NPSTC

NATIONAL PUBLIC SAFETY TELECOMMUNICATIONS COUNCIL

June 15, 2011

The Honorable Julius Genachowski
Chairman, Federal Communications Commission
445 12th Street, S.W., Room 8B201
Washington, D.C. 20554

Subject: Order and Authorization, In the matter of LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component (FCC File No. SAT-MOD-20101118-00239), Call Sign: S2358

Dear Mr. Chairman:

The National Public Safety Telecommunications Council (NPSTC) is a federation of public safety organizations whose mission is to improve public safety communications and interoperability through collaborative leadership. NPSTC pursues the role of resource and advocate for public safety organizations in the United States on matters relating to public safety telecommunications. Accordingly, NPSTC provides guidance on issues that can either negatively impact or benefit the operation of public safety communications.

In its previous letter January 25, 2011, NPSTC emphasized the need to ensure public safety use of GPS is protected from potential interference that could result by the proposed LightSquared system deployment. Public safety relies on the reception of GPS for wireless 9-1-1 location, dispatch of "closest responder" based on GPS location, mapping/response directions to responders based on GPS, synchronization of simulcast systems across the country based on GPS time signals and a myriad of other mission critical functions.

NPSTC has fully cooperated and has participated in the LightSquared/US GPS Industry Council working group process established pursuant to the Commission's Order and Authorization granting LightSquared a conditional waiver.[1] NPSTC created its own working group involving approximately 20 public safety practitioners, communications system consultants and industry. Input from members of the NPSTC working group was collected and funneled to the LightSquared/US GPS Industry Council working group through our representatives, under the process established by LightSquared and the US GPS Industry Council. Throughout the process, NPSTC maintained a dialogue with that working group and our representatives participated in testing of public safety equipment, to the extent the compressed schedule established for results from the working group process allowed.

[1] Order and Authorization, *In the matter of LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component, SAT-MOD-20101118-00239, Call Sign: S2358*, released January 26, 2011.

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Attached is our contribution provided to the LightSquared/US GPS Industry Council Working Group on June 13 for use in its report to the Commission. In summary, the testing conducted confirmed that interference to public safety operations will occur and NPSTC has summarized insight gained into the extent of the interference and some potential mitigation procedures.

NPSTC looks forward to reviewing the final LightSquared/US GPS Industry Council report, as well as any information submitted from other parties, and responding to any Commission Public Notice seeking comment on that information.

We appreciate your attention to this matter.

Respectfully submitted,

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cc:

Admiral James A. Barnett, Jr.
Chief, Public Safety and Homeland Security Bureau

The Honorable Lawrence E. Strickling
Assistant Secretary for Communications & Information
National Telecommunications and Information Administration

Geoff Stearn
Vice President, Spectrum Development
LightSquared

Attachment

NPSTC Discussion and Concerns Regarding Interference to GPS Services Due to Terrestrial LTE Operations on Adjacent L-Band Allocations

Overview

It has been shown that strong RF emissions located in frequency bands near the radiolocation allocation of 1559 – 1610 MHz; with the US GPS system centered at 1575.42 MHz, can impact the availability, acquisition and accuracy of GPS services. While such interruptions may affect multiple services, Public Safety and associated supporting services have unique needs that are critical to the public welfare.

GPS is utilized within the Public Safety services in a number of ways. The list includes, but is not limited to:

