Gerst Capital, LLC
4962 El Camino Real, Suite 206
Los Altos, CA 94022
Phone (650) 917– 1453

March 3, 2016

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, D.C. 20228

Re: IB Docket No. 13-213, RM-11685

Dear Ms. Dortch,

On March 3, 2016, I met with Commission staff to discuss the evidence that Globalstar's proposed Terrestrial Low Power Service (TLPS) may adversely interfere with Bluetooth Low Energy (BLE) devices.

The following individuals were in attendance:

- Julius Knapp, Chief Engineer, FCC Office of Engineering and Technology
- Jose Albuquerque, Chief, FCC International Bureau Satellite Division
- Mark Settle, Policy and Rules Division Chief, FCC Office of Engineering and Technology
- Vance Denson, QA Engineer, Frontline Test Equipment
- Sean Clinchy, Product Manager, Frontline Test Equipment

I presented the attached slides which describe the testing conducted by Frontline Test Equipment in late 2015. That testing showed the following:

- When Wi-Fi traffic is not active, BLE traffic uses all 37 data channels available.
- When Wi-Fi traffic is active (on channels 1, 6, and 11), BLE traffic uses ***only*** the 2 data channels at the highest end of the BLE spectrum.

The 2 data channels at the highest end of the BLE spectrum, where BLE traffic moves when crowded-out by Wi-Fi, is precisely where TLPS would operate. Therefore, in a typical real-world environment[1], what happens to BLE traffic and BLE device performance when Wi-Fi and TLPS are both active? The answer to this question is knowable, ought to be known, and can be easily known with simple tests. I urged the Commission to require these tests because the public should know what is likely to happen when a senior citizen with a BLE hearing aid walks into a crowded airport if both Wi-Fi and TLPS are active.

Respectfully Submitted,

Greg Gerst
Gerst Capital, LLC

cc: Julius Knapp
Jose Albuquerque
Mark Settle
Edward Smith
Johanna Thomas
Louis Peraertz
Erin McGrath
Brendan Carr

[1] One category of real-world environment is detailed in ACRP Report 127 titled "A Guidebook for Mitigating Wi-Fi Interference at Airports". A webinar review was conducted on November 5, 2015 and can be accessed at http://www.trb.org/ElectronicSessions/Blurbs/173178.aspx.

Preliminary Wi-Fi/BLE Coexistence Tests & Review of Open Issues

Presented to Members of the:

Office of Engineering Technology

International Bureau

GERST CAPITAL

4962 El Camino Real, Suite 206
Los Altos, CA 94022
Phone: (650) 917-1453

AGENDA

1) **Review of Preliminary Tests conducted by Frontline Test Equipment[1] (FTE)**

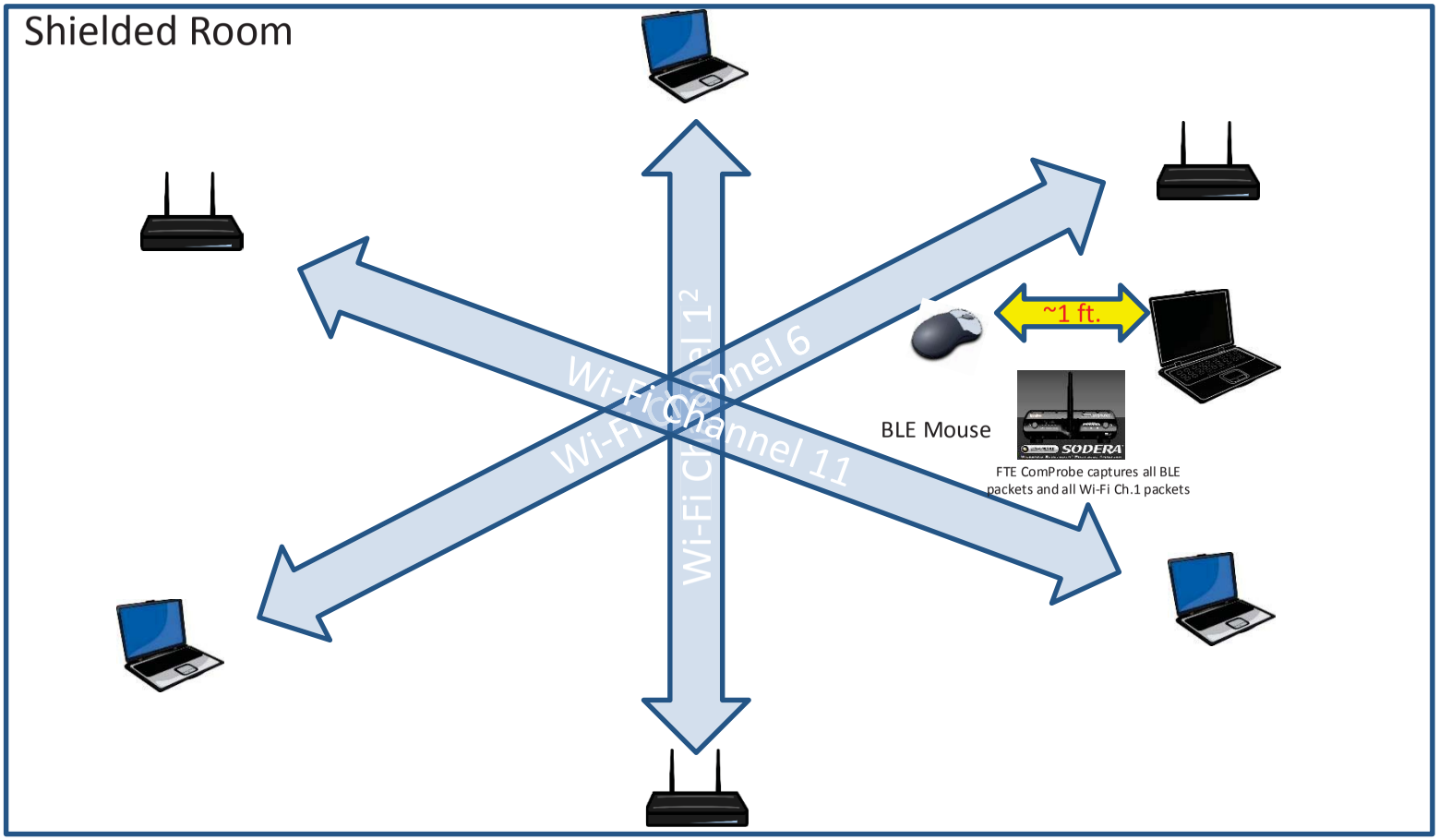
- **Clearly shows Wi-Fi traffic pushes ALL BLE data to channels 35 and 36.**
- **What happens to BLE when TLPS is introduced?**
- **Simple testing would allow for a quantitative, risk-informed decision.**

