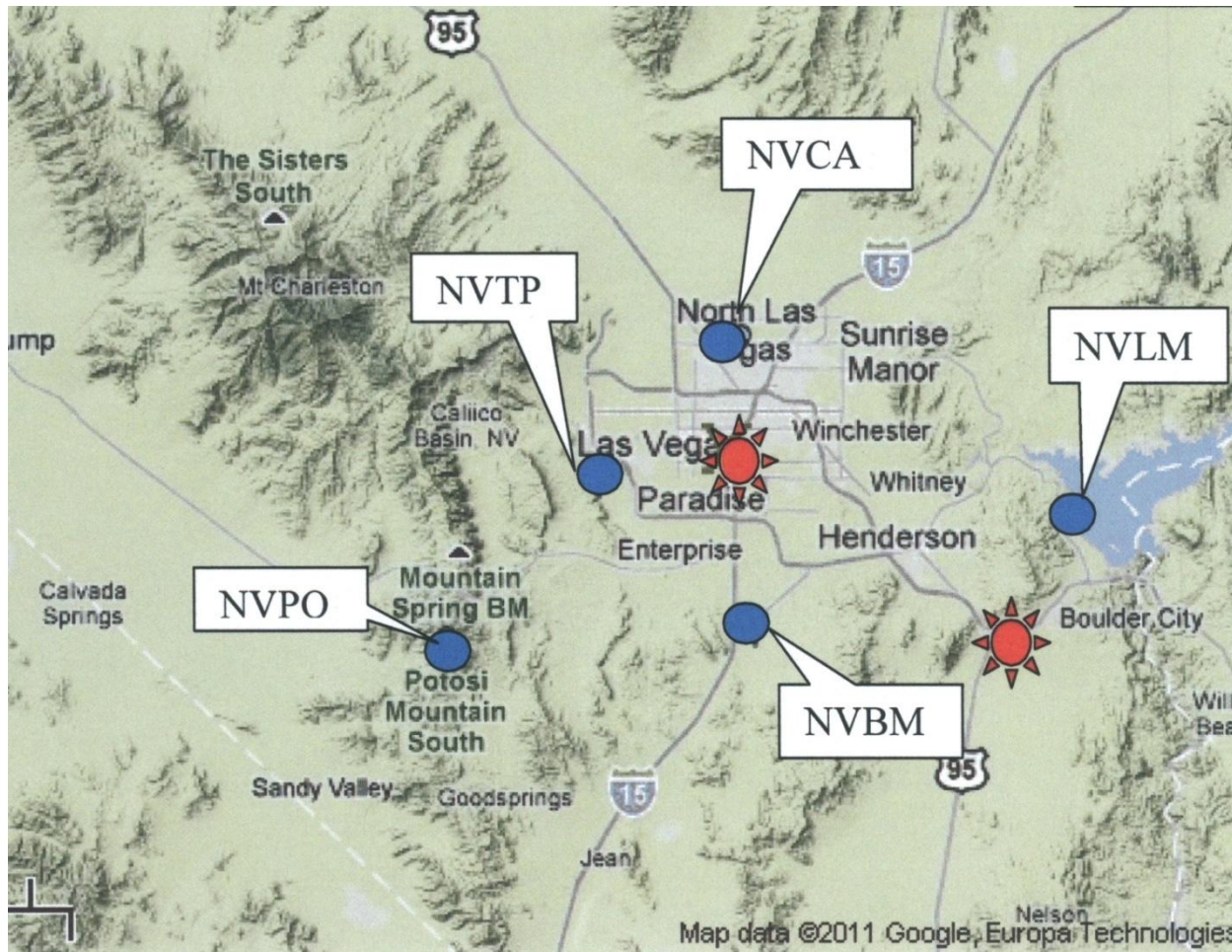


Site 53 LightSquared Transmitting Sectors @ 30° and 270°





Intermittent interference from the LightSquared signal transmissions at Site 53



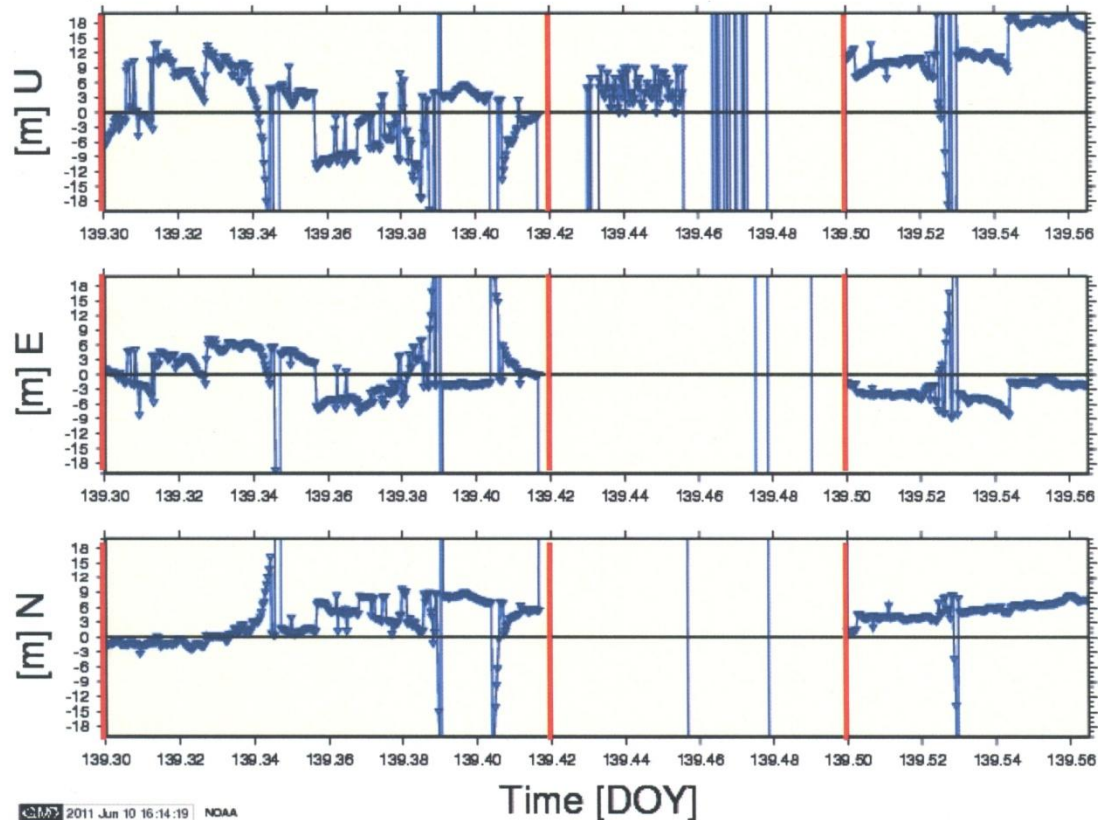
Intermittent interference from the LightSquared signal transmission was noted during NOAA / NGS testing in Las Vegas by several CORS stations 12 and 26 Km. from rural Site 53 on May 19 -20.



Loss of Tracking at NVBM 26 Km. From Site 53 on May 19



Las Vegas CORS nvbm



On May 19 CORS station NVBM (26 Km. from Site 53) lost track and was not able to track GPS satellites beginning just before 3:00 am (DOY 139.42) to 5:00 am (DOY 139.50) PDT. CORS Station NVLM (12 Km. from Site 53) was also not able to track GPS satellites during the same time period



LightSquared & Federal Working Groups Completed Activities



- **TWG Final report filed with the FCC June 30**
- **NPEF Final Report public version filed with the FCC on July 06.**

http://www.ntia.doc.gov/filings/2011/NTIA_FCCletter_LightSquared_GPS_07062011.pdf

- **RTCA report focusing on aviation receivers available to the public on the FCC website:**

http://licensing.fcc.gov/myibfs/download.do?attachment_key=900115



The Way Ahead



- LightSquared agrees that transmissions in the upper 10 MHz channel — the channel nearest to the 1559-1610 MHz GPS band — will adversely affect the performance of a significant number of legacy GPS receivers.
- LightSquared's Proposed Solution
 - First, it will operate at lower power than permitted by its existing FCC authorization.
