Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:	)	
	)	
LightSquared Subsidiary LLC	)	IB Docket No. 11-109
	)	
Request for Modification of its Authority for an	)	
Ancillary Terrestrial Component	)	

COMMENTS OF
INFORMATION TECHNOLOGY AND INNOVATION FOUNDATION

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[1] ITIF is a nonprofit, non-partisan public policy think tank committed to articulating and advancing a pro-productivity, pro-innovation and pro-technology public policy agenda internationally, in Washington and in the states. Through its research, policy proposals, and commentary, ITIF is working to advance and support public policies that boost innovation, e-transformation and productivity.

The Information Technology and Innovation Foundation (ITIF) offers the following comments on the FCC's Order and Authorization in the above titled matter. ITIF offers these comments in reaction to the interference testing conducted by the GPS Technical Working Group (TWG), presented as the *Final Report* dated June 30, 2011.[2]

Summary

We believe that the significance of this matter goes far beyond the immediate question of granting LightSquared (LS) the right to operate an ancillary terrestrial component, as it establishes precedent in determining how future rights conflicts between spectrum-based applications and networks will be resolved. The consumer demand for satellite-based two-way communication systems is not as strong as once envisioned, while the demand for terrestrial broadband is intense and growing. It is therefore critical for the Federal government to repurpose satellite spectrum for terrestrial broadband use.

It's reasonable to believe that the FCC will be petitioned several more times in the near future with similar requests to re-purpose spectrum currently assigned to satellite systems to more practical terrestrial systems. For such matters to be decided expeditiously in the public interest, a clear set of guidelines are needed regarding the nature of interference, the costs of mitigation and the timelines for transition.

[2] GPS Working Group, "Final Report", June 30, 2011, http://fjallfoss.fcc.gov/ecfs/document/view?id=7021690471.

The testing that was conducted by the GPS TWG is useful as far as it goes: It establishes that there is an interference problem between both consumer GPS and LS and between High Precision, Timing, and Network (HPTN) receivers and LS. It finds significant problems with existing equipment when the proposed terrestrial LS system operates in the upper 10 MHz segment of the LS allocation, and minor problems when the LS system operates exclusively in the lower 10 MHz. It supports the proposed LS compromise of limiting operation to the lower 10 MHz while exploring device mitigations for the design problems with current consumer equipment that prevent robust operation while the upper 10 MHz of the LS allocation is in use as a terrestrial system.

However, the Final Report is vague on two major counts, as it does not disclose which devices are affected and more importantly, why they're affected. These questions need to be answered in order for spectrum to be put to maximum use, even if the answers are embarrassing to some device manufacturers.

The fact that the TWG performed "black box" tests exclusively (and chose to hide the identity of the devices under test) means that the overall job of characterizing the interference and suggesting mitigation strategies is no more than 25 per cent done, if that. The testing suggests that high precision receiver manufacturers have cut costs by employing a common RF front end for both GPS and the satellite-based StarFire augmentation signals transmitted in the middle of the LS allocation rather than separating the GPS and augmentation receivers behind discrete analog front ends. This design trade-off is responsible for at least some of the interference problems detected by HPTN devices, and the GPS manufacturers have had ample warning that adjacent bands would not forever be assigned to low-power applications. It also finds that some consumer GPS devices lack any filters at all and are needlessly susceptible to a wide variety of environmental noise sources.

Quite correctly, the FCC has asked the GPS Industry Council and LS for additional information regarding the devices tested, the nature of the failures they experienced, and the device effects of limiting LS to the lower 10 MHz of the downlink band.[3] This matter cannot be settled until we understand whether the devices that failed to operate in the TWG's testing experienced failures that can easily be corrected, can be corrected only with great difficulty, or cannot be corrected at all.

Consequently, this is a matter that requires further study. The TWG Final Report obliquely references presentations made by filter manufacturers regarding potential solutions to the receiver saturation problem that is probably at the root of many of the observed problems. Developing a better understanding of both analog and digital techniques that improve inter-channel noise immunity and inter-channel transmitted signal coherence will inform the inquiry and prevent undesirable outcomes for LS and the others who will seek to re-purpose satellite spectrum toward more useful ends.

