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May 15, 2015

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,

As a former engineer and manager of wireless communication system development & test organizations, I understand the difference between a product "demonstration" and system-level product "test". Under Globalstar's tight control, TLPS has undergone basic "customer-level" demonstrations, but has yet to go through anything approaching engineering "system testing" of the type conducted by wireless system manufacturers around the world.

For this reason, I approached Ixia, a leading provider of network systems test equipment, with a proposal to conduct preliminary engineering testing to assess one key technical risk regarding Globalstar's TLPS proposal: The impact of Channel 14/TLPS on Wi-Fi Channel 11. On April 28th and 29th, I spent approximately 12 hours with Ixia personnel in Portland, Oregon conducting controlled "system-level" testing to begin quantifying the impact of TLPS on Channel 11.

In my April 14, 2015 Ex Parte presentation, I described four technical facts, one of which was labeled "Fact #3: TLPS Increases Adjacent-Channel Interference with Channel 11".[1] The attached presentation addresses "Fact #3" with a combination of analysis and controlled laboratory testing.

The key findings are:

1. Using the most restrictive emissions mask from the IEEE 802.11-2012 specification, mathematical analysis proves the power ratio of adjacent channel interference (ACI) from 22MHz channel spacing (Ch11<>TLPS) is twice that of 25MHz channel spacing (1<>6 & 6<>11), or 3dB on a log scale.

2. The "real-world" Wi-Fi environment I observed on the 8th floor of the FCC headquarters would lead to a material degradation on Channel 11 if TLPS were deployed.

3. Many large-scale Wi-Fi deployments employ Radio Resource Management systems that automatically adjust network parameters based on, among other things, measured interference levels. If such a system overlaps with a TLPS-enabled deployment, the result will be a degradation in network quality and performance for ALL non-TLPS users in that area.

4. Controlled testing with Ixia conclusively proves the "network-level" impact of ACI from TLPS is worse than "non-overlapping" ACI normally encountered. With just 12 hours to configure the testbed and execute tests, we were able to show the severity of ACI-induced packet errors for channels spaced 22MHz apart are materially worse than channels spaced 25MHz.

5. Further testing of this and other issues are required to provide the FCC with a sufficient level of information to make a risk-based decision on Globalstar's TLPS proposal.

[1] See slide 11 of Ex Parte presentation titled "Analysis of Globalstar's TLPS Proposal" filed 4/15/15 at http://apps.fcc.gov/ecfs/comment/view?id=60001029136

If there were only one message to convey to all FCC staff regarding the attached analysis, it is the statement made on slide 28:

Ixia's IxVeriWave product is a leading tool for testing Wi-Fi systems. With a representative set of TLPS-enabled clients and Bluetooth devices, Ixia test equipment could be used to execute comprehensive testing that would quantify virtually all key technical risks associated with Globalstar's TLPS Proposal. Based on our experience, such testing could be designed and executed in a matter of weeks.

With this in mind, I request that the FCC assist interested parties in communications with client device manufacturers. To my knowledge, it has not been possible for anyone other than Globalstar to obtain client devices capable of operating on Wi-Fi channel 14. If manufacturers were made aware of the FCC's interest in this area, it would likely make it easier for interested parties to obtain client devices for controlled testing.

I look forward to participating in a conference call with members of the OET's engineering staff to discuss the attached analysis and test results. I suggest we allow members of commissioners' staff to listen into this call if they are interested. If that is not possible, I will be happy to review this same material on separate calls with commissioners' staff members, or any other FCC staff who are not able to participate in the first discussion.

Pursuant to Section 1.1206(b)(2) of the Commission's rules, an electronic copy of this letter and attachments are being filed for inclusion in the above-referenced dockets.

Respectfully Submitted,

Greg Gerst
Gerst Capital, LLC

cc: Renee Gregory
Louis Peraertz
Priscilla Argeris
Erin McGrath
Brendan Carr
Julius Knapp
Mindel De La Torre
Ronald Repasi
Bruce Romano
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Patrick Forster
Troy Tanner
Jennifer Gilsenan
Lynne Montgomery
Rashmi Doshi
Chad Beattie
Reza Biazaran
Jose Albuquerque
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Analysis of Globalstar's TLPS Proposal: Beginning to Quantify Impact on Wi-Fi Channel 11

Presentation material to be discussed on a conference call with Gerst Capital and Engineers in the FCC Office of Engineering and Technology

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IMPORTANT DISCLOSURES

1. **Ixia takes no position in the Globalstar TLPS Proceeding. Ixia is willing to work with any interested party to design and conduct testing relevant to the TLPS proposal.**

2. **Neither Gerst Capital nor Ixia compensated the other for any aspect of this testing, including travel, equipment, or personnel.**

AGENDA

Beginning to Quantify the Impact of TLPS on Wi-Fi Channel 11

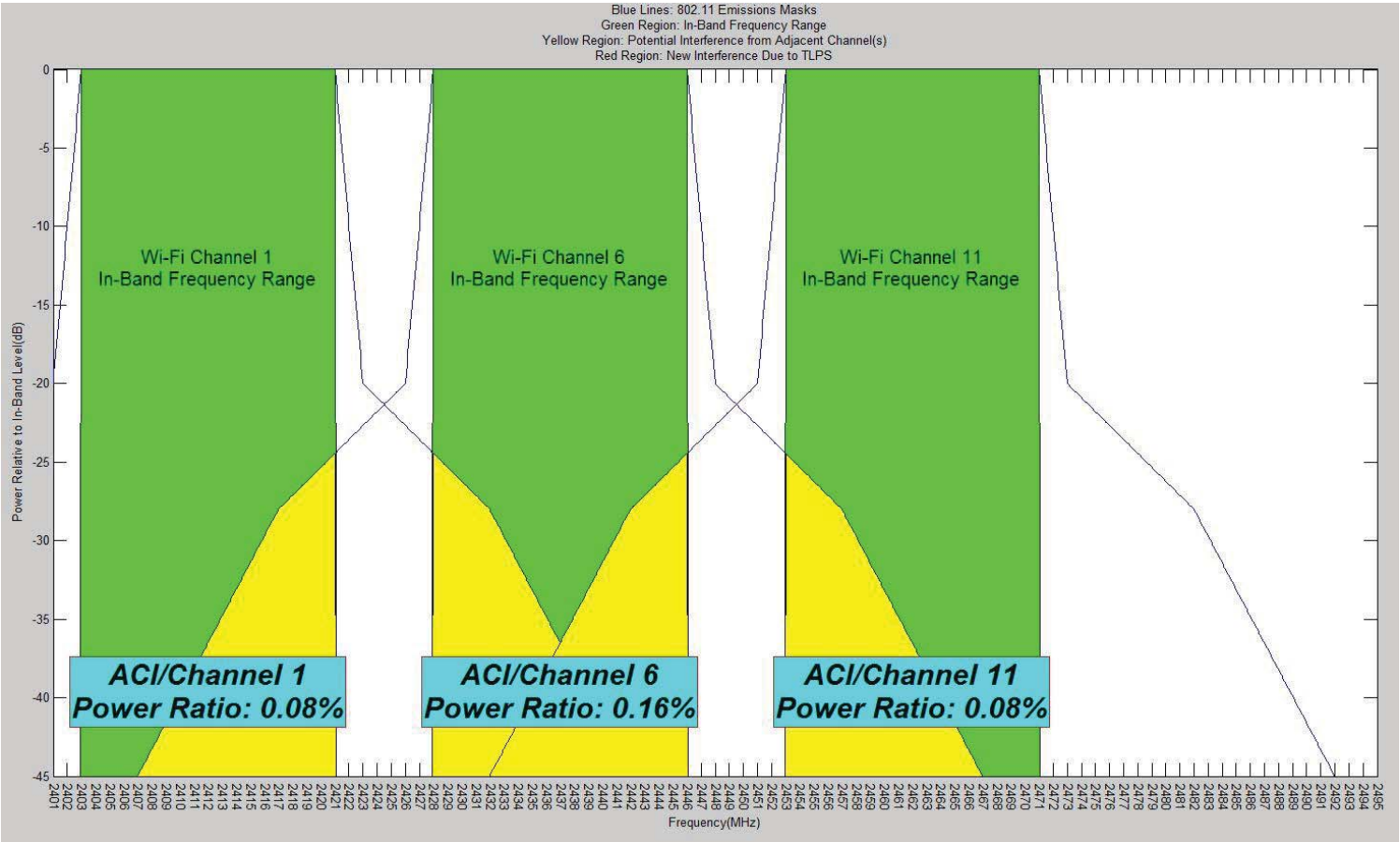
1) **Analytical View of Adjacent Channel Interference (ACI) with and without TLPS**

