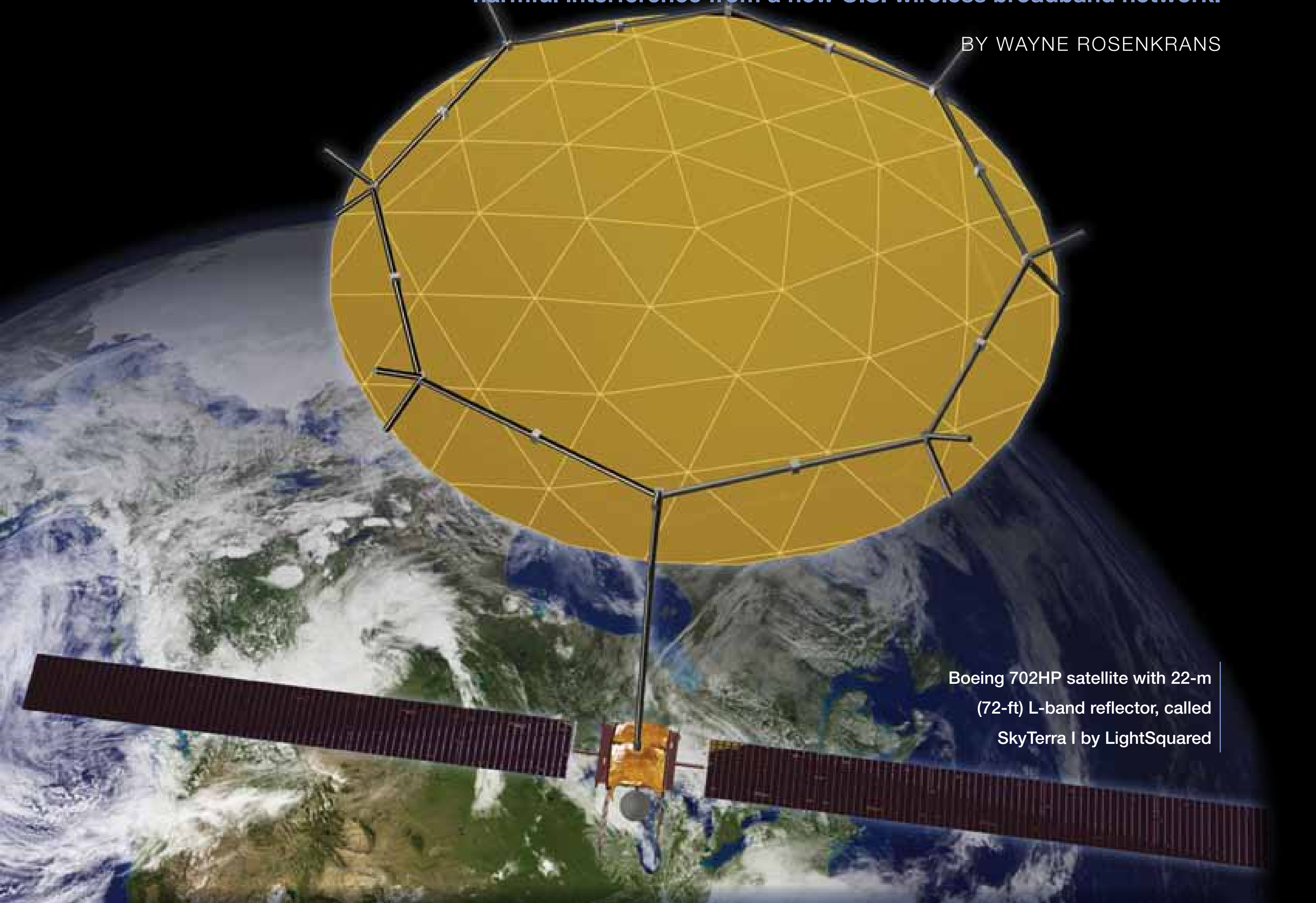
LightSquared on Track

GPS specialists race the clock to resolve concerns about harmful interference from a new U.S. wireless broadband network.

