L. Barbee Ponder IV
General Counsel & Vice President Regulatory Affairs

September 10, 2015

Via Electronic Filing

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

Re: *Ex Parte* Notice: *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks* – IB Docket No. 13-213

Dear Ms. Dortch:

Globalstar, Inc. ("Globalstar") writes to inform the Commission of the results of a recent deployment of Terrestrial Low Power Service ("TLPS") conducted by Roberson and Associates at a college campus in Chicago, Illinois over the summer.[1] By adding an additional 22 MHz channel (TLPS Channel 14) to the campus' 2.4 GHz Wi-Fi network, users experienced increased aggregate throughput in excess of 90%. Significantly, due to the ability of TLPS to relieve existing Wi-Fi congestion immediately, this near-doubling of network throughput after the introduction of TLPS allowed for an improved experience for all users regardless of whether they remained on Channels 1, 6 and 11 or were operating on Channel 14.

With this filing, Globalstar also provides additional information regarding the network operating system ("NOS") that it commits to employ as part of any commercial offering of TLPS. Globalstar's NOS will not only authenticate clients onto the TLPS network, but will also provide a platform for operators of licensed and unlicensed services to quickly provide notice to Globalstar of any claimed interference to their services. While Globalstar firmly believes that its TLPS offering will have no negative impact on any other licensed or unlicensed service, Globalstar commits to deploy a NOS that can quickly and efficiently provide remedial measures if necessary.

Globalstar also addresses questions about the potential future deployment of LTE-U in the 2.4 GHz band. Globalstar's TLPS opportunity is based on the existing

[1] *See* Globalstar Experimental License, Call Sign WH2XNQ (effective April 2, 2015).

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IEEE 802.11 standard commonly referred to as "Wi-Fi." Given the extraordinary benefits of TLPS that are available immediately to consumers through the use of an embedded ecosystem of hundreds of millions of 802.11 devices, as recently demonstrated in Chicago, Globalstar has no plans to deploy any LTE-U service in unlicensed spectrum. Moreover, Globalstar commits not to deploy LTE-U in the 2.4 GHz band until the Commission has otherwise allowed LTE-U deployment to proceed in unlicensed spectrum.

The Chicago TLPS deployment confirms the substantial consumer benefits available immediately to Wi-Fi users, as well as its compatibility with other unlicensed services.

Attached is a report from Roberson and Associates, LLC ("Roberson and Associates"), titled "Terrestrial Low Power Service (TLPS) Deployment and Summary Measurements," that, together with the attached Declaration provided by Kenneth J. Zdunek, Ph.D., confirms the critical and fundamental consumer benefits of TLPS. By enabling consumers to spread their wireless broadband usage over four rather than just three channels in the 2.4 GHz band, TLPS will help relieve worsening congestion in the band and immediately improve the experience of consumers in any Wi-Fi-congested area of the United States. These benefits will be realized upon the Commission adopting its proposed rules in the proceeding.[2]

Over the last three months, Roberson and Associates has conducted extensive measurements involving the concurrent operation of Channels 1, 6 and 11 and TLPS access points in a real-world environment.[3] These measurements provide compelling support for the extraordinary benefits of TLPS. As the presentation indicates, in a deployment scenario where 6 out of 12 client devices were shifted from maximally utilized Channels 1, 6 and 11 to TLPS Channel 14, average throughput on a per client device basis for the network overall increased by **92.0%**. Indeed, the total capacity of the

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[2] *See Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Notice of Proposed Rulemaking, 28 FCC Rcd 15351 (2013).

[3] For this TLPS deployment on a Chicago, Illinois university campus, Roberson and Associates installed TLPS Ruckus access points configured to operate on Channel 14 using IEEE 802.11 technology. These TLPS access points were combined with the campus wireless network of Wi-Fi access points operating on Channels 1, 6 and 11. The TLPS client devices in this real-world deployment included a variety of tablets and smartphones manufactured by Apple, Google and Microsoft.

four-channel wireless network was maximized in this scenario, where half of the clients were migrated to Channel 14. Significantly, even the 6 client devices remaining on Wi-Fi Channels 1, 6 and 11 experienced an **89.5%** increase in average downlink throughput. The integration of TLPS into this network allowed the offloading of traffic from Channels 1, 6 and 11, yielding faster data rates and a higher quality of service on those three Wi-Fi channels.

The Roberson and Associates report further demonstrates that there are no interference or compatibility issues between TLPS and Wi-Fi, nor with TLPS and Bluetooth operations in the 2.4 GHz ISM band. In addition, Roberson and Associates observed no perceptible effect on Channel 11 from substantial TLPS traffic streaming video applications (including Skype, Hulu and YouTube), and found no perceptible impact from TLPS operations on the operation of Bluetooth Standard and Low Energy devices, including heart monitors, speakers, mice and headsets.

Roberson and Associates' presentation confirms the results of the demonstration at the Commission's Technology Experience Center ("TEC") five months ago. At the request of the Commission's Office of Engineering & Technology ("OET"), Globalstar and other parties conducted this demonstration to evaluate the compatibility of TLPS with unlicensed services. At the FCC TEC, the activation of TLPS on non-overlapping Channel 14 yielded an approximately 40% increase in aggregate measured data throughput across the 2.4 GHz 802.11-capable spectrum when client devices were spread evenly over the four channels (3 client devices per channel).[4] Meanwhile, TLPS transmissions had no negative impact on the data throughput on Wi-Fi Channel 11 or any other 802.11 Wi-Fi channels at the TEC while also having no negative impact on Bluetooth operations.[5]

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[4] As indicated above, during the Chicago deployment, Roberson and Associates moved additional client devices to Channel 14 in order to optimize the aggregate throughput for all 12 client devices operating across the four non-overlapping channels. This approach yielded an average increase of 92.0% per device when 6 of the 12 client devices were moved to Channel 14.

[5] *See* Letter from Regina M. Keeney, Counsel to Globalstar, Inc., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 13-213 (Mar. 10, 2015) (attaching report of AT4 wireless, Inc. and Roberson and Associates, LLC, "Globalstar TLPS Operation Demonstration" (Mar. 6 and 9, 2015), and report of Michael Needham and Dr. Kenneth Zdunek, Roberson and Associates, LLC, "Bluetooth – TLPS Demonstrations at the FCC Technology Experience Center" (Mar. 10, 2015)).

Globalstar's proposed Network Operating System and Interference Mitigation Procedures should alleviate any further concerns regarding TLPS.

While the record in this proceeding demonstrates that TLPS will not have any negative impact on unlicensed services, Globalstar nevertheless commits to employ interference detection and mitigation techniques. TLPS will be a managed service with networked access points that will be controlled through a carrier-grade network NOS analogous to the systems used to manage pico- and femto-cellular infrastructure. The NOS will be used not only to authenticate users on the TLPS network and ensure the security of TLPS operations, but also will be capable of mitigating harmful interference to other licensed or unlicensed services in the highly unlikely event that it occurs.

Globalstar has identified the existing Wi-Fi network management system of ViaSat, Inc. ("ViaSat") as an ideal platform for its TLPS NOS. The attached presentation titled "TLPS NOS Management" provides further detail on how a TLPS NOS based on the ViaSat platform will be used to authenticate users and respond to complaints of harmful interference to licensed or unlicensed services. This management system will include a communications hotline for the reporting of harmful interference, and will provide the means for modifying TLPS emissions characteristics remotely, including reducing power levels, shifting to a different channel and powering off access points.

Globalstar will not deploy any LTE-U based service in unlicensed spectrum until the Commission has otherwise allowed such deployments to proceed.

Some commenters have expressed concern about potential Globalstar deployment of wireless broadband services based on an LTE-U wireless protocol. Globalstar responds that its TLPS offering is and has always been based on the IEEE 802.11 protocol, not LTE, given the immediate consumer benefits available from the 802.11 ecosystem. Further, Globalstar has no objection to the FCC prohibiting it from deploying any LTE-U or LAA service which might raise concerns in the 2.4 GHz band until such time as the Commission has otherwise allowed the deployment of these services to proceed in unlicensed spectrum.