2) **Technical Issues Remain Unresolved**

[1]*For more information, visit http://www.fte.com/company/aboutus.aspx .*

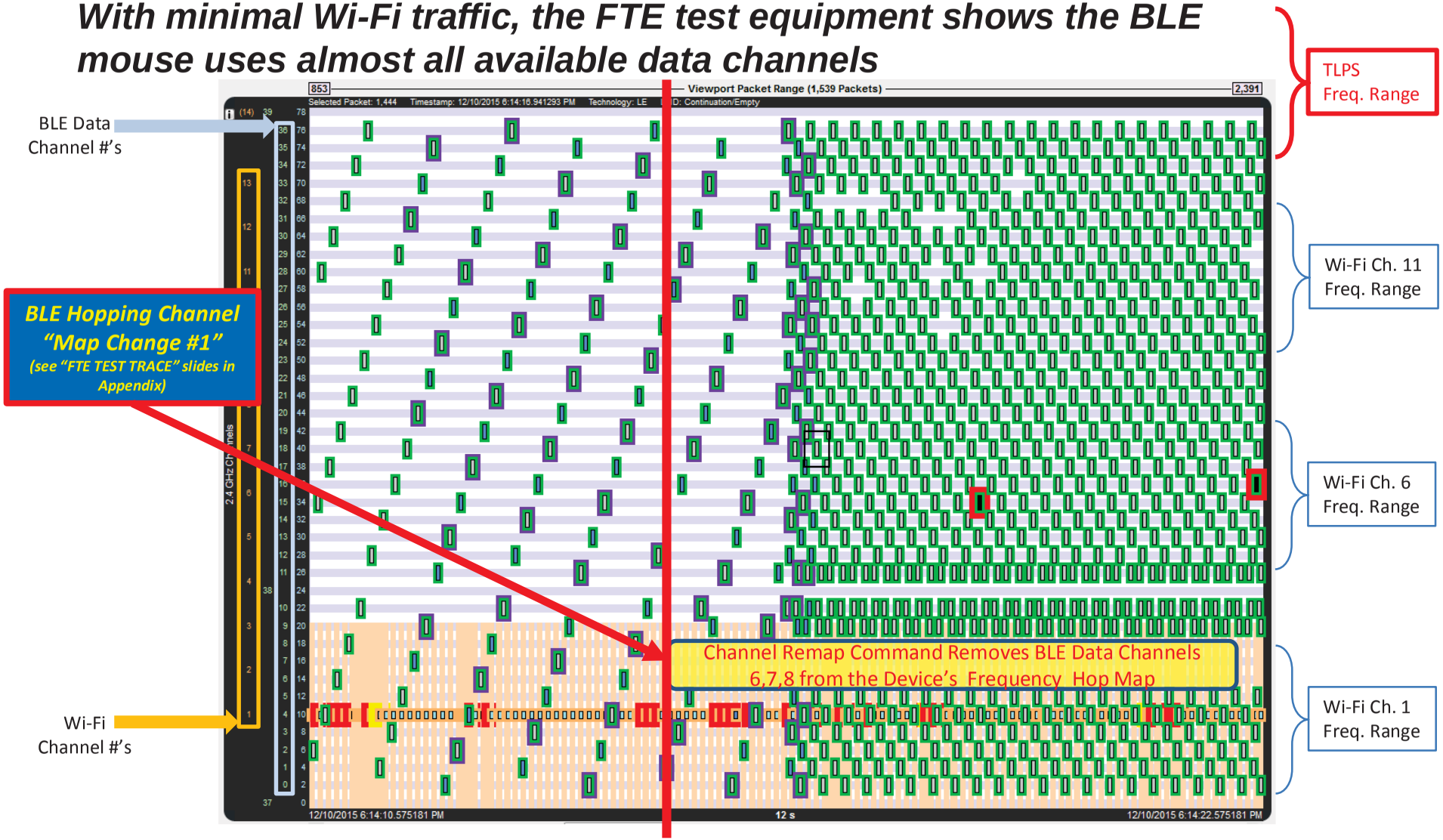
FTE conducted a simple test to demonstrate the impact a congested Wi-Fi environment can have on a Bluetooth Low Energy (BLE) device.

