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February 23, 2014

Via Electronic Filing

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street SW
Washington, DC 20554

Re: *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*
ET Docket No. 13-49 – *Ex Parte* Notice

Dear Ms. Dortch:

Globalstar, Inc. ("Globalstar"), through counsel, hereby submits into the record of the above-captioned proceeding the attached technical report from Roberson and Associates, LLC ("Roberson"), *Further Analysis of Proposed U-NII-1 Rule Changes on Globalstar Operations* (the "Further Roberson Report"). This independent technical study provides further record support for the finding that an unlimited deployment of outdoor Unlicensed National Information Infrastructure ("U-NII") devices in the U-NII-1 band at 5150-5250 MHz would have a substantial detrimental impact on customers of Globalstar's licensed mobile satellite service ("MSS") operations within the United States and throughout North America.

The Further Roberson Report is the second detailed analysis from Roberson and Associates in this proceeding. On November 29, 2013, Globalstar submitted a comprehensive technical report from Roberson and Associates that demonstrates that aggregate emissions from unlimited U-NII-1 access points operating at 5170-5250 MHz would cause interference to Globalstar's MSS feeder uplinks.[1] This harmful interference to Globalstar's licensed MSS feeder uplinks in turn would have detrimental effects on Globalstar's duplex service downlink to end users in the 2483.5-2500 MHz band.[2] As Roberson and Associates described, Globalstar's MSS network in North America would suffer a reduction in system capacity.

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[1] Supplemental Comments of Globalstar, Inc., ET Docket No. 13-49 (Nov. 29, 2013) ("Globalstar Supplemental Comments"), attaching *Impact of U-NII-1 Rule Changes on Globalstar Operations*, Roberson and Associates, LLC, Chicago, Illinois (Nov. 27, 2013) ("November Roberson Report").

[2] Globalstar's feeder uplinks from its gateway earth stations carry the "return" traffic from parties communicating with Globalstar's MSS users, and Globalstar's satellites then translate,

The Further Roberson Report provides additional technical analysis on these U-NII-1 issues and responds to an *ex parte* filing submitted on January 22, 2014, by the National Cable & Telecommunications Association ("NCTA").[3] In this report, Roberson and Associates find that nothing in NCTA's filing changes Roberson's fundamental conclusion that the unlimited deployment of outdoor U-NII-1 devices would reduce the capacity of Globalstar's MSS system in North America and impact Globalstar's customers.

As described in the Further Roberson Report, the January 22 NCTA filing was neither a definitive nor reliable examination of the likely effects of the Commission's proposed U-NII-1 rule change.[4] Importantly, the NCTA filing underestimated the likely number of outdoor access points that will be deployed in the U-NII-1 band if the Commission permits the unlimited, uncontrolled deployment of these outdoor devices.[5] In their initial report, Roberson and Associates estimated the deployment of 4.4 million outdoor U-NII-1 access points based on a representative, real-world urban density of approximately 16 access points per square kilometer.[6] This estimate conservatively assumed a U-NII-1 access point deployment by just a single commercial operator in urban areas, however, and did not include any deployments in outer suburban or rural areas. Multiple outdoor deployments are more likely, given the tremendous growth in mobile data traffic and the needs of other communications carriers to offload such traffic from their macro networks.[7] Accordingly, the Further Roberson Report projects at least four national-equivalent outdoor deployments in the U-NII-1 band. Applying reasonable operating parameters for these outdoor access points, these national deployments would degrade Globalstar's network capacity in North America by as much as fifty percent.

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amplify, and downlink this return traffic to its MSS customers in the Upper Big LEO band at 2483.5-2500 MHz.

[3] *5 GHz UNII-1: Wi-Fi and Globalstar Sharing Analysis*, Rob Alderfer, CableLabs, Dirk Grunwald and Kenneth Baker, University of Colorado ("NCTA Report"), attached to Letter from Rick Chessen, NCTA, to Julius Knapp, FCC, ET Docket No. 13-49 (Jan. 22, 2014).

[4] Further Roberson Report at 3-9.

[5] NCTA Report at 8-10, 14-15.

[6] November Roberson Report at 7. The Roberson Study's estimate was based on Google's deployment of 500 routers throughout Mountain View, CA in an area of 31 square kilometers, not just on Google's access deployments on its own "campus." See *Google WiFi,* http://en.wikipedia.org/wiki/Google_WiFi.

[7] *See* Letter from Regina Keeney, Counsel to Globalstar, to Marlene Dortch, FCC Secretary, ET Docket No. 13-49, at 2-3 (Feb. 7, 2014). Wireline providers, wireless carriers, commercial entities, educational institutions, municipalities and other government facilities, and residential users are also likely to deploy substantial numbers of outdoor access points nationwide. In addition, if the Commission permitted outdoor U-NII-1 deployment, other national administrations might follow and cause an even greater detrimental impact on Globalstar's licensed services.

The Further Roberson Report points out that the January 22 NCTA filing also failed to account for an unavoidable degradation of Globalstar's satellite RF power that would result from the proliferation of outdoor devices in the U-NII-1 band. Interference from these access points to Globalstar's feeder uplink will inevitably absorb a substantial portion of Globalstar's satellite power resources due to the retransmission of this uplink interference into the service downlink at 2483.5-2500 MHz. The Further Roberson Report also explains that NCTA overestimated the number of unlicensed outdoor access points that are necessary to produce a given level of degradation to Globalstar feeder uplinks at 5170-5250 MHz. NCTA's filing presented a flawed analysis of access point duty cycles, incorrectly applying the "binomial probability theorem."[8] Notwithstanding NCTA's claims, high duty cycles at peak traffic times would have a harmful effect on Globalstar's MSS network.[9]

As the Further Roberson Report recognizes, however, NCTA's January 22 filing did indicate some areas of agreement with Globalstar. NCTA agreed with Globalstar that outdoor U-NII-1 access points will cause harm to Globalstar if the number of access points is large enough. NCTA also relied on Roberson's calculation of the relationship between feeder uplink interference and Globalstar downlink capacity degradation to reach conclusions about what constitutes an acceptable level of interference to Globalstar.

Finally, the Further Roberson Report describes another critical development for the U-NII-1 issues in this proceeding: Globalstar has identified a means and has agreed to measure actual uplink interference from outdoor U-NII-1 devices *at the satellite*.[10] Such measurements could largely resolve any continuing disagreement between the parties on the likely number of outdoor U-NII-1 access points and their operating characteristics by replacing conjecture with empirical data. Moreover, Globalstar believes that this capability could serve as the foundation of an agreement between the parties – including a standard for harmful interference in the band – that allows the outdoor deployment of unlicensed U-NII-1 access points while protecting Globalstar's primary operations from harmful interference.

To realize this goal and reach a mutually acceptable resolution of the U-NII-1 issues, Globalstar has engaged in technical discussions with NCTA. Globalstar has sought common ground with NCTA on the definition of potential harmful interference to Globalstar, an appropriate means of measuring that interference, and any reasonable mitigation options to address such harm. To this end, Globalstar has presented a specific proposal to NCTA designed to permit large numbers of outdoor U-NII-1 devices while providing reasonable protection to Globalstar, its MSS network, and its customers. As described in Attachment 1 to this letter, this proposal focuses on two approaches to limiting the harmful effects from the outdoor deployment of U-NII-1 access points: antenna standards limiting access point antenna gain at 30 degrees,

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8 NCTA Report at 10-12.

9 Further Roberson Report at 7-9.

10 Further Roberson Report at ii, 12.

and a sequenced roll-out mechanism for outdoor U-NII-1 devices based on Globalstar's continuous measurement of the noise rise at its satellites. While NCTA has rejected this proposal without offering any alternative approach, Globalstar remains committed to reaching a voluntary, mutually acceptable solution in this proceeding.

Pursuant to section 1.1206(b)(2) of the Commission's rules, 47 C.F.R. § 1.1206(b)(2), this *ex parte* letter and the attached Further Roberson Report are being filed electronically for inclusion in the public record of the above-referenced proceeding.

Respectfully submitted,

/s/ *Regina M. Keeney*
Regina M. Keeney

Attachments

cc:	Renee Gregory	Mark Settle	Mindel De La Torre
	Louis Peraertz	Navid Golshahi	Roderick Porter
	David Goldman	Karen Rackley	Jose Albuquerque
	Jeffrey Neumann	Bruce Romano	Jennifer Gilsenan
	Erin McGrath	Bryant Wellman	Robert Nelson
	Julius Knapp	Aole Wilkins	Karl Kensinger
	Geraldine Matise	John Leibovitz	Chip Fleming

ATTACHMENT 1

GLOBALSTAR PROPOSAL FOR DEPLOYMENT OF OUTDOOR
UNLICENSED DEVICES IN THE 5 GHz U-NII-1 BAND (5150-5250 MHz)

- **Globalstar proposal presented to NCTA.** Globalstar has presented a proposal to NCTA that would enable unlicensed operators to deploy large numbers of outdoor U-NII-1 devices while providing reasonable protection to Globalstar, its MSS network, and its customers.

- **Response to NCTA "worst-case" interference scenario.** In discussions with Globalstar, NCTA stated a worst-case interference scenario with a **4.5 dB** in noise floor at Globalstar satellites – this assumed (i) 12.5 million outdoor U-NII-1 devices, (ii) operations at 1 watt, (iii) 50% access point duty cycle, and (iv) omni-directional antenna pattern.

- **Unacceptable impact on Globalstar network capacity**. Independent technical analysis by Roberson and Associates, LLC, demonstrates that a 4.5 dB rise in the noise floor would reduce Globalstar's licensed MSS capacity by **10-12%** in North America. This harmful consumption of capacity is unacceptable to Globalstar.

- **Two approaches to limiting harmful effects of U-NII-1 outdoor deployment.** In a proposal to NCTA, Globalstar has described two approaches to limiting the harmful effects to Globalstar from an outdoor deployment in the U-NII-1 band. These are **antenna standards** and a **sequenced roll-out mechanism** for outdoor U-NII-1 devices.

- **(1) Antenna standard: reduced energy at 30 degree elevation or greater.** NCTA's worst-case scenario includes the use of omni-directional antennas with -6 dBi gain at 30 degrees elevation angle. To lower the noise rise at its satellites, Globalstar proposed a further limit on U-NII-1 access point antenna gain at 30 degrees and higher to -11 dBi gain, or -17 dB relative to maximum gain of +6dBi (equivalent to a 5 dB reduction in radiated power at 30 degree or greater elevation).

    - Reduced U-NII-1 energy at 30 degrees or more would *by itself* diminish the noise rise at Globalstar's satellites to **1.5-1.75 dB**, equating to a **2-3% reduction** in capacity (still a significant impact in Globalstar's view).
    - This impact is very close to the maximum total impact previously predicted by NCTA in its January 22, 2014 ex parte filing.
    - This approach should not unduly constrain U-NII-1 deployment by cable operators and other unlicensed service providers, since omni-directional antennas are not commercially optimal.

- **(2) U-NII-1 roll-out mechanism: sequenced outdoor deployments based on Globalstar measurements.** To prevent uncontrolled harm to its network, Globalstar proposed a sequenced roll-out of outdoor U-NII-1 access points. Following an initial roll-out of up to **three million** outdoor U-NII-1 devices, further outdoor U-NII-1 deployments would be tied to Globalstar's continuous, quarterly monitoring of the noise floor at its satellites.