2) **Adjacent Channel Rejection Testing with Ixia**
   - 25MHz Spacing: Test with Channel 6 Desired & Channel 11 Adjacent Channel Interferer
   - 22MHz Spacing: Test with Channel 11 Desired & TLPS/Channel 14 Adjacent Channel Interferer
   - 20MHz Spacing: Test with Channel 6 Desired & Channel 10 Adjacent Channel Interferer

3) **Results Summary and Implications**

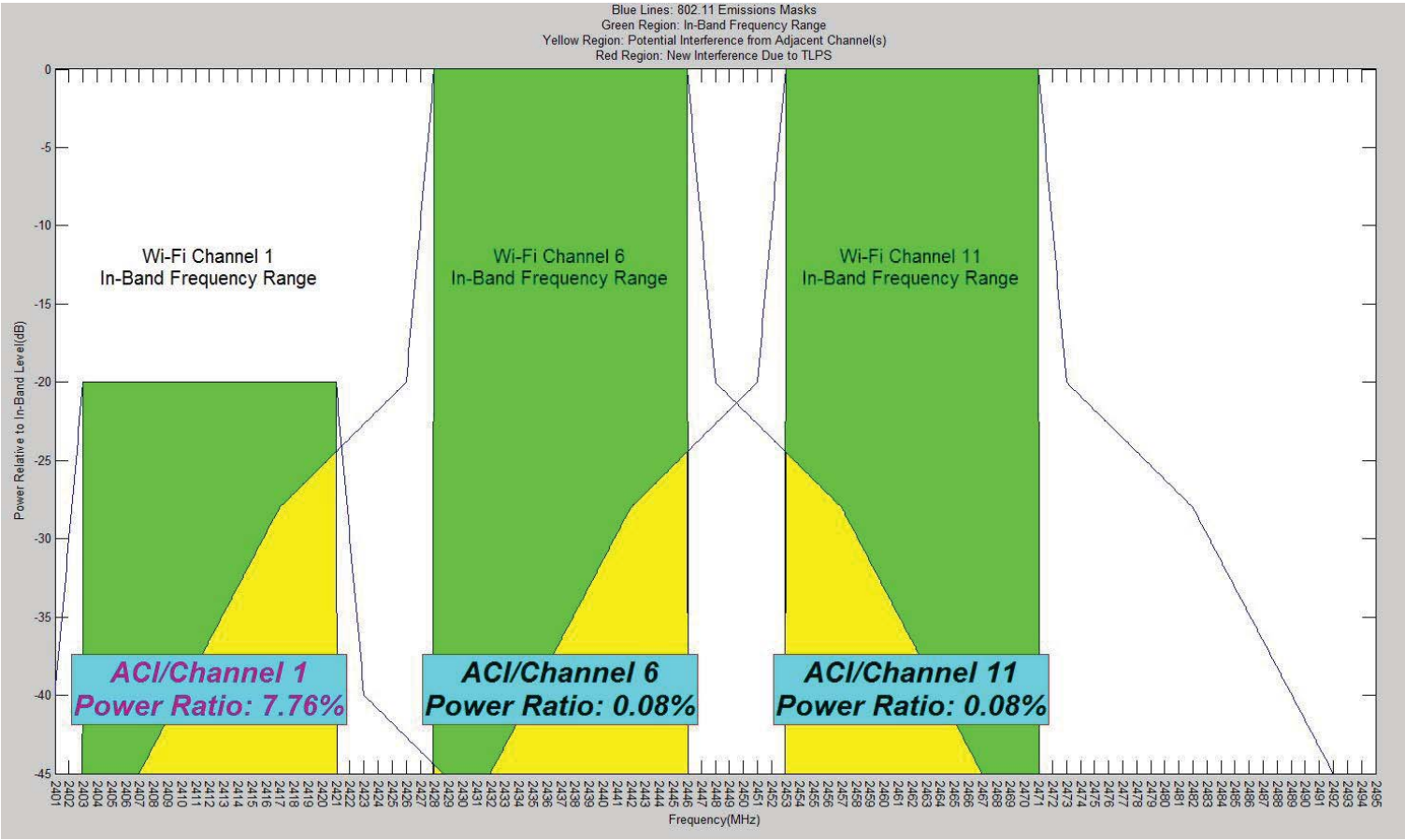
ANALYTICAL VIEW: ACI WITH EVEN STRENGTH CHANNELS TODAY

Adjacent Channel Interference (ACI) is a non-issue for non-overlapping channels at even strength