1) Location of police officers via embedded GPS systems in portable "Handie-Talkie" radios, automatically reported to a dispatch center allowing:
    a. Rapid response to an officer in need; "man down" signaling. This can be critical to the health and safety of an officer including ultimately saving an officers life;
    b. Efficient and rapid dispatch of the closest officer to a situation;
    c. Tracking of officers movements and timing for introduction as evidentiary information.
2) Mobile data / computing and location of police and official vehicles for Automatic Vehicle Locations (AVL) services as well as location and time-stamping of documentary video evidence; Location Reporting is a key factor in CAD systems:
    a. AVL allows rapid and efficient dispatch of police and fire equipment in response to calls, including E911 emergencies, from the public;
    b. Location and Time-stamped video can play a critical role as introduced evidence in the prosecution of crimes and cases. It can also play a role in resolution of disputes after traffic accidents and incidents.
    c. AVL, coupled with navigation, allows officers and officials to quickly respond to remote and difficult to locate locations.
3) GPS is utilized by thousands of systems to maintain accurate timing:
    a. Microsecond timing is utilized to maintain single frequency networks in simulcast systems.
        i. Such systems provide higher reliability coverage and service areas,
        ii. Fill in "dead zones" that would otherwise exist due to RF shadowing and building penetration losses; particularly in dense, urban environments,
        iii. Utilize scarce and valuable spectrum in a more efficient manner.
    b. Sub-millisecond timing is utilized to synchronize digitized voice and data in Public Safety and associated services such as Project 25. This will become more critical as Phase 2 is deployed.
    c. Millisecond timing is also derived from GPS for IP network timing, allowing voted use of multiple receive sites in non-simulcast systems; thereby enhancing the overall readability of signals – particularly from handheld devices.
4) GPS timing is also prevalent in system timing critical to total infrastructure solutions:
    a. GPS timing and synchronization of microwave backhaul; minimizes "robotics" and reliability concerns of connectivity in P25 systems
    b. GPS timing; time and date stamping at dispatch centers.
    c. GPS timing is used to provide Network time synchronization to multiple systems used by E911.
        i. Synchronized timing is provided to:

1. CAD systems
2. Radio systems
3. Logging recorders
4. Mobile Computer Terminals

d. Synchronized timing is necessary to accurately create call incidents to be used for investigations.

5) Embedded GPS receivers in cell phones and cellular terminals play a role in E911 dispatch.
   a. Phase 2 E911 deployment, now available in many urban areas of the country and underway across much of the country, locates the caller within 30 – 50 meters in many cases.
   b. Many E911 calls now originate from cell phones; in certain locations, the percentage of E911 calls from cell phones exceeds 70% of all E911 calls.

Disruption of GPS service affects each of the above-listed use cases in unique ways. A considerable investment of public funds has been made at the Federal, State, and Local levels to build out communications networks for the safety of our EMS, fire/rescue and law enforcement responders, and numerous public works agencies leading to the ultimate protection of human life of the civilian population as well as the responding officers and officials. The summarized list, above, states generalized use-cases of GPS within this service; specific impediments follow:

Infrastructure / Network Timing Issues

In simulcast systems, GPS is utilized to maintain critical network timing of RF frequency, data synchronization, and timing offset thereby allowing multiple transmitters to occupy the same channel, in overlapping service contours, in a constructive fashion. Such timing must be maintained with microsecond-level accuracy. To that end, GPS is utilized to train crystal, oven-stabilized crystal, and rubidium oscillators. Should GPS signaling be lost, the system will ultimately fail. Generally when tracking of at least 4 satellites in the GPS constellation is lost, an immediate alarm is sent to the dispatch or control center. Depending upon the reference clock system in use, timing may be lost in as little as 20 minutes; however, most systems will free-run with sufficient accuracy to maintain the network for a minimum of 4 hours. Certainly, within 24 hours the frequency reference system will fail and either the system will generate self-interference or the affected site(s) will shut down as not to interfere with other sites within the network; this is dependent upon the version and type of simulcast system deployed. In the latter case, increasing coverage loss, depending upon the version of simulcast deployed, could take place.

Mitigation of infrastructure issues is possible and would require replacement of roof and tower-mounted antennas (which contain integrated antenna, low noise amplifier, and filtering) with new design antennas that contain multiple narrowband SAW filters, thus protecting the GPS receiver. In some cases where the GPS receiver is located within the antenna, replacement of the complete device would be necessary. Laboratory and Live-Air testing has tentatively proven that replacement of the external antenna with a new High Rejection antenna will mitigate future problems associated with blocking issues caused by strong L-band emissions. LightSquared has publicly stated that they will fund the replacement program for Public Safety infrastructure systems. Replacement of antennas must be complete prior to deployment of the terrestrial L-band system on a market by market basis.

Mobile Data / Computing and AVL

Mobile PC-based and stand-alone devices have been deployed into the Public Safety space for several years. Laboratory testing (Q1/2011), as well as Live-Air testing (Q2/2011), has suggested that these devices have the highest sensitivity to blocking of GPS due to L-band terrestrial transmissions. Lab testing has suggested that affected ranges may exceed 1 km; Live-Air testing confirmed blocking ranges in excess of 600 meters when a single L-band transmitter was in operation at 1552 MHz with an EIRP of +59dBm. Final deployment will involve 2 transmitters (at ~1552 MHz and ~1530 MHz), each at +62dBm. The latter case can also produce a 3rd order IM product (when the 5 or 10 MHz bandwidth of the LTE emission is considered) that falls directly upon the GPS allocation. It is estimated that the combined outage radius under this condition will exceed 850 meters and may extend to 1300 meters. Considering the proposed typical terrestrial LTE deployment separation distance of ~2 km, vast service outages are predicted.