    - If the initial outdoor U-NII-1 deployment did not increase the noise floor by 2 dB or greater, an additional deployment of up to one million outdoor devices would be

permitted. Further U-NII-1 deployments, in "batches" of up to one million, would similarly depend on the noise rise at Globalstar's satellites remaining below 2 dB.
  - As long as noise rise remains below 2 dB, there would be no limit on the number of additional outdoor U-NII-1 deployment "batches."
  - If noise rise reached 2 dB or greater, further outdoor U-NII-1 deployments would be predicated upon additional mitigation measures – such as lowering power levels or improving antenna designs.

- **NCTA has rejected this reasonable proposal without proposing any alternative methods for protecting Globalstar from a substantial harmful impact from outdoor U-NII-1 devices.**

ATTACHMENT 2

Roberson and Associates, LLC
Technology and Management Consultants

Further Analysis of Proposed U-NII-1 Rule Changes on Globalstar Operations

Prepared for Globalstar Inc., by:

Roberson and Associates, LLC
Chicago, Illinois

Principal Contributors:

Dennis A. Roberson
Kenneth J. Zdunek

Date: February 23, 2014

Further Analysis of Proposed U-NII-1 Rule Changes on Globalstar Operations

Summary

Roberson and Associates, LLC's ("Roberson's'") analysis of the National Telecommunications & Cable Association's ("NCTA's") January 22, 2014 *ex parte* filing and accompanying report by Grunwald, Alderfer, and Baker, demonstrates that nothing in that filing changes the fundamental conclusion in our previous November 2013 technical report: If the Federal Communications Commission ("FCC") adopts its proposed rules for the 5 GHz U-NII-1 band, the unfettered deployment of outdoor U-NII-1 devices at U-NII-2A power levels will have a substantial detrimental impact on the capacity of Globalstar's mobile satellite system, the availability of satellite RF transmit power to Globalstar's users, and the quality of service for its customers. The impact to Globalstar is a 10-50% degradation in user capacity, depending on unlicensed access point deployment assumptions.

In contrast to the position it took in its July 2013 report, NCTA no longer maintains that effectively unlimited deployment of up to 2 billion outdoor access points would not harm Globalstar, but instead relies on the Roberson-calculated relationship between uplink interference and Globalstar capacity degradation. NCTA still argues that harmful interference will not occur under the Roberson model, however, based chiefly on NCTA's assumption that a relatively small number of outdoor access points will ultimately be deployed in the U-NII-1 band under an unlicensed regulatory model. Specifically, NCTA bases its assumption on the number of outdoor access points needed to support only one national-level deployment in the U-NII-1 band. If NCTA's assumption is adjusted to account for four nationwide U-NII-1 outdoor deployments – given the likelihood of cable operators, wired and wireless operators, private and non-operator commercial entities, government agencies, and entities within Mexico and Canada all deploying outdoor access points – then there would be a 15% capacity reduction to Globalstar, even assuming the availability of 12, 20 MHz channels for unlicensed use beyond the four channels in the U-NII-1 band.

In its January 22 filing, NCTA also presents the results of a "Dynamic Simulation Model." NCTA provides insufficient information, however, to validate the model's outputs and its conclusion that unlicensed outdoor access points in the U-NII-1 band will cause no harmful interference to Globalstar. The Dynamic Simulation Model also underestimates the number of outdoor access points, assuming again a level of deployment consistent with only one national network. Once this input is adjusted to a level consistent with four national level deployments, the Dynamic Simulation Model yields a capacity reduction of 8% or more to Globalstar.

NCTA's January 22 filing further ignores the unavoidable reduction in Globalstar satellite downlink RF power due to uplink interference (described in the November Roberson report), and applies flawed reasoning in asserting that a capacity degradation to Globalstar is acceptable because

Globalstar has not yet loaded its recently upgraded network to its design capacity. Finally, NCTA presents a critique of the November 2013 Roberson analysis that contains an obvious calculation error regarding the number of simultaneously operating access points, and ignores the Roberson report's consideration of variation for such access point parameters as duty cycle, antenna gain, and signal blocking.

Despite disagreements regarding the assumptions regarding unlicensed deployment, it appears that progress has been made between Roberson and NCTA toward agreement on certain basic issues relating to the effect of outdoor U-NII-1 access points on Globalstar operations. In its January 22 ex parte, NCTA: a) states that outdoor access points in the U-NII-1 band can cause degradation to Globalstar if the number is large enough; b) utilizes an outdoor access point deployment density for a single operator that is consistent with the estimate used in the November 2013 Roberson analysis; and c) relies on Roberson's calculation of the relationship between uplink interference and Globalstar downlink capacity degradation to reach conclusions about what constitutes an acceptable level of interference to Globalstar.

Significantly, Globalstar has now determined that it has measurement capabilities that could largely resolve the continued disagreement between Roberson and NCTA on the likely number of outdoor U-NII-1 access points and their operating characteristics. The Globalstar network operations group has conducted extensive measurements on its satellites and has confirmed the ability to reliably measure noise rise (equivalent to interference) on its feeder uplinks while the satellites are over the continental U.S. Previously, Globalstar made noise floor measurements over longer time periods over other regions of the earth. There were no significant changes in the noise floor over this time period, and no significant differences between these historical measurements and the recent noise measurements over the United States. These results provide confidence that any future noise rise measured by Globalstar will be attributable to aggregate interference from outdoor U-NII-1 access points, since no other operations are authorized in that spectrum. Importantly, with this measurement capability, Globalstar will be able quantify aggregate interference from the population of outdoor U-NII-1 access points regardless of the actual number of such access points or their operational parameters.

Given Globalstar's ability to measure uplink interference at the satellite, an appropriate interference threshold can be determined and applied to protect Globalstar's licensed operations. If outdoor U-NII-1 deployments are permitted, procedures for interference mitigation could be developed to curtail unlicensed use when this interference threshold is approached. Ongoing discussions have been taking place between Globalstar and NCTA since December 2013 to come to agreement on: 1) what level of interference would be harmful to Globalstar; 2) how interference should be measured; and 3) what mitigation approaches can be applied if harmful interference is approached or occurs.

If the FCC permits outdoor U-NII-1 operations, we believe that an appropriate regulatory framework for these operations can then be established. This requires: a) specifying a level of harmful interference to Globalstar based on the noise rise in the satellite feeder uplinks; b) monitoring interference at the Globalstar satellite on a regular basis; and c) establishing a

mitigation approach that must, at a minimum, include adjustment to the outdoor unlicensed access point operating parameters (for example, output power) or limiting further deployment of outdoor access points via network management. This approach is a common solution for spectrum sharing. For example, such monitoring is part of the sharing framework recommended by the Commerce Spectrum Management Advisory Committee for the 1695-1710 MHz spectrum used by NOAA satellite downlinks.

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1. Recap of Globalstar Interference Scenario and Degradation to Globalstar Operations

1.1 Globalstar Overview

Globalstar currently operates a full-duplex "bent-pipe" global mobile satellite service network using a constellation of non-geostationary low earth orbit satellites. The Globalstar system architecture consists of earth station "gateways" that interconnect with terrestrial networks and communicate to the satellites using a 5096-5250 MHz uplink. For communications to the mobile user handheld devices, frequency translating repeaters (transponders) on the satellite convert the 5 GHz uplink signals conveying user information on multiple CDMA channels to 2483.5-2500 MHz at the satellite for retransmission to the mobile user devices.[1]

1.2 Proposed U-NII-1 Rule Changes and Interference Scenario

As described in the FCC's NPRM, potential rule changes for unlicensed wireless devices operating in the U-NII-1 band include: a) an increase in the power limits of operation from 50 mW to 250 mW, with a maximum EIRP of 30 dBm with 6 dBi antenna gain (1 Watt EIRP); and 2) elimination of the restriction on outdoor operation.[2] These changes would adopt U-NII-2A rules for the U-NII-1 band.

Figure 1 illustrates the interference to the Globalstar feeder uplinks created by unlicensed access points operating in the U-NII-1 band. The emissions from outdoor access points intended for the wireless LAN client devices are also radiated in the direction of the Globalstar satellites. These emissions degrade the uplink signals sent from the gateway to the satellite by adding their undesired interfering power to the received signal at the satellite, thereby causing a rise in the uplink noise-plus-interference level (noise rise). Significantly, all U-NII-1 access points within the Globalstar satellite uplink "footprint" – an area of approximately 2900 km radius on the earth's surface – contribute to this aggregate uplink interference. Any outdoor U-NII-1 access points operating in Mexico and Canada also contribute to this aggregate interference. The degraded received signal at the satellite – consisting of the desired Globalstar uplink plus noise and the unlicensed device interference – is then translated to the 2500 MHz downlink, degrading the received signal at the Globalstar customers' handheld devices.

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[1] Information provided by Globalstar, Inc., and "The Globalstar System," *Applied Microwave and Wireless*, summer 1995.

[2] *See Revision of Part 15 of Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, ET Docket No. 13-49, Notice of Proposed Rulemaking, 28 FCC Rcd 1769 (2013) ("NPRM").

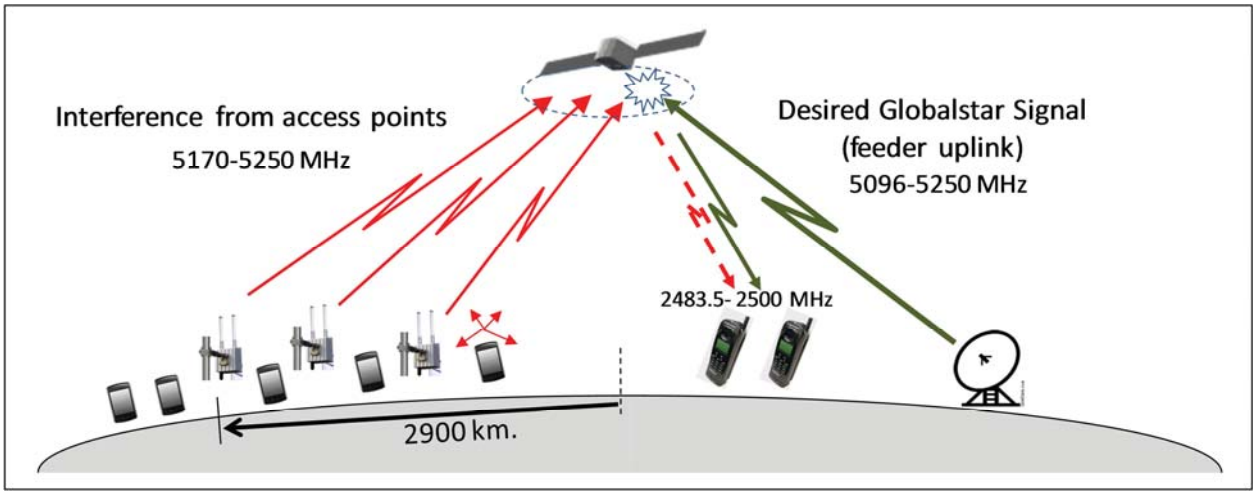

Figure 1: Globalstar Interference Scenario

1.3 Summary of Degradation to Globalstar

Roberson's previous analysis[3] has shown that if 4.4 million unlicensed access points operate outdoors on the four 20 MHz 802.11 channels in the U-NII-1 band at U-NII-2A power levels (the equivalent of 1.1 million unlicensed access points operating outdoors in one of the 20 MHz 802.11 channels), Globalstar's user capacity for the downlink satellite channels corresponding to that ground station-to-satellite uplink spectrum would be reduced by approximately *one-half*, assuming a reference unlicensed access point with 100% duty cycle and no urban blocking.[4] This reduction in CDMA capacity results from the need to compensate for U-NII-1-based interference and maintain the desired signal-to-noise ratio at the Globalstar devices. This previous analysis also demonstrated how the degradation to Globalstar would vary with different U-NII-1 access point operating characteristics. For example, if access points are assumed to have (i) a duty cycle of 80% during peak traffic periods, (ii) a 9 dB access point antenna loss due to the elevation angle to the satellite, and (iii) a 3 dB additional propagation loss due to clutter, Globalstar will suffer a 10% capacity reduction. Appendix C contains further justification for busy period duty cycles in the 80% range.

