products outside the usable channel bandwidth. These theoretical profiles significantly exceed the emissions mask of practical 802.11 transceivers in DSSS (802.11b) or OFDM (802.11g/n) modes.

The limitations imposed by the 802.11 standard coupled with the standard's significantly larger channel bandwidth require an OOBE limit that is less stringent than that previously applied to more narrow-banded (<10 MHz channels) commercial wireless services in other parts of the spectrum. Extensive study of practical 802.11 terminal and base station transceiver emissions in OFDM modes (*see* Figure 5) indicates that OOBE limits highly analogous to those recently proposed for terminal utilization in nearby BRS/EBS spectrum (2502-2690 MHz) are appropriate to TLPS. While different in protocol and device transceiver architecture, the channel bandwidths and power levels associated with terminal operation in future TD-LTE services in the BRS/EBS bands are functionally similar to TLPS terminal and base station operation. Based on TLPS requirements and the recent BRS/EBS proposal, an appropriate OOBE limit is the following:

> ***"For digital stations with EIRPs below 36 dBm, the attenuation factor shall be not less than 40 + 10 log (P) dB at the channel edge, 43 + 10 log (P) dB at 5 MHz from the channel edges, and 55 + 10 log (P) dB at X MHz from the channel edges where X is the greater of 6 MHz or the actual emission bandwidth."***

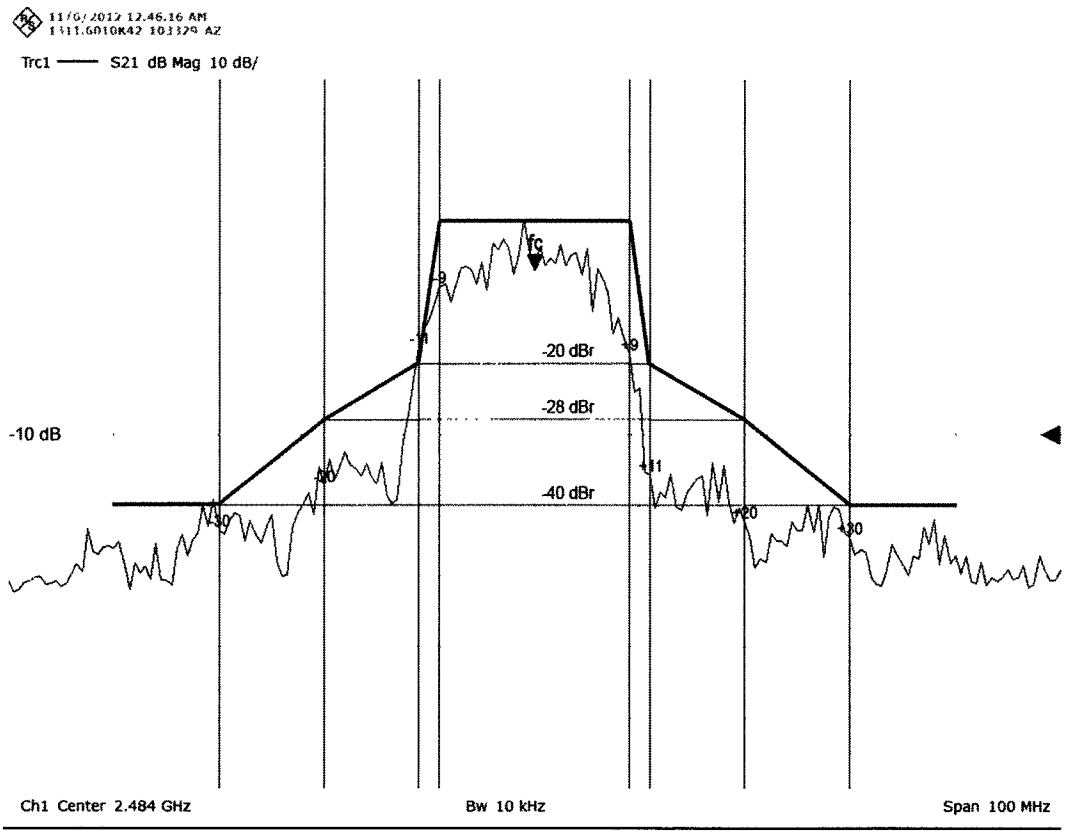

Figure 5: Laboratory Emissions Profile of 802.11 – The emissions profile of practical 802.11 devices studied in the laboratory is significantly more confined than commonly referenced theoretical profiles. This 802.11g (OFDM) example exhibits far greater sideband suppression than may be commonly inferred from generic mask diagrams of the standard.