BY WAYNE ROSENKRANS



Boeing 702HP satellite with 22-m (72-ft) L-band reflector, called SkyTerra I by LightSquared

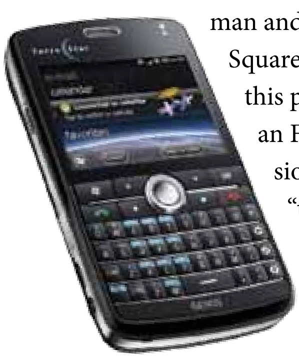
By June 15, U.S. aviation industry leaders, manufacturers of global positioning system (GPS) receivers,[1] a mobile satellite service (MSS) company and the federal government expect a joint work group's final report to break through a 5-month-old legal and technical impasse. The unresolved question is whether the wireless broadband network now being built by LightSquared Subsidiary[2] — the first of its kind to blend satellite-based mobile communication with terrestrial base stations sharing satellite frequencies — will cause any harmful interference to GPS receivers.

LightSquared has its new satellite ready for full operation in geostationary orbit and base stations under construction to launch this network, possibly within a few months, offering nationwide digital voice, video and data at broadband Internet speeds. Designed to be sold on a wholesale basis to partner companies, these services will accommodate smartphones, tablet computers and other portable devices. The system provides the option to users to communicate only via 40,000 cellular-like base stations while their mobile devices are in range, only via satellite while anywhere in the country, or both ways, with one mobile device and telephone number.

In LightSquared's MSS ancillary terrestrial component (ATC) design, its satellite operating in the L-band[3] can be configured with a large number of high-gain multiple-beam antenna patterns, with each beam providing coverage to a specific circular area on the ground. Beams on separate frequencies can overlap, or more than one satellite can transmit on the same frequency if there is sufficient geographic separation in the beams on the ground.

LightSquared has provided MSS since 1996 but never before offered terrestrial service using its MSS ATC authority. The company has committed to the U.S. Federal Communications Commission (FCC) to initially cover 100 percent of the U.S. population with its satellite and, in phases, at least 260 million people in the United States by the end of 2015 with LTE (long term evolution), the name of a fourth-generation (4G) radio technology for mobile telecommunications networks.

Only six months ago, company officials considered external concerns about their system's effect on GPS receivers important to acknowledge but basically outdated because of protections built into the design of the network, FCC public records show. But by the end of April, Sanjiv Ahuja, chairman and CEO of LightSquared, reframed this perspective to an FCC commissioner, saying that "the company's goal [is] to work for the coexistence of a new, competitive wireless network and a robust GPS system" during a meeting about progress toward implementing the new network and cooperation with the GPS industry.



The FCC — which on Jan. 26 granted authority to LightSquared to operate this network through a conditional waiver of one element of FCC rules — has the responsibility to decide how effectively GPS-related concerns have been addressed.

While the FCC conducts the current LightSquared proceeding in its role as regulator, it also leads implementation of the federal government's 10-year *National Broadband Plan* to reallocate many portions of the U.S. radio frequency spectrum long dedicated to MSS. A key goal is to create affordable Internet access nationwide through wireless broadband technology. As a regulator responsible for public safety, the FCC — with advice from the National Telecommunications and Information Administration (NTIA) — has noted since 2003 that emissions from MSS ATC would have to be "carefully controlled to avoid interference with GPS receivers."

The U.S. GPS Industry Council, a trade association working with the Air Transport Association of America (ATA) and other aviation organizations, worked to persuade the FCC to require further study of potential interference.

LightSquared expects to use its allocated MSS L-band frequencies for ATC base stations and for mobile devices. These MSS frequency bands "bracket" the band used for the L1 GPS signal. Many experts have urged caution, predicting a grave risk of overloading and/or desensitizing safety-critical receivers that turn GPS signals into useful positioning, navigation and timing data.