Mitigation means are possible long term. The denial of service radius can be reduced to an acceptable distance of 15 meters or less through the use of replacement antennas on the vehicle. Replacement High Rejection antennas are being introduced and are becoming available as of Q2/2011. High Rejection GPS antennas have higher cost associated with the additional filtering and gain stages necessary to protect the target receivers. Communications systems utilized for Public Safety exhibit long lifetimes; similar to those utilized in the aviation industry. It is not uncommon for radio equipment to be utilized in service for a decade or longer. Vehicles; however, are replaced at more frequent intervals. As vehicles are replaced, High Rejection antennas can be affixed during the transfer process. An active program of replacement is, of course, possible; however, such replacement has not been budgeted by most jurisdictions nor has LightSquared suggested that a replacement program, such as that offered for Public Safety infrastructure equipment, is forthcoming. It would be reasonable to consider that, given a 3–5 year time frame, affected antennas might be replaced to an acceptable level although the time frame required may exceed this amount.

Portable Handset (Handie-Talkies) Devices

Just as in the mobile environment, the portable environment is represented by long-lived equipment. Unlike mobile devices that have external antennas, portable devices utilize unified designs in which much of the filtering and LNA stages are part of the handset device. Simple replacement of the antenna will not alleviate the problem. While it is possible to improve the performance and protection of the GPS receiver through re-designs of antenna to incorporate additional filtering and gain stages, upgrading units already in the field is not practical. Even if such antennas were designed, portable devices are power drain-sensitive. Any improved antenna design will consume more power from the portable device yielding a shorter battery life. Laboratory testing has suggested denial of service radii up to 400 meters are possible for some devices; Live-Air testing verified denial of service radii of up to 140 meters for single frequency (~1552 MHz) LTE operation. This is expected to increase to ~200 meters in the vicinity of dual frequency L-band LTE base station operations. Denial-of-GPS-Service to portable devices represents perhaps the largest concern to the Public Safety market. Officers rely on "Man-Down" signaling for immediate response under life and death situations. In certain circumstances, and officer may be unable to voice their location; GPS tracking is the only backup they may have for rescue or aid.

Cellular Location Service Performance / E911 Calls

The performance of Cellular-based devices does not directly impact the performance of a Public Safety system; however, it does affect the ability of EMS, fire/rescue and law enforcement personnel to respond to an incident. As mentioned in the summary, E911 calls made from cellular telephones and terminals are rapidly overtaking conventional POTS calls to the dispatch center. In some locations, cellular-based E911 calls now exceed 70% of all calls received and that number is expected to continue to increase. Interference to GPS services, particularly location reporting, directly impacts the ability of Public Safety services to respond in a timely manner to received calls. We are therefore concerned with the impact of L-band-based LTE signals on cellular E911 services.

Expected Performance of GPS Systems

Performance of Public Safety Location services are generally more stringent than those mandated for consumer devices / E911 performance. Contractual obligations to equipment manufacturers often place accuracy requirements of 15 meters for delivered equipment; 15 meters is considered to be the maximum acceptable inaccuracy of positioning data for Public Safety systems today. E911 consumer devices such as those incorporated in cell phones are subject to Federal E911 location accuracy performance requirements. Title 47 of the Code of Federal Regulations (CFR 20.18) states that for or handset-based technologies, such as GPS or assisted GPS, the location accuracy of E911 calls placed from cell phones to public safety answering points (PSAP's) will have an accuracy of 50 meters for 67 percent of calls and 150 meters for 95 percent of calls.

Any long term use of L-band terrestrial systems that pose a threat to GPS performance must be able to show that 15 meter accuracy is maintained at any location where GPS service is available.