3. Typical Terrestrial Low Power Service (TLPS) Mobile Terminals Will Comply with Proposed OOBE Limits Without Remedial Filtration.

A primary advantage of TLPS is the ability to rapidly enable service through the utilization of a substantial pre-existing ecosystem of 802.11 compliant transceiver chipsets. However, a disadvantage of utilizing this ecosystem is the difficulty in applying remedial filtration where it may be necessary to meet OOBE limits comparable to those currently proposed for BRS/EBS spectrum. Thus, the practical utility of current 802.11 device and chipset populations will be determined by their ability to meet the proposed emissions mask without hardware modification (e.g. the addition of passive filtration components).

Like all broadband signaling standards, 802.11 emissions generate significant spectral regrowth products that extend well beyond the usable signal bandwidth. However, unlike most broadband standards, 802.11 compliant transceivers display remarkable uniformity in their emissions mask across disparate chipset and overall device architectures. This is due to the general lack of passive filtration in the RF path of 802.11 devices. 802.11 transceivers achieve their spectral mask via software defined pulse shaping. While less efficient (i.e. selective) than comparatively high-performance passive-filtration-based control of the emissions mask, pulse shaping permits high predictability in spectral regrowth characteristics across disparate devices and a more linear relationship between conducted output power and OOBE characteristics.

Surveys of current-generation devices in the OET (FCC Office of Engineering and Technology) certification database indicate that typical 802.11 terminals in the 2.4 GHz band (e.g. smart phones, tablets, etc.) have a maximum conducted output power of less than 20 dBm (approximately 100 mW) and an average conducted output power of less than 17 dBm (approximately 50 mW). When applied to a practical 802.11 transceiver in OFDM mode (802.11 g/n), these conducted power levels produce Out of Band Emissions that are well within the limits proposed in Globalstar's Petition for Rulemaking. This allows for the conclusion that conducted power levels associated with typical mobile devices will permit compliance with the OOBE limits proposed for TLPS without the need for additional hardware based filtration.