The November Roberson analysis also showed that there is an unavoidable user capacity degradation that occurs due to the waste of satellite downlink RF transmit power. This waste of satellite power results from Globalstar's "bent pipe" satellites repeating the uplink interference

[3] *See Impact of Proposed U-NII-1 Rule Changes on Globalstar Operations*, appended to *Supplemental Comments of Globalstar, Inc.*, ET Docket No. 13-49 (November 29, 2013) ("November Roberson Report" or "November Roberson analysis").

[4] We do not assert that during peak periods all outdoor access points will be transmitting simultaneously. 100% duty cycle is a worst-case reference, and peak period duty cycles will likely be in the 80% range. In the November Roberson Report, we analyzed the degradation to Globalstar's system assuming 100%, 80%, and 50% peak period duty cycles. In particular, an 80% duty cycle is supported by studies that show that the maximum downlink capacity is achieved at this level (*see* Nickolas J. LaSorte, Dan Bloom, et al., "Comparison of Duty Cycle Measurement Techniques of 802.11b/g in the Frequency and Time Domain," *Instrumentation and Measurement Technology Conference (I2MTC), 2013 IEEE International*, 6-9 May 2013, Minneapolis, MN.)

from U-NII-1 access points. This effect diverts satellite RF power away from user communications. The capacity degradation due to this effect is similar in magnitude to the capacity reduction described above. This capacity reduction represents a base, inherent level of capacity reduction that cannot be avoided, even if there is no compensation to maintain signal-to-noise ratio to Globalstar devices (described above).

Finally, the Roberson analysis demonstrated that if system capacity (the number of users during peak periods) is maintained in the presence of increased interference, then there will be a degradation to user call quality evidenced by a) an increase in coverage "holes" over the service area (an increase in "no service available" indication to the user); b) an increase in dropped calls; and c) a reduction in call quality.

2. Response to January 22, 2014 NCTA Filing

Roberson has studied NCTA's January 22 ex parte filing[5] and finds nothing in that report that changes our previous conclusions contained in the November Roberson Report. If the FCC adopts its proposed rules in the U-NII-1 band, the resulting unlimited deployment of outdoor U-NII-1 devices at U-NII-2A power levels will have a substantial detrimental impact on the capacity of Globalstar's mobile satellite system, the availability of satellite RF transmit power to Globalstar's users, and the quality of service for its customers.

2.1 Response to Critique of the November 2013 Roberson Analysis

There are several criticisms of the November 2013 Roberson analysis presented by NCTA in its January 22 filing. These are addressed below.

1. The number and density of outdoor access points that will operate in the U-NII-1 band, the number of unlicensed channels available for nationwide deployments, and realistic access point parameters.

NCTA asserts that Roberson overestimates the number of unlicensed outdoor access points that will operate in the U-NII-1 band, given the availability of other unlicensed bands. NCTA provides the following Table[6] to show that the worst-case capacity degradation on Globalstar will be 1.5% rather than the 56% worst-case degradation described in the Roberson analysis.

[5] *See 5 GHz UNII-1: Wi-Fi and Globalstar Sharing Analysis*, attached to Letter from Rick Chessen, NCTA, to Julius Knapp, FCC, ET Docket No. 13-49 (January 22, 2014) ("*January 22 NCTA filing*"),
[6] *See Attachment to January 22 NCTA filing*, page 14.

Table 1: NCTA Capacity Degradation Calculation

Parameter	NCTA Reported Roberson Worst Case	NCTA Claimed Actual Worst Case from Recent Ex Parte
AP Density	4.4M APs	Half of public AP **MAY** be indoors
Duty Cycle	100%	10%
Channelization	All APs use only 4, 20MHz channels in UNII-1	4 UNII-1 channels plus 8 additional channels
Equivalent Outdoor APs at 100% Duty Cycle in Single UNII-1 Channel	1.1 M	18,150
Capacity Degradation	56%	1.50%

In this table, NCTA does not dispute the number of outdoor access points that will be capable of U-NII-1 operations (4.4 M nationwide)[7], but asserts that access point operations will be distributed across 12 total unlicensed channels (4 U-NII-1 channels, 5 U-NII-3 channels, and 3, 2.4 GHz channels). NCTA also claims that half of these access points may be indoors and that the busy hour access point duty cycle is 10%.

NCTA then uses the following calculation to compute an equivalent number of access points.

$$1{,}100{,}000_{APs} * 0.5_{outdoor} * 0.1_{dutycycle} * 0.33_{channels} = 18{,}150_{AP\ equivalents}$$

From this calculation, the capacity degradation to Globalstar can be ascertained using the relationship between access points and capacity degradation provided by the November Roberson Report, reproduced in the January 22 NCTA filing[8], and also below.

[7] Roberson and Associates arrived at its estimate of 4.4 million access points for a single operator deployment by analyzing Google's 100% outdoor deployment in the City of Mountain View, CA, which deployed access points at a density of 16/sq km for urban areas. This 4.4 million estimate is actually understated, however, since non-urbanized areas were assigned zero access point density, a figure materially below real-world rural deployment patterns. In addition, since the Google access point density is an outdoor density, we disagree that an additional factor of 50% should be applied to this number.

In its January 22 filing, NCTA arrived at a number of approximately 3 million access points by assigning access point densities based on varying population densities across small geographic areas. We assert that 3 million is too low an estimate, since it understates the number of access points in low population density areas such as parks and commercial areas, where the demand for unlicensed access and access point usage will be high.

[8] *See Attachment to January 22 NCTA filing*, pages 14, 15.

Table 2. Globalstar Relative Capacity as a Function of Number of Unlicensed Access Points

Number of Access Points U-NII-2 Rules Outdoor (6 dB antenna elevation loss) in 20 MHz BW	Uplink Degradation (dB)	Uplink Eb/(No+Io+Ia) (dB)	Required Downlink Eb/(No+Io,red) (dB)	Overall Eb/No+Io) (dB) Required [Eb/(No+Io)min]	Incr = Increase in downlink (Eb/No+Io) needed to maintain Eb/(No+Io)MIN, ovr (db)	Io, downlink dBW/Hz	Reducs in Downlink Io (dB) Required	Relative Capacity
.-	0	19.9	1.063	1.01	0	-209.60	0.00	1
32,000	1	18.9	1.077	1.01	0.0145	-209.67	0.07	0.985
72,000	2	17.9	1.095	1.01	0.0325	-209.75	0.16	0.965
185,000	4	15.9	1.150	1.01	0.0875	-210.03	0.43	0.906
365,000	6	13.9	1.235	1.01	0.1725	-210.48	0.88	0.816
650,000	8	11.9	1.375	1.01	0.3125	-211.32	1.72	0.673
1,100,000	10	9.9	1.610	1.01	0.5475	-213.15	3.55	0.442
1,820,000	12	7.9	2.000	1.01	0.9375	-220.32	10.72	0.085

NCTA's conclusion is that the capacity degradation to Globalstar is less than 1.5%, which in NCTA's view does not constitute a significant degradation to Globalstar.

In its January 22 filing, NCTA also argues that Roberson did not include realistic assumptions for access point duty cycles, access point antenna gain values versus elevation angle, or the effects of blocking and clutter on propagation.

Response:

There are key errors in NCTA's analysis of the capacity degradation to Globalstar.

NCTA's first error is its failure to account for the likelihood that there will be more than one nationwide deployment of *outdoor* U-NII-1 unlicensed access points. NCTA appears to assume that cable operators will be the only entities to deploy these access points, which is highly improbable. The November Roberson analysis noted that there would likely be more than one nationwide outdoor U-NII-1 deployment, and Roberson's quantitative analysis assumed for illustration's sake that that this operator would use the U-NII-1 channels, a subset of the unlicensed channels available. If the analysis of outdoor access point deployment is expanded to include the additional unlicensed channels available in all unlicensed bands, then it is also necessary to account for the likelihood of additional nationwide deployments utilizing these bands.

We conservatively estimate that there will be at least four effective nationwide deployments of outdoor U-NII-1 access points. In our view, three nationwide deployments can be attributed to the cable industry and two wireless operators.[9] The fourth nationwide equivalent deployment can be attributed to non-operator entities. These entities include non-DoD Federal government agencies;

[9] Licensed wireless operators are expected to offload wide-area traffic to unlicensed spectrum to help mitigate congestion on their networks. *See* "ROI Analysis of WiFi Offloading," Wireless 20/20 (2012), www.wireless2020.com/wifioffloading/ROIAnalysisofWiFiOffloading.pps, and "Most mobile data will soon be offloaded to Wi-Fi networks, says Juniper Research" (June 12, 2013), http://www.zdnet.com/most-mobile-data-will-soon-be-offloaded-to-wi-fi-networks-says-juniper-research-7000016750/.

the Department of Defense; State and Local Government including Law Enforcement and Muni-WiFi; and non-operator commercial enterprises such as business campuses, education, theme parks and other outdoor venues (sports stadiums). This conservative approach has the effect of increasing the number of nationwide outdoor access points by a factor of four, compared to the number for a single deployment used in the November 2013 Roberson analysis. Appendix A contains additional information on typical outdoor deployments and justification for high outdoor deployment densities by operator and non-operator entities.

Second, contrary to NCTA's claims, the busy hour duty cycle of access points will be much higher than 10%. The reference used by NCTA to establish the 10% value used in their calculation is based on measurements taken in 2005, and is not representative of the planned intensive uses of unlicensed spectrum in the U-NII-1 band and elsewhere. In its subsequent quantitative analysis in the January 22 filing, NCTA uses a 40% busy period duty cycle for access points, a figure that Roberson believes is also too low for busy periods.[10] Appendix C provides additional discussion of the justification for high busy period access point duty cycles.

Appropriate adjustments can be made to this NCTA calculation to include four nationwide deployments and a "middle-ground" assumption of a 40% busy hour access point duty cycle. Although we believe the access point deployment densities are consistent with 100% outdoor deployment, we also use NCTA's 50% indoor/outdoor parameter for this calculation. The result of applying this modified set of assumptions (generally falling between those previously applied by Globalstar and NCTA) is shown below:

$$1{,}100{,}000_{APs} * 0.5_{outdoor} * 0.4_{dutycycle} * 0.33_{channels} * 4_{deployments} = 290{,}000_{AP\ equivalents}$$

The result is 290,000 "access point equivalents." Interpolating the values in Table 2 above yields a capacity degradation of 15% to Globalstar. Given this analysis, the NCTA critique that the Roberson analysis overestimates the degradation to Globalstar by failing to consider the total number of unlicensed channels available for use is without basis.