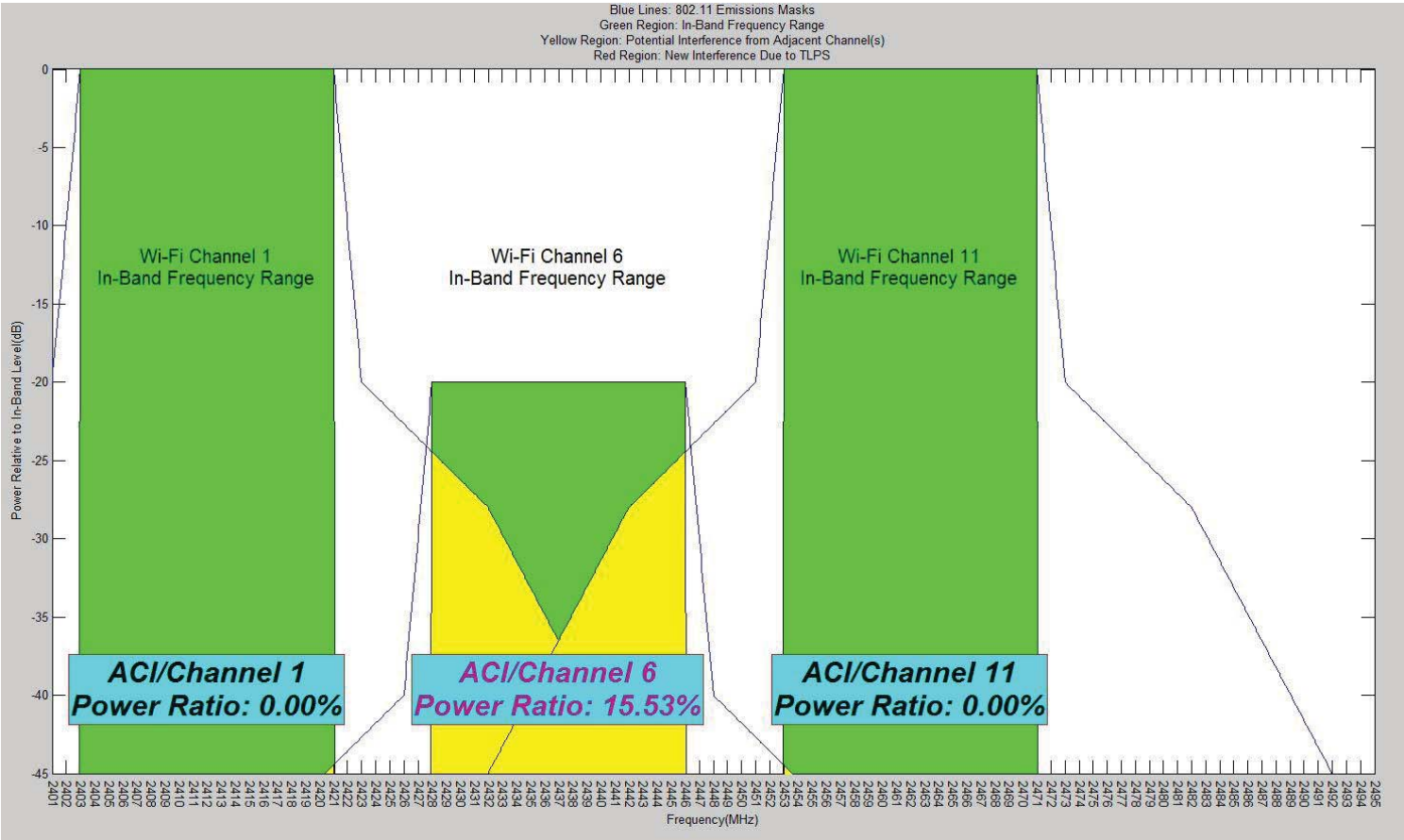
ANALYTICAL VIEW: CHANNEL 1 IS 20dB LOWER THAN ADJACENT CHANNELS

ACI becomes an issue when the desired channel's power is lower than an adjacent channel. Channel 1 has one source of non-overlapping ACI