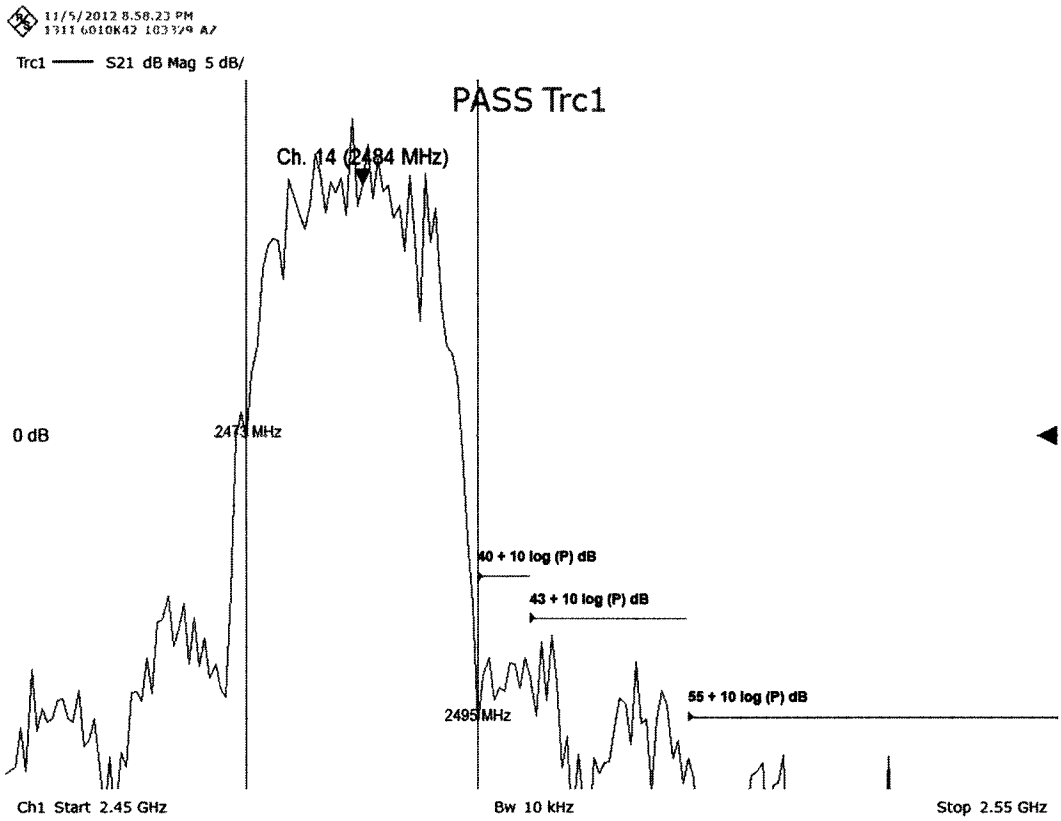

Figure 6: OOBE Analysis of TLPS Terminal – OFDM (802.11g) emissions from a TLPS terminal with a conducted output power below 20 dBm (100 mW) comply with the emissions mask proposed in Globalstar's Petition for Rulemaking without the need for hardware modification. Pulse shaping alone is sufficient to meet OOBE limits similar to those proposed for BRS/EBS terminals using broad (20 MHz) channels.

4. Terrestrial Low Power Service (TLPS) Base Stations Will Comply with Proposed OOBE Limits Through the Use of Remedial Filtration.

While TLPS mobile terminals will likely have technical requirements for maximum conducted powers less than 20 dBm (100 mW), TLPS base stations may be constructed that emit maximum conducted output powers approaching the Part 15 limit of 30 dBm (1 W). Laboratory analysis of representative 802.11 transceivers indicates that conducted output powers exceeding 23 dBm (200 mW) may generate spectral regrowth products that exceed the OOBE limits proposed in Globalstar's Petition for Rulemaking (*see* Figure 7). These regrowth products cannot be sufficiently suppressed through software defined pulse shaping alone.