Regarding access point operating parameters, the Roberson analysis did not adopt any one set of assumptions for duty cycle, antenna gain, or clutter, but instead considered the sensitivity of Globalstar capacity degradation to realistic ranges of all these factors, as shown in Figures 5, 7, and 8 in the November Roberson Report.[11] The result was that the capacity degradation to Globalstar was never less than 10% even for these access point parameters.

[10] *See Attachment to January 22 NCTA filing*, pages 21-22.
[11] *See* November Roberson Report, pages 18, 22, 24.

2. Access point duty cycles and the binomial probability theorem.

NCTA's January 22 filing further asserts that the Roberson analysis did not properly account for the effect of duty cycles across a large population of access points. NCTA states that for a given average access point duty cycle,

> The probability that all (or a significant number of) access points will be transmitting at the same time, and thus all collectively adding noise to Globalstar's system as they [Roberson] suggest, is extremely small. … Assuming a very high 80% duty cycle, the chance that 4.4 million access points will all be transmitting at the same time is less than one thousandth of one percent (<0.000001). In other words, laws of probabilities dictate that Globalstar's "worst case" scenario is extremely unlikely to occur.[12]

While it is true that the likelihood that *all* access points will be transmitting at the same time is very small, that fact is irrelevant. The theorem on binomial probabilities, as applied to wireless access points, states that if each access point has an X% duty cycle, then X% or more access points are active *half* the time. In other words, the average number of access points transmitting at any given time is X%.

The plot in the figure below illustrates this mathematical principle. This plot shows the binomial distribution function of the number of simultaneously transmitting access points, for an average access point duty cycle of 80%.[13] The height of each bar represents the fraction of time that a certain number of access points are simultaneously transmitting. On average (half the time or equivalently 30 minutes out of an hour), 80% of the access points are simultaneously transmitting, as shown by the sum of heights of the blue bars in the figure.

The Roberson analysis correctly characterizes access point duty cycles in its calculation of capacity degradation. Accordingly, as Roberson described in the November Report, high access point duty cycles during peak traffic times create periods of significant degradation to Globalstar. This NCTA criticism of the November Roberson analysis is without basis.

[12] *Attachment to January 22 NCTA filing*, pages 11-12.
[13] *See* http://www.math.uah.edu/stat/applets/SpecialCalculator.html

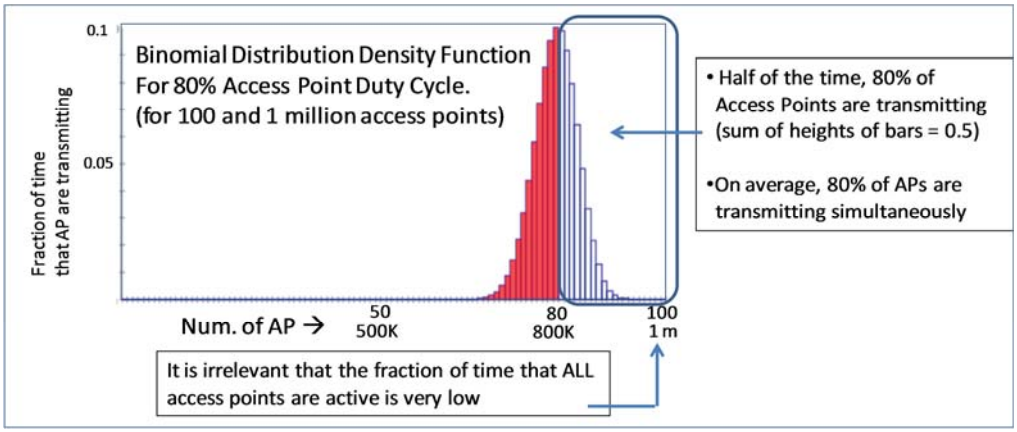

Figure 2. Binomial Distribution Density Function for Access Points

2.2 NCTA Dynamic Model

In its January 22 filing, NCTA describes and presents the results of a "Dynamic Simulation Model" for estimating interference to the Globalstar feeder uplink due to outdoor U-NII-1 access points.[14] Using the relationship established in Table 7 of the November Roberson analysis,[15] NCTA concludes that there will be an insignificant effect on Globalstar's capacity. We disagree with this conclusion.

Roberson has studied NCTA's description of the Dynamic Model as well as the model's outputs, and finds nothing that changes our conclusions in the November 2013 Roberson report. If the FCC adopts its proposed rules for the U-NII-1 band, the unfettered deployment of outdoor U-NII-1 devices at U-NII-2A power levels will have a substantial detrimental impact on the capacity of Globalstar's mobile satellite system, the availability of satellite RF transmit power to Globalstar's users, and quality of service for its customers.

The reasons for this conclusion are as follows.

1. The Dynamic Model underestimates the number of outdoor U-NII-1 access points that will be deployed under an unlicensed regulatory model. NCTA assumes a level of access point deployment consistent with only one nationwide operator deployment, when, as described above, there will likely be at least four nationwide equivalent deployments. In addition, the NCTA improperly assigns access point density based on small scale geographic population density, which underestimates the number of access points deployed in areas such as urban parks and other public areas with low population density but high user density.

2. Given the unrestricted nature of unlicensed operations, there is no assurance that the Dynamic Model's parameters for access point antenna gain and clutter are representative of

[14] *See Attachment to January 22 NCTA filing*, pages 16-28.
[15] *See Attachment to January 22 NCTA filing*, page 27.

actual deployments. Observations of urban access point deployments (see Appendix A, Austin, TX deployment) show many urban sites will have clear signal paths to the satellites.

3. Insufficient information has been provided on the operation of the Dynamic Model to validate its outputs. Specifically, the outputs of the model have not been verified with appropriate test cases for which the outputs can be estimated independently. Validation of a complex model using test cases is essential before its outputs can be trusted.

We further observe that a representative static model – like the model applied in NCTA's July 2013 NCTA analysis and applied also in the November Roberson report – should produce similar results to the Dynamic Model if the inputs to the Dynamic Model are chosen appropriately. In this case, the November Roberson analysis pointed out calculation errors made by the NCTA in its use of the static model.[16] NCTA has now apparently abandoned that static model. Since we lack the ability to validate the NCTA Dynamic Model, we cannot rule out errors of a similar nature within this new model.

2.2.1 Correction to the Dynamic Model Parameters to Account for Multiple Nationwide Deployments

Notwithstanding the inability to validate the operation of the NCTA Dynamic Model, it is possible to estimate what outputs the Dynamic Model would produce if the number of outdoor access points were increased to levels consistent with four nationwide deployments. The January 22 NCTA filing states that with 3 million access points deployed nationwide, the maximum number of access points creating interference to Globalstar at any one time is 250,000.[17] This results in a Globalstar uplink noise rise of approximately 1.12 dB.[18] Four similar nationwide deployments would result in 1 million simultaneously visible access points, resulting in a noise rise on the order of 3.4 dB, and a corresponding capacity reduction of 8% or greater, based on the relationship in Table 1. This noise rise and capacity reduction will likely be even greater, however, since we assert that NCTA has underestimated the number of outdoor access points (Globalstar estimates 4.4 million outdoor access points based on the Google Mountain View 100% outdoor deployment). Other examples, of outdoor urban deployment, such as in Austin, Texas (see Appendix A), also support this higher number.

For these reasons, nothing in the Dynamic Model alters our conclusion that the deployment of unlicensed outdoor U-NII-1 access points will cause significant degradation to Globalstar.

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[16] *See* November Roberson Report, page 25.
[17] *See Attachment to January 22 NCTA filing*, page 24.
[18] *See Attachment to January 22 NCTA filing*, page 26.

2.3 Progress: Areas of Agreement between the NCTA and Globalstar

Notwithstanding the numerous points of disagreement between NCTA and Globalstar regarding the assumptions about unlicensed outdoor U-NII-1 access point deployment, NCTA's January 22 filing does make clear that progress between the two sides has been made in several areas.

1. There is agreement that some number of outdoor U-NII-1 unlicensed access points can degrade Globalstar's licensed operations. Applying its own assumptions, the January 22 NCTA filing estimates a 1-2% reduction of Globalstar's capacity. As described above, however, allowing for the likelihood of multiple national deployments of outdoor U-NII-1 access points and the unrestricted nature of unlicensed deployment, the degradation will be considerably larger. Given this scenario, the parties should be given an opportunity to reach a consensus on the definition of harmful interference and practical mitigation approaches.
2. NCTA relies on the relationship between uplink interference levels measured at the satellite and Globalstar downlink capacity degradation established by Roberson to draw conclusions about what constitutes harmful interference to Globalstar. This forms the basis for establishing a harmful interference threshold for Globalstar.

3.0 Globalstar Proposal for Interference Protection Criterion

In December 2013, discussions were initiated between Globalstar and NCTA with the mutually-agreed-upon goal of reaching consensus on the following issues:

1) What constitutes harmful interference to Globalstar.

2) How interference should be measured.

3) What mitigation approaches should be applied if harmful interference occurs.

The following describes the Globalstar position on these items:

<u>Harmful Interference</u>

A reasonable position is that harmful interference occurs to Globalstar when there is a particular level of Globalstar user capacity degradation. For example, a 2 dB noise rise in the satellite feeder uplink due to unlicensed access points corresponds to an approximate 4% reduction to Globalstar's capacity as shown in Figure 3 below. Other levels of capacity degradation could be chosen to specify the noise rise limit at which harmful interference occurs. The relationship between uplink noise rise due to outdoor U-NII-1 access point interference and Globalstar capacity is plotted in

Figure 3 based on Table 7 from the Roberson November 2013 report (also Table 2 above). This table was also relied on by NCTA in its January 22 filing.[19]

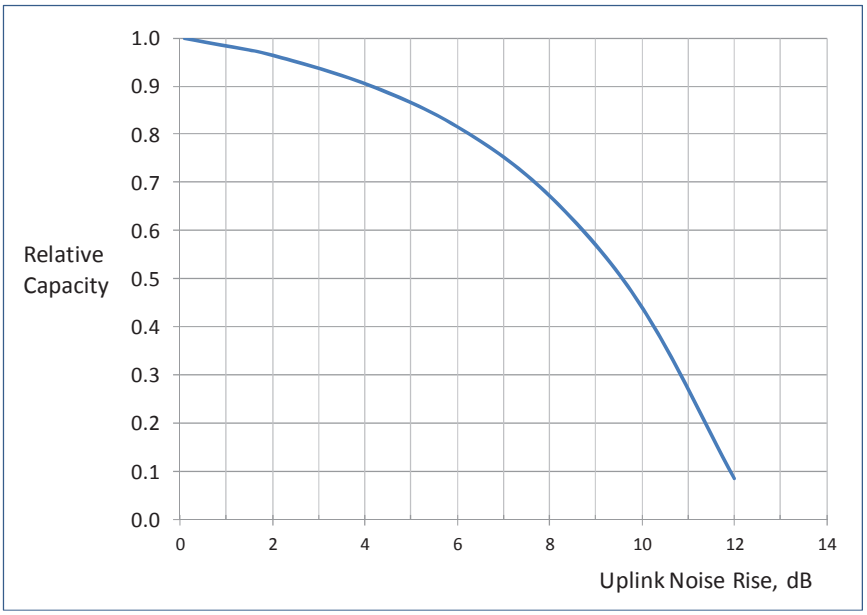


Figure 3. Relative Globalstar Capacity as a Function of Uplink Noise Rise due to Access Point Interference

Measurement of Interference

The Globalstar network operations group has conducted extensive measurements on its satellites and has confirmed the ability to reliably measure noise rise (equivalent to interference) on its feeder uplinks while the satellites are over the continental U.S. Previously, Globalstar made noise floor measurements over a period of two years over other regions of the earth. There were no changes in the noise floor over this time period, and no differences between these historical measurements and the recent measurements over the United States. These test results provide confidence that any future noise rise measured by Globalstar will be attributable to aggregate interference from outdoor U-NII-1 access points, since no other operations are authorized in that spectrum. A more detailed description of the monitoring approach proposed by Globalstar is contained in Appendix B. Monitoring the interference to a primary licensee to implement interference protection criteria is a common element of spectrum sharing solutions. For example, such monitoring is part of the sharing framework for proposed for NOAA satellites in the 1695-1710 MHz spectrum.[20]

[19] *See Attachment to January 22 NCTA filing*, page 27.
[20] *See* Appendix 1-1, *Commerce Spectrum Management Advisory Committee Final Report: Working Group 1—1695-1710 MHz Meteorological-Satellite, Rev.1* (July 23, 2013), http://www.ntia.doc.gov/files/ntia/publications/wg1_report_07232013.pdf.