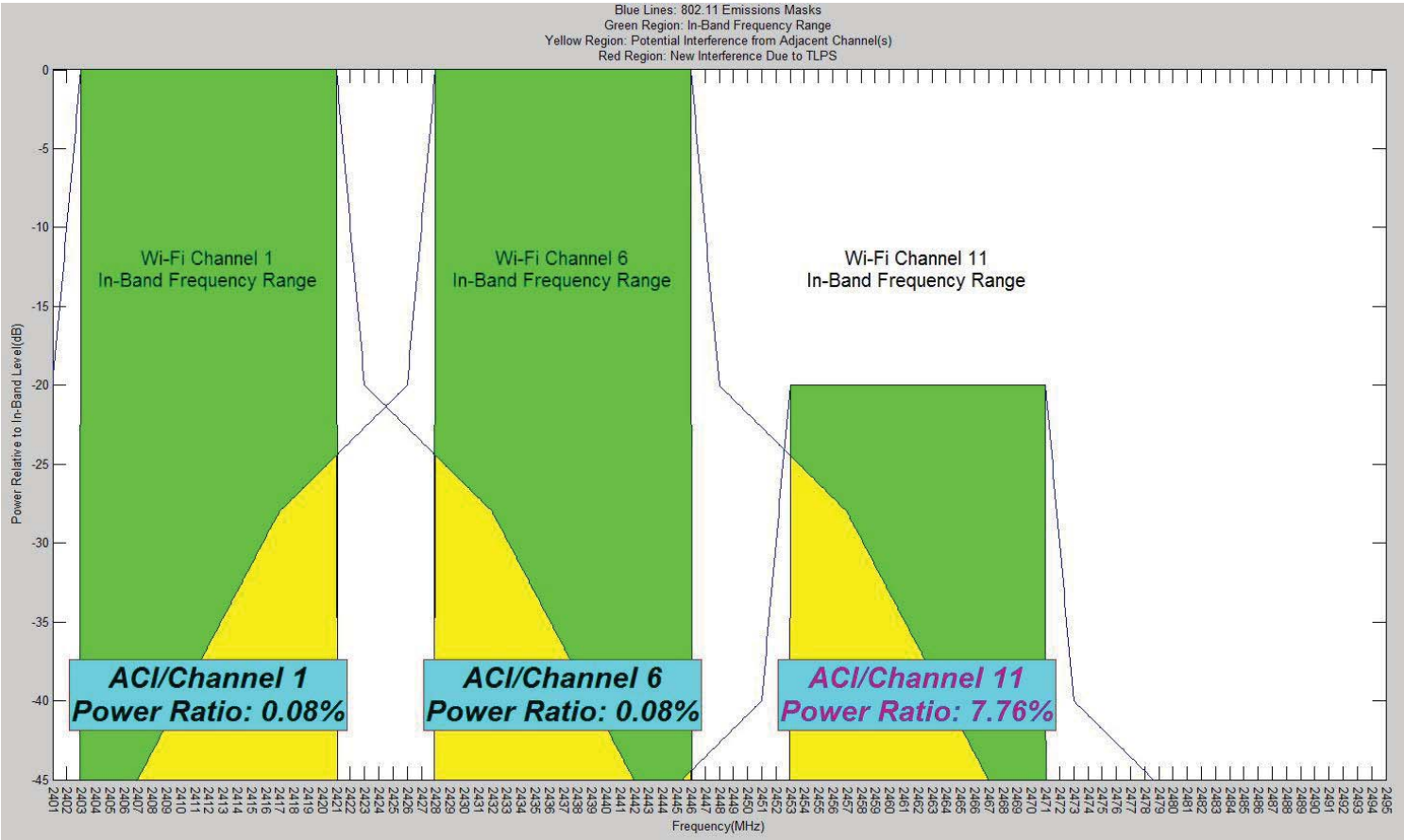
ANALYTICAL VIEW: CHANNEL 6 IS 20dB LOWER THAN ADJACENT CHANNELS

Channel 6 has two sources of non-overlapping ACI, worse than Channel 1



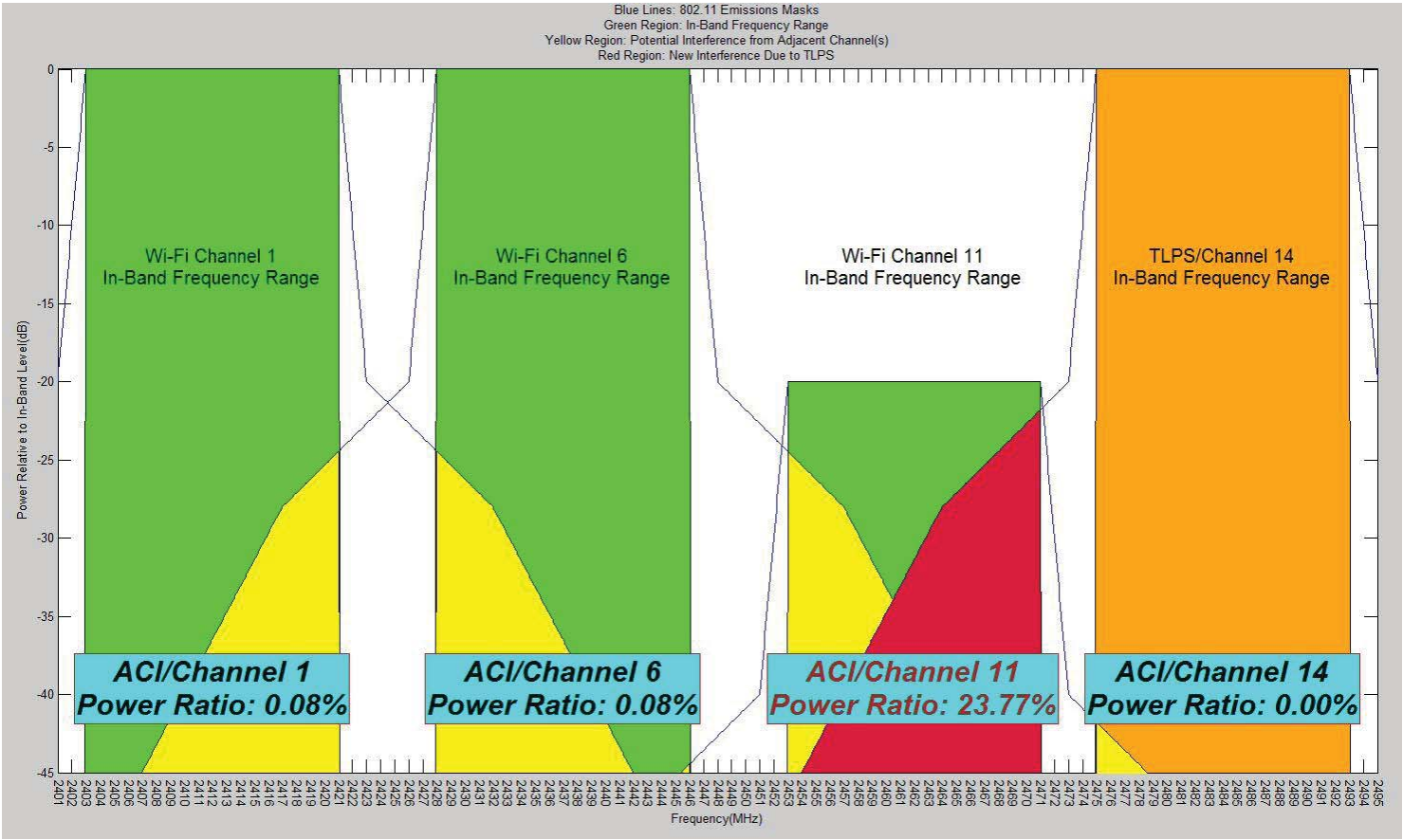
ANALYTICAL VIEW: CHANNEL 11 IS 20dB LOWER THAN ADJACENT CHANNELS, NO TLPS

Channel 11, like channel 1, currently has a single source of non-overlapping ACI

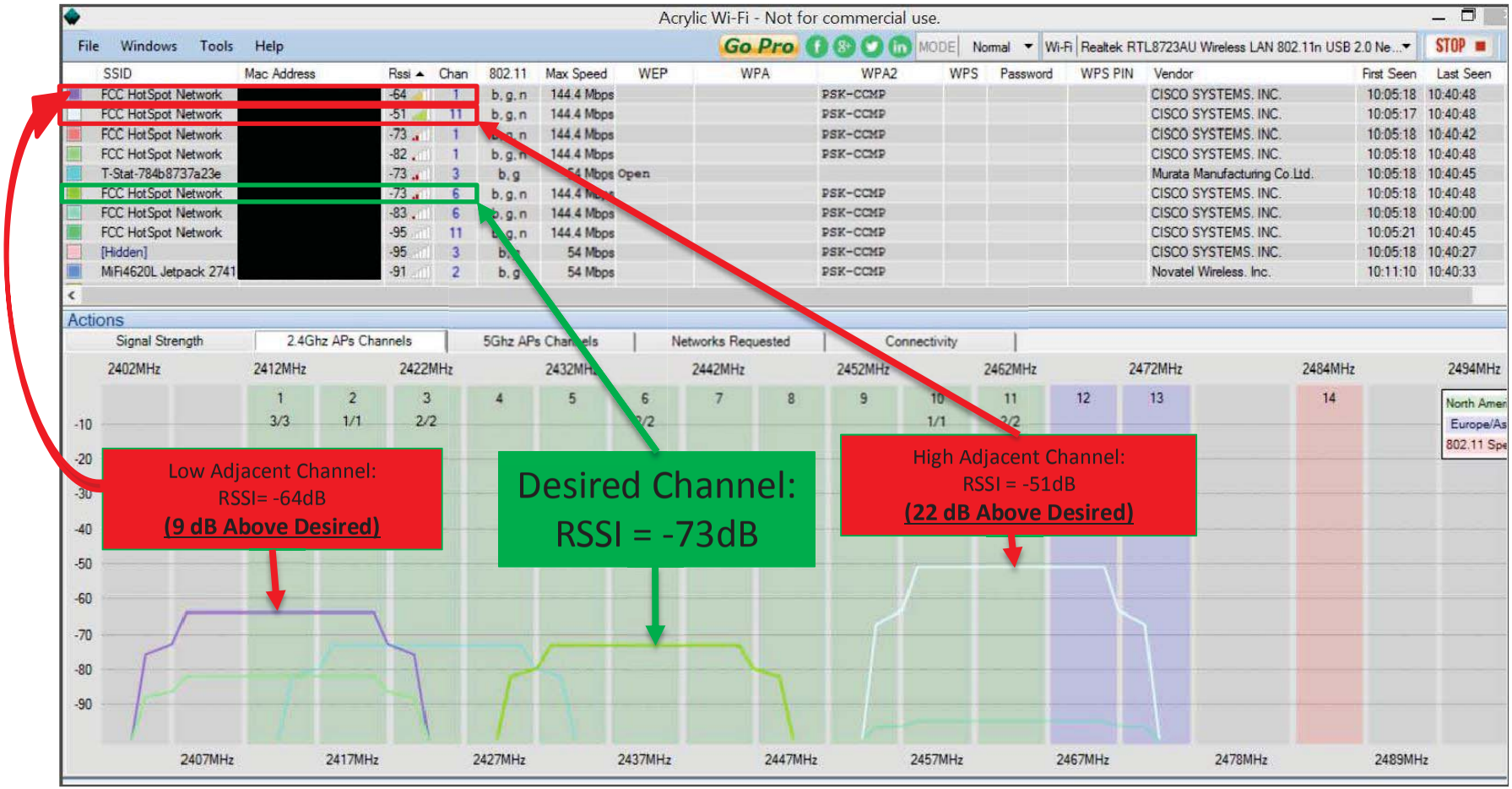


ANALYTICAL VIEW: CHANNEL 11 IS 20dB LOWER THAN ADJACENT CHANNELS, W/ TLPS

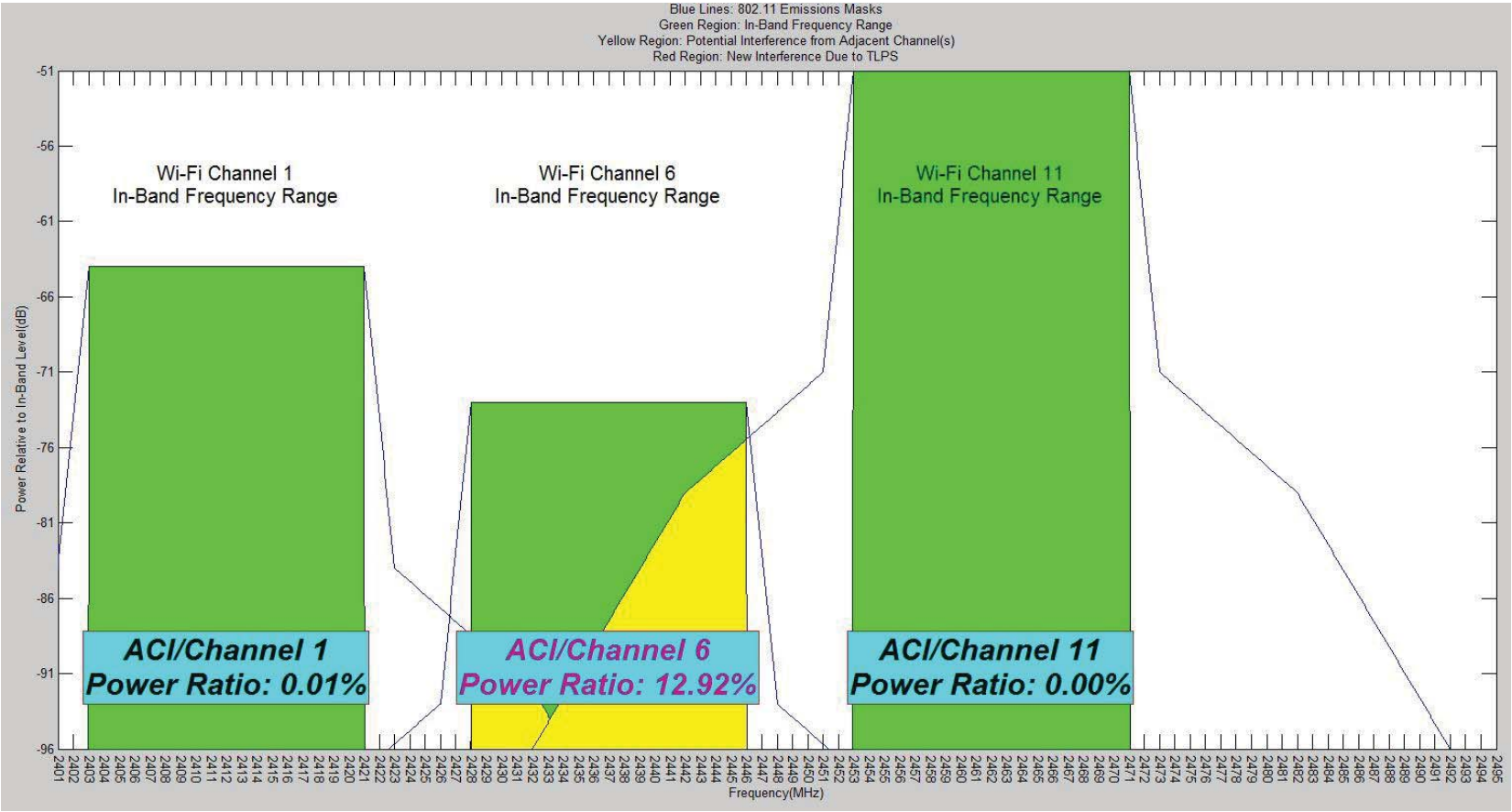
Due to the new source of ACI from TLPS, combined with the narrower 22MHz channel spacing, channel 11 now becomes the worst Wi-Fi channel