* * *

It has been almost two years since the Commission proposed rules to allow the deployment of TLPS and the record on this matter has been fully developed. Further delaying final action in this proceeding only postpones the enormous consumer benefits that TLPS will generate by helping to alleviate the worsening congestion in the heavily used 2.4 GHz band. Unlike other spectrum initiatives that will take years if not a decade

or more to benefit consumers, TLPS offers *immediate* relief from broadband congestion and provides substantial benefits anywhere it is deployed. Globalstar urges the Commission to adopt its proposed rules without further delay.

Respectfully submitted,

/s/ *L. Barbee Ponder IV*
L. Barbee Ponder IV
Globalstar, Inc.
General Counsel & Vice President
Regulatory Affairs

Attachments

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems	)	IB Docket No. 13-213

DECLARATION OF KENNETH J. ZDUNEK, Ph.D.

1. I am Vice President and the Chief Technology Officer of Roberson and Associates, LLC. I received BSEE and MSEE degrees from Northwestern University, and a Ph.D. EE degree from Illinois Institute of Technology. I have over 35 years of experience designing, analyzing and measuring the performance of wireless systems in both lab and operating environments.
2. Prior to joining Roberson and Associates, I was Vice President of Networks Research at Motorola. While at Motorola I was an architect of cellular and public safety wireless networks, and was awarded 17 patents in the wireless field. I was elected a Fellow of the IEEE (Institute of Electrical and Electronic Engineers), and am a Registered Professional Engineer in the State of Illinois.
3. Concurrent with my position at Roberson and Associates, I am an Adjunct Professor in the Electrical and Computer Engineering Department at the Illinois Institute of Technology, where I do research in the areas of RF spectrum sharing, measuring and optimizing spectrum utilization, and cognitive radio; I teach a graduate a course in wireless systems design.

4. In the time period May – August 2015, engineers under my direction at Roberson and Associates deployed wireless local area network access points using the IEEE 802.11n protocol on Channel 14 at the student center at a university in Chicago at 3201 South State Street. The deployment was conducted with the cooperation and assistance of the university Office of Technology Services, which maintains and manages the campus Wi-Fi network.
5. In this declaration I provide a statement regarding the facts and parameters of the demonstration network. I provide a report titled "Terrestrial Low Power Service (TLPS) Deployment and Summary Measurements," describing the compatibility measurements and demonstrations executed with the purpose of assessing the ability of Globalstar's proposed TLPS to successfully coexist with the existing Wi-Fi network in the student center, specifically with devices utilizing the IEEE 802.11n protocol on Channel 11 in the 2.4 GHz Industrial, Scientific and Medical band.
6. It was also the purpose of the deployment and demonstration to assess the coexistence of TLPS with Bluetooth devices and services.
7. An additional purpose of the deployment and demonstration was to assess the ability of TLPS operating on IEEE Channel 14 to increase the user throughput and overall system capacity of the existing Wi-Fi network.

<u>Summary of Deployment</u>

8. Three Ruckus model 7982 access points were configured to operate on Channel 14 using the IEEE 802.11n protocol. Backhaul and connection to the internet was provided via the existing campus backbone and gateway. The Channel 14 (TLPS) access points were

combined with the campus wireless network and devices manufactured by Meru Networks operating on Channels 1, 6 and 11 using the IEEE 802.11n protocol.

9. The TLPS client devices consisted of Google Nexus 7 tablet computers, Microsoft Surface Pro and Surface 3 tablet computers, an Apple iPhone4 and an Apple iPad.
10. The Bluetooth devices evaluated for compatibility included both Standard and Low Energy devices: a heart rate monitor, stereo speaker, computer mice and headsets.
11. The deployment configuration and technical parameters of the TLPS access points, including power levels, were coordinated with the local Broadcast Auxiliary Service (BAS) licensees, WGN-TV and WBBM-TV, as required under the FCC experimental license WH2XNQ.
12. In contrast to the demonstration of TLPS at the FCC conducted in March 2015, the university deployment in Chicago was performed utilizing the pre-existing campus backbone network and the existing access points operating on Channels 1, 6 and 11.
13. Additional details and photographs of the experimental deployment are included in the attached report.

<u>Summary of Results of Compatibility Measurements</u>

14. Extensive measurements over a period of three months were performed with TLPS devices and access points operating within, and simultaneously with, the existing campus Wi-Fi network operating in the 2.4 GHz band. Several hundred individual measurement trials were run under approximately twenty experimental scenarios. Multiple test runs for each experimental scenario (typically 10 trials) were performed to obtain statistically significant results.

15. In the university deployment, both the existing IEEE Channel 6 and TLPS operating on Channel 14 are adjacent to existing IEEE Channel 11. The device throughput measurements assessing the compatibility of TLPS with existing Channel 11 operations demonstrated that TLPS has the same small quantitative impact as Channel 6 on Channel 11.
16. Regarding the demonstrations performed to assess any qualitative, user-perceptible impact on Channel 11 operations, it was observed that TLPS had no user-detectable effect on Channel 11 executing streaming video applications.
17. Regarding the measurements and demonstrations conducted to assess the impact of TLPS operations on overall user and network throughput, it was found that the addition of TLPS on IEEE Channel 14 significantly increased overall network and individual device throughput levels. The quantitative levels of improvement are shown in the attached report.
18. Regarding the demonstration scenarios executed with the Bluetooth devices to assess the compatibility of TLPS with Bluetooth, it was found that simultaneous operation of wireless devices and access points on IEEE Channels 1, 6, 11 and TLPS on Channel 14 produced no user perceivable impact to Bluetooth devices.
19. Full details of the measurements and results regarding the impact of TLPS on IEEE Channel 11, the impact of TLPS on overall wireless network capacity, and the impact of TLPS on Bluetooth, are provided in the attached report.

Conclusions

20. The measurements and demonstrations performed show that TLPS is fully compatible with 2.4 GHz unlicensed operations. No harmful interference or compatibility issues were identified.

21. No user-perceptible impact on Channel 11 streaming video services, or on Bluetooth Standard or Low Energy devices was observed during operation representative of real-world conditions.

22. It can be concluded that TLPS provides significant overall capacity gains and materially increases the throughput experience of all users on the network. Specifically:

- As greater numbers of users are moved from existing Wi-Fi Channels 1, 6 and 11, to TLPS on Channel 14, congestion is eased on those Wi-Fi channels. This allows for a significant improvement to the user experience for those users remaining on the existing Wi-Fi channels, as well as those users moved to Channel 14.

- As shown in the attached report, if 3 users on a network with 12 active clients altogether are moved to Channel 14, the average throughput experienced by each user increases 56%.

- Also shown in the attached report, for the deployment scenario where 6 out of 12 client devices are shifted from maximally utilized IEEE Channels 1, 6 and 11 to TLPS Channel 14, the average throughput, on a per client device basis for the network overall, increases by 92%.

- The uncongested nature of Channel 14 allows the channel to handle a traffic load approximating that of the existing Channels 1, 6 and 11 combined.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge, information and belief.

Executed this 9th day of September 2015.

Kenneth J. Zdunek, Ph.D.

Terrestrial Low Power Service (TLPS) Deployment and Summary Measurements

Roberson and Associates, LLC

May – August 2015

Study conducted for

Globalstar
Be Heard.