(See Appendix for a series of slides illustrating the detailed time progression of the test.)



[2]Measurement from client on Wi-Fi channel 1 shows power levels consistent with those of at least one real-world RF environment measured at an airport terminal.

With minimal Wi-Fi traffic, the FTE test equipment shows the BLE mouse uses almost all available data channels



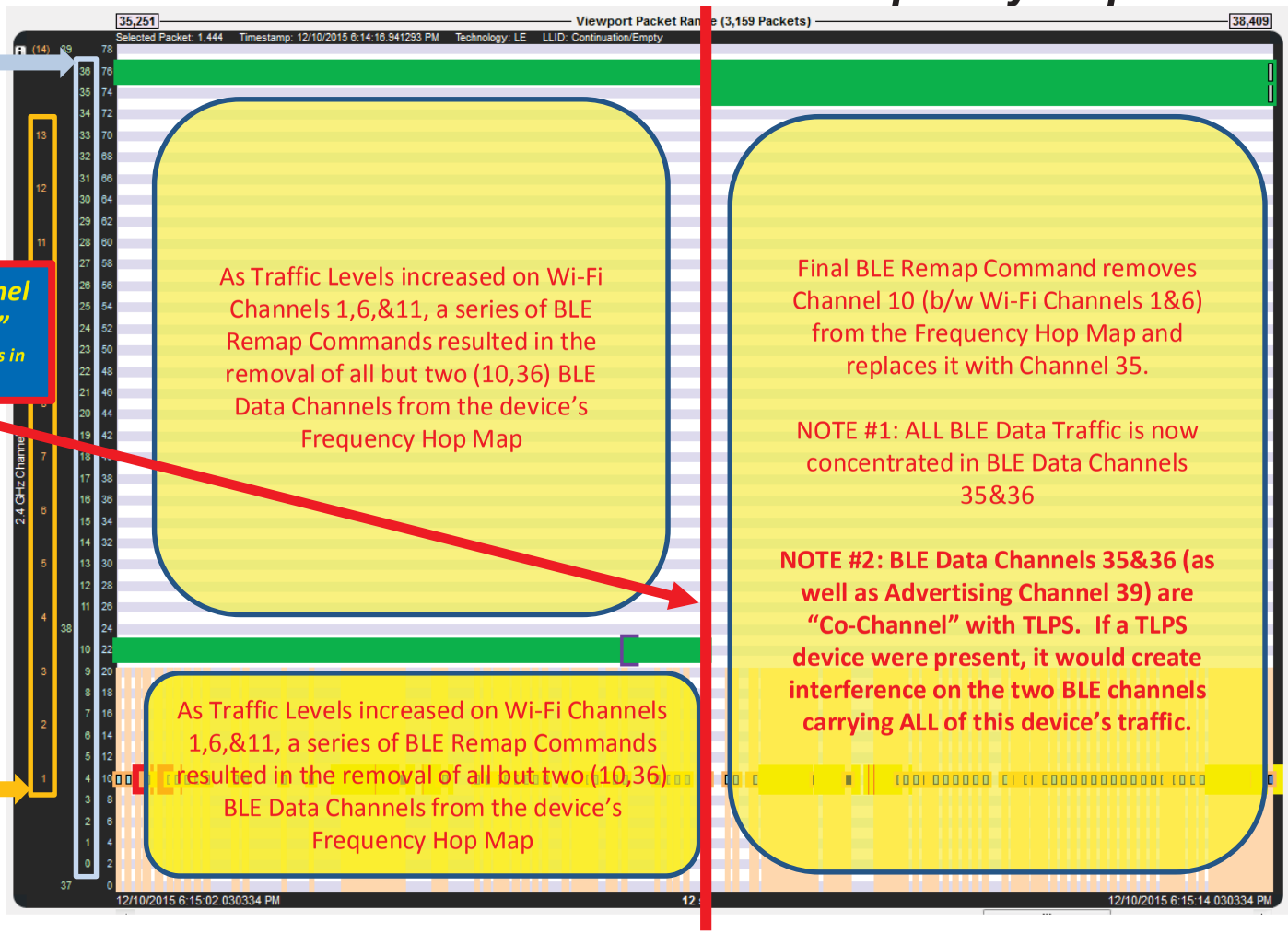
Vertical Axis: Frequency/BLE Channel Map/BT Channel Map/Wi-Fi Channel Map
Horizontal Axis: Time/Packet Counter

By the end of the test, Wi-Fi traffic caused all but two of the BLE data channels to be removed from the device's frequency map