Alternative methods of measuring interference have been considered. Measurement of the effects of interference on performance metrics at the Globalstar handheld device, rather than measuring the uplink interference at the satellite, is not practical or reliable. First, there is no current capability or method to instantaneously and continuously measure device level performance metrics across the entire population of end users. Second, measurement of the noise rise on the Globalstar uplink is the most direct way to monitor interference caused by outdoor access points in the U-NII-1 band. For traffic levels on the Globalstar downlink below the designed capacity level, the CDMA closed loop power control algorithm will compensate for increased interference until all the available downlink power is consumed (a portion being wasted on the interference). Then, since no more power is available for additional users, the effects of interference will be felt in aggregate by increased "no service available" indications across the users requesting service, and by an increase in dropped calls and poor call quality across all users. The degraded subscriber performance ("system busy" indications and poor call quality) resulting from uplink interference due to outdoor unlicensed access points will happen suddenly during high traffic periods. Since performance degradation measured at an individual handheld device can be caused by locally generated interference or poor propagation conditions that are independent of the uplink interference, there would be a likelihood of falsely triggering uplink interference mitigation mechanisms.

For these reasons, interference should be measured at the Globalstar satellite.

Mitigation

Mitigation of interference should include the provision for adjustment to the outdoor unlicensed access point operating parameters (for example, output power) via a suitable network management system, and potentially limiting further outdoor deployments until the interference level is reduced below the protection limit.

4.0 Conclusion and Recommendations

4.1 Conclusion

The core question for the FCC in the U-NII-1 band is the following: Will allowing unlimited, unlicensed outdoor deployment of high power U-NII-1access points create a significant probability of degradation to the operation to Globalstar's satellite service and its users?

The answer is yes. With satellite technical parameters provided by Globalstar, Roberson has conducted analyses to determine the degradation to Globalstar operations and subscribers that will result from interference to Globalstar's feeder uplinks from unlimited outdoor U-NII-1 access points. Globalstar will experience: 1) degraded signal-to-noise plus interference (equivalently, denial-of-service to users during Globalstar busy periods); 2) degradation to the downlink RF power at the satellite available to users (also manifested as a capacity reduction); and

3) degradation in user quality of service – dropped calls and reduced service area. The degradation in downlink RF power at the satellite is directly attributable to increased uplink interference and the wasted downlink power due to retransmission of that interference.

Assuming reasonable outdoor deployments of outdoor U-NII-1 access points and reasonable operating characteristics for those access points, the degradation to Globalstar's operations can be substantial. We project at least four national-equivalent outdoor deployments in the U-NII-1 band considering all of the entities that will likely use this band within the Globalstar satellite footprint: multiple service providers with national deployments, federal agencies, DoD, state and local government, non-operator commercial entities, private individuals, and entities in Canada and Mexico. These national deployments of outdoor U-NII-1 access points will cause uplink interference resulting in a 4-10 dB rise in the noise floor and a 10% to 50% capacity degradation.

In addition, using the relationship established in the November 2013 Roberson analysis between Globalstar uplink interference and Globalstar downlink degradation, we believe that it is possible to establish a harmful interference threshold for Globalstar that will permit successful operation of both Globalstar's licensed service and outdoor U-NII-1 operations. For example, referring to Figure 3, if the harmful interference limit is defined as the level of interference that causes a 2 dB rise in the noise floor, this would correspond to approximately a 4 % Globalstar capacity degradation.

While NCTA agrees with Roberson that outdoor U-NII-1 deployment will harm Globalstar if the number of access points is large enough, NCTA's analysis is otherwise undercut by flawed assumptions regarding (i) the number of outdoor U-NII-1 access points likely to be deployed under the FCC's proposal, and (ii) the number of outdoor U-NII-1 access points needed to create harmful uplink interference to Globalstar. NCTA applies different assumptions for the technical parameters of U-NII-1 access point deployment, including the fraction of access points deployed outdoors versus indoors. The Roberson analysis uses the Google outdoor deployment example as representative of outdoor deployment: 100% of access points in the Google deployment are outdoors. Any indoor deployments are in addition to this density.

Based on flawed assumptions on the number of outdoor U-NII-1 access points and their operating characteristics, NCTA claims that the amount of interference from outdoor U-NII-1 access points will be small (a 1 dB noise rise in Globalstar's feeder uplink), which it argues is not sufficient to cause harmful interference to Globalstar. (In its January 22 filing, NCTA in making this claim relies on Roberson's analysis of the relationship between feeder uplink interference and Globalstar downlink degradation.) In its January 22 filing, NCTA also employed a "Dynamic Simulation Model" to reach a similar conclusion, that unlimited outdoor U-NII-1 deployments will not result in an unacceptable level of interference (approximate 1 dB noise rise) or cause an unacceptable level of capacity degradation (1-2%) to Globalstar. However, when appropriate corrections are made to NCTA's Dynamic Model calculations – including accounting for multiple national outdoor U-NII-1 deployments – the level of harm to Globalstar increases substantially to a capacity reduction of 10% or greater during periods of peak traffic.

Significantly, Globalstar indicates that it has now developed a practical approach for measuring (monitoring) feeder uplink interference at regular time intervals at its satellites. Extensive recent

measurements conducted by Globalstar on its satellites have demonstrated that direct measurement of this interference (noise rise) is practical and repeatable. This ability to measure *actual* interference can moot the disagreement on the assumptions that are the basis for *projecting* future interference. If there is agreement on a harmful interference threshold, Globalstar will be able to accurately monitor the noise level on the uplink to reliably detect when that threshold is being approached or exceeded. Under an appropriate regulatory framework, if the harmful interference threshold were being approached, interference reduction measures would be triggered. Monitoring interference to a primary spectrum license holder caused by secondary users is a common component of spectrum sharing regulatory frameworks.

4.2 Recommendations

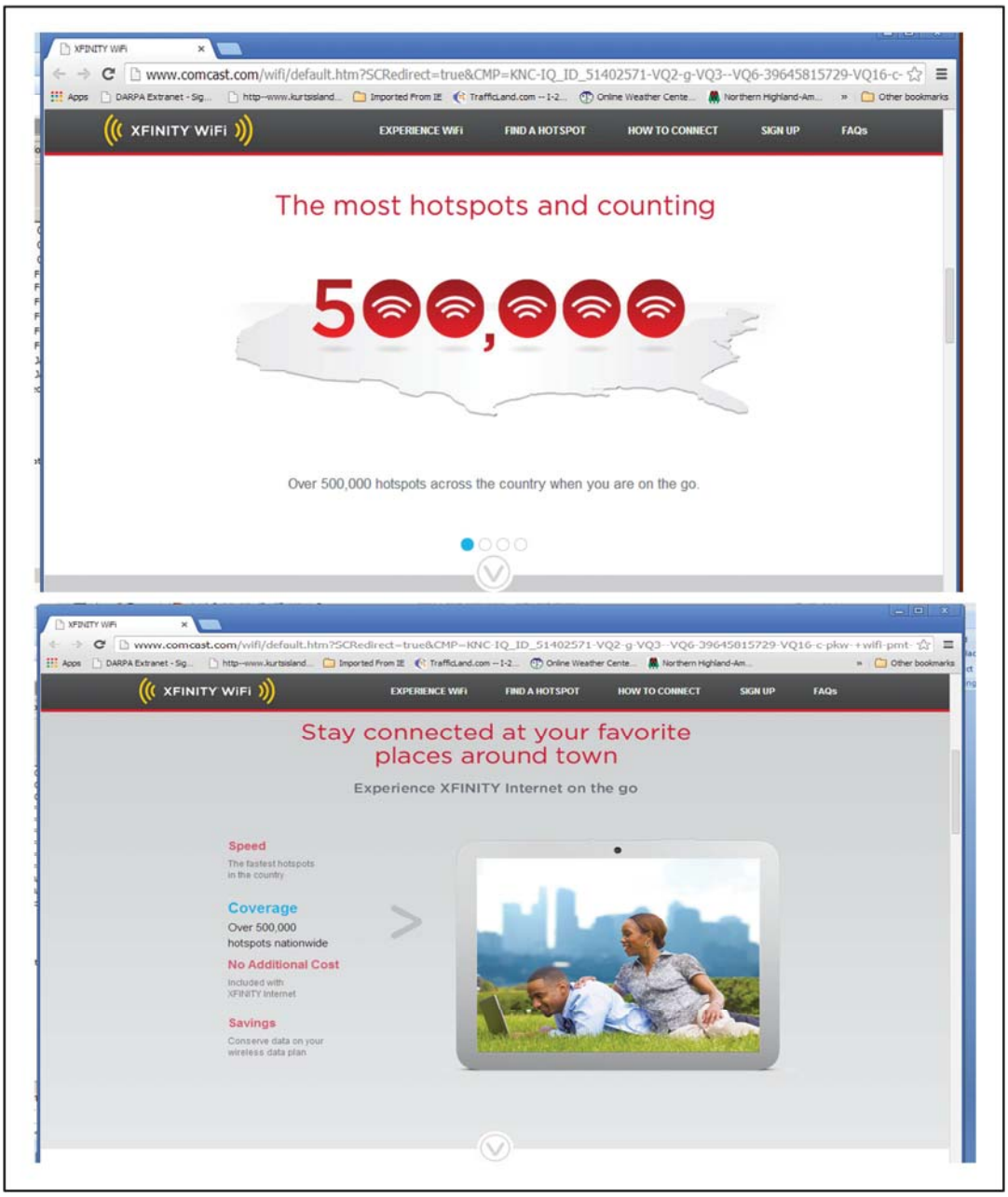
We provide the following recommendations regarding the development of a framework to protect Globalstar's licensed feeder link operations while allowing secondary, shared use by outdoor U-NII-1 access points:

1. Allow the discussions between Globalstar and NCTA to continue for a reasonable time so that the parties can reach agreement on the following: the level of interference that constitutes harm to Globalstar (interference protection criterion); the method for measuring interference; and the mitigation approach that would be required if the interference protection criterion was exceeded.