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1) Deployment Overview

Summary of Deployment

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- **Purpose:**
  - Assess TLPS coexistence with existing unlicensed services in the Industrial, Scientific and Medical band, in a structured Wi-Fi network environment including:
    - 802.11 2.4 GHz Channel 11
    - Bluetooth services
  - Assess the increase in user throughput and system capacity with the addition of Channel 14 to the network
  - Measure downlink and uplink throughput data and tests to determine whether operations on Channel 14 produce any impact perceptible to a user
- **Equipment:**

  Ruckus model 7982 access points configured to operate on Channel 14 using IEEE 802.11 deployed at a university campus center in Chicago:
  - Backhaul to internet via campus backbone and gateway
  - TLPS APs were combined with campus wireless network of Meru Networks manufactured Wi-Fi APs operating on Channels 1, 6 and 11
  - TLPS client devices: Google Nexus 7 tablets, Microsoft Surface Pro and Surface 3 tablets, Apple iPhone4 and iPad (both used for detecting presence of Channel 14 APs and testing basic functionality)
  - Bluetooth (Standard and Low Energy) client devices: heart monitor, speaker, mice, headsets
  - Traffic loads utilizing widely-used audio/video streaming, speed testing and traffic generating software applications (e.g., Hulu, Skype (HD video), YouTube; OOKLA, FCC Speed Test, iperf; Chrome, IE and Firefox browsers)
  - Test operation coordinated with local BAS licensees (WGN-TV and WBBM-TV) under FCC experimental license
- **Length:**

  Extensive measurements over 3 months were made with TLPS operating within the existing Wi-Fi network:
  - Several hundred tests were run testing capacity and coexistence across multiple applications and data types
  - Repetitive test runs for each scenario used to obtain statistically significant results

Location of Access Points (University Campus Center)

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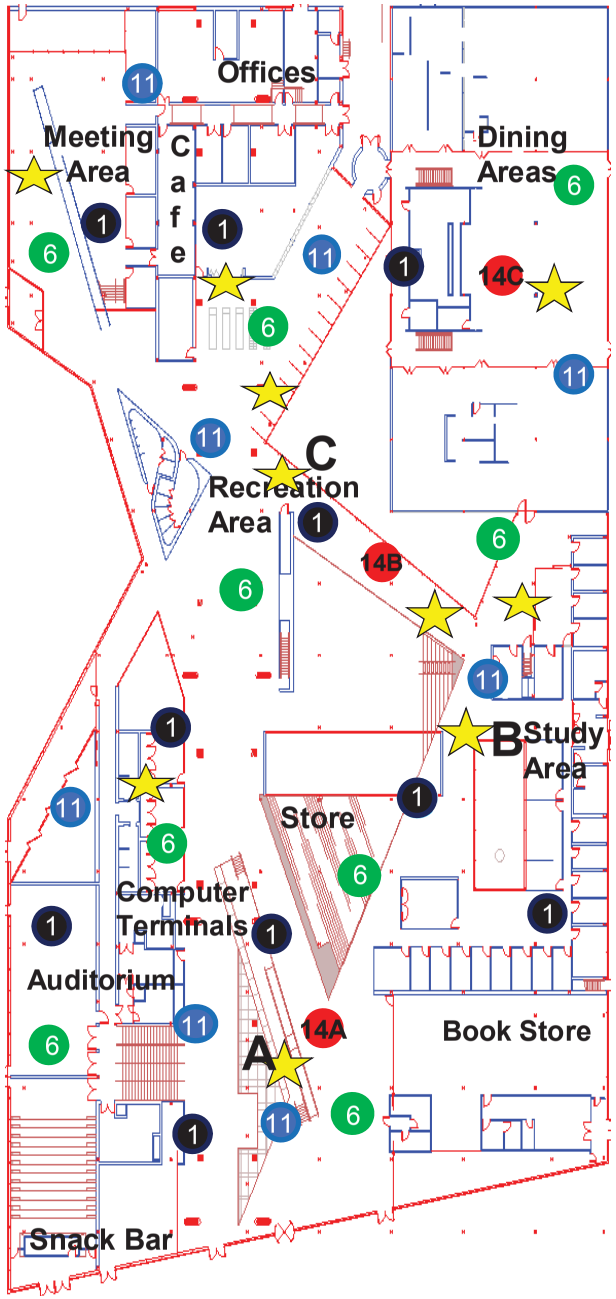
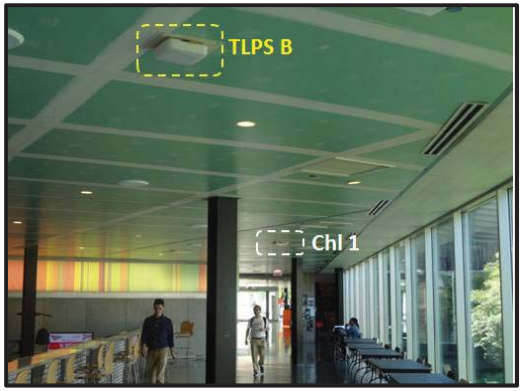
Technology and Management Consultants



Test locations (Primary denoted by letters)

Location of TLPS AP A (yellow) & Ch. 11 AP (white)

Location of TLPS AP B (yellow) & Ch. 1 AP (white)



Dimensions:

- Area ~ 105,066 square feet (426' long x 270' wide)

Baseline Throughput Measurements

Roberson and Associates, LLC
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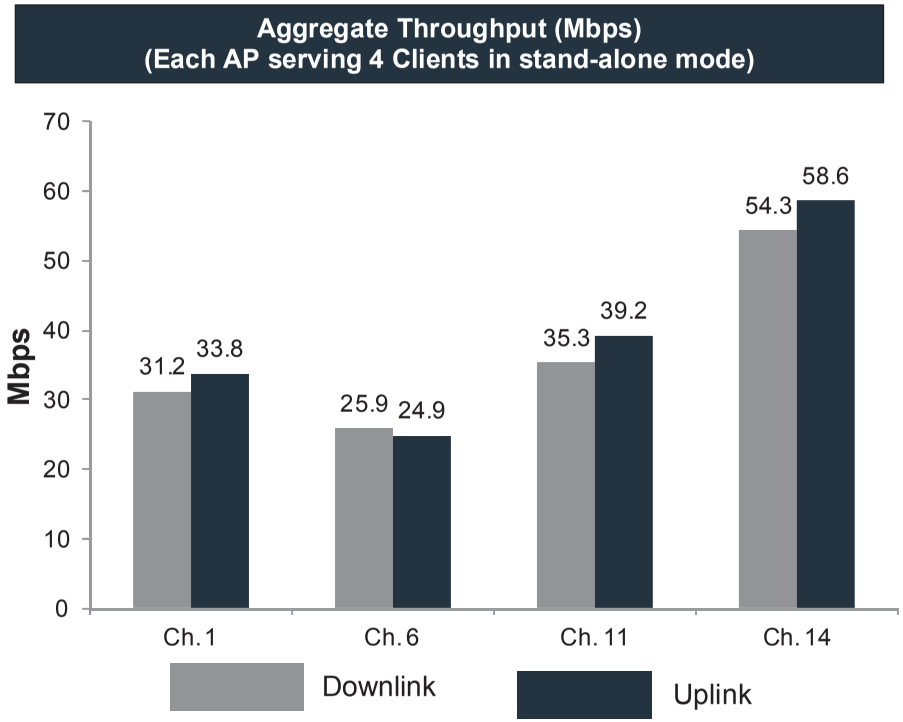
Representative baseline throughput measurements of Channels 1, 6, 11 & 14 on a stand-alone basis



As measured, Channel 14 has stand-alone aggregate capacity / throughput that is significantly higher than that of existing Wi-Fi channels (even when congestion is comparatively limited on 1, 6 and 11 due to the university being in summer session). Throughput on each of Channels 1, 6 and 11 is highly volatile and dependent on time of day and location of access points in the network. In contrast, Channel 14's performance remains largely consistent. The data above provides an example of the baseline throughput measurements for each channel in late May 2015 (summer session). These measurements varied throughout the testing period based on network congestion.

Note: Measurements made between May 26-31, 2015.