BLE Data Channel #'s

BLE Hopping Channel "Map Change #9"
(see "FTE TEST TRACE" slides in Appendix)

Wi-Fi Channel #'s



TLPS Freq. Range

Wi-Fi Ch. 11 Freq. Range

Wi-Fi Ch. 6 Freq. Range

Wi-Fi Ch. 1 Freq. Range

Vertical Axis: Frequency/BLE Channel Map/BT Channel Map/Wi-Fi Channel Map
Horizontal Axis: Time/Packet Counter

Output from FTE Software detailing two 4-second traces from the beginning and end of the test:

Minimal WiFi Traffic
Selected Duration: 0:00:03.990078

BLE Data Channel	Packets w/ No Error	Packets w/ CRC Error	Channel Available
0	15	0	Yes
1	14	0	Yes
2	15	0	Yes
3	15	0	Yes
4	15	0	Yes
5	15	0	Yes
6	0	0	No
7	0	0	No
8	0	0	No
9	29	0	Yes
10	29	0	Yes
11	29	0	Yes
12	14	0	Yes
13	15	0	Yes
14	14	0	Yes
15	13	1	Yes
16	14	0	Yes
17	14	0	Yes
18	15	0	Yes
19	14	0	Yes
20	15	0	Yes
21	15	0	Yes
22	16	0	Yes
23	14	0	Yes
24	15	0	Yes
25	13	0	Yes
26	15	0	Yes
27	14	0	Yes
28	12	0	Yes
29	15	0	Yes
30	14	0	Yes
31	13	0	Yes
32	14	0	Yes
33	14	0	Yes
34	14	0	Yes
35	15	0	Yes
36	14	0	Yes
Total	**531**	**1**	**34 Yes 3 No**
	>99%	<1%	92% Yes 8% No

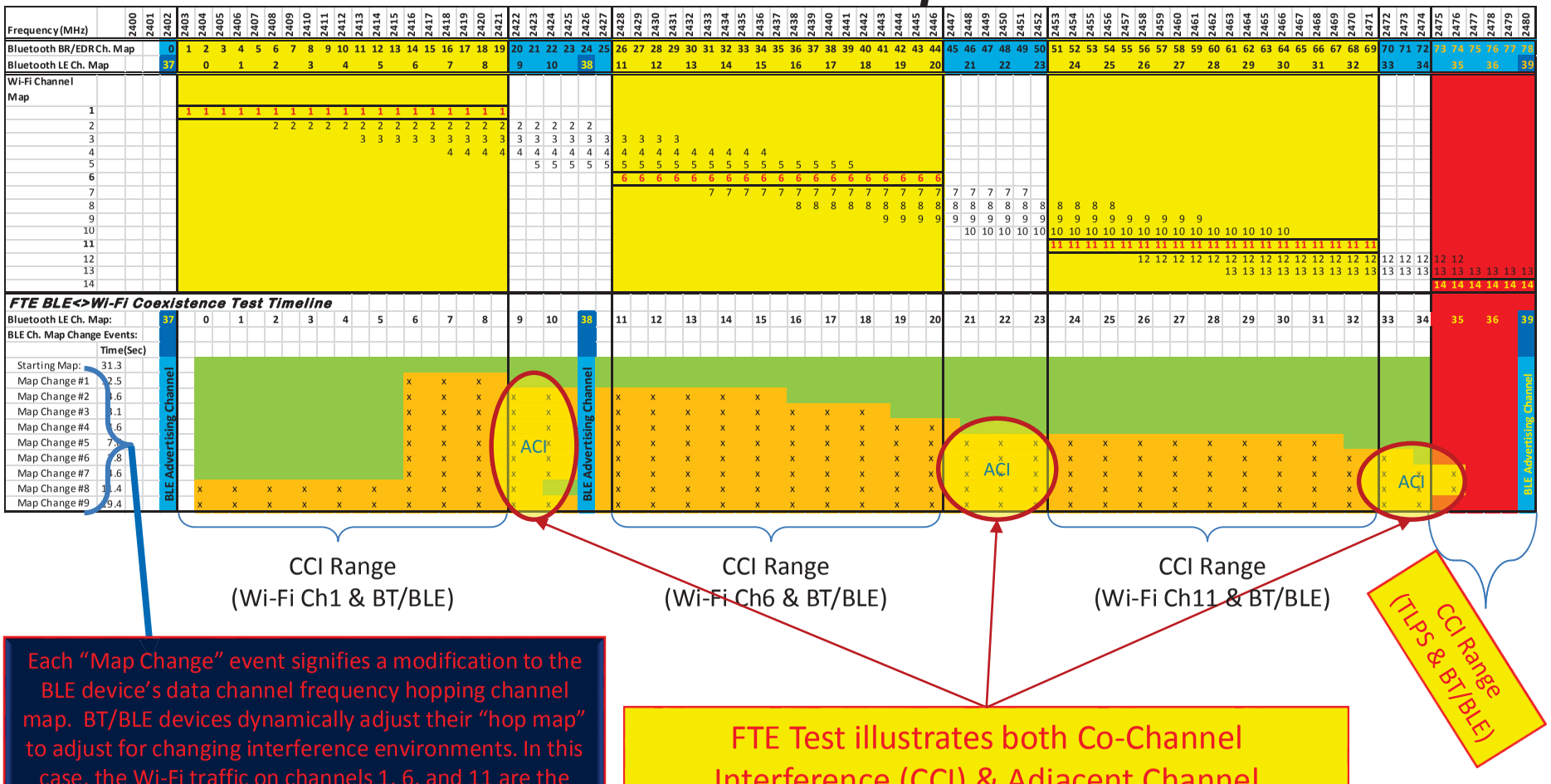
WiFi Traffic on Channels 1, 6, and 11
Selected Duration: 0:00:03.997541