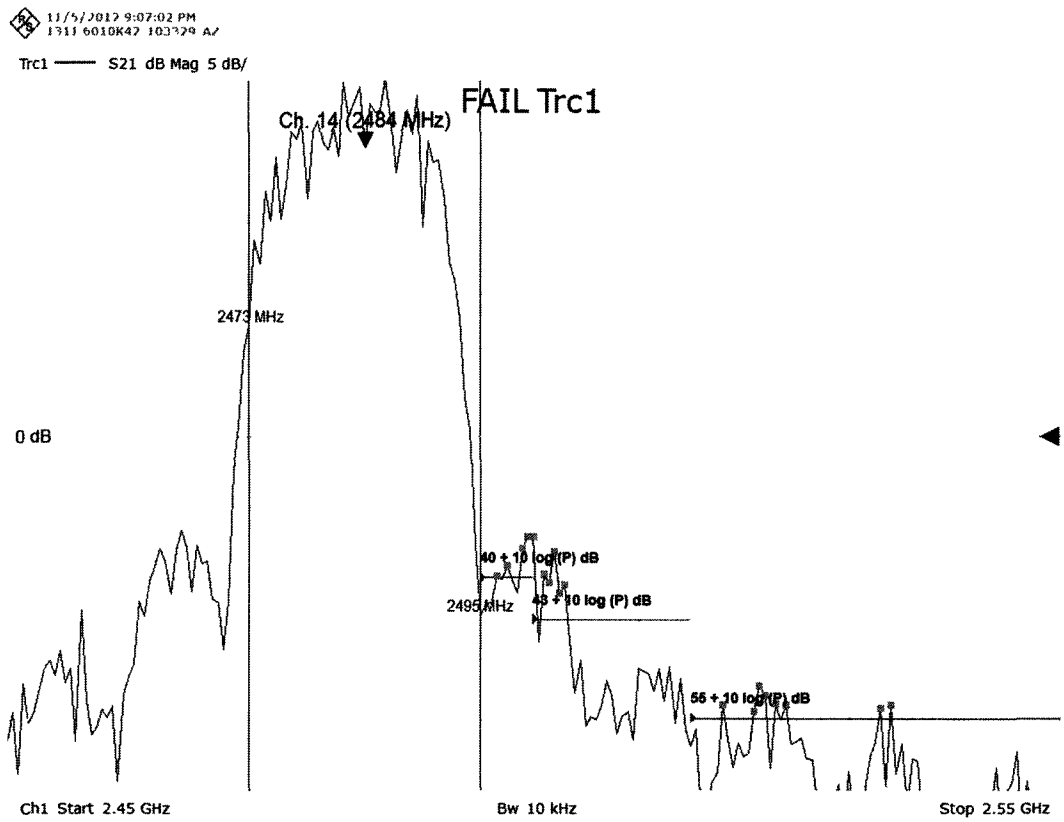

Figure 7: OOBE Analysis of TLPS Base Station – OFDM (802.11g) emissions from a TLPS base station with a conducted output power above 23 dBm (200 mW) do not comply with the emissions mask proposed in Globalstar's Petition for Rulemaking. For such applications, pulse shaping alone will not be sufficient to meet OOBE limits. Instead, TLPS base stations with conducted powers above 23 dBm will require the addition of remedial hardware filtration (e.g. a high selectivity passive filtration component).

TLPS base stations with conducted power outputs in excess of 23 dBm (200 mW) will require remedial filtration. This will take the form of passive filtration devices applied to the RF path of the 802.11 transceiver in a band-pass configuration. Such devices will exhibit high RF rejection above 2495 MHz and may be constructed from SAW (Surface Acoustic Wave), FBAR (thin Film Bulk Acoustic Resonator), or cavity resonator based technologies. The choice of filtration technology and method of design integration will be influenced by the form factor, economics, and power level (i.e. requirement for selectivity) associated with any given TLPS base station application. In all cases, current and anticipated filtration technologies may be readily adapted to TLPS base station utilization in ways that neither delay nor meaningfully impact the utility of the proposed service.

An inexpensive prototype filter for TLPS base stations (*see* Figure 8) is representative of technologies that will allow TLPS to readily meet OOBE restrictions at power levels where pulse shaping and other modulation derived methods are inadequate to suppress spectral regrowth products.