2) TLPS Capacity Gain / Channel Impact

Steps to Measure Capacity Gain with TLPS

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This measurement procedure assesses aggregate network throughput with the addition of Channel 14 to the network and measures the throughput gain by all users

1. Establish the baseline: determine average downlink throughput per device when 12 clients are on Channels 1, 6 and 11 (no TLPS in use)
2. Determine average downlink throughput per device when 3 clients are moved to Channel 14 and 9 remain on 1, 6 and 11 (3 per channel)
   - Determine the gain in average device throughput for:
     - Channels 1, 6 and 11 devices
     - Channel 14 devices
     - All devices on network
3. Repeat Step 2 with 6 devices on Channels 1, 6 and 11 (2 per channel) and 6 on Channel 14

Downlink Average Throughput Per Device

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Step 1

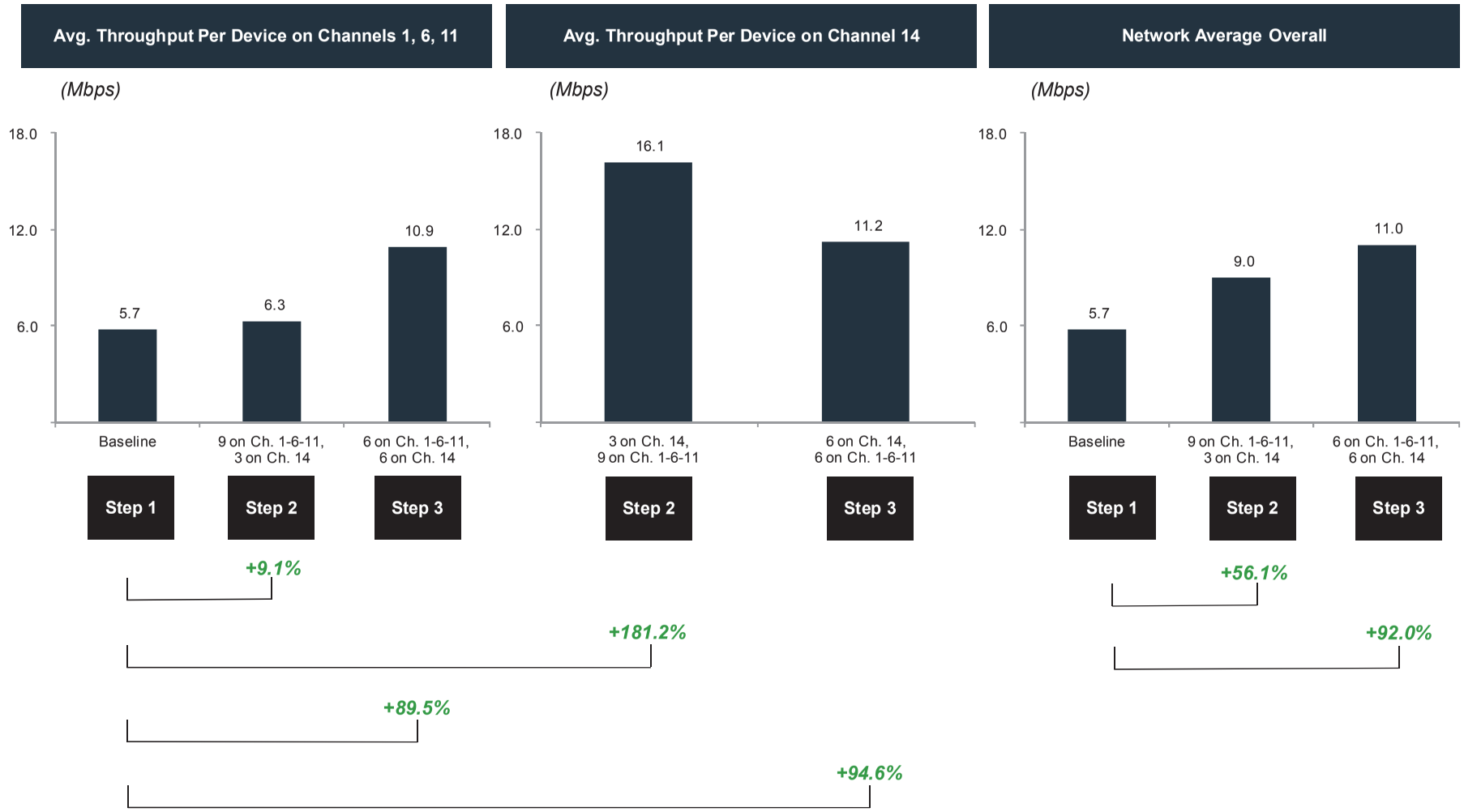
*Establish baseline for average device throughput on Channels 1, 6 and 11 (4 devices on each channel) – **no devices on Channel 14***

Step 2

Move 3 devices to Channel 14 such that there are 3 devices on each of Channels 1, 6, 11 and 14

Step 3

Move 6 devices total to Channel 14 such that there are 2 devices on each of 1, 6 and 11 and 6 in 14



Downlink Average Throughput Per Device

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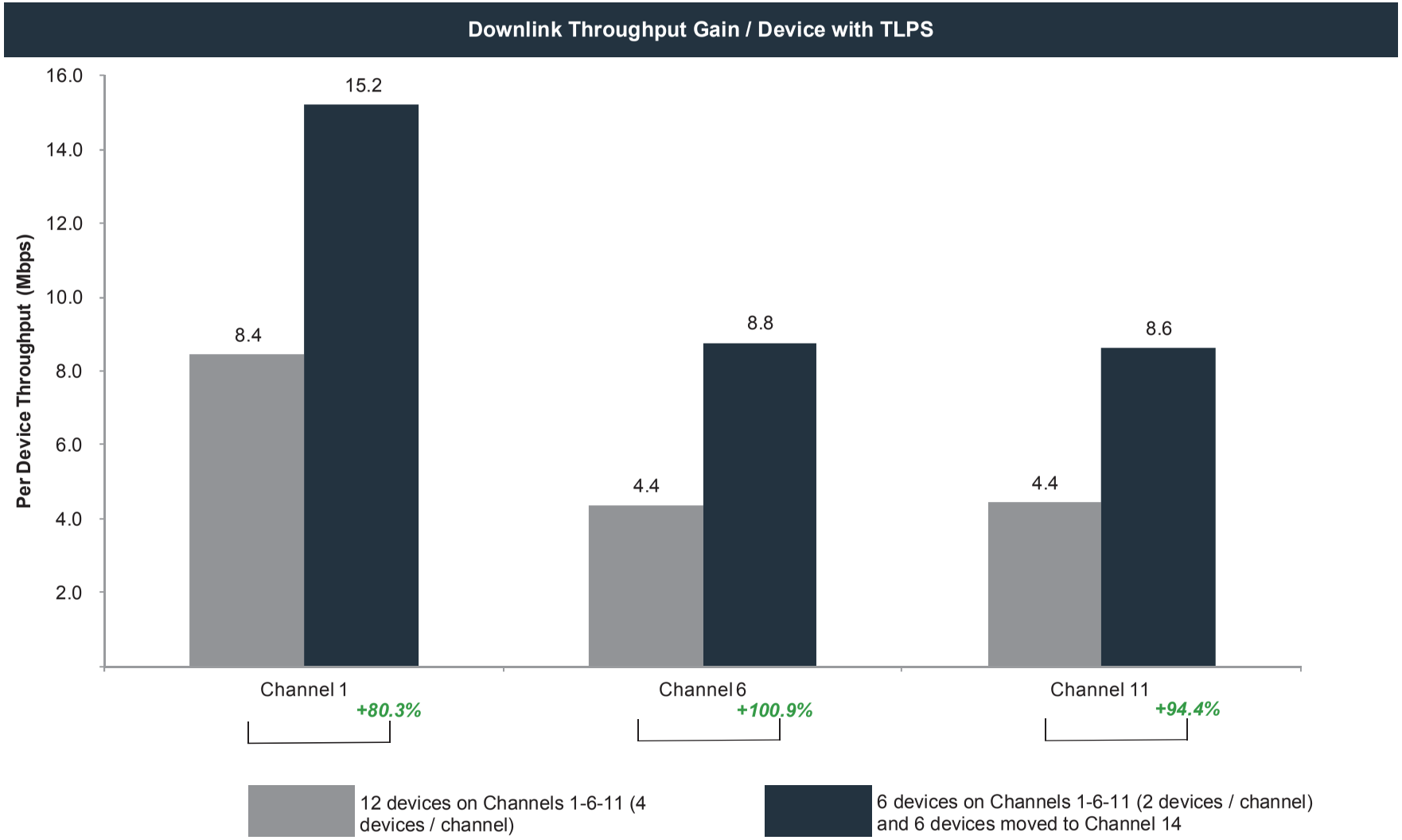

- Channel 11 not negatively impacted by operations on Channel 14
- The 2 remaining clients on Channel 11 experienced proportional capacity gains after the addition of Channel 14

Discussion of Incremental Capacity Gain with TLPS

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Significant capacity gains for all channels were observed as devices were moved from Channels 1, 6 and 11 to Channel 14