2. Adopt rules allowing outdoor U-NII-1 operations as long as those rules incorporate sufficient protection to prevent harm to Globalstar's licensed operations. Protections for Globalstar should include the specification of an interference protection limit as measured by the noise rise on the Globalstar feeder uplink; the requirement for Globalstar to regularly monitor and report the measured noise floor measurements; and the specification of a mitigation approach that would be triggered if the interference protection criterion is exceeded.

Appendix A: Evidence of Unlicensed Outdoor Deployment

1. Cable Operator Deployment Scale and Outdoor Deployment



2. Non-Operator Outdoor Deployment Examples

University Campus: Outdoor Coverage Map
http://it.stonybrook.edu/services/wi-fi-wolfienet

Outdoor AP Locations, New York City Parks
http://www.nycgovparks.org/facilities/wifi

Onsite WI-FI at Walt Disney World

Complimentary wi-Fi is offered at all Disney Resorts and throughout the theme parks. If you have a Wi-Fi enabled laptop or PDA, you can also access the internet from common areas at the resort. Just select the correct network, connect and accept the terms and conditions. Covered cellular carriers include AT&T, Verizon, Spring, T-Mobile and MetroPCS.

Outdoor locations

Common areas with free wifi:
Bus stops, feature pool, main lobby, porte cochere

http://www.wdwinfo.com/wdwinfo/resorts/wireless.htm

Residential Outdoor Wi-Fi

Non-Operator Outdoor Deployments, continued.

Outdoor Wi-Fi in San Jose, CA

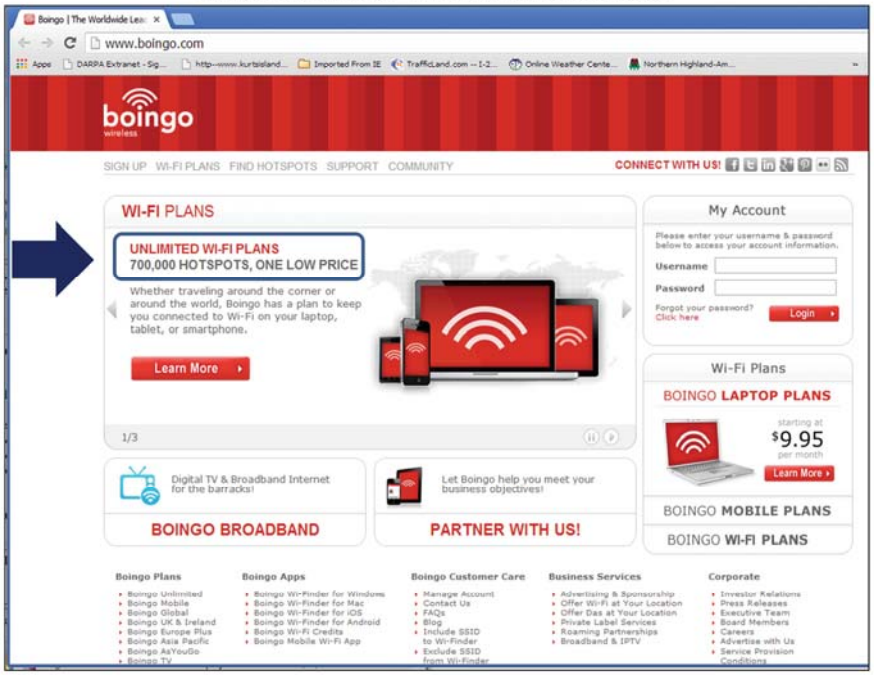
Outdoor Wi-Fi Parking Lot Coverage

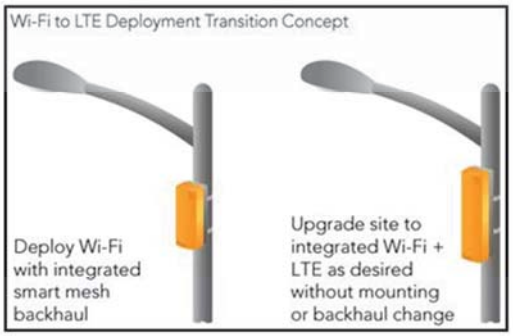
Wi-Fi coverage for Trailer Parks and Camp Grounds is becoming increasingly important

Free Wi-Fi Access in Albuquerque, NM

3. Non-Cable Wi-Fi Service Providers

Evidence of Other Wi-Fi Service Providers





Wireless Operator Application of Outdoor Wi-Fi

Non-Cable Service Providers, continued.

Examples of Additional Service Providers for Wi-Fi: Orlando, FL

Wi-Fi Service systems being used now in the Orlando area are listed below.

Boingo Wireless, Inc. is an ultra-high-speed wireless Internet service available in thousands of locations such as hotels, airports, cafes, and other public places, in dozens of countries throughout the world. Both directly and through major carrier and ISP partners, Boingo provides business travelers with a wireless broadband Internet connection to improve productivity while on the road. Through its Wi-Fi software and Roaming System, Boingo makes finding and connecting to Wi-Fi networks point-and-click simple and secure. More information about Boingo is available at www.boingo.com.

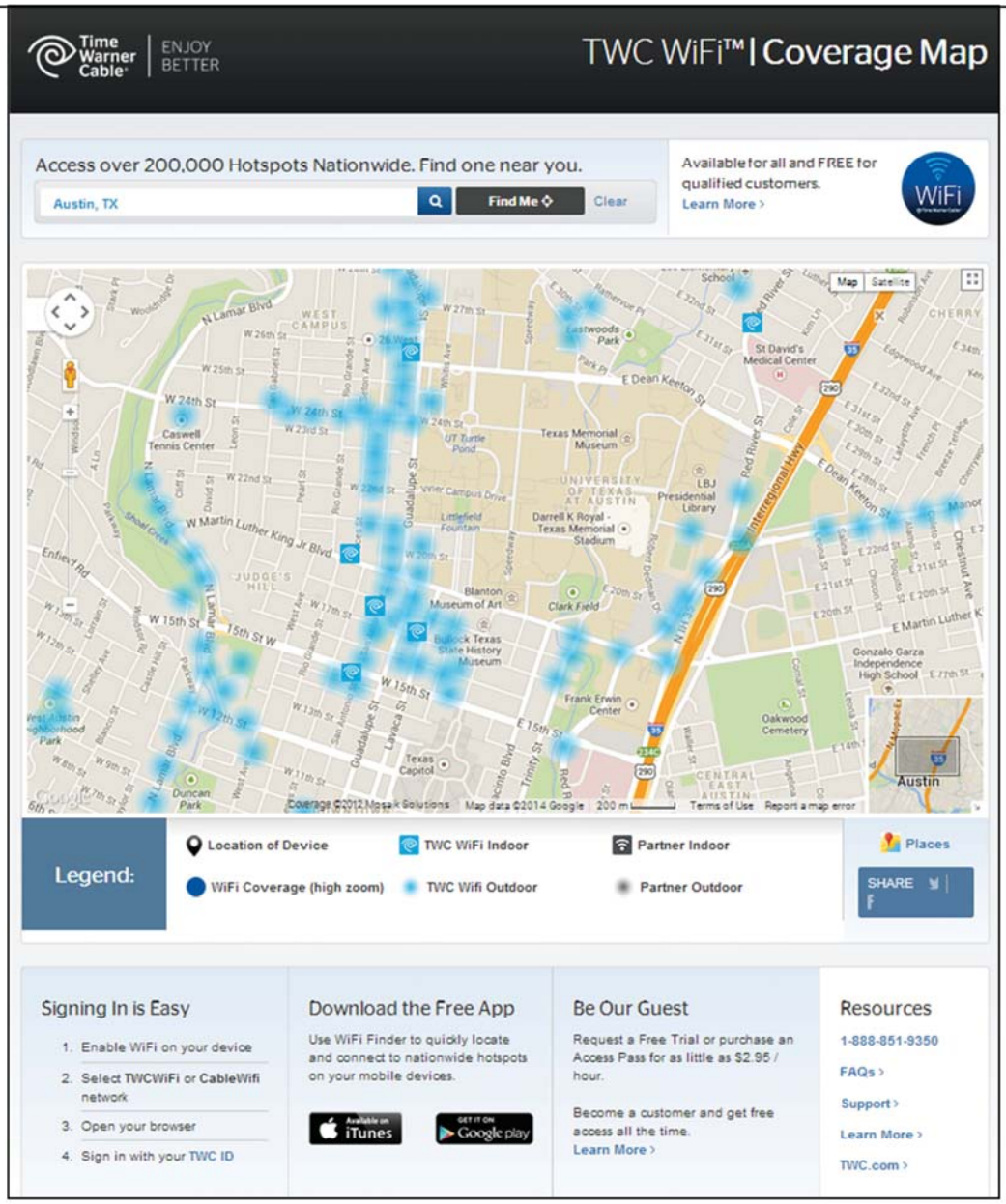
Trustive - Wireless Internet access provider (virtual WISP or VWISP) Wireless freedom For more info go to www.trustive.com/

Wayport is the one of the leading providers of high-speed wired and Wi-Fi (802.11b) wireless Internet access for travelers throughout an extensive network of hotels, airports, cafes, and other public places, in dozens of countries throughout the world. For more information on locations go to www.wayport.com/

T-Mobile Wireless Internet Access - T-Mobile Hot Spots Wireless Internet Access Service, Services T-Mobile HotSpot provides high-speed Wi-Fi wireless Internet access in convenient public locations. For locations go to www.t-mobile.com/hotspot/