Extent of Testing to Date; Concern Over Limited Levels of Testing

To date, interference testing has taken 3 forms:

1) Individual equipment manufacturer testing of their own devices under laboratory conditions, conducted and radiated, beginning in Q4/2010;
2) Working Group radiated testing of GPS equipment under laboratory conditions, utilizing calibrated anechoic chambers in three phases:
    a. Precision Timing and Aviation devices (including equipment representative of Public Safety infrastructure equipment),
    b. General Location and Navigation devices (including Public Safety subscriber units);
    c. Cellular industry handset devices.
3) Live Sky testing:
    a. Holloman AFB; testing was not generally open to manufacturers, and,
    b. Las Vegas multi-site testing during a 2 week period in May, 2011.

Testing listed in Item 1, above, was undertaken by a limited number of manufacturers to determine the potential effects of LightSquared L-band LTE signals upon manufactured GPS-enabled devices. Some of these tests are a matter of public record with the FCC.

Testing listed in Item 2 represent the majority of all testing done to date. To its advantage, the repeatability of testing inherent in controlled laboratory conditions allows direct comparison of performance from a cross-section of devices. To its deficit, such testing does not, by design, represent the peak interference levels that may be present in real-world deployment. In an anechoic chamber, reflections are eliminated to the best extent possible. The device under test is illuminated only with the main, incident ray from the emitting antenna. Contrast this to real world conditions where a cellular-based system may illuminate a device with multiple direct and reflected rays as well as from direct and reflected energy from adjacent cells. In addition, time constraints forced limitations upon the total number of devices tested as well as the specific tests that could be performed. Public Safety was allowed to test approximately 50% of the devices originally submitted for evaluation. Similar limitations generally occurred within all product groups submitted to the General Location and Navigation sub-group.

Item 3, Live Sky testing, represents the closest approximation to date of a real-world deployment. Results from Live Sky testing indicate that multiple reflections were present in the received interference levels. To wit, at least one manufacturer of Public Safety equipment observed denial of service radii of just over 600 meters for one class of GPS-enabled mobile computing device and 140 meters for one type of portable radio devices. Contrasted to laboratory measurements where the device was only illuminated with a single, direct ray, the denial of service radii were approximately 350 and 90 meters respectively. The additional contribution of interference energy comes from several sources: The L-band LTE sector bore sight to the device under test provides a direct and, at times, at least one reflected ray. Since the deployed antenna height above ground level of the L-band LTE base station was under 20 meters at one test site, several close-in buildings provided strong reflections that created constructively to the total received power. Furthermore, additional reflections from the adjacent cells from nearby objects, buildings and other contributing structures also added to the total received interference power. At times and at certain locations, peak interference power levels exceeded 3dB above the expected free space path loss for a line of sight signal at 1550 MHz. For this reason, the denial of service radius observed during Live Sky testing at times exceeded that of the laboratory measurements.

In addition, Live Sky testing did not fully exercise the interference environment as would have been the case in a wider scale deployment. Under varying conditions of terrain, multiple sites could simultaneously contribute to the total interference power at the input of the victim device. Testing in the City of Las Vegas was performed over relatively uniform ground level heights for subscriber devices. While a single, high site system was deployed on the Las Vegas Strip, when considered with other deployed sites, of which only one other site was simultaneously active during any given test period, separation distances between sites were not typical of a true deployment scenario. Therefore, total interference power at the victim receiver was not fully representative of an actual deployment although interference potential of a full deployment can be inferred.

One factor to which a communications system is generally designed is the average signal power level delivered to the target receiver. To calculate the link budget of a communications system, several loss factors are taken into account. These include shadow margin, propagation path loss exponent, and a host of other factors. Due to these factors, an additional link margin factor is usually built into the system. When one considers interference to an existing system, however, one must assume the peak power delivered to the victim device; it is the peak interference level that will limit the robustness of the deployed, adjacent service – in this case, GPS. To that end, a cautious approach to deployment of L-band terrestrial LTE is warranted. Deployment, if approved, should take place in stages. While listed in the Mitigation Means section of this submission text, prudent deployment would dictate use of 5 MHz, followed by 10 MHz downlinks at ~1529 MHz. During these first phases of deployment, further controlled testing of potential interference due to LTE emissions at 1552 MHz should be performed if eventual operation at that allocation is contemplated. These tests must include further Live Sky testing under controlled conditions.