BLE Data Channel	Packets w/ No Error	Packets w/ CRC Error	Channel Available
0	0	0	No
1	0	0	No
2	0	0	No
3	0	0	No
4	0	0	No
5	0	0	No
6	0	0	No
7	0	0	No
8	0	0	No
9	0	0	No
10	0	0	No
11	0	0	No
12	0	0	No
13	0	0	No
14	0	0	No
15	0	0	No
16	0	0	No
17	0	0	No
18	0	0	No
19	0	0	No
20	0	0	No
21	0	0	No
22	0	0	No
23	0	0	No
24	0	0	No
25	0	0	No
26	0	0	No
27	0	0	No
28	0	0	No
29	0	0	No
30	0	0	No
31	0	0	No
32	0	0	No
33	0	0	No
34	0	0	No
35	276	0	Yes
36	263	0	Yes
Total	**539**	**0**	**2 Yes 35 No**
	100%	0%	5% Yes 95% No

<u>Minimal Wi-Fi traffic</u>: BLE Packets transmitted across 34 of 37 possible data channels

<u>Wi-Fi traffic on Channels 1/6/11</u>: Approximately same number of packets now transmitted on only 2 of 37 possible data channels. ***<u>TLPS will impair these channels.</u>***

BT/BLE vs. Wi-Fi/TLPS Channel Maps



Each "Map Change" event signifies a modification to the BLE device's data channel frequency hopping channel map. BT/BLE devices dynamically adjust their "hop map" to adjust for changing interference environments. In this case, the Wi-Fi traffic on channels 1, 6, and 11 are the sole sources of interference[3] (Avg Wi-Fi Ch1 Rate from Map#1-#9 period: 255kbps, Avg BLE Rate: 13.4kbps)

FTE Test illustrates both Co-Channel Interference (CCI) & Adjacent Channel Interference (ACI) effects of Wi-Fi Traffic on the BLE device's frequency hopping channel map.

[3]*Per Bluetooth Specification version 4.2, the number of BLE data channels ranges from a maximum of 37 to a minimum of 2. When using the advertising channels, BLE devices must cycle through all three channels (37,38,39). The Bluetooth BR/EDR specification allows for a range of N_{min} to 79 hopping channels, where N_{min} is 20.*

RECENT FTE WEBINAR ILLUSTRATES SAME EFFECT

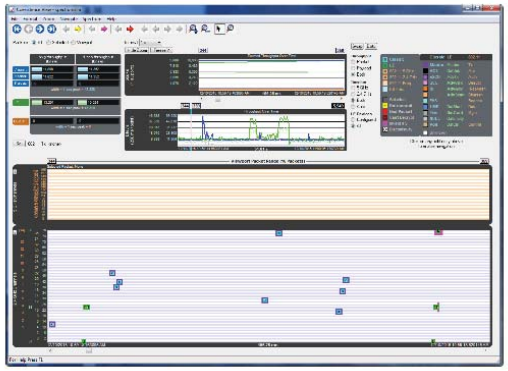
FTE Webinar conducted on February 18, 2016 shows effect of Wi-Fi traffic on a BLE device's channel map, and possible instances of Wi-Fi induced BLE packet errors[4].

Coexistence View

Is my product able to coexist with multiple wireless technologies?

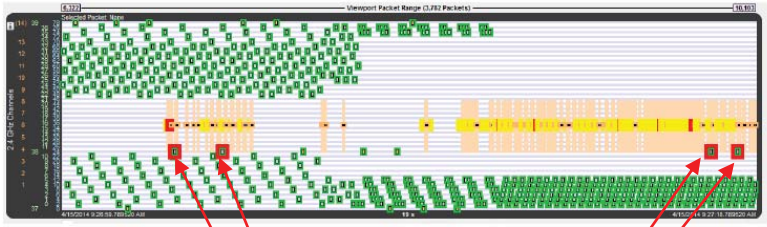
The Coexistence view displays *Bluetooth* Classic, low energy, and 802.11 packets and throughput in one synchronized view. This gives the user the best chance at identifying collisions and other issues resulting from wireless communications technologies that may interact (as in the case of *Bluetooth* HS and 802.11) or that simply coexist in the same 2.4 GHz band.

The user can quickly select and analyze any range of all captured data, color-coded by technology and packet type, and view throughput by range and technology.



frontline Debug Communications Faster

Coexistence View



Is your product able to coexist with multiple wireless technologies?

frontline Debug Communications Faster

Per Webinar:

"..could be that those low energy packets are somehow conflicting or interfering with Wi-Fi, or vice versa.."