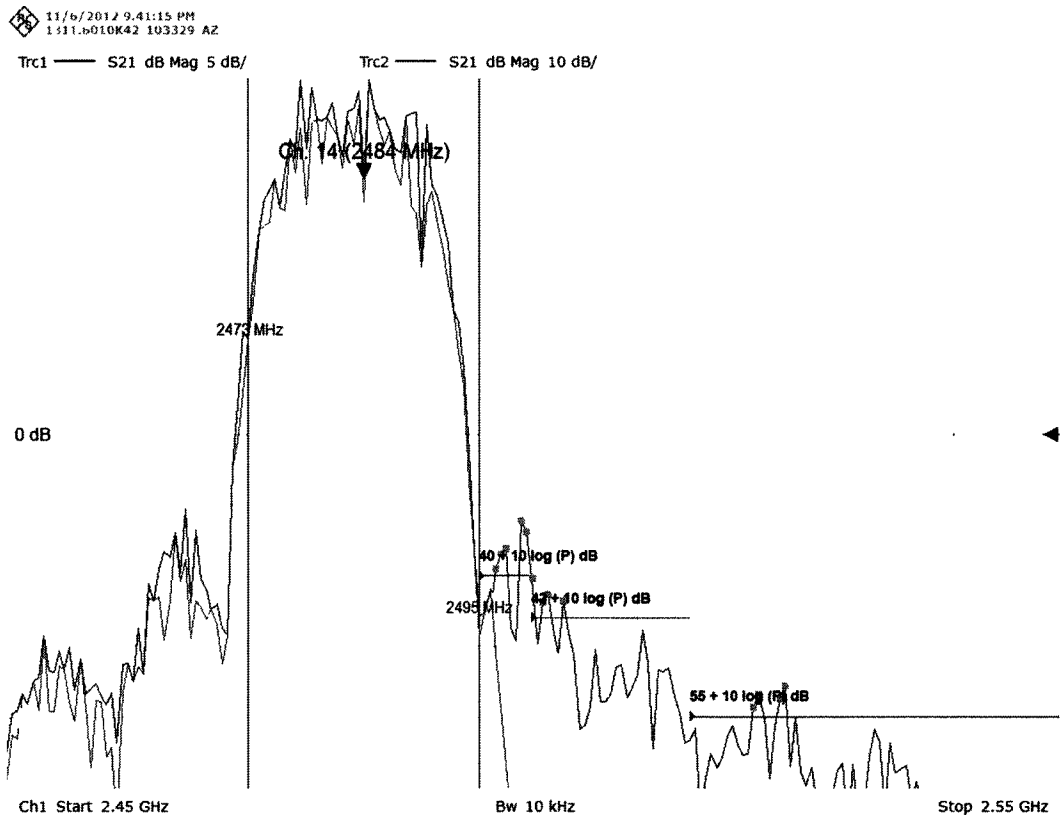

Figure 8: OOBE Analysis of TLPS Base Station with Remedial Filtration – As shown previously, OFDM (802.11g) emissions from a TLPS terminal with a conducted output power exceeding 23 dBm do not comply with the emissions mask proposed in Globalstar's Petition for Rulemaking (Trc1). The addition of high selectivity remedial hardware filtration suppresses regrowth products above 2495 MHz and permits a TLPS base station to readily meet the proposed OOBE limits.

5. Terrestrial Low Power Service (TLPS) Terminals and Base Stations That Comply with Proposed OOBE Limits are Unlikely to Cause Harmful Interference to BRS systems Operating on Channel BRS-1 at 2496-2502 MHz.

The proposed Terrestrial Low Power Service is unique in the extremely low power levels associated with both mobile terminal and fixed base station usage. TLPS fixed and mobile stations will comply with Part 15 maximum conducted power limits of 30 dBm (1 W) across the entire band (2473 – 2495 MHz). This is half the 33 dBm (2 W) maximum conducted power limit applied to mobile terminals in the EBS and BRS bands (*see* Part 27.50(h)(2)), and an extremely small fraction of the EIRP permitted for EBS and BRS fixed base stations. Because of the low power levels associated with fixed TLPS utilization, TLPS infrastructure elements will have significantly reduced impact on the RF environment relative to the exponentially higher

powered base stations that generally characterize more conventional commercial wireless services.

In addition to a uniquely low-power footprint, the Terrestrial Low Power Service described in Globalstar's Petition for Rulemaking will be limited by a proposed OOBE standard that is based upon that proposed for mobile terminal devices in BRS/EBS spectrum. This proposed BRS/EBS OOBE standard has been carefully studied by users of that spectrum and deemed appropriate for protection of adjacent wideband channels (exceeding 20 MHz) within the BRS/EBS services. Thus, a similar OOBE standard applied to an adjacent band operator should be adequate to protect Channel BRS-1.

Adding additional margin to the proposed OOBE standard is the practical reality that TLPS base stations with conducted output powers exceeding 23 dBm (200 mW) will utilize high selectivity passive filtration to achieve the required emissions mask. A consequence of passive filtration use will be the achievement of a considerably more confined spectral mask than that required in the proposed rulemaking, a technical reality that further mitigates risk of harmful impact (*see* Figure 8).

CERTIFICATION

I, John Dooley, am Managing Director of Jarvinian Ventures, a wireless investment fund. I am an Engineer with 17 years of experience in the development of advanced wireless technologies. I am qualified to provide the opinions and analyses presented in this Declaration.

Under penalty of perjury, I hereby declare that the preceding is true and correct to the best of my information, knowledge, and belief:

John Dooley

Dated: November 13, 2012