- 12 devices operating on Channels 1, 6 and 11 (4 devices per channel) produced a baseline average throughput per device of 5.7 Mbps, with no operations on Channel 14.
- When 3 of the 12 devices are moved to Channel 14 such that there are 3 devices operating on each of the 4 channels, average throughput per device on the network increases from 5.7 to 9.0 Mbps, a 56.1% increase. The 3 devices that are moved to Channel 14 experience a 181.2% increase in average throughput to 16.1 Mbps, while the 9 devices remaining on Channels 1, 6 and 11 (3 on each channel) experience a 9.1% increase in average throughput to 6.3 Mbps.
- When 3 additional devices are moved from Channels 1, 6 and 11 to Channel 14 such that there are 2 devices operating on each of channels 1, 6 and 11 and 6 devices operating on Channel 14, the average throughput across all devices and channels increases 92.0% to 11.0 Mbps. The 6 devices remaining on Channels 1, 6 and 11 (2 devices per channel) experienced an 89.5% increase in average throughput to 10.9 Mbps, while the 6 devices that were moved to Channel 14 experienced a 94.6% increase in average throughput to 11.2 Mbps.
- By optimally spreading the entire load of all 12 devices over 4 channels, rather than 3, all 12 devices experienced an average 92.0% increase in throughput, with Channel 14 providing approximately the same amount of wireless throughput capacity as Channels 1, 6 and 11 combined.
- Significantly, the 2 devices remaining on Channel 11 experienced a 94.4% increase in average throughput.

3) Application Tests

Application Tests

- Over the 3 month period, several applications were tested, including:
  - YouTube streaming
  - Hulu streaming
  - Skype voice and video calls
  - Other data applications
- Applications ran on standard 2.4 GHz Wi-Fi Channels 1, 6 and 11 in the presence of heavy background traffic on Channel 14 – every application was tested on Channel 11. Channels 1 and 6 were also tested.
- Tests were conducted in 5 locations across the campus including the university campus center, a campus office and residence units
- In every test site, there was no perceptible quality impact on Channels 1,6 and 11 performance. In the case of the residences, significant throughput gains were experienced when Channel 14 was added to the network.

Demonstration of Video Application and TLPS Coexistence

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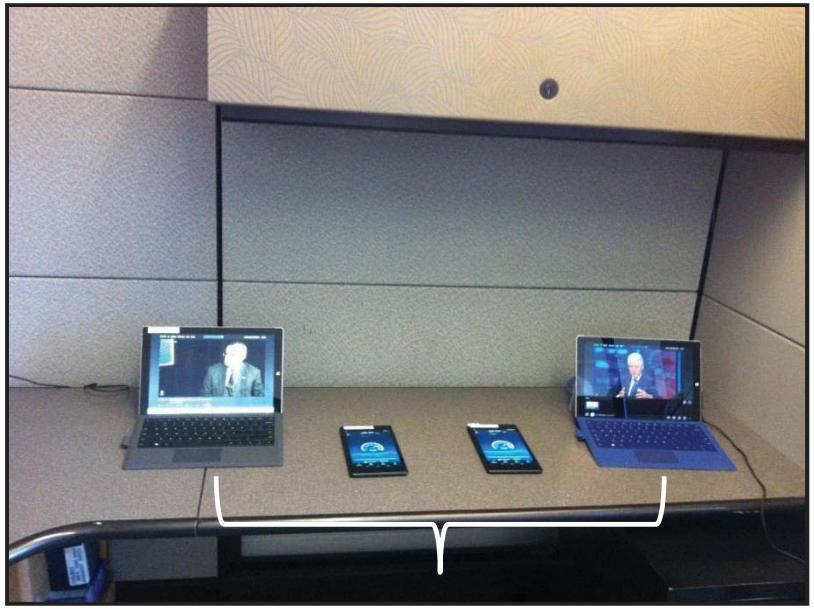
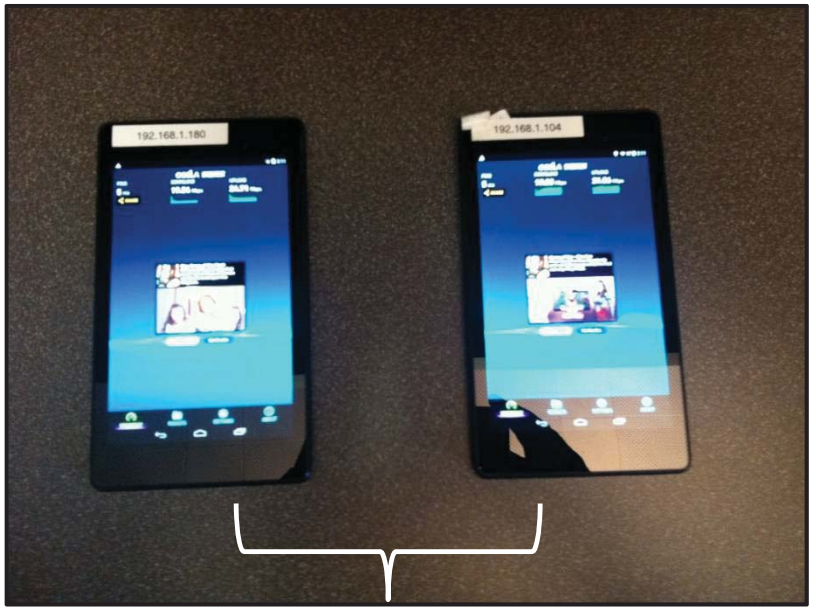
Qualitative demonstrations with Hulu video application conducted in a university office building

- Hulu application running TV reruns on two Channel 11 Surface devices
- Continuous background traffic was generated on two channel 14 Nexus tablets in an alternating sequence of DL and UL traffic (total average 39.42 Mbps DL and 45.77 Mbps UL)
- Channel 14 AP (located in same office room) approximately 10 feet away from the Channel 14 tablets
- Channel 11 AP (located in an adjacent office) approximately 20 feet away from the Channel 11 Surface Pros
- 10 test runs were conducted over 5 days with an average of 20 minutes per run
- No quality impact was perceived at any time on the Channel 11 Hulu videos



30” separation



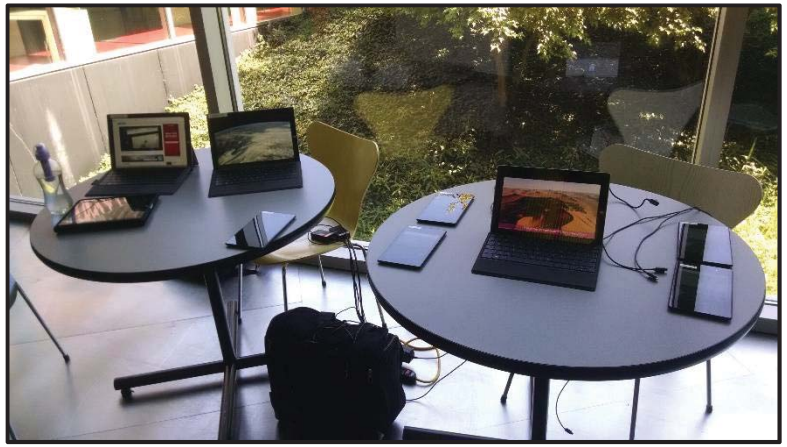
10” separation

Demonstration of Channel 11 and TLPS Coexistence

Roberson and Associates, LLC
Technology and Management Consultants

Qualitative demonstrations with Channel 11 conducted in a university campus center

- The test setup is shown below with various applications including YouTube, Skype and Internet Explorer running on devices attached to Channel 11
- Concurrently, a number of devices attached to Channel 14 were used to generate continuous streaming background traffic on both the uplink and downlink, located within a few feet of the devices running applications on Channel 11
- The access points for Channels 11 and 14 were located approximately 40 to 50 feet on either side of the device tables
- Demonstrations occurred on August 11 and 18, 2015, and lasted 30-45 minutes
- Tests were observed by Roberson engineers and third parties



Left Table		
Device (quantity)	Channel	Application
Surface (2)	11	YouTube
Nexus (1)	11	Skype
iPad (1)	14	Safari

