TECHNICAL EXHIBIT FOR EXPERIMENTAL LICENSE APPLICATION
File #: 0742-EX-PL-2014
Submitted: October 20, 2014

Overview

In a recent petition for rule making (currently the subject of a Notice for Proposed Rulemaking: RM-11685), Globalstar outlined a unique new terrestrial application for Mobile Satellite Service (MSS) spectrum. The proposed Terrestrial Low Power Service (TLPS) would use 11.5 MHz of Globalstar S-Band spectrum paired with approximately 10 MHz of upper ISM spectrum to effectively enable the previously unusable 802.11 Channel 14 as a managed wireless service offering. This proposal is significant, since TLPS would mean a fourth orthogonal 802.11 channel in the extremely overcrowded and interference limited 2.4 GHz band. Most importantly, it is anticipated that licensed control of TLPS will permit the service to achieve and maintain extremely high spectral efficiencies.

The proposed research and experimental efforts will seek to determine the device performance requirements of carrier grade TLPS service, the implementation and network management techniques that achieve high spectral efficiencies, and the types of passive filtration and active modulation techniques that permit TLPS devices to comply with anticipated regulatory standards.

Description of Proposed TLPS Service

The IEEE 802.11 standard specifies fourteen (14) 22 MHz channels in the 2.4 GHz band. These channels occupy spectrum in the range of approximately 2401 – 2495 MHz. Channels 1 through 13 have a 5 MHz center frequency of channel separation, with Channel 14 having a 12 MHz center frequency of channel separation. This channel configuration results in four (4) effectively non-overlapping 2.4 GHz 802.11 channels (*see* Figure 1).

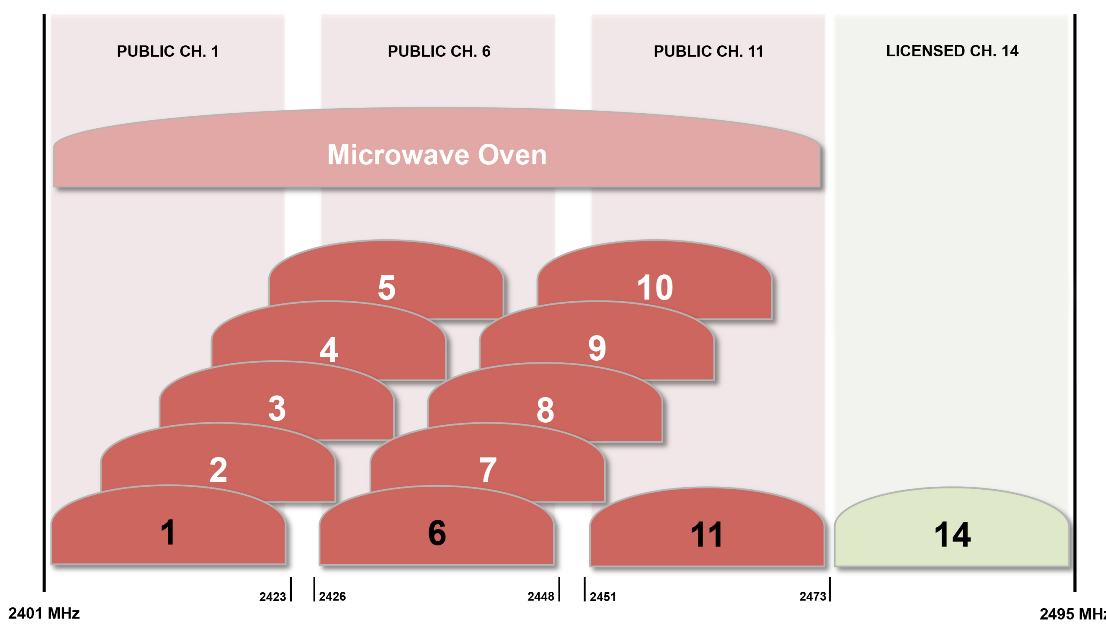

Figure 1: 802.11 Channelization – The IEEE 802.11 standard specifies 14 channels in the 2.4 GHz band. These channels have a 5 MHz separation (except for Channel 14, which has a 12 MHz separation). In the United States, only channels 1-11 are authorized for unrestricted Part 15 operation. The spectral masks of Channels 12-14 extend outside the ISM band and into Mobile Satellite Service (MSS) spectrum above 2483.5 MHz.