The L-band of the spectrum is one of only three MSS frequency bands also capable of supporting broadband service, said the FCC.[4] The portion of the L-band allocated to LightSquared comprises 1525–1559 MHz and 1626.5–1660.5 MHz. GPS receivers operate in the adjacent 1559–1610 MHz band (Figure 1).

One example of a system-level concern came from Lockheed Martin, which operates two regional positioning service satellites integral to the U.S. Federal Aviation Administration's (FAA's) wide area augmentation system (WAAS). On Feb. 25, the company urged the FCC to withhold all authority for LightSquared to begin operating MSS ATC service "until the FCC is able to determine that the new service can be provided compatibly with radio navigation satellite services in the L1 band and under what specific conditions."

Earth stations that uplink the signal to these satellites depend on an extremely sensitive GPS/WAAS receiver with a much higher-gain antenna than those common in aviation GPS receivers, said Jennifer Warren, vice president, technology policy and regulation, Lockheed Martin. "If signal reception is disrupted, these antennas will be unable to perform a safety-critical function to uplink the proper [WAAS] signal for broadcast from the regional positioning service satellites' L1 signals." This erroneous broadcast would not be detected immediately by normal methods but quickly would trigger a WAAS shutdown if there were no WAAS backup, she added.

Current Proceeding

The FCC's waiver conditions have shifted the adversarial interactions of this proceeding into a cooperative and constructive mode. This mode was facilitated by LightSquared's agreement to convene an expert technical team, called the LightSquared Work Group (Table 1, p. 34, and Table 2, p. 35), "to study fully the potential for overload interference/desensitization to GPS receivers, systems and networks."

LightSquared had considered its waiver request as "a minor modification to its license" to operate an MSS ATC network, said Jeffrey Carlisle, the company's vice president, regulatory affairs and public policy.

A series of interactions and agreements since 2001 with the GPS and aviation industries also persuaded LightSquared that mitigation of harmful interference to GPS receivers was a settled issue by 2010, he said. Moreover, plans for a wireless broadband network based on MSS ATC — including its scale and frequency re-use plan — had been widely known since 2003, yet further concerns were not raised by representatives of the GPS or aviation communities during other FCC proceedings between 2003 and late 2010, Carlisle added.

"No party objected [previously to FCC] approval of LightSquared's business plan either initially or on reconsideration," he recalled. In November 2010, he had said that "concerns raised by some parties regarding the coordination with GPS operations are irrelevant to this proceeding and should be resolved through collaborative processes among the interested parties that are already in place" in light of protective measures already required by the FCC.

The following month, Fred Campbell, president and CEO of the Wireless Communications Association International, said that many industry groups and the FCC were unprepared for the full implications and scope of the LightSquared network. "Until LightSquared's recent proposal, the deployment in the L-band of 40,000 terrestrial base stations using the LTE air interface was not contemplated by the [FCC]," Campbell said. Even the prior FCC decisions did not "expect an MSS ATC licensee to deploy 40 million mobile devices," he said.