Right Table		
Device (quantity)	Channel	Application
Surface (1)	11	YouTube / Internet Explorer
Nexus (4)	14	Background Traffic

Results of Demonstration of Channel 11 and TLPS Coexistence

Roberson and Associates, LLC
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- During the HD YouTube demonstrations, no interruption in the video playback was observed (the web pages were closed and reopened before starting the video to clear the buffer cache in the browser)
- During the Skype video call demonstrations, no interruption or degradation in quality of the video call was observed
- During the web browser demonstrations, browsing was demonstrated both with and without the presence of Channel 14 activity, and no quality impact was perceived
- Operation of an iPad and iPhone 4 on Channel 14 were also demonstrated to show TLPS compatibility with Apple devices

Demonstration of Bluetooth and TLPS Coexistence

Roberson and Associates, LLC
Technology and Management Consultants

- Loaded Channels 1, 6, 11 and 14 with 6 to 8 client devices each generating continuous uplink and downlink traffic through 2-way video Skype calls
- Demonstrated operation of several Bluetooth (BT) and Bluetooth Low Energy (BLE) devices (a BT speaker, BT and BLE mice and a BLE wrist-worn heart monitor) in the presence of Channel 1, 6, 11 and 14 activity
- The devices generating background traffic on Channels 1, 6 and 11 were between 10 and 20 feet away from the BT/BLE device table
- The access points for Channels 1, 6 and 11 were located approximately 30 to 40 feet from the table
- The Channel 14 access point was approximately 10 feet away
- Demonstrations occurred on August 11 and 18, 2015, and lasted 20-30 minutes
- Tests were observed by Roberson engineers and third parties

On the table are the BT speaker, BT and BLE mice, all attached by BT and BLE links to the laptop running a music player

Shown above is the wrist-worn BLE heart monitor, which communicated with an Android smart phone application to display heart rate

Results of Demonstration of Bluetooth and TLPS Coexistence

- For the BT speaker demonstration, the speaker was moved 10 to 20 feet away from the laptop, with no interruption or gaps in the music
- For the BLE heart monitor demonstration, the test engineer wearing the watch moved between 10 and 20 feet away from the smartphone with no interruption of the continuous measurement of the heart rate
- For the wireless mice test, the mice were used to control the music player on the laptop and open and close browser windows with no interruption or delay observed in their operation

4) Conclusions

Conclusions

- TLPS is compatible with existing 2.4 GHz unlicensed operations:
  - No harmful interference or compatibility issues identified with existing Wi-Fi operations
  - No incremental interference from Channel 14 operations on Channel 11 compared to Channel 6 operations on Channel 11
  - No perceptible impact on Channel 11 streaming video (e.g., Skype, Hulu, YouTube) or on Bluetooth Standard and Low Energy devices
- TLPS provides significant overall capacity gains and materially increases the throughput experienced by all users of the network:
  - As an increasing number of users are moved to Channel 14, congestion is eased on Channels 1, 6 and 11
  - This allows for a significant improvement in the user experience for both (i) users remaining on existing Wi-Fi channels, and (ii) users moving to Channel 14
  - As presented here, if 3 users out of a network of 12 clients are moved to channel 14, the average throughput experienced by each user increases 56%. Moving an additional 3 users provides a 92% increase to average throughput across all 12 clients using the 4 channels.
  - The uncongested nature of Channel 14 allows it to handle a load comparable to that of Channels 1, 6 and 11 combined

Appendix

Baseline Throughput Measurements

Roberson and Associates, LLC
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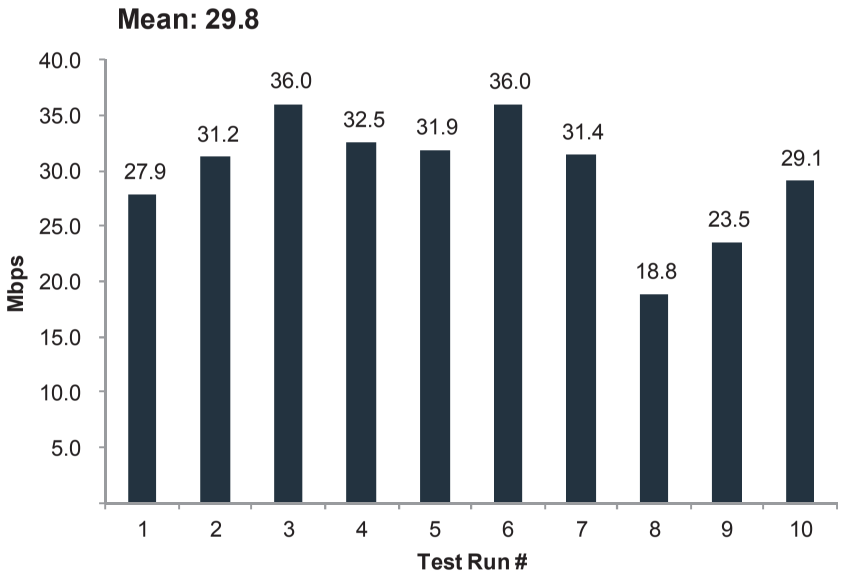
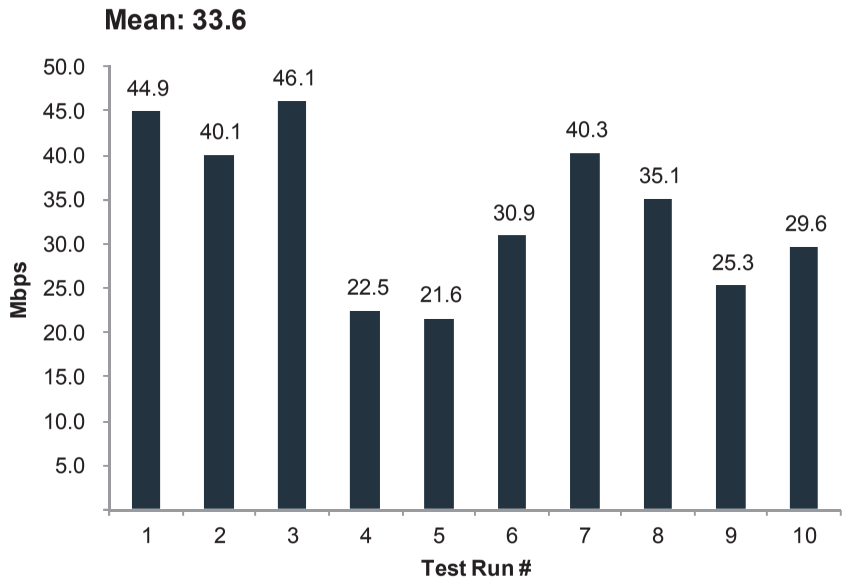
The campus center represents an uncontrolled, real-world Wi-Fi network environment where throughput measurements of Channels 1, 6 and 11 on a stand-alone basis varied as a function of time and location. The dynamic nature of users moving in and out of the network necessitated repetitive runs to gather reliable estimates of mean throughput values.

Time of Day Variations in Throughput: Aggregate Downlink Throughput (Mbps)

Channel 11 AP Serving 4 Clients at 11AM at Location A



Channel 11 AP Serving 4 Clients at 1PM at Location A



The above measurements show variability inherent in a real-world Wi-Fi network deployment. The diagram on the left (right) represents measured throughput at 11 am (1 pm) on August 21, 2015 at a Channel 11 AP serving 4 clients. A variation of 15% in mean throughput values is not unexpected, due to dynamic changes in the network conditions such as number of users, application types, etc. The throughput measurements were made with no traffic on Channel 14.