[4]Replay of the Webinar titled "Bluetooth Technology and Mesh Networks: With the ComProbe Sodera Wideband Bluetooth Protocol Analyzer" is available upon request at http://www.fte.com/company/contactus.aspx . Relevant discussion begins at 8:22 of the Webinar.

AGENDA

1) Review of Preliminary Tests conducted by Frontline Test Equipment1 (FTE)

- Clearly shows Wi-Fi traffic pushes ALL BLE data to channels 35 and 36.
- What happens to BLE when TLPS is introduced?
- Simple testing would allow for a quantitative, risk-informed decision.

2) Technical Issues Remain Unresolved

[1]*For more information, visit http://www.fte.com/company/aboutus.aspx .*

TECHNICAL ISSUES REMAIN UNRESOLVED

Globalstar's BT/BLE<>TLPS demonstrations are inadequate

- **March 2015 TAC demonstration restricted Wi-Fi/TLPS traffic rates to 3.75Mbps, resulting in channel occupancies well below real-world levels.**
- **Channel occupancy is a key determinant of interference.**
- **Globalstar's BT/BLE<>TLPS demonstrations provide no quantitative data that would allow the FCC make a risk-informed decision.**
- **Quantitative tests can be configured/executed at limited cost and in a short time.**

The single BLE<>TLPS quantitative test documented in the proceeding shows the BLE packet error rate doubled after introducing TLPS

- **The packet error rate doubled EVEN at unrealistically low Wi-Fi/TLPS traffic levels.**
- **Globalstar refused a request by BT SIG to increase Wi-Fi/TLPS traffic rates to more realistic levels.**
- **Had BT SIG been allowed to collect BLE PER data across a limited range of Wi-Fi/TLPS traffic levels, critical "PER vs. Occupancy" data would be part of the record today.**

TECHNICAL ISSUES REMAIN UNRESOLVED

The FCC's Emissions Report contains an error that supports a key (Globalstar) claim in the NPRM that is demonstrably false

- **NPRM Paragraph 44: "Globalstar maintains that Wi-Fi enabled devices can be upgraded through software based modification". Similar claim referenced elsewhere.**
- **Was the Ruckus access point hardware tested by the OET "identical"[5] to commercially available hardware with the same FCC ID?**
  - **Engineering analysis proves the answer to this question is "no". Specifically, the coexistence filter used in commercial versions of the product was removed in TLPS-enabled versions.**
  - **During the July 27th ex parte meeting, an FCC engineer's response to this direct question was, "..I can neither confirm nor deny."**
- **Resolution simply requires the FCC to ask Globalstar and/or Ruckus for an answer to the above question.**
  - **If the response is "no", the FCC can post a correction to the record by removing the phrase "..and contained modular transmitters approved under Sections 15.247 and 15.407 of the Commission's rules" from Section 1.1 "Executive Summary" of the OET's emissions report.**
  - **If the response is "yes", the relevant differences[6] between the commercial version's Part 15.247 report and the OET report must be explained.**
- **Is there any reason the FCC wouldn't correct an error in a key proceeding document where an interested party has documented the error, cited relevance to the NPRM, and the resolution consists of getting an answer to a simple question?**

[5]*The word "identical" is used as defined in 47 CFR 2.908 (https://www.law.cornell.edu/cfr/text/47/2.908) which states "**As used in this subpart, the term identical means identical within the variation that can be expected to arise as a result of quantity production techniques**."*

[6]*See Letter and attachment from Gerst Capital, LLC to Marlene H. Dortch, FCC Secretary, IB Docket 13-213 (May 14, 2015).*

QUESTIONS FOR THE BUREAUS

1) **Do the Bureaus have questions or concerns related to material presented by Gerst Capital in this proceeding?**
   - **Were there errors of analysis, logic, etc.?**
   - **Was the information and analysis presented in a clear, understandable manner?**

2) **Is there further information the Bureaus require, or would like to have, from Globalstar and/or opposition parties before making a recommendation to the Commissioners?**

3) **Given current information in the record, do the Bureaus view their recommendations to the Commissioners being driven by policy considerations, or technical considerations?**