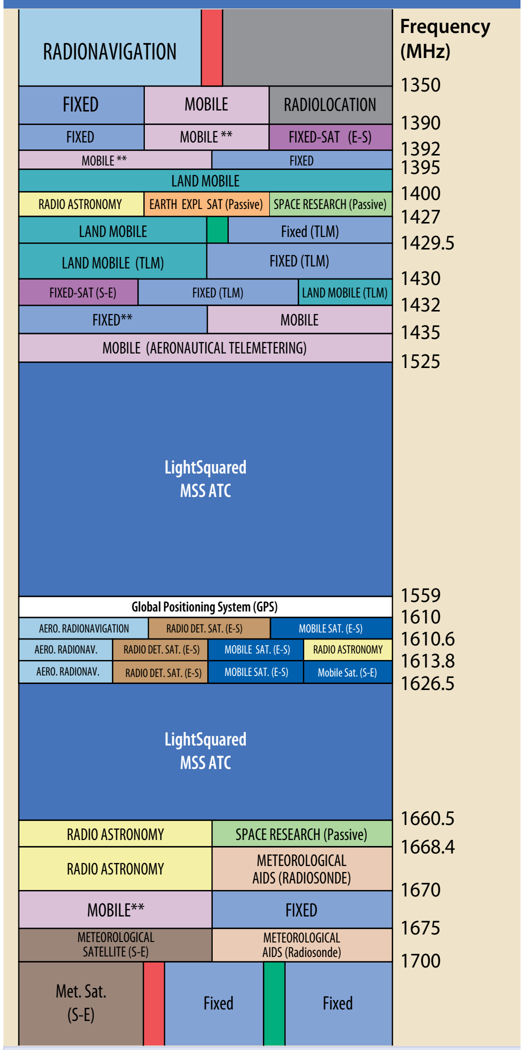
This year, Kris Hutchison, president of Aviation Spectrum Resources, a communications company serving the air transport industry, noted on March 29 that LightSquared may have misinterpreted the aviation and GPS industries' silence on MSS ATC between 2003 and 2010.

"Participation in proceedings that occurred years ago and addressed interference arising from a markedly different deployment scenario … does not resolve concerns that arise from the current interference environment between more sophisticated and extensive GPS and ancillary terrestrial component operations," Hutchison said.

For example, existing FCC regulations on MSS ATC — such as separating base stations from airport runways, taxiways, aprons and takeoff and landing flight paths by at least 190 m (623 ft) — originally resulted from concerns about interference to the satellite communication transceivers aboard aircraft, an issue raised in 2003 by The Boeing Co.

In explaining its conditions for the waiver, the FCC noted that in addition to concerns renewed by the private sector, the federal government's NTIA had submitted concerns about "the potential for adverse impact of mobile satellite service/ancillary terrestrial component operations in the L-band on GPS and other global navigation satellite system receivers."

LightSquared Neighborhood: Subset of U.S. Radio Frequency Allocations



ATC = ancillary terrestrial component; LightSquared = LightSquared Subsidiary; MSS = mobile satellite service

Note: Current spectrum allocations discussed in this article for LightSquared and GPS have been overlaid on a small fraction of the October 2003 *U.S. Frequency Allocation Chart,* available at <www.nti.doc.gov/osmhome/allochrt.html>. They show only relative position and are not to scale.

Source: U.S. National Telecommunications and Information Administration; U.S. Federal Communications Commission

Figure 1

Work Group Testing

Analysis of interference to GPS receivers involves consideration of factors such as the number of GPS satellites available, the received signal strength of the GPS signal, whether GPS receivers have an obstructed or clear view of the sky, LightSquared's terrestrial broadband signal strength, and distance of the GPS receiver from the terrestrial wireless broadband transmitter, either a base station tower or handset, according to the FCC.

The concept behind most testing is to provide an interfering set of simulated signals at the LightSquared downlink and uplink frequencies in the presence of a controlled set of simulated GPS L1 and L2 signals, with varying signal-power levels and varying numbers of satellites, including WAAS signals for some tests. Unlike earlier preliminary tests by individual companies, the emulated LightSquared signals are amplified and filtered using proprietary transmit filters provided by LightSquared.

To support this testing and analysis, LightSquared also has been providing technical details of its equipment, channelization plan, output power, out-of-band emission characteristics and emissions mask for its MSS ATC network.

The Work Group's April 15 report to the FCC details progress so far, and tables in this article focus on its Aviation Sub-Team, which is studying the risk of harmful interference to GPS receivers common in commercial aviation. Six other sub-teams also are conducting tests and analysis on other categories of GPS receivers.