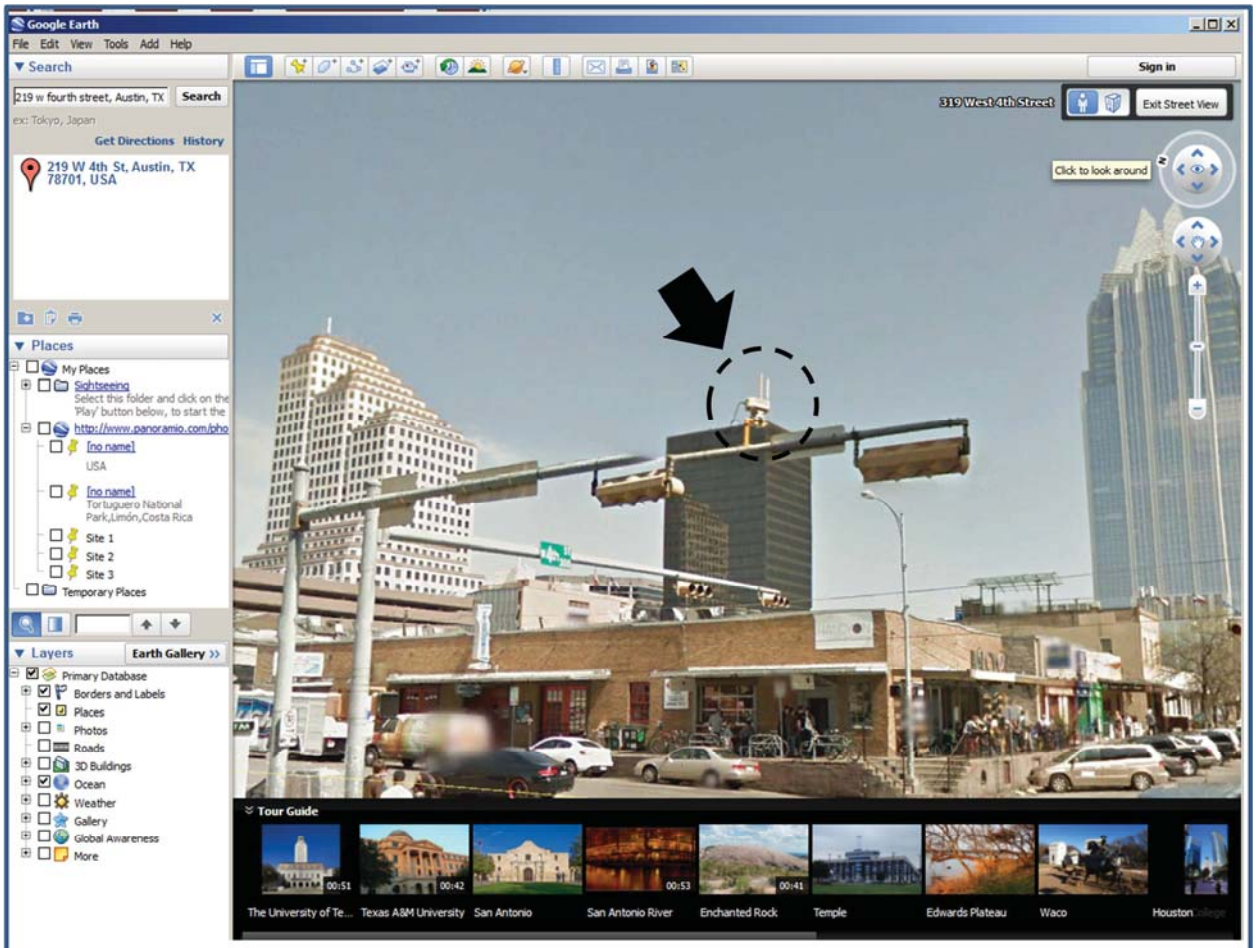
hereUare Communications provides a suite of innovative services based on the internationally recognized IEEE 802.11 (Wi-Fi) standard and tailored to meet the unique requirements of the high-speed public wireless industry. www.hereuare.com/

4. Example of Outdoor Deployment Density: Austin, TX



Inspection of this coverage map reveals 32 outdoor access points within 0.78 sq mi. of the Austin, TX city center, or 16 access points per square km.

http://timewarnercable.cellmaps.com/WiFi.html#/#c=30.28205683168144 8,-97.74136838951875&z=15&term=Austin,%20TX



Austin, TX Outdoor Urban Deployment.

5. Additional References for Outdoor Deployment

- Map of outdoor, indoor/outdoor, and indoor Wi-Fi hotspots in DC area: http://geospatial.dcgis.dc.gov/agencyapps/wifi.aspx

- Comcast deployment of Wi-Fi at sports stadium: http://corporate.comcast.com/comcast-voices/xfinity-wifi-now-at-citizens-bank-park

- Comcast deploys 350 Wi-Fi hotspots in Atlanta, including 2 parks, and 3 college campuses and 1 college center for 3 other schools: http://www.ajc.com/news/business/comcast-launches-free-wi-fi-hotspots/nX2Th/

- AT&T news release, rolls out 26 outdoor Wi-Fi hotspots in 20 NYC parks: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CFkQFjAD&url=http%3A%2F%2Fwww.att.com%2FCommon%2Fabout_us%2Ffiles%2Fpdf%2Frumsey_wi-fi_advisory.pdf&ei=_JUHU4NmjKTIAayygOgL&usg=AFQjCNHJ7gyG_xBchJdjk7SKrVv1s62VIA&sig2=26g0vswyFZ98Mwlekvi3ig&cad=rja

- 336 Wi-Fi APs at AT&T Park in San Francisco: http://reviews.cnet.com/2300-6452_7-10013414-3.html (AT&T Park can hold 43415 people: http://en.wikipedia.org/wiki/AT&T_Park)

- Disneyworld has Wi-Fi hotspots in 8 different parts of park: https://disneyworld.disney.go.com/guest-services/internet-access/

- Stadium Wireless company that deploys Wi-Fi access to stadiums/golf courses: http://www.stadiumwireless.co.uk/blog/stadium-wireless-takes-wifi-to-the-golf-course/

- Xirrus Wi-Fi deploys Wi-Fi system for PGA golf courses in Europe, 3.5k users: http://www.xirrus.com/Company/Press/Press-Releases/UK/PGA-European-Tour-deploys-Xirrus-Wi-Fi-to-provide

Appendix B: Measurement of Uplink Interference at the Globalstar Satellite

The Globalstar network operations group has conducted extensive measurements on its satellites and has confirmed the ability to reliably measure noise rise (equivalently interference) on its feeder uplinks globally and while the satellites are over the continental U.S. The straightforward relationship between interference and noise rise is shown in Figure 4 below. For example, when the noise power is equal to the interference power (I/N = 0 dB), the noise rise is 3 dB.

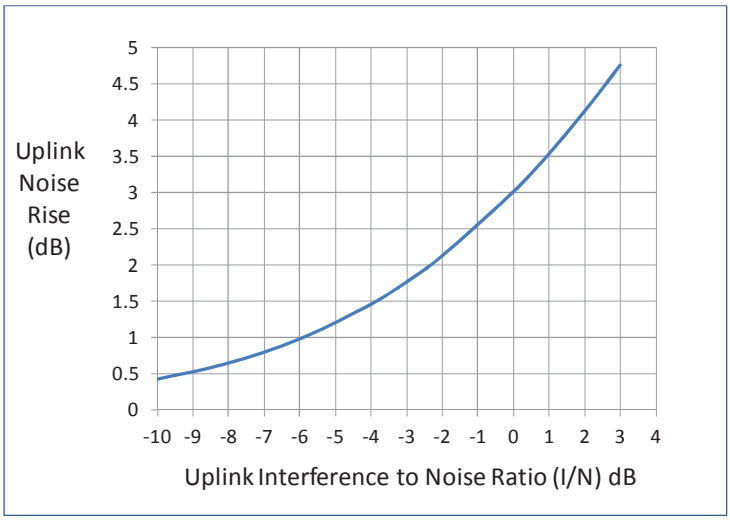


Figure 4. Relationship between Uplink Noise Rise and I/N

Figure 5 is a simplified block diagram of the satellite transponder that shows where the noise power and noise power-rise measurements are being made.

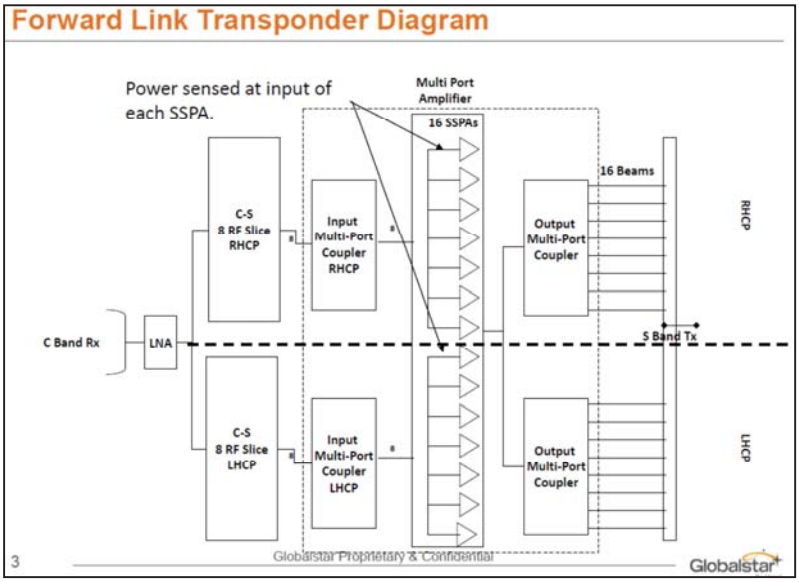


Figure 5. Globalstar Forward Link Transponder Diagram

The procedure for measuring the noise floor level is as follows:

1. Measure 8 Globalstar satellites for a period of 24 hours.
2. When the Globalstar satellite is out of range of any feeder uplink, the satellite is receiving only noise, and that level of power is identified as the noise floor.

The plot in Figure 6 below is the power level recorded at the points in the block diagram above. It can be seen that the measured power drops to the noise floor when the satellite is out of range of a ground station.

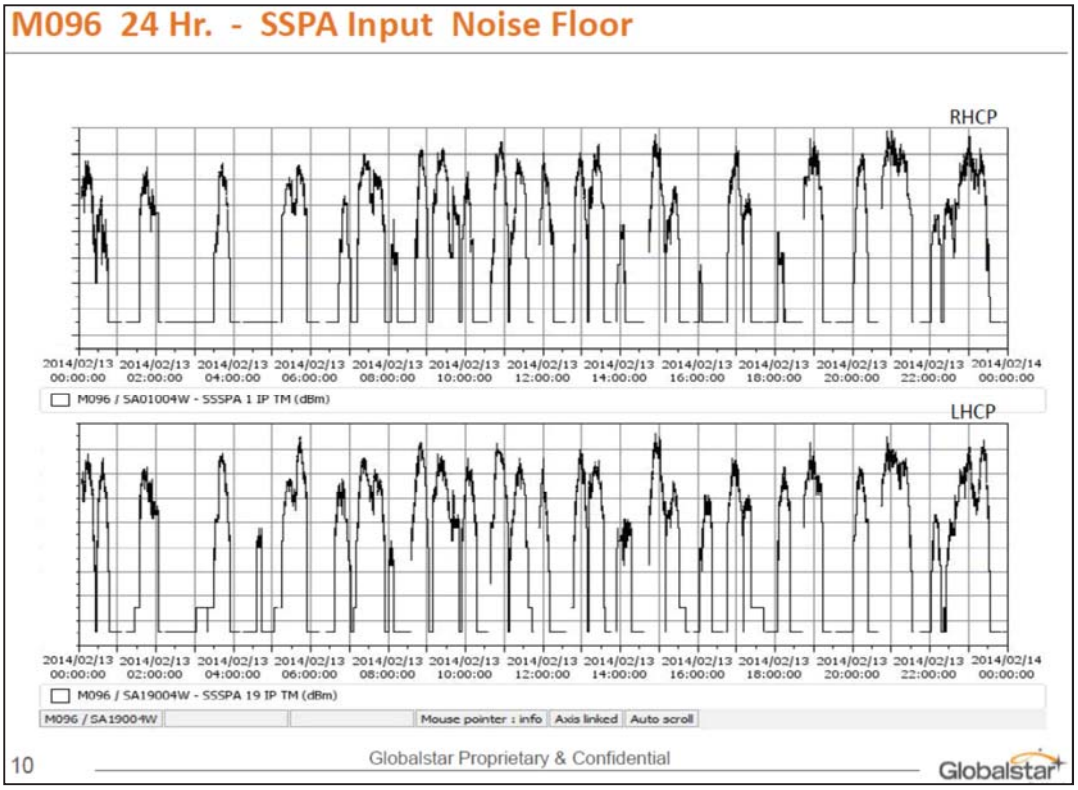


Figure 6. Satellite M096 Measured Power.