APPENDIX

Diverse group of opposition parties with a variety of concerns

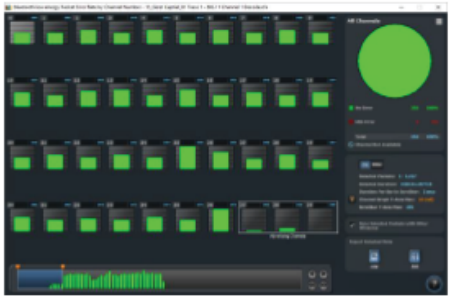
Oppose		
Filer/Participant	**Type**	**Rationale/Position**
ABC Television Network	Corporation	Interference with broadcast auxiliary service frequencies in the 2.5GHz band.
Alarm Industry Communications Committee	Interest Group	Wi-Fi interference, specifically to alarm devices transmitting signals on Wi-Fi Ch 11.
ARRL (the national association for Amateur Radio)	Interest Group	"This plan would thus, for the first time, create a multiple-use, radio frequency environment in which Part 15 unlicensed devices do not have to protect a licensed, allocated radio service from harmful interference. This is untenable as a precedent and it makes the entirety of the Notice proposal likewise untenable."
Bluetooth SIG	Interest Group	Interference with Bluetooth and Bluetooth low energy. Limited testing showed doubling of packet error rate for Bluetooth devices in presence of TLPS. Fairness regarding differentiated rules in the ISM band.
CBS Television Stations	Corporation	Interference with broadcast auxiliary service frequencies in the 2.5GHz band.
Consumer Electronics Association	Interest Group	Globalstar demonstrations "not well-conceived", "not open and transparent" and "serious questions still remain regarding the ability of TLPS to co-exist with existing unlicensed users". Calls for joint testing.
Engineers for the Integrity of Broadcast Auxiliary Services Spectrum (EIBASS)	Interest Group	Interference with licensed Broadcast Auxiliary Services. Concern over credibility of Globalstar's proposed Network Operations Center.
Entertainment Software Association (ESA)	Interest Group	Interference with Bluetooth, (particularly game controllers). Unreliable demonstrations and unanswered questions.
Etymotic Research, Inc.	Corporation	Interference with Bluetooth and Bluetooth Low Energy, specifically to hearing aids. Unworkable NOS proposal.
Google	Corporation	Concerns over interference. Concerns over policy fairness, precedent and allowing benefits to accrue to single corporation.
Hearing Industries Association (HIA)	Interest Group	Interference with unlicensed technologies in the 2.4GHz band including Bluetooth low energy.
Hearing Loss Association of America (HLAA)	Interest Group	Interference with Bluetooth and Bluetooth low energy, specifically in hearing aids.
Meredith Corporation/KPHO Broadcasting Corporation	Corporation	Interference with broadcast auxiliary service frequencies in the 2.5GHz band.
Microsoft	Corporation	Interference with Bluetooth and Wi-Fi. Lack of testing and technical information, unreliable demonstrations and unanswered questions.
National Cable & Telecommunications Association (NCTA)	Interest Group	Wi-Fi interference. Unreliable and unrepresentative demonstrations by Globalstar. CableLabs measurements demonstrate negative impact on Wi-Fi Channel 11 from TLPS.
Society of Broadcast Engineers	Interest Group	Interference to BAS channels A8 and A9 coupled with high noise levels in the 2.5GHz band which make 2.4GHz band important.
Sony Computer Entertainment America	Corporation	Interference with Bluetooth, particularly in game consoles.
Sprint Corporation	Corporation	Meeting OOBE limits and interference above 2496 MHz and protection of Channel BRS-1.
WGN Continental Broadcasting Company, LLC	Corporation	Interference with broadcast auxiliary service frequencies in the 2.5GHz band.
Wi-Fi Alliance	Interest Group	Interference with Wi-Fi and inconclusive demonstrations by Globalstar. Lack of meaningful test results.
Wireless Communications Association International (WCAI)	Interest Group	TLPS will cause harmful interference to BRS and EBS. Globalstar has failed to address unanswered questions about such interference, and meeting OOBE limits at 2495 MHz.
Wireless Internet Service Providers Association (WISPA)	Interest Group	Interference with Wi-Fi. Lack of testing and inadequate demonstrations by Globalstar.

FTE TEST TRACE: “Starting Map”

Frames 1 – 1,217

Duration 31.29 seconds

Channel Map Change: All Bluetooth channels available



Average 802.11 throughput: 30,526 bits/second

Average Bluetooth LE throughput: 1,770 bits/second

NOTE: While a single ComProbe captures every BT/BLE packet, it has a single Wi-Fi radio allowing it to capture packets on a single channel. In this series of slides, the trace only captures Wi-Fi packets on channel 1. A comprehensive testbed should include one ComProbe device per Wi-Fi channel used.

FTE TEST TRACE: “Map Change #1”

Frames 1,218 – 3,213

Duration 12.48 seconds

Channel Map Change: Removal of 6, 7, 8 (2.416, 2.418, 2.420)

Average 802.11 throughput: 36,454 bits/second

Average Bluetooth LE throughput: 1,770 bits/second

FTE TEST TRACE: “Map Change #2”

Frames 3,214 – 3,957

Duration 4.58 seconds

Channel Map Change: Removal of 9, 10, 11, 12, 13, 14, 15 (2.422 – 2.436)

Average 802.11 throughput: 32,834 bits/second

Average Bluetooth LE throughput: 16,074 bits/second

FTE TEST TRACE: “Map Change #3”

Frames 3,958 – 9,361

Duration 3.07 seconds

Channel Mapping: Removal of 16, 17, 18 (2.438 – 2.442)

Average 802.11 throughput: 1,064,065 bits/second

Average Bluetooth LE throughput: 16,149 bits/second

FTE TEST TRACE: “Map Change #4”

Frames 9,362 – 10,223

Duration 4.64 seconds

Channel Map Change: Removal of 19, 20 (2.444 – 2.446)

Average 802.11 throughput: 56,529 bits/second

Average Bluetooth LE throughput: 10,102 bits/second

FTE TEST TRACE: “Map Change #5”