"LightSquared plans in all three phases [of network deployment] to operate base stations at least 4 MHz away from the GPS band at 1559 MHz," the

Assessing Risk of Harmful Interference by LightSquared Emissions to GPS Receivers in Commercial Aviation

Test Site/Laboratory	Test Description and Methods	Scope and Objectives
Conducted Emissions Testing (under way as of mid-April)		
Zeta Associates Fairfax, Virginia This laboratory testing is similar to that required in the United States to certify on-ground and airborne GPS aviation receivers. However, newly written minimum operational performance standards are being provided by a working group of the RTCA special committee dedicated to GPS issues.	Emulated LightSquared satellite signals are being combined with simulated GPS/WAAS signals and fed into the receiver input port for the devices under test. "The emissions represent the output of the antenna unit and cabling designed for each tested receiver, including the effects of antenna filtering, low noise amplification and all incurred losses of signal," the TWG said.	For airborne GPS receivers, the testing follows procedures from RTCA standards. However, a variation of these procedures called "signal tailoring" adds the emissions anticipated from LightSquared base stations, the ancillary terrestrial component of the company's mobile satellite service, to the interference test environment.
Radiated Emissions Testing Within Anechoic Chamber (completed as of mid-April)		
USAF White Sands Missile Range, New Mexico Radiated emissions testing within an anechoic chamber has been performed using a test plan developed by a team led by the USAF GPS Directorate and approved in March 2011 by the directorate's chief engineer.	Simulated GPS signals were broadcast by one antenna within the facility, and emulated LightSquared base station signals were broadcast by another antenna. Aviation GPS receivers were located within one area of the chamber, connected to appropriate antennas, and the outputs of the receivers were logged as the LightSquared signal levels were varied.	The FAA has not yet determined the extent to which USAF results for these non-military aviation GPS receivers will be made available to the TWG for possible use in the final LightSquared Work Group report to the FCC by June 15, the TWG said.
Live Sky Radiated Emissions Testing (still pending as of mid-April)		
USAF Holloman Air Force Base, New Mexico (Expected flight phases and operational scenarios for these "live sky" GPS receiver tests appear in Table 2.)	Upon test plan approval, testing will be performed by FAA personnel and contractors in the vicinity of an actual LightSquared base station installed at this military base.	In some scenarios, aviation GPS receivers would be located in an aircraft on the ground, and their outputs would be logged as the LightSquared signal levels vary. In other scenarios, the same receivers would operate in flight around the LightSquared base station.

FAA = U.S. Federal Aviation Administration; FCC = U.S. Federal Communications Commission; GPS = global positioning system; LightSquared = LightSquared Subsidiary; TWG = LightSquared Technical Working Group; USAF = U.S. Air Force; WAAS = wide area augmentation system

Notes: The LightSquared Technical Working Group reported that in early 2011, FAA-funded laboratory testing by Zeta Associates would assess selected GPS position, navigation and timing devices for harmful overload/desensitization interference from components of the planned LightSquared satellite-terrestrial wireless broadband network. The devices are the Canadian Marconi GLSSU 5024; Garmin 300XL, GNS 430W and GNS 480; Rockwell Collins GLU–920, GLU–925 and GNLU–930 multimode receivers; Symmetricomm timing card (used for an FAA automation system); WAAS NovAtel G–II ground reference station; and Zyfer timing receiver (used for the WAAS ground network). The receiver list and test methods are subject to change.

Source: Joint reports to the U.S. Federal Communications Commission by LightSquared and the U.S. GPS Industry Council