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[3] Federal Communications Commission, "Re: Request for additional information," Julius P. Knapp to Jeffrey Carlisle and Charles R. Trimble, August 10, 2011.

This understanding will also illuminate which party – LS or the GPS manufacturers – should bear the mitigation expenses, and what sort of timeline is reasonable for phasing in more robust, interference-immune receivers.

High Precision GPS

High precision GPS (HPGPS) uses an augmentation satellite such as StarFire to supplement the basic GPS signal. Starfire uses a frequency band in the middle of the LS frequencies, as illustrated in the following diagram from the John Deere presentation.[4]

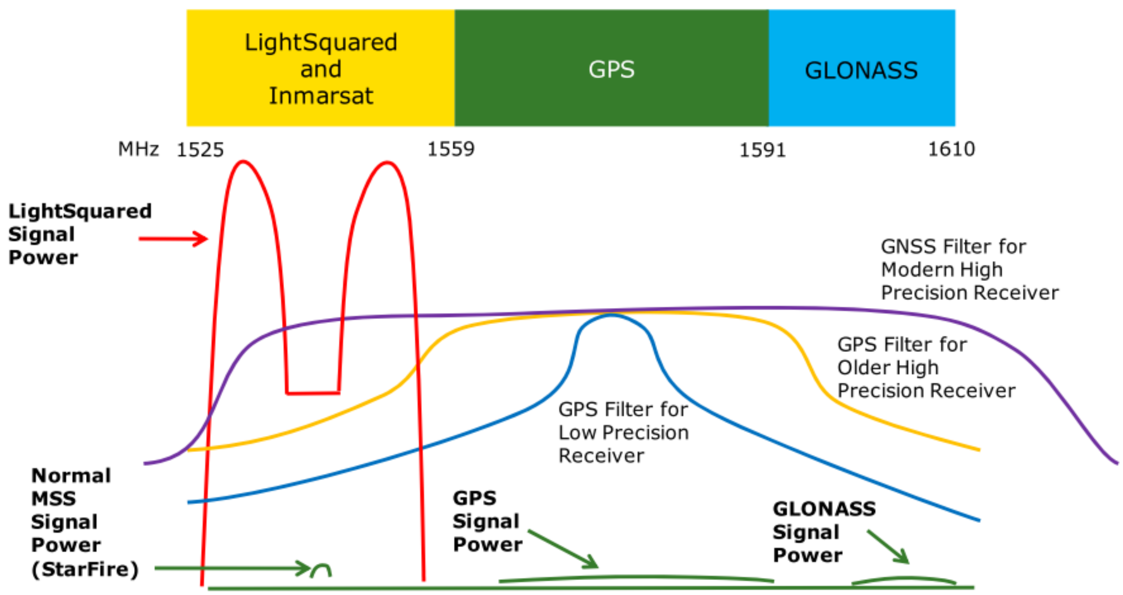

Figure 1: Location of StarFire Augmentation Signal. Source: John Deere

The diagram is not completely accurate, as the noise floor of the LS system is not necessarily higher than the signal peak of StarFire. The problem that arises in a system

[4] John Deere, "LightSquared Interference to GPS and StarFire", May 26, 2011, http://www.gpsworld.com/machine-control-ag/precision-ag/john-deere-lightsquared-interference-report-11713.

such as this one is that the single analog front end receives both the GPS signal and the StarFire signal indiscriminately, as illustrated by the curve labeled "GNSS Filter for Modern High Precision Receiver."

Such a front end will amplify the entire range from StarFire to GPS, including the upper LS band (as well as part of the lower LS band, according to Deere's diagram) unless it's equipped with pre-correlator filters that cancel signals in the intermediate bands.