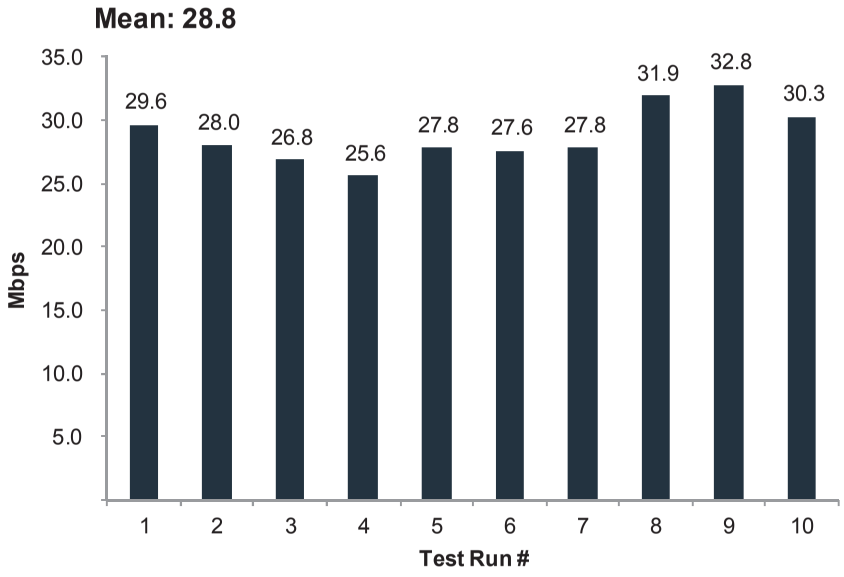
Baseline Throughput Measurements

Roberson and Associates, LLC
Technology and Management Consultants

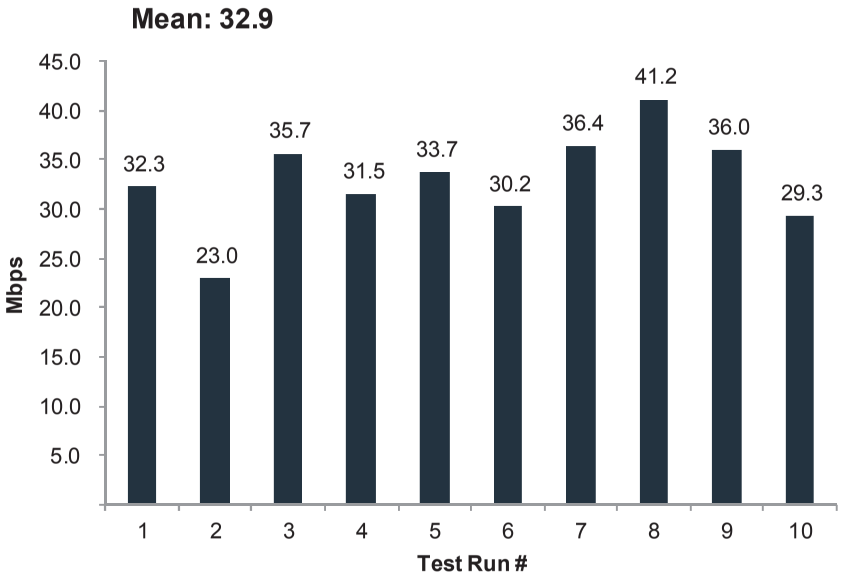
Throughput on two distinct Channel 11 access points was measured

Location Variations in Throughput: Aggregate Downlink Throughput (Mbps)

Channel 11 AP Serving 4 Clients at Location B



Channel 11 AP Serving 4 Clients at Location C



The above measurements show variability as a function of location of access points operating on the same Wi-Fi channel in a real-world network. The two diagrams represent measured throughput at two separate Channel 11 APs at approximately the same time on August 21, 2015. A variation of 15% in mean throughput values is not unexpected, due to variations in network load and radio network conditions in the vicinity of the access points.

TLPS NOS Management

September 2015

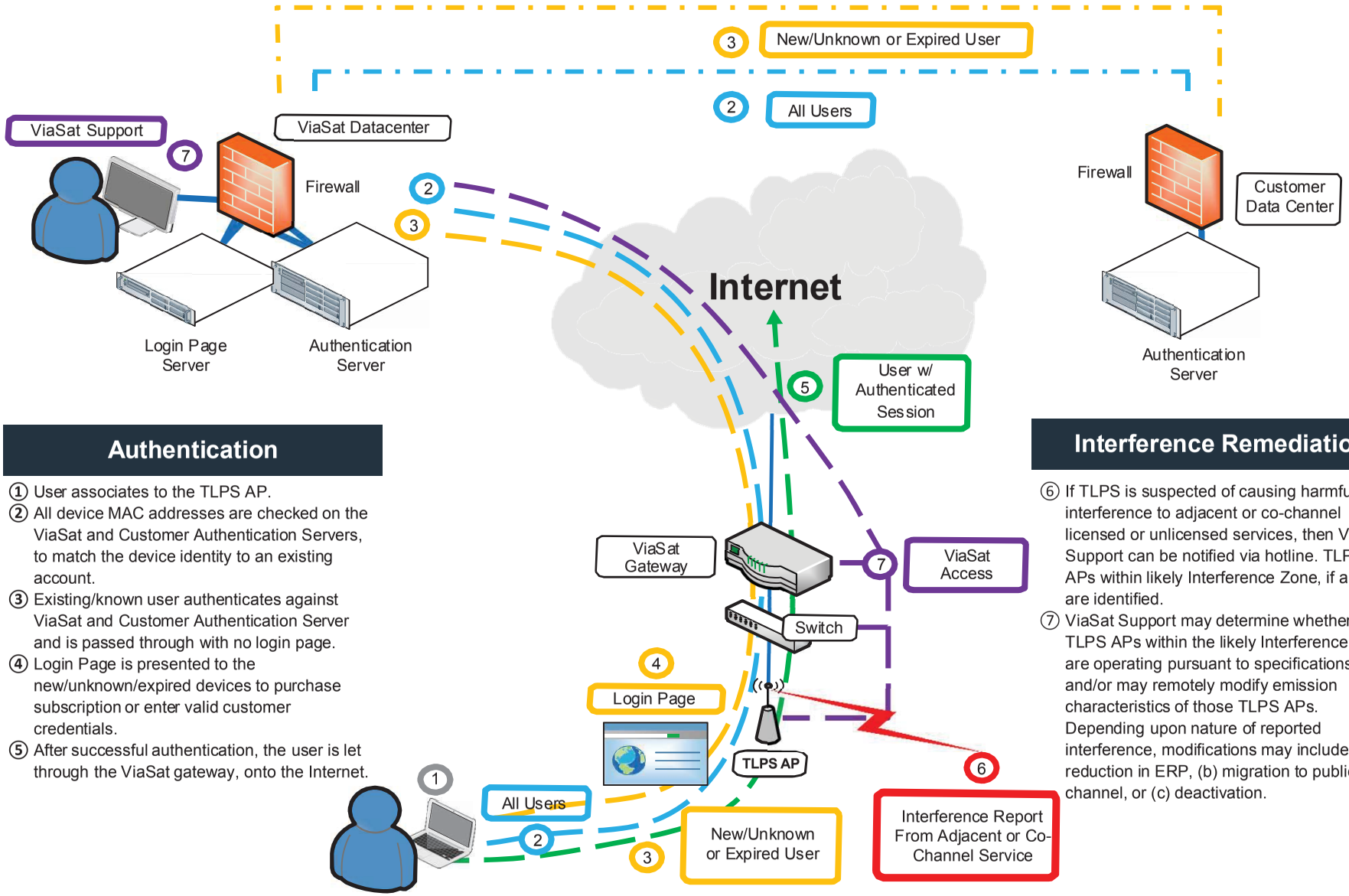
Globalstar

Managed TLPS Solution Overview

TLPS will be controlled by a Network Operating System (NOS) that permits remote monitoring and control of critical network functions. These NOS services can be implemented today, as similar systems are in use by major wireless operators, including carriers and MSOs. The NOS will authenticate users to ensure that only authorized users have access to network resources. Additionally, the NOS enables network operators to manage the TLPS access points remotely and recognize that other licensed and unlicensed services may be operating in close proximity on or near the same frequencies. This management includes coordination with licensed services including the monitoring and protecting critical Mobile Satellite Services. Further, with regard to interference with unlicensed operations, our network operators can be contacted and work through determination protocols and possible resolution. The NOS will also provide any required mitigation and correction for unlawful emissions, should they ever arise, to ensure deployments remain in regulatory compliance.