The Wi-Fi Sniffer Snapshot Taken from 8th Floor of FCC Headquarters on April 14, 2015 demonstrates that a 20dB higher adjacent channel constitutes a “real-world” scenario

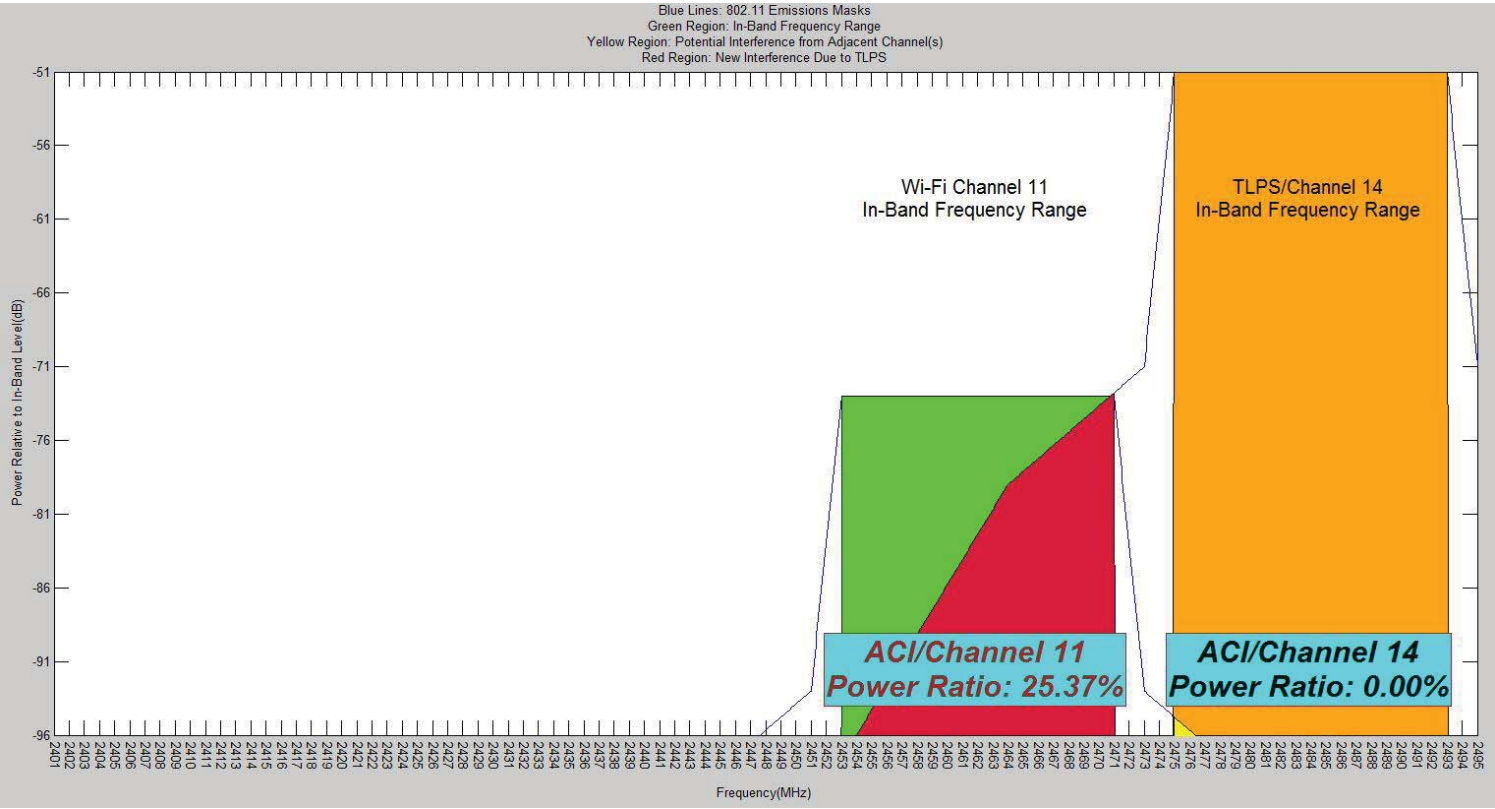


Adjacent Channel Interference Environment Using Receive Levels from 8th Floor of FCC Headquarters



ANALYTICAL VIEW: TLPS IMPACT ON CHANNEL 11 IN THE "REAL WORLD"

Channel 11 Desired: Using receive levels seen on 8th Floor of FCC Building, Assume TLPS in Operation with non-TLPS subscriber on Channel 11



Narrower 22MHz Channel Spacing Doubles ACI/Desired Power Ratio vs. 25MHz Channel Spacing, even without Lower Channel ACI Effect!