The result of this amplification is to effectively deafen the receiver to both GPS and StarFire, due to receiver saturation that comes about from the amplification of the LS signal, a signal that can and should be filtered. This sort of saturation can be overcome by separating the analog front end for the StarFire receiver from the front end of the GPS receiver. It can also be overcome with a notch filter across the upper LS frequency, but HPGPS providers have not needed to employ such filters before now as a practical matter.

In other words, the common analog front end amplifies the LS allocation when it should be filtered, a very bad design indeed and one that blatantly violates design guidelines issued by the DoD's 2008 Global Positioning System Standard Positioning Service Performance Standard.[5]

[5] Assistant for GPS, Positioning, and Navigation, "Global Positioning System Standard Positioning Service Performance Standard" (United States Department of Defense, September 2008), http://www.pnt.gov/public/docs/2008/spsps2008.pdf.

Cellular GPS

The Final Report shows that consumer-grade cellular GPS devices are not affected equally by LS operation. Some devices were disabled by narrowband LS operation in the lower 5 MHz, while others were functional when the LS simulation was operational in both the upper and lower 10 MHz bands. This indicates that GPS manufacturers have substantial control over the interference that disables some but not all devices.[6]

Figure 3.2.3 Maximum Tolerable LS Blocker Level: 3GPP/3GPP2 GPS Sensitivity

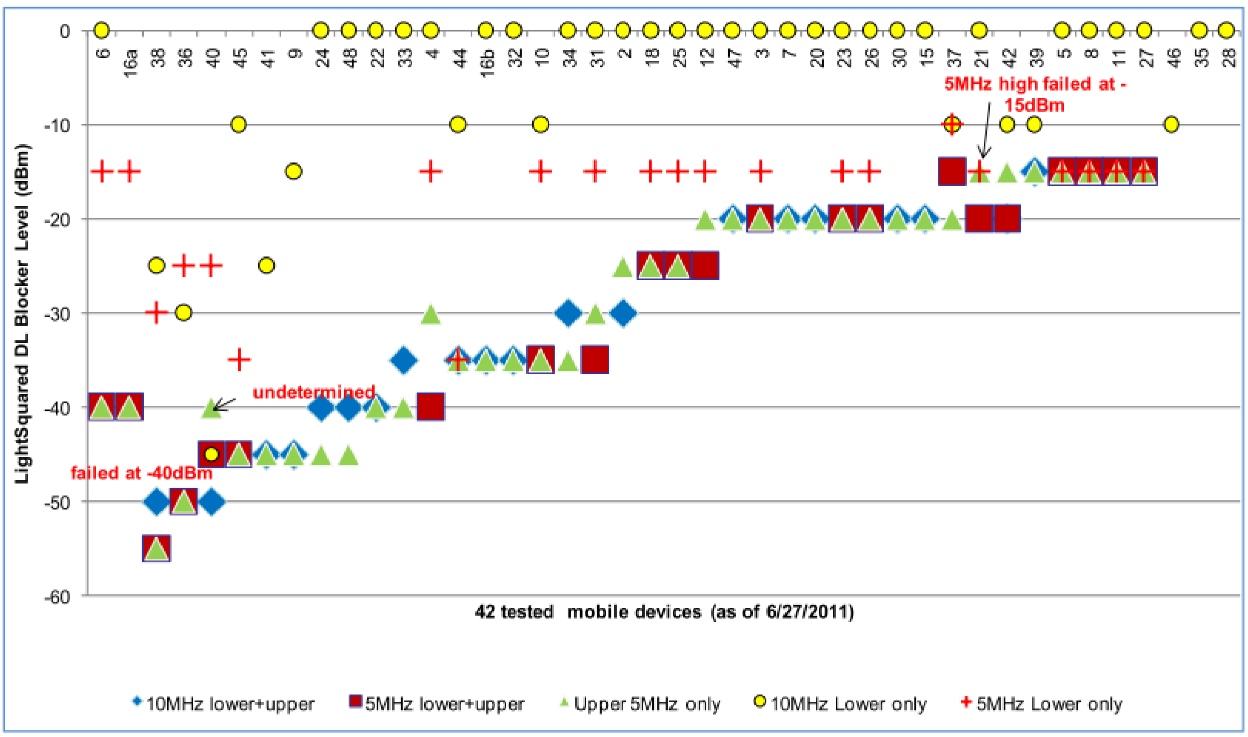

Figure 2: Generic GPS Device Effects. Source: Final Report

As the Final Report indicates, degradation was not uniform:

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[6] GPS Working Group, "Final Report," page 81.