While 802.11 was conceived by the IEEE to take advantage of Part 15 unlicensed operation in the 2.4 GHz Industrial, Scientific, and Medical (ISM) Band, both the frequency span and Out of Band Emissions (OOBE) limits imposed on the ISM Band precludes unlicensed operation of all 802.11 specified channels. The 2.4 GHz ISM allocation terminates at 2483.5 MHz, with emissions in the 2400 – 2483.5 MHz band being subject to attenuation equivalent to 50 + 10 log (P) dB of conducted output power at 2483.5 MHz (*see* Part 15.249(d)). This strict OOBE limit prohibits full power (30 dBm conducted output power, *see* Part 15.247(b)(3)) use of 802.11 Channels 12 (2456 – 2478 MHz) and 13 (2461 – 2483 MHz), while the band termination prohibits any use of Channel 14 (2473 – 2495 MHz) (*see* Part 15.205).

Strict OOBE limits associated with the ISM band termination are critical to the protection of Mobile Satellite Service (MSS) operations above 2483.5 MHz from uncoordinated terrestrial interference. However, the presence of these "edge of band" attenuation limits effectively create an 11 channel unlicensed 802.11 service in the United States, which terminates at 2473 MHz. This leaves more than 10 MHz of the upper 2.4 GHz ISM Band that is unusable by unlicensed broadband applications. In extensive spectral studies conducted throughout selected Metropolitan Statistical Areas (MSAs), only extremely low power and frequency agile Bluetooth emissions are commonly observed above 2473 MHz (*see* Figure 2).