WHAT HAPPENS IN A MIXED TLPS & NON-TLPS ENVIRONMENT?

Due to increased ACI on Channel 11, the presence of a TLPS deployment will cause problems for non-TLPS networks using Radio Resource Management/Self Organizing Network systems (RRM/SON)

- RRM/SON systems continuously monitor, among other things, interference statistics across all APs in a network. If the RRM/SON system detects interference on a given channel, it can automatically move clients to a different AP and/or modify that AP's channel setting.

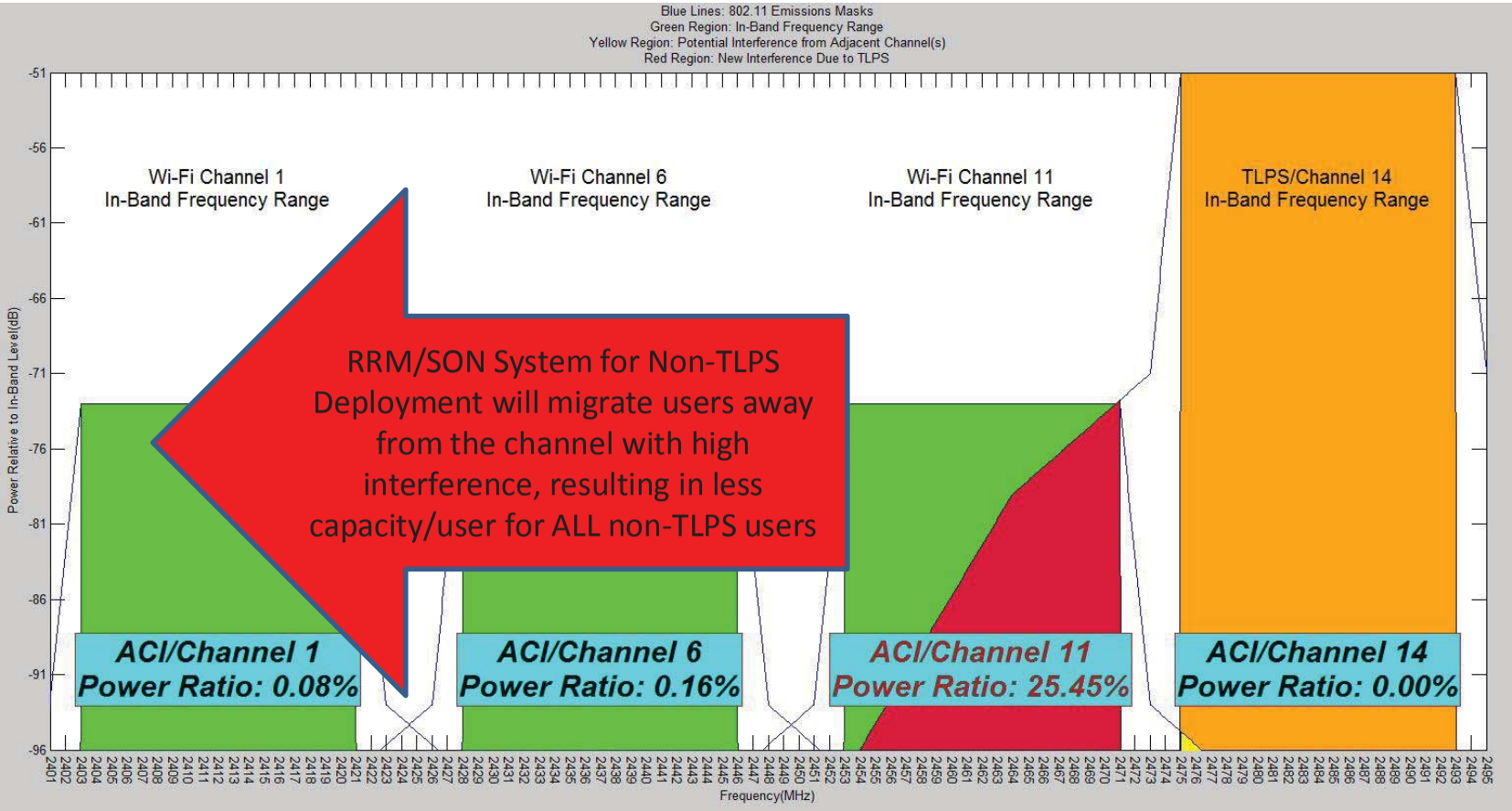
- For Non-TLPS deployments, increased ACI on Channel 11 due to co-located TLPS devices is considered noise outside that network's control.

- The net result is the TLPS deployment will negatively impact any co-located non-TLPS deployment by forcing more users onto Channels 1 & 6 than would otherwise be the case.

- In the scenario above, Wi-Fi users who fail to pay for Globastar's TLPS service will suffer a DECREASE in service quality.

WHAT HAPPENS IN A MIXED TLPS & NON-TLPS ENVIRONMENT?

For Non-TLPS Deployments with Automatic Radio Resource Management Software, the presence of TLPS will cause the system to "push" users from Channel 11 to Channels 1&6, resulting in more congestion on the lower two channels



AGENDA

Beginning to Quantify the Impact of TLPS on Wi-Fi Channel 11

1) Analytical View of Adjacent Channel Interference (ACI) with and without TLPS

2) Adjacent Channel Rejection Testing with Ixia
   - 25MHz Spacing: Test with Channel 6 Desired & Channel 11 Adjacent Channel Interferer
   - 22MHz Spacing: Test with Channel 11 Desired & TLPS/Channel 14 Adjacent Channel Interferer
   - 20MHz Spacing: Test with Channel 6 Desired & Channel 10 Adjacent Channel Interferer

3) Results Summary and Implications

FACT 3: TLPS INCREASES ADJACENT CHANNEL INTERFERENCE WITH CHANNEL 11

Recall Fact #3 From April 14th Ex Parte: TLPS will increase adjacent channel interference for Wi-Fi Channel 11[1]

"Free Wi-Fi" Channel Spacing vs. Adjacent-Channel Interference has been studied extensively.
Not so for TLPS & Channel 11

25 MHz

Both channels operate at maximum capacity (Ch1<>Ch6, Ch6<>Ch11)

22 MHz ?

There are no controlled, quantitative studies to determine the impact of 22MHz channel spacing (Ch11<>Ch14/TLPS)

20 MHz

Both channels operate materially below capacity (Ch1<>Ch5,Ch7<>Ch11,etc.)