> This data generally shows that testing with LightSquared operations at the higher 5 MHz and 10 MHz band (1550.2 MHz to 1555.2 MHz) caused GPS failure for a significant number of the tested devices. In contrast, when testing in the lower bands (1526-1536 MHz) fewer devices had a level of susceptibility below -15dBm. Please refer to the Tables in Section 3.2.8 above which show the percentages of device susceptibility at various threshold levels. Note that devices that passed above 0dBm were at the maximum level of the test system capability to apply a blocker signal amplitude in CDMA devices, and -10dBm in WCDMA tested devices.[7]

This test and related tests show that degradation effects were not uniform for all consumer devices tested.

The Cellular Sub-Team was optimistic about technology mitigation of observed interference effects in the near future:[8]

> Future cellular devices may have filter technology options available (according to one supplier which made a presentation to the TWG) to further reduce susceptibility to adjacent band signals. While the group wants to ensure it is making no commercial endorsement regarding this or any other company, the largest supplier of cellular GPS chip

[7] Ibid.
[8] Ibid, page 119.

technology, Qualcomm, in its recent FCC report (Appendix C.5) reports existing or new filter technology as a relatively straightforward and low cost remedy for future consumer devices. Quoting from their April 2011 submission, in relevant part:

> *FBAR/BAW based filters may be a potential candidate due to their low insertion loss and high stopband rejection... Filter vendors should be able to assess the feasibility of such solutions and provide a better estimate on the associated cost.*

As in every similar case, this technology while it shows promise needs to be studied for full production viability in large volume, widespread deployments.

In light of these findings, the LS compromise position – to limit operation to the lower 10 MHz band while exploring mitigation to enable operation in the upper 10 MHz band as well – certainly appears reasonable.

General Location/Navigation

Unlike the Cellular Sub-Team, the General Location/Navigation Sub-Team failed to reach consensus on the interpretation of observed test results. One side – the GPS manufacturers (GPSM) – offered sensational claims:[9]

> …LightSquared's discussions of margin and percentage of areas affected are doubly frightening. Not only are they false and misleading,

[9] Ibid, page 124.

> but the mere suggestion that it could be acceptable to cripple some percentage of General Location/Navigation GPS devices—not to mention those used in business sectors such as aviation and agriculture—is unthinkable. In safety of life applications, there is no margin for error and no room for inaccuracy. The GPS service must be preserved – our lives depend on it.

In our experience, no GPS device in operation has ever operated in a completely error-free manner. GPS devices fail for a variety of reasons, lose contact with the GPS satellites under a number of conditions, and have location errors. In addition, navigation instructions are often wrong, sometimes comically so (circular routes.)

This statement is therefore "alarming" and lacking credibility.

The LS language is much less emotional:[10]

> In assessing the performance of legacy devices, LightSquared interprets the results based on definition of harmful interference as a 6 dB change in C/N 0 and a probabilistic propagation model. This analysis shows that 13 devices passed when tested against upper channel configurations and all 29 devices passed when tested against the lower 10 MHz channel configuration. The analysis established that all devices tested against the Lower 10 MHz channel experienced a 6 dB change in C/N 0 only at signal strengths greater than -25 dBM; a signal strength

[10] Ibid, page 125.

> which will occur only in up to 1.2% of LightSquared‘s service area as shown in the maps below.