Frames 10,224 – 12,729

Duration 7.62 seconds

Channel Map Change: Removal of 21 – 31 (2.448 – 2.468)

Average 802.11 throughput: 113,307 bits/second

Average Bluetooth LE throughput: 15,031 bits/second

FTE TEST TRACE: “Map Change #6”

Frames 12,730 – 15,096

Duration 3.8 seconds

Channel Map Change: Removal of 32, 33 (2.470, 2.472)

Average 802.11 throughput: 310,204 bits/second

Average Bluetooth LE throughput: 18,603 bits/second

FTE TEST TRACE: “Map Change #7”

Frames 15,097 – 33,771

Duration 4.58 seconds

Channel Map Change: Removal of 34, 35 (2.474 – 2.476)

Average 802.11 throughput: 2,222,005 bits/second

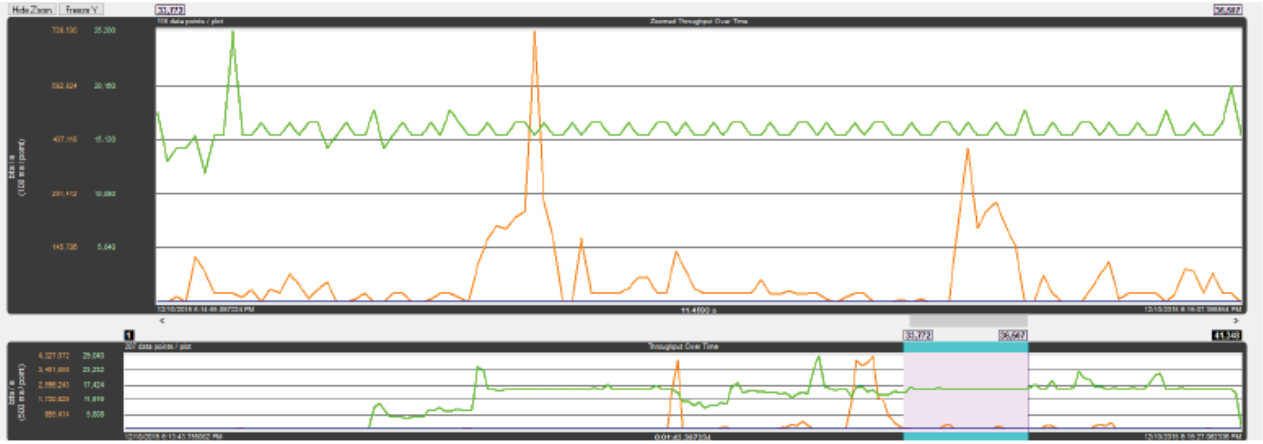
Average Bluetooth LE throughput: 14,949 bits/second

FTE TEST TRACE: “Map Change #8”

Frames 33,772 – 36,502

Duration 11.42 seconds

Channel Map Change: Removal of 0-5 (2.404 – 2.414) – Addition of 10 (2.424)



Average 802.11 throughput: 58,717 bits/second

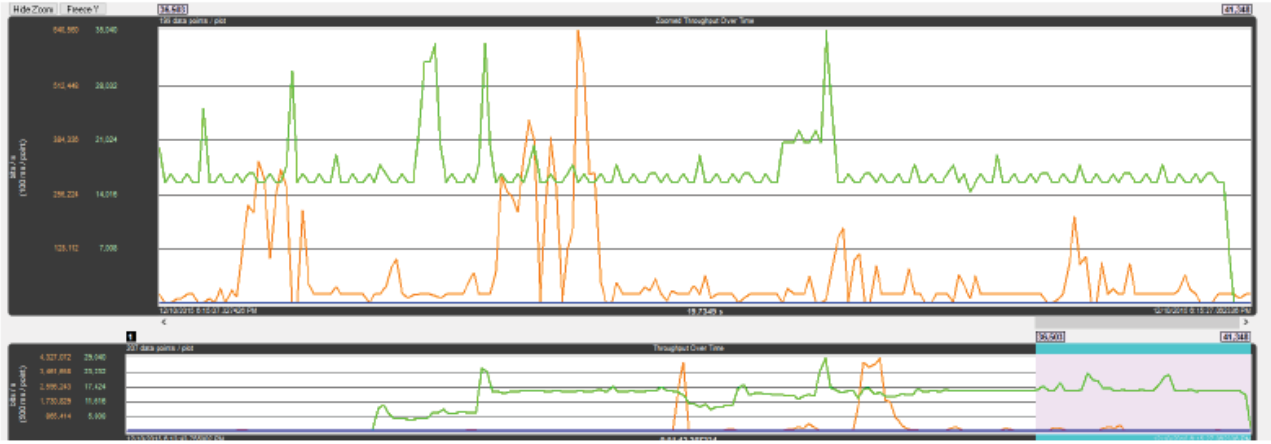
Average Bluetooth LE throughput: 16,134 bits/second

FTE TEST TRACE: “Map Change #9”

Frames 36,503 – 41,340 (End)

Duration 19.35 seconds

Channel Map Change: Removal of 10 (2.424) – Addition of 35 (2.476)



Average 802.11 throughput: 64,671 bits/second

Average Bluetooth LE throughput: 17,082 bits/second