The procedure that Globalstar is using to confirm the ability to measure changes in the noise floor over the U.S. is as follows:

1. While one of the satellites is in range of a ground station, turn off the feeder uplink. This causes the measured power at the satellite to drop to the noise floor.
2. Increase the uplink power in increments until the rise in the noise floor can be observed, noting the uplink power level at which this occurs.

As a result of repeated tests conducted during the last 8-10 weeks, the Globalstar network operations team has confirmed the ability to reliably measure an initial noise rise level of equal-to-or-less-than 3 dB. Noise rise increments of approximately 1 dB are subsequently able to be detected.

Previously, Globalstar made noise floor measurements over periods of up to one year over other regions of the earth. There were no significant changes in the noise floor over this time period, and no significant differences between these historical measurements and the recent measurements over the United States. These test results provide confidence that any noise rise measured by Globalstar will be attributable to aggregate interference from outdoor U-NII-1 access points, since no other operations are authorized in that spectrum.

Appendix C: Frequently Asked Questions Regarding Unlicensed Access Point Harm to Globalstar Operations

1. Can Globalstar mitigate or compensate for the effects of interference by increasing power on its feeder uplinks while reducing transponder gain?

Response:

It is not possible to compensate for the effects of interference in this manner without negative impact to Globalstar. The Globalstar operations group has confirmed that while it is theoretically possible to increase gateway EIRP slightly to compensate for small degradations in the uplink signal-to-noise-plus-interference ratio caused by access point emissions, the service life of the satellite transponders will be noticeably decreased as a result of reducing transponder gain and changing the amplifier operating point. The system was not designed to deal with the increased interference anticipated from the proposed rules. Compensating for the higher levels of U-NII-1 interference would require costly ground station antenna and amplifier replacement, and, due to satellite transponder limitations, it is not possible to compensate for interference without limit. The service life of the satellite will be correspondingly decreased as larger amounts of compensation are applied.

2. Can outdoor U-NII-1 access point antenna gain be limited to prevent degradation to Globalstar?

Response:

Using the approach described in the November Roberson report to calculate the capacity degradation to Globalstar due to uplink interference, the following graph shows the relationship between downlink capacity and access point antenna gain for elevation angles of 30 degrees and higher. For a population of access points operating at U-NII-2A power levels at 80% duty cycle with an EIRP of 1 Watt, if the relative antenna gain is at least 18 dB below the maximum allowed gain of 6 dBi, then the capacity degradation to Globalstar will be approximately 2%. Further analysis is required to confirm that an antenna with this operating characteristic can be practically implemented and that this characteristic can be maintained over a large population of access points during wide scale deployment.

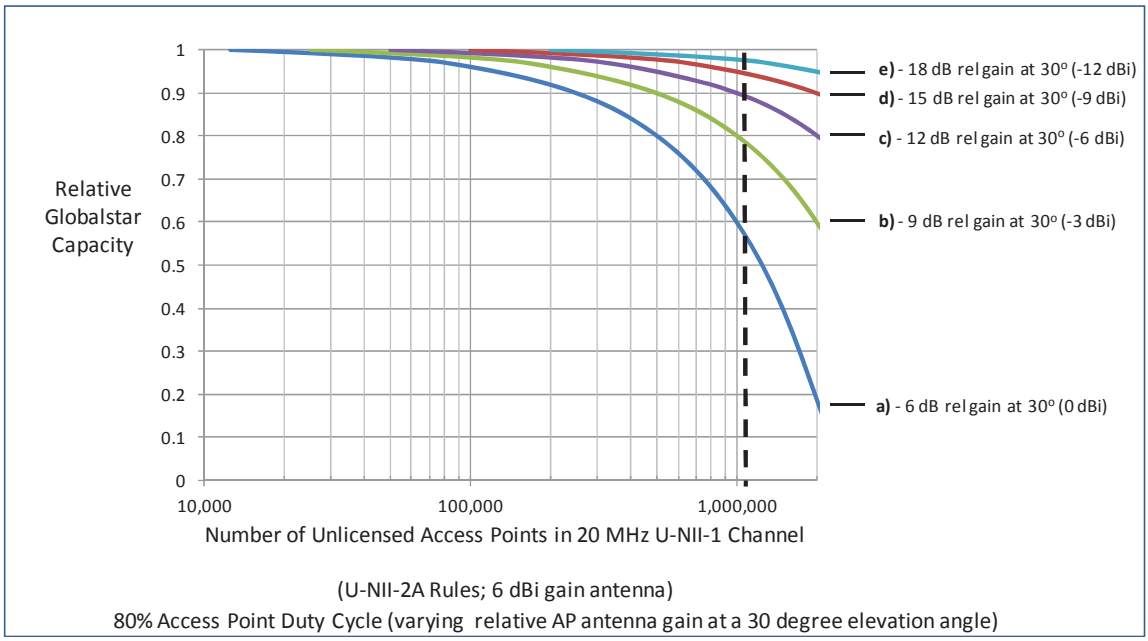


Figure 7. Effect of Limiting Access Point Antenna Gain at Elevation Angles Greater Than 30 Degrees

3. Is there sufficient link margin on Globalstar's downlink to absorb the degradation in end-to-end signal-to-noise-plus-interference caused by unlicensed outdoor U-NII-1 access points?

<u>Response:</u>

In the CDMA communication protocol employed in Globalstar's downlink, a number of user devices within a coverage cell share the same spectrum using orthogonal codes. Capacity is limited by (i) the finite downlink power available at the satellite that must be shared by all users, (ii) the co-channel interference between users operating on adjacent beams and overlapping satellites, and (iii) the adjacent-channel interference between users operating in the same cell. In order to limit this interference, transmit power is controlled using a closed loop algorithm to the minimum level necessary to maintain acceptable communications (no inherent additional link margin). Increasing the transmit power to CDMA users in order to overcome external interference created by unlicensed access points both steals the (finite) power available to other users and increases the CDMA co- and adjacent-channel interference, reducing capacity accordingly. For this reason, there is no way to compensate for increased external interference without causing harm to Globalstar.

4. What is the justification for high busy-period access point duty cycles?

Response:

A recent study, also cited by the NCTA, measured Wi-Fi duty cycles at "179 locations in Belgium and the Netherlands, for five different environments."[21] The study measured "average" or "median" duty cycles, not peak-period duty cycles, which are most relevant to assessing what degradation will be caused to Globalstar. However, the study recognizes that certain applications like video and file transfer result in very high duty cycles (of between 82-94percent), and notes "[t]hus during intensive applications much higher duty cycles can occur." Given that video downloads and streaming video represent a rapidly growing share of mobile traffic, over time the heavy use of such applications will push up duty cycle averages. Furthermore, more than half of the 179 environments in this study were non-urban environments, but instead were either "industrial," "suburban," "office," or "residential," which bring down the averages.[22] Further, the study explicitly recognized that as the number of "client devices" (subscribers) using the access point increases, so does the duty cycle, until it reaches the theoretical maximum duty cycle (which ranges from 57% to 97%, depending on the data rate). The study accordingly states that "the presented maximum duty cycles are a *realistic worst-case value*, which is even more pessimistic for a higher amount of clients."[23]

[21] Joseph *et al*., at 10, *Determination of the Duty Cycle of WLAN for Realistic Radio Frequency Electromagnetic Field Exposure Assessment, Progress in Biophysics and Molecular Biology*, 2012).
[22] Joseph *et al.* at § 2.2.2 & Table 2; *id.* at § 4 ("Largest duty cycles are observed in urban and industrial environments.").
[23] *Id.* at § 2.3.2 & Table 3.

Appendix D: Company Profile

Profile: Roberson and Associates, LLC
Roberson and Associates, LLC, is a technology and management consulting company with government and commercial customers that provides services in the areas of RF spectrum management, RF measurements and analysis, and technology management. The organization was founded in 2008 and is composed of a select group of individuals with corporate and academic backgrounds from Motorola, Bell Labs, IBM, IITRI (now Alion), independent consulting firms, and the Illinois Institute of Technology. Together the organization has over 400 years of the high technology management and technical leadership experience with a strong telecommunications focus.

Profiles: Roberson and Associates, LLC, Staff
Dennis A. Roberson, President and CEO, Roberson and Associates
Mr. Roberson is the Founder, President and CEO of Roberson and Associates, LLC. In parallel with this role he serves as Vice Provost for Research and Research Professor in Computer Science at Illinois Institute of Technology where he has responsibility for IIT's corporate relationships including IIT's Career Management Center, Office of Compliance and Proposal Development, Office of Sponsored Research and Programs, and Technology Transfer efforts. He also supports the development and implementation of IIT's Strategic Plan, the development of new research centers, and the successful initiation and growth of IIT related technology-based business ventures. He is an active researcher in the wireless networking arena and is a co- founder of IIT's Wireless Network and Communications Research Center (WiNCom). His specific research focus areas include dynamic spectrum access networks, spectrum occupancy measurement and spectrum management, and wireless interference and its mitigation and of which are important to the Roberson and Associates mission. He currently serves on the governing and / or advisory boards of several technology-based companies. Prior to IIT, he was EVP and CTO at Motorola and he had an extensive corporate career including major business and technology responsibilities at IBM, DEC (now part of HP), AT&T, and NCR. He is and has been involved with a wide variety of Technology, Cultural, Educational and Youth organizations currently including the FCC Technical Advisory Council and Open Internet Advisory Committee, and the Commerce Spectrum Advisory Commi ttee. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe. Professor Roberson has BS degrees in Electrical Engineering and in Physics from Washington State University and a MSEE degree from Stanford.

Kenneth J. Zdunek, Ph.D. –V.P. and Chief Technology Officer
Dr. Zdunek is Vice President and the Chief Technology Officer of Roberson and Associates. He has 35 years of experience in wireless communications and public safety systems. Concurrently he is a research faculty member in Electrical Engineering at the Illinois Institute of Technology, in Chicago, Illinois, where he conducts research in the area of dynamic spectrum access and efficient spectrum utilization, and teaches a graduate course in wireless communication system design. He is a Fellow of the IEEE, recognized for his leadership in integrating voice and data in wireless networks. Prior to joining Roberson and Associates, he was VP of Networks Research at Motorola, a position he held for 9 years. Dr. Zdunek was awarded Motorola's patent of the year award in 2002 for a voice-data

integration approach that is licensed and extensively used in GSM GPRS. He holds 17 other patents, included patents used in public safety trunked systems and cellular and trunked systems roaming. He directed the invention and validation of Nextel's iDEN™ voice-data air interface and IP based roaming approach, and was the principal architect of Motorola's SmartNet™ public safety trunking protocol suite. In the 1990's, he directed a Spectrum Utilization and Public Safety Spectrum Needs Projection submitted to the FCC in support of the 700 MHz spectrum allocation for Public Safety. He was awarded the BSEE and MSEE degrees from Northwestern University, and the Ph.D. EE degree from the Illinois Institute of Technology. He is a registered Professional Engineer in the State of Illinois. He is past president, and on the board of directors of the Chicago Public Schools Student Science Fair, Inc.