[1]*See slide 11 of Ex Parte presentation titled "Analysis of Globalstar's TLPS Proposal" filed 4/15/15 at http://apps.fcc.gov/ecfs/comment/view?id=60001029136*

Using Ixia's IxVeriWave[1] Platform, we conducted controlled testing on TLPS to start quantifying "Fact #3" from the April 14, 2015 Ex Parte Presentation

Objectives

- **Begin to quantify the impact of adjacent channel interference for 22MHz channel spacing (11/TLPS) vs. 25MHz spacing (1/6 and 6/11)**
- **Use IEEE 802.11-2012[2] "Adjacent Channel Rejection"[3] (ACR) specifications as the guideline for test configuration**
- **Conduct "apples-to-apples" testing in a precisely controlled environment with simultaneous access to all statistics at the PHY, MAC, and Network layers.**

[1]Data Sheets for Ixia hardware/software used in this testing are included as attachments to this presentation. Further information on Ixia (NASDAQ: XXIA) can be found via the "Supporting Links" slides. See also: http://www.ixiacom.com/products/ixveriwave

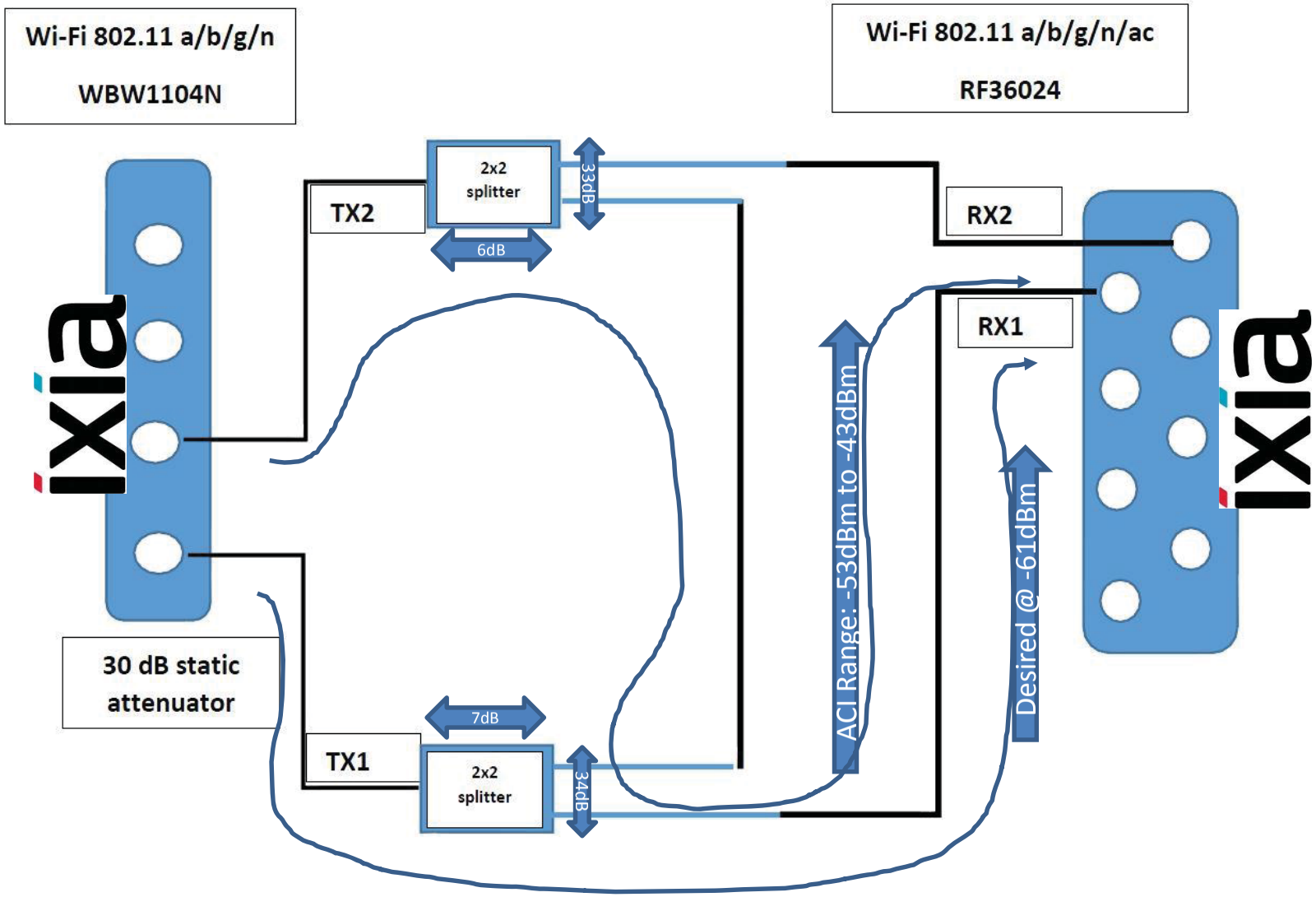
[2]See "Supporting Links" slide to download IEEE 802.11-2012 Specification. For 802.11n ACR specification, refer to section 20.3.21.2 on page 1745. For 802.11g, refer to section 19.5.3. on page 1647.

[3]IxVeriWave meets the more stringent "Alternate adjacent channel rejection" 802.11 specification in Table 18-14 on page 1612. Since it is used to test conformance to every variant of the 802.11-2012 specification, IxVeriWave must exceed the most stringent requirements for all possible Wi-Fi configurations and will therefore use higher quality hardware than commercial Wi-Fi products. ***"Consumer-grade" client devices (and likely most all APs) will be MORE susceptible to ACI effects that what is shown in these tests.***

Test Scenarios

- **25MHz Channel Spacing:**
  - Configure Channel 6 as the "Desired" channel with the received power level constant across all tests
  - Configure Channel 11 as the adjacent channel "Interferer"
  - Record key "Desired" channel statistics as the adjacent channel "Interferer" power is increased.
  - Measure over "ACI level" ("Interferer" minus "Desired" power) range from 0% packet error rate (PER) to >50%
- **22MHz Channel Spacing:**
  - Without modifying testbed hardware, configure Channel 11 as "Desired" and TLPS/Channel 14 as "Interferer"
  - Using identical steps, record "Desired" channel statistics over the same "ACI level" range used in the 25MHz tests
- **20MHz Channel Spacing:**
  - Without modifying testbed hardware, configure Channel 6 as "Desired" and Channel 10 as "Interferer"
  - Using identical steps, record "Desired" channel statistics over the same "ACI level" range used in 25MHz tests

Testbed


Wi-Fi 802.11 a/b/g/n
WBW1104N
Wi-Fi 802.11 a/b/g/n/ac
RF36024
2x2 splitter
33dB
6dB
TX2
RX2
RX1
ACI Range: -53dBm to -43dBm
Desired @ -61dBm
30 dB static attenuator
7dB
TX1
2x2 splitter
34dB
ixia
ixia

Test Procedure for 25MHz, 22MHz, & 20MHz Channel Spacing Scenarios:

1) Configure “desired” channel on ports TX1/RX1, and “interferer” on ports TX2/RX2. For each channel, configure a single AP/single virtual client transmitting UDP frames from TX->RX at 3049 frames/second, with frame size set to 1518 bytes. This will achieve a “UDP-Level” throughput level of ~37MBps. Each TX/RX pair will operate at MCS7, giving a PHY channel capacity of 64MBps, with the associated “UDP-level” capacity being ~63Mbps . The configuration results in both the “desired” and “interferer” channel utilization of approximately 59%.
2) Measure desired channel power level at port RX1. Adjust TX1 port power level until RX1 power level is -61dBm, per section 20.3.21.2 of IEEE 802.11-2012 for testing adjacent channel rejection at MCS7.
3) Begin transmission of network data on desired channel and verify 0% packet errors.
4) Begin increasing TX2 power level in 1dB steps until > 0% packet errors are observed at port RX1. Back off TX2 power by 1dB, configure RX1 port to the “interferer” channel and measure the received power power level. This TX2 power level will be the starting “interferer” power for all subsequent tests, and the difference between the “interferer” channel’s measured power at RX1 and the “desired” channel’s power (-61dB) power at RX1 is the starting “ACI Level”.
5) At that “ACI Level”, observe the following key statistics for a period of 30 seconds: “Receive Frame Rate”, “Receive FCS Errored Frame Rate”. Record the observed median value for each.
6) At the same ACI Level, begin Wireshark data collection for a period of 10 seconds. Record the “% Malformed Frames” recorded by Wireshark.
7) Increase “ACI Level” 1dB by increasing TX2 port power level, repeat steps 5 & 6.
8) Collect statistics across “ACI Level” range determined during 25MHz channel spacing test scenario.