Globalstar has identified the existing ViaSat Wi-Fi network management system as an ideal platform for the TLPS NOS. ViaSat's system provides a proven and robust capability to control access to wireless networks and implement corrective responses. The management system provides for a communication hotline where any problematic interference zones can be identified. If appropriate, ViaSat support can remotely modify emission characteristics of TLPS APs including (a) reducing ERP, (b) migrating to a separate operating channel, or (c) powering down until another solution can be implemented.

Managed TLPS Solution



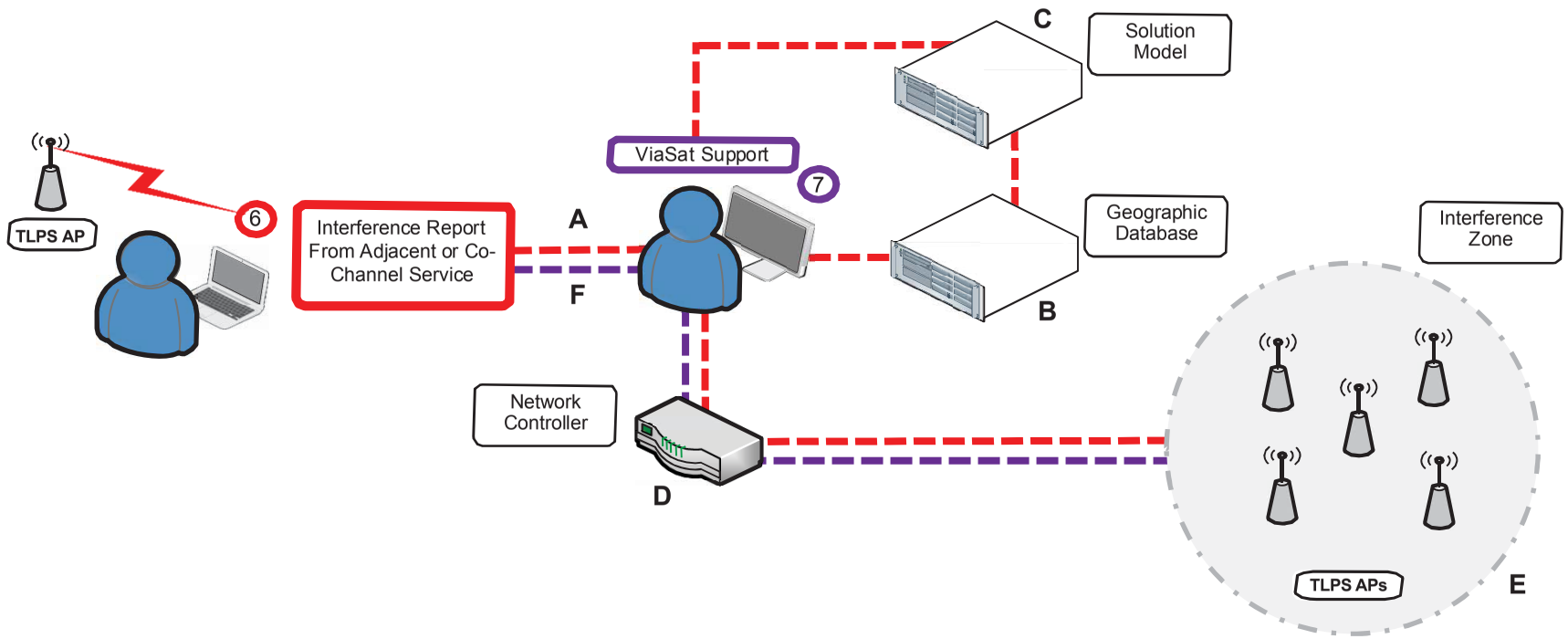
Authentication

① User associates to the TLPS AP.
② All device MAC addresses are checked on the ViaSat and Customer Authentication Servers, to match the device identity to an existing account.
③ Existing/known user authenticates against ViaSat and Customer Authentication Server and is passed through with no login page.
④ Login Page is presented to the new/unknown/expired devices to purchase subscription or enter valid customer credentials.
⑤ After successful authentication, the user is let through the ViaSat gateway, onto the Internet.

Interference Remediation

⑥ If TLPS is suspected of causing harmful interference to adjacent or co-channel licensed or unlicensed services, then ViaSat Support can be notified via hotline. TLPS APs within likely Interference Zone, if any, are identified.
⑦ ViaSat Support may determine whether TLPS APs within the likely Interference Zone are operating pursuant to specifications and/or may remotely modify emission characteristics of those TLPS APs. Depending upon nature of reported interference, modifications may include (a) reduction in ERP, (b) migration to public channel, or (c) deactivation.

TLPS Interference Remediation



Determination and Remediation of Claimed Harmful Interference to Licensed or Unlicensed Services

A. Adjacent or co-channel operator reports suspected TLPS interference via web or telephone hotline.

B. ViaSat Support Center compares interference complaint with TLPS geographic database to establish potential Interference Zone and determine whether any active TLPS APs are present within that Zone.

C. ViaSat Support Center determines whether TLPS APs within potential Interference Zone are operating pursuant to specifications and network plan and, if necessary, assembled data is applied to interference solution model.

D. ViaSat support evaluates solution for execution and sends remedial commands to TLPS APs within the Interference Zone.

E. TLPS APs within the Interference Zone operate with modified emissions characteristics to minimize or eliminate claimed interference.

F. ViaSat Support Center confirms successful implementation of remedial commands with adjacent or co-channel operator.

ViaSat Letter to Globalstar

ViaSat

ViaSat, Inc
Wireless Services Division
2908 Finfeather Rd, Bryan, TX 77801
(979) 775-3797

August 18, 2015

For more than 18 years ViaSat Inc.'s Wireless Services division (formerly NetNearU) has provided end-to-end wireless communications networks, passenger Wi-Fi services, broadband services, as well as tactical and cyber security and information assurance systems to U.S. government, critical infrastructure, enterprise commercial, carrier and cable company networks. As a network operations service provider, ViaSat provides managed daily services securing and operating highly distributed, multi-site, multi-state critical infrastructure for our customers' networks. We offer a unique combination of experience and technology when designing networks and when leveraging existing infrastructure, to achieve a cost effective, secure wireless network solution with measurable results.

ViaSat offers best-in-class end-user support for major government customers, including operating Wi-Fi networks on all U.S. Naval bases worldwide (supporting nearly 100,000 Navy sailors), as well as serving as the underlying managed services provider of Wi-Fi networks for large carriers such as Comcast, Time Warner Cable, Cablevision, Sprint, and many more providing services to over 10 million access points nationwside. These companies chose ViaSat because of our technical sophistication, experience, capabilities of our software tools, 24/7 staffed network operating centers and turnkey deployment services.

ViaSat's management system is interoperable with most major WiFi hardware vendors. This capability allows our customers to choose the best suited hardware for their needs and environment and thus are not restricted to any specific suite of equipment. Our engineers ensure proper installation, full testing, interoperability and security through our network management system platform.

ViaSat's wireless customer support staff is a well-trained and professionally managed team dedicated solely to the support of the networks we manage, including network management, monitoring, roaming, analytics and more. ViaSat operates a U.S.-based 24/7 help desk and also maintains Tier 1, Tier 2 and engineering support staff to ensure that customer questions are resolved efficiently and completely by ViaSat.

In the case of Globalstar and TLPS, ViaSat can provide a suite of services ranging from authentication of users on the network through the ability to respond in real time to any interference issues should they be reported. In addition, ViaSat runs remote diagnostics on access points to assure they run within desired technical parameters. In the event of a malfunction or interference complaint, ViaSat can reduce the power to access points in an affected area, power off access points in an affected area or change the channel assignment to another channel. After taking these steps our management tools permit us to investigate the source or sources of interference concern and, should interference be from TLPS access points, correct the problem before returning these access points to service.

ViaSat looks forward to the potential of being the network management partner for Globalstar and supporting the capabilities of TLPS to enhance the quality of service for consumers, enterprises and governments. As one of the world's largest Wi-Fi service operators, ViaSat is well positioned to understand the growing demands and stresses on today's wireless networks. The addition of a fourth 2.4 GHz channel has significant value for our customers and we fully support the Commission's adoption of the TLPS proposed rules.

Best regards,

Robert M. Brown
VP, Sales & Business Development – Wireless Services

Globalstar