Table 1

Live Sky Operational Scenarios Using Aircraft at Holloman Air Force Base

Flight Phase/Type of Field Test	Flight Conditions and Test Elements
En route GPS acquisition	The aircraft would be in level flight at 18,000 ft above ground level (AGL) using normal en route GPS-based navigation for a sufficient time to have up-to-date satellite ephemeris data, stored position, velocity and receiver clock bias/drift information, the TWG said, noting, "Normal navigation is then somehow interrupted for a short time (e.g., by a momentary aircraft power failure) and the receiver must re-establish navigation by a full 'warm-start' GPS-signal acquisition."
En route tracking/data demodulation	The aircraft would be in level flight at 18,000 ft AGL using GPS and WAAS satellite signals. Usability of WAAS signals for integrity and error correction depends on the aircraft position being within an area covered by WAAS ground reference stations. "Certain components of total radio frequency interference vary as a function of location (e.g., [GPS] self-interference, terrestrial radio frequency interference)," the TWG said.
Terminal area tracking/data demodulation	The aircraft would be in level flight with its GPS receiver antenna at an intermediate value between the en route and Category I precision approach scenarios, the TWG said. The airborne GPS antenna height is 1,756 ft (535 m).
Nonprecision approach tracking/data demodulation	RTCA-recommended GPS test procedures call for 100-ft (30-m) obstacle clearance surface distance (i.e., to the LightSquared base station as the closest possible obstacle and source of potential interference) with the Category I airborne antenna gain pattern below the aircraft.
Category I precision approach tracking/ data demodulation	RTCA-recommended GPS test procedures call for a 97-foot (30-m) obstacle clearance surface distance and a 175-ft (53-m) AGL antenna height for the GPS receiver.
Category II/III precision approach tracking/ data demodulation	RTCA-recommended GPS test procedures call for a 70-ft (21-m) obstacle clearance surface distance and an 85-ft (26-m) antenna height for the airborne GPS receiver. Such operations "require a Category II/III [ground-based augmentation system] to be installed at the airport," the TWG said.
Surface acquisition and tracking/ data demodulation	The aircraft would be at the gate or taxiing, and the antenna height of the aircraft GPS receiver would be 4 m (13 ft), a nominal height for a regional or business jet. The aircraft would be stationary or taxied slowly. The GPS receiver signal tracking and acquisition would be tested.

GPS = global positioning system; LightSquared = LightSquared Subsidiary; TWG = LightSquared Technical Working Group; WAAS = wide area augmentation system

Note: The National Space-Based Positioning, Navigation and Timing Systems Engineering Forum <www.pnt.gov/interference/lightsquared> will complete related studies by May 31.

Source: Joint reports to the U.S. Federal Communications Commission by LightSquared and the U.S. GPS Industry Council

Table 2

report said, offering a hint about types of mitigations that may be in the works.

The Aviation Sub-Team also is focusing on base station carrier frequency configurations that "have the potential to create third-order intermodulation products [that is, spurious signals overlapping GPS signals] that may fall within the GPS L1 band," the report said.

Giving a sense of how the LightSquared proceeding and wireless broadband pressures ultimately may influence GPS, the FCC said in March: "We emphasize that responsibility for protecting services rests not only on new entrants but also on incumbent users themselves, who must use receivers that reasonably discriminate against reception of signals outside their allocated spectrum. In the case of GPS, we note that extensive terrestrial operations have been anticipated in the L-band for at least eight years. We are, of course, committed to preventing harmful interference to GPS, and we will look closely at additional measures that may be required to achieve efficient use of the spectrum, including the possibility of establishing receiver standards relative to the ability to reject interference from signals outside their allocated spectrum."

To read an enhanced version of this story, go to <flightsafety.org/aerosafety-world-magazine/april-2011/lightsquared>.

Notes

1. The term "GPS receiver" has been used generically for various types of devices under test.
2. "LightSquared Subsidiary" encompasses the firm's most recent predecessor company names, Mobile Satellite Ventures and SkyTerra Communications.
3. The L-band is a general designation for frequencies from 1 GHz to 2 GHz. In the United States, the FCC has allocated L-band spectrum for mobile satellite service downlinks in the 1525–1544 MHz and 1545–1559 MHz bands and for mobile satellite service uplinks in the 1626.5–1645.5 MHz and 1646.5–1660.5 MHz bands.
4. Other companies authorized by the FCC to provide MSS ATC services are Globalstar, the DBSD North America subsidiary of ICO Global Communications, and Terrestar Networks, according to the federal government's *National Broadband Plan*.