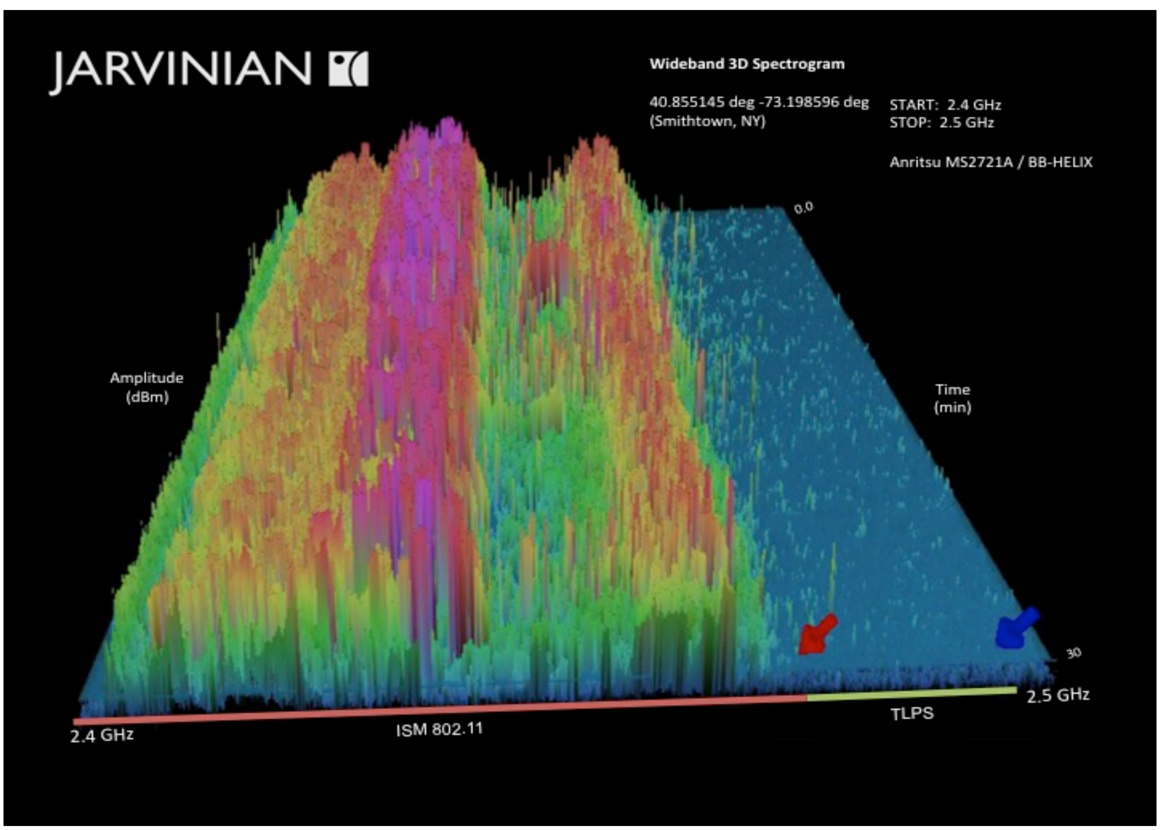

Figure 2: 3D Spectrographic View of 2.4 GHz Band – An 802.11 enabled TLPS will straddle the Big LEO MSS terrestrial band (2483.5 – 2495 MHz) and a generally unused portion of the upper ISM band (2473 – 2483.5 MHz). In most environments, MSS terrestrial spectrum exhibits extremely low interference levels, while the upper ISM band contains only transient low power Bluetooth emissions.