 - *LightSquared ATC stations during Las Vegas Live Sky Tests were transmitting at 10% of FCC authorized power (32 dBW). They intend to operate in the lower 10 MHz block of their network at this power level for an undefined period of time.*
 - Second, LightSquared will agree to a temporary standstill in the terrestrial use of its upper 10 MHz of its frequencies immediately adjacent to the GPS band.



The Way Ahead (2)



- **Six months into the standstill period, LightSquared will commence a process of working with the Commission (FCC) and NTIA to explore options to enable mutual GPS and LightSquared operations at/near the band borders."**
- **Third, LightSquared will commence terrestrial commercial operations only on the lower 10 MHz portion of its spectrum.**
 - **They will coordinate and share the cost of underwriting a workable solution with GPS manufacturers of legacy precision measurement devices that may be at risk.**



The Way Ahead (3)



- The Coalition to Save Our GPS States:
- Until it can be conclusively shown that there will be no interference to critical GPS uses, LightSquared should not be allowed to deploy in the upper or lower MSS band.
- The Coalition further notes that “LightSquared already owns valuable high quality spectrum assets, including 59 MHz of nationwide ubiquitous spectrum in an advantageous frequency position.”
- On June 30 the FCC issued a Notice seeking public comment on the three LightSquared recommendations. Comments are to be filed by July 30 and reply comments by August 15, 2011.