It’s sound engineering practice to apply probabilistic propagation and noise models to such systems, and to consider 98.8% success as a reasonable goal for interference mitigation for the most poorly-designed legacy devices. Consumer GPS is at best a hit-or-miss system under the best of circumstances today.

The uncooperative tone evident in the GPSM statement quoted above is evident throughout the remainder of the Final Report. GPSM touts a worldwide installed base of a billion devices, but fails to concede that the proposed LS system is a US-only network. GPSM insists on noise margins they don’t have without the LS system, and they refuse to concede that low-cost consumer GPS devices are routinely replaced and recycled. They characterize the engineering simulations of proposed new filters as “mere conjectures of what might be possible” when such simulations are a vital and important part of the engineering design process.[11] This is akin to dismissing gravity as a “mere theory.”

Once again, the LS statement is much more credible:[12]

> Both Avago and Taiyo have provided convincing evidence that at least 40 dB additional rejection of LS signals could be created at frequencies less than 1555 MHz and greater than 1626.5 MHz. The minor resulting

[11] Ibid, page 178.
[12] Ibid. page 179.

degradation in sensitivity (typical of new filters using BAW technology and offering the targeted additional rejection, c.f. Appendices G.4 and G.5) is not operationally perceptible in the field. The General Navigation equipment manufacturers have not provided any concrete evidence that it is. LightSquared is aware that other vendors, who declined to participate in the TWG process, have also performed this evaluation with similar results. The filter vendors have stated that the performance realized with physical samples is usually quite close to that predicted by simulations – there is no reason to believe that that would not be true in the present case.

Consequently, the overall LS interpretation of the data collected by the General Location/Navigation Sub-Team is more credible than that of the GPSM.

It will be possible to fit future consumer GPS devices with noise filters, just as the better ones are so equipped today. The use of proper filtering may very well improve the overall reliability of GPS in comparison with its present state, with or without the LS network.

Open Issues

Testing has identified significant compatibility problems between the proposed LS system and legacy GPS devices of both the consumer and high-precision variety. Test results suggest but do not prove conclusively that consumer device effects are largely caused by inadequate filters. More work needs to be done in terms of direct device-to-device comparisons to determine the root cause of the interference effects observed in some devices but not in others.

Testing has also indicated that the high-precision GPS problem is also device-related, but in a more subtle way. The StarFire system occupies the middle of the LS frequency band, and this location causes problems in its own right. One possible mitigation for high-precision GPS is a spectrum swap between LS and Starfire, such that StarFire is moved to the upper portion of the LS allocation, and LS is reassigned to a contiguous band of frequencies spanning the range from its current lower 10 MHZ to the new location for StarFire. GPSM comments on this plan:[13]

> For augmentation signals received from satellites in the MSS band, it may be conceivable to design a satellite receiver that operates in the highest part of the MSS band and not be interfered with by LightSquared signals in the lower part of the MSS band, although this will require further work to verify. Should that be the case, it would require migrating all US augmentation services to the highest part of the MSS band, and would make any US solution incompatible with international equipment, which operate over the entire MSS band. The GPS Community has identified no prospective augmentation solution that exists for the installed base.

This approach needs to be investigated.

[13] Ibid, page 294.

Conclusion

The LightSquared/GPS testing presented in the Final Report is good first step, for the most part, toward characterizing and resolving interference concerns. LS for its part has proposed a step forward that will enable it to begin operation in the lower 10 MHz of its assigned spectrum while exploring additional measures that will ultimately permit it to operate over 20 MHz of spectrum overall.

Additional testing is needed to determine the causes of legacy GPS device failures and best engineering practices for future GPS devices.

A number of spectrum swap and reassignment measures have been proposed, each of which also needs to be explored. It appears that many, but not all, of the problems with existing GPS devices are the result of poor engineering practice and failure to abide by DoD directives on noise immunity. Additional testing can determine the extent to which this is the case.

It's important to resolve this matter in such a way as to facilitate future reallocation of spectrum currently assigned to satellite services to terrestrial ones, even if a portion of the legacy installed base of low-cost GPS devices is impacted.