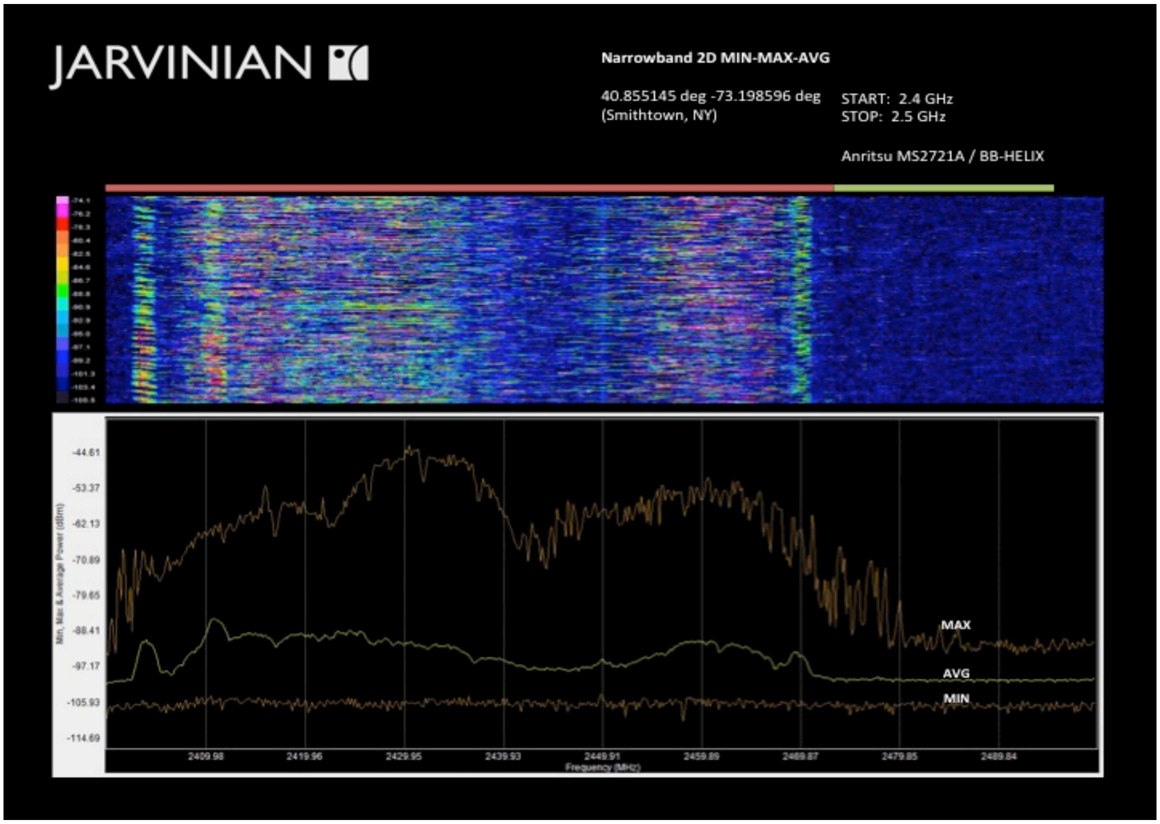

Figure 3: 2D Spectrographic View of 2.4 GHz Band – Severe 2.4 GHz ISM Interference – A 2D Min / Max / Average version of Figure 12, the distribution of energy across the public 802.11 band may be seen more clearly. An ordinary laptop may detect 50-75 discreet public channel APs in this environment.

A Terrestrial Low Power Service (TLPS) contemplates use of IEEE 802.11 Channel 14 as a controlled broadband service that will operate at standard ISM power limits as defined in Part 15 (30 dBm maximum conducted output power / 36 dBm maximum Effective Radiated Power (ERP)). This service will occupy 11.5 MHz of terrestrially authorized MSS spectrum and approximately 10.5 MHz of upper ISM spectrum.

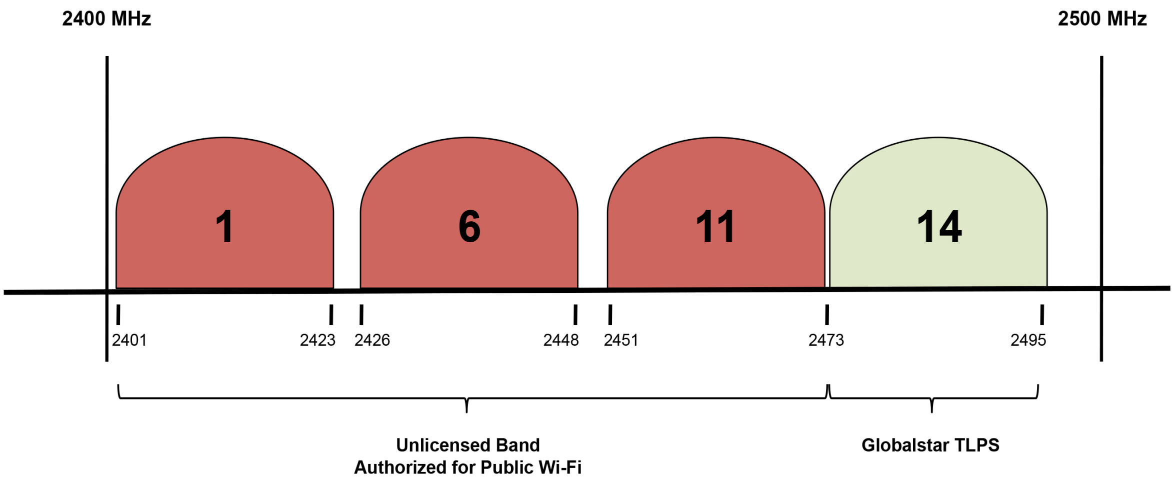

Figure 4: Channel 14 as Fourth Non-Overlapping Channel – Channel overlap in the IEEE 802.11 specification means that the overwhelming majority of 802.11 access points operate on Channels 1, 6, and 11. Thus, due to the extreme prevalence of unlicensed 802.11 activity, these three channels are highly compromised by the effects of co-channel interference. TLPS will liberate a fourth non-overlapping 802.11 channel, which will maintain low-interference and high spectral efficiency characteristics as a managed service offering.

Employing Channel 14 in the IEEE 802.11 specification to enable TLPS will create a number of unique advantages. These include:

(a) Broad and Immediate Ecosystem – 802.11 compliant hardware is already capable of utilizing Channel 14 with a device firmware modification. This means that TLPS will benefit from a substantial existing ecosystem, which can be utilized almost immediately.

(b) Use of Fallow Upper ISM Spectrum – TLPS permits a largely unusable portion of the ISM spectrum to be rapidly utilized in a manner that will protect critical MSS functionality through management of terrestrial interference.