Mitigation Means

Mitigation of interference to GPS services from L-band emissions can take several forms; a balanced approach may satisfy the needs of current users as well as expansion of 4G services nationwide. These steps include:

From the equipment manufacturer and GPS equipment professional / Public Safety user:

1) Replacement of infrastructure antennas with High Rejection types;
2) Replacement of mobile antennas, also with High Rejection variants once available, although this can be cost-prohibitive in the moderate term;
3) Long term potential replacement of removable antennas for vehicles (2–5 years) when possible and long term replacement of portable devices (>>5 years in some cases).

From the L-band Terrestrial Service Provider side:

1) Initial operation at 1528 MHz; 5 MHz followed by 10 MHz LTE. Initial tests have suggested that operation at power levels up to +62dBm utilizing either bandwidth profile (5 or 10 MHz) at ~1530 MHz do not negatively impact current Public Safety GPS devices although Working Group test have only been performed at 5 MHz bandwidth to date.
2) Long term (3 – 5 years) it may be possible to deploy base station equipment at ~1550 MHz. This is dependent upon replacement of currently-deployed Public Safety equipment (as well as consumer and other commercial antennas and devices also deployed currently).
3) Sensitivity of Public Safety devices to +23dBm emissions near 1630 MHz (uplink / subscriber devices) must be fully understood. This impact must be addressed.
4) It may also be worth considering use of alternative, staggered downlink allocations in lieu of ~1550 MHz:
    a. LightSquared may have access to 5 MHz of spectrum at 1670 – 1675 on a Nationwide basis; limited by certain Federal exclusionary zones.
    b. Likewise, operation of downlink systems above ~1630 MHz should exhibit similar levels of insensitivity to interference as that of ~1530 MHz.
    c. A double-pass duplexer for the LTE L-band subscriber device could be utilized to receive downlink signals above 1630 and below 1538 MHz. The subscriber devices may be able to utilize ~1550 and ~1630 MHz as uplink channels at power levels of +23dBm. While slightly more difficult to produce than a standard duplexer, it nonetheless should alleviate concerns over interference predicted from the current proposed band plan.

5) It has also been noted that Harbinger, the parent of LightSquared, has bid on S-band spectrum located in the 2 GHz range. If the 40 MHz sought in that band were to be acquired, it could be paired with L-band MSS spectrum; the former utilized for downlink purposes leaving up to 40 MHz of spectrum at L-band for uplink-only purposes. A time-staggered ramp up of frequency use at L-band for uplink channels could insure that much of the current equipment now susceptible to interference would be replaced or retired. Furthermore, since the proposed uplink power is 40dB lower than that of the downlink proposal, any denial of service zones should be minimal although this is yet to be verified.

Conclusions

Theoretical analysis, organized, industry-wide and individual company laboratory testing, and fielded, Live Sky testing has indicated that terrestrial use of L-band allocations near accepted and utilized Satellite Navigation allocations (1559 – 1610 MHz), including GPS, does diminish location accuracy and / or preclude, under certain circumstances, GPS service entirely. Each impacted device will exhibit a denial of service radius. To that end, the critical needs of Public Safety can be addressed by the following statements:

1. With respect to the maximum acceptable Denial of Service distance from a transmitter that Public Safety and associated services would accept:

   Ideally the maxim acceptable denial of GPS service area from any transmitting source should be zero for applications that are in the best interest of the public's safety. After giving careful consideration to the various location dependent applications that exist, denial of service distances greater than 10 meters (or approximately 33 feet) may create occlusion regions where persons wearing court ordered electronic monitoring devices would be undetected. In a dense urban environment where cell site density may be potentially high to meet subscriber capacity, the likelihood of cell site coverage overlap is also high leading to excessively large regions where public safety GPS applications may be degraded. This nominal distance is representative of the distance between a transmitting antenna to ground level if the antenna is mounted on a three-story building in an urban area.

2. The maximum acceptable Time to First Fix (acquisition) Time that Public Safety can accept is best answered by Federal E911 requirements and concerns over the best interest of the public at large:

   Phase II E-911 systems are designed to automatically display a cell phone subscriber's location and call back number to the call taker or dispatcher answering an E911call at a PSAP (Public Safety Answering Point). If a caller is unable to speak or the call is being made from a weak signal area such that the call taker has difficulty in understanding the caller, every second delayed in determining the caller's location may be the difference between life and death. The same applies to Emergency Medical Service (EMS), Fire/Rescue and law enforcement vehicles when they are en route to a scene or transporting patients to the closest available hospitals. Other than delays associated with an initial cold start of a GPS, the time to first fix for public safety applications should be zero.