(c) High Broadband Capacity – A majority of mobile device data connectivity already occurs on the three interference prone non-overlapping public 802.11 channels (1, 6, and 11). A managed fourth non-overlapping channel will expand upon the already high spectral efficiency of ISM based 802.11 connectivity, adding significant additional broadband capacity.

Research and Experiment Equipment

The proposed research and experiment program will use existing 802.11 compliant devices, such as tablets, smart phones, and other devices with 2.4 GHz 802.11 transceiver chipsets. The program will also use existing 802.11 compliant access points. In all cases, firmware modifications to the transceiver will enable operation of 802.11 Channel 14. Also, in all cases, conducted power output will not exceed 30 dBm and ERP will not exceed 36 dBm.

General Research and Experiment Objectives

(a) Determine the precise noise and interference characteristics present in the 2473-2495 MHz band - Passive RF surveys of Channel 14 (2473-2495 MHz) will be conducted in the test environment for the purposes of understanding baseline noise and interference characteristics in this portion of S-Band spectrum.

(b) Determine the efficacy of the TLPS application - 802.11 Channel 14 will be enabled in commercial-off-the-shelf (COTS) devices and access points and a series of SNR and effective bit throughput tests on Channel 14 and other orthogonal 802.11 channels will be conducted in the test environment. The relative range, speed, and service quality of Channel 14 vs. public ISM 802.11 channels will be evaluated.

(c) Determine basic methods for control of TLPS operation - A rudimentary network operating system (NOS), which is equivalent to that employed in CMRS femto-cellular applications, will be enabled. This NOS will control TLPS co-channel interference through coordination of conducted output power levels and antenna radiation patterns.

(d) Determine the potential for TLPS regulatory compliance with existing devices - 802.11 Channel 14 will be enabled in existing low power devices (e.g. tablets and smart phones). The spectral regrowth characteristics of Channel 14 will be studied and power control / pulse shaping techniques applied to determine the maximum conducted output power where practical devices are in compliance with anticipated out of band emissions (OOBE) rules.

Research and Experiment Objectives Specific to this License Application

(a) Determine the efficacy of TLPS for outdoor small cell use in diverse semi-urban environments.

Outdoor 802.11 deployments present a compelling opportunity for cable operators and other networks that can utilize access to backhaul and rights of way across a large geography. In their most ideal embodiment, outdoor 802.11 access points may act as small cells with high QoS and spectral efficiency. Unfortunately, however, practical outdoor 802.11 deployments often fall far short of carrier expectations. At 2.4 GHz, interference limitations restrict channel availability and reduce effective bandwidth and range. Conversely, at 5 GHz, high attenuation rates limit propagation distance and effective range. The result is a very small 5 GHz layer that cannot uniformly cover outdoor environments and a comparatively broad 2.4 GHz layer that cannot reliably deliver high-speed connectivity.

The proposed experiment will evaluate the impact of TLPS spectrum on outdoor 802.11 deployments. Specifically, this experiment will evaluate:

- The effective range of outdoor 5 GHz 802.11 systems (U-NII-1/2/3, ISM) in diverse environments
- The effective range of outdoor 2.4 GHz 802.11 systems (ISM Band)
- The effective range of outdoor TLPS 802.11 systems

(b) Determine the efficacy of TLPS for latency intolerant / high priority applications.

Licensed wireless services are often characterized by careful resource and network management. This is especially true when the targeted application is latency intolerant or requires high uptime reliability.

In unlicensed 802.11 networks, uneven latency, data rates and uptime are considered normal. For many data applications, this is acceptable, if sub-optimal. However, for any service that is either real-time or critical to safety, the unpredictability of public spectrum resources is highly disadvantageous. For all the convenience of public 802.11 connectivity, the efficacy of real-time functions like IP telephony and critical functions like medical monitoring are impossible to guarantee on unlicensed spectrum.

The proposed experiment will evaluate the impact of TLPS spectrum on latency intolerant / high priority applications. Specifically, this experiment will evaluate:

- The application reliability of latency intolerant applications using 5 GHz 802.11 connectivity
- The application reliability of latency intolerant applications using public 2.4 GHz 802.11 connectivity
- The application reliability of latency intolerant applications using licensed 2.4 GHz TLPS 802.11 connectivity