Test Data for 25MHz Channel Spacing (Channel 6 Desired, Channel 11 Adjacent Channel Interferer)

						Collected	Collected	Collected	Derived	Derived	Derived	Derived	Derived	Derived	Derived	Analytical	Analytical
MSC Level	**Desired Channel**	**ACI Channel**	**Desired Power at RX1 (dBm)**	**ACI Power at RX1 (dBm)**	**ACI Level (ACI Pwr - Desired Pwr) at RX1 (dB)**	**Desired Channel Receive Total Frame Rate**	**Desired Channel Receive FCS Errored Frames**	**Wireshark "% Malformed frames"**	**Malformed Frames ~= A/[(1/C)-1]**	**Re-transmissions (= if(A>3049), A-3049,0))**	**Lost Frames (= if(A<=3049), 3049-A, 0))**	**FCS + Lost Frames + Malformed Frames (= B+D+F)**	**"True" Packet Error Rate (=G/[A+D])**	**"Traditional " Packet Error Rate (= B/A)**	**% Malformed +Lost (= [D+F]/[A+ D])**	**Computed Potential ACI/Desired Power Ratio (%)**	**Computed Potential ACI/Desired Power Ratio (dB)**
						A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**		
7	**6**	**11**	-61	-53	8	3049	0	0.0%	-	0	0	0	0%	0%	0%	0.5%	-23
7	**6**	**11**	-61	-52	9	3070	1	0.0%	-	21	0	1	0%	0%	0%	0.6%	-22
7	**6**	**11**	-61	-51	10	3200	3	0.1%	3	151	0	6	0%	0%	0%	0.8%	-21
7	**6**	**11**	-61	-50	11	3846	15	2.8%	111	797	0	126	3%	0%	3%	1.0%	-20
7	**6**	**11**	-61	-49	12	4500	35	2.1%	97	1451	0	132	3%	1%	2%	1.2%	-19
7	**6**	**11**	-61	-48	13	4900	150	1.3%	65	1851	0	215	4%	3%	1%	1.6%	-18
7	**6**	**11**	-61	-47	14	4700	147	2.1%	101	1651	0	248	5%	3%	2%	2.0%	-17
7	**6**	**11**	-61	-46	15	4500	550	3.2%	149	1451	0	699	15%	12%	3%	2.5%	-16
7	**6**	**11**	-61	-45	16	4400	1500	4.9%	227	1351	0	1727	37%	34%	5%	3.1%	-15
7	**6**	**11**	-61	-44	17	4300	1500	5.6%	255	1251	0	1755	39%	35%	6%	3.9%	-14
7	**6**	**11**	-61	-43	18	4235	2880	6.8%	309	1186	0	3189	70%	68%	7%	4.9%	-13
7	**6**	**11**	-61	-42	19	4200	3100	4.0%	175	1151	0	3275	75%	74%	4%	6.2%	-12

Test Data for 22MHz Channel Spacing (Channel 11 Desired, TLPS/Channel 14 Adjacent Channel Interferer)

						Collected	Collected	Collected	Derived	Derived	Derived	Derived	Derived	Derived	Derived	Analytical	Analytical
MSC Level	Desired Channel	ACI Channel	Desired Power at RX1 (dBm)	ACI Power at RX1 (dBm)	ACI Level (ACI Pwr - Desired Pwr) at RX1 (dB)	Desired Channel Receive Total Frame Rate	Desired Channel Receive FCS Errored Frames	Wireshark "% Malformed frames"	Malformed Frames ~ = A/[(1/C)-1]	Re-transmissions (= if(A>3049), A-3049,0))	Lost Frames (= if(A<=3049), 3049-A, 0))	FCS + Lost Frames + Malformed Frames (= B+D+F)	"True" Packet Error Rate (=G/[A+D])	"Traditional " Packet Error Rate (= B/A)	% Malformed +Lost (= [D+F]/[A+ D])	Computed Potential ACI/Desired Power Ratio (%)	Computed Potential ACI/Desired Power Ratio (dB)
						A	B	C	D	E	F	G	H	I	J		
7	**11**	**14**	-61	-53	8	3122	0	1.4%	44	73	0	44	1%	0%	1%	1.0%	-20
7	**11**	**14**	-61	-52	9	3418	0	6.8%	249	369	0	249	7%	0%	7%	1.3%	-19
7	**11**	**14**	-61	-51	10	3325	0	5.4%	190	276	0	190	5%	0%	5%	1.6%	-18
7	**11**	**14**	-61	-50	11	3500	0	7.4%	280	451	0	280	7%	0%	7%	2.0%	-17
7	**11**	**14**	-61	-49	12	3680	0	10.2%	418	631	0	418	10%	0%	10%	2.5%	-16
7	**11**	**14**	-61	-48	13	3600	0	10.2%	409	551	0	409	10%	0%	10%	3.2%	-15
7	**11**	**14**	-61	-47	14	3500	3	9.7%	376	451	0	379	10%	0%	10%	4.0%	-14
7	**11**	**14**	-61	-46	15	3550	10	12.0%	484	501	0	494	12%	0%	12%	5.1%	-13
7	**11**	**14**	-61	-45	16	2500	30	8.7%	238	0	549	817	30%	1%	29%	6.4%	-12
7	**11**	**14**	-61	-44	17	2000	39	14.4%	336	0	1049	1424	61%	2%	59%	8.0%	-11
7	**11**	**14**	-61	-43	18	2000	80	25.0%	667	0	1049	1796	67%	4%	64%	10.1%	-10
7	**11**	**14**	-61	-42	19	2100	20	30.0%	900	0	949	1869	62%	1%	62%	12.7%	-9

Test Data for 20MHz Channel Spacing (Channel 6 Desired, Channel 10 Adjacent Channel Interferer)

						Collected	Collected	Collected	Derived	Derived	Derived	Derived	Derived	Derived	Derived
MSC Level	Desired Channel	ACI Channel	Desired Power at RX1 (dBm)	ACI Power at RX1 (dBm)	ACI Level (ACI Pwr - Desired Pwr) at RX1 (dB)	Desired Channel Receive Total Frame Rate	Desired Channel Receive FCS Errored Frames	Wireshark "% Malformed frames"	Malformed Frames ~= A/[(1/C)-1]	Re-transmissions (= if(A>3049), A-3049,0))	Lost Frames (= if(A<=3049), 3049-A, 0))	FCS + Lost Frames + Malformed Frames (= B+D+F)	"True" Packet Error Rate (= G/[A+D])	"Traditional" Packet Error Rate (= B/A)	% Malformed +Lost (= [D+F]/[A+D])
						A	B	C	D	E	F	G	H	I	J
7	**6**	**10**	-61	-53	8	3000	9	1.7%	52	0	49	110	4%	0%	3%
7	**6**	**10**	-61	-52	9	2600	130	2.1%	56	0	449	635	24%	5%	19%
7	**6**	**10**	-61	-51	10	2000	70	2.3%	47	0	1049	1166	57%	4%	54%
7	**6**	**10**	-61	-50	11	2100	3	2.4%	52	0	949	1004	47%	0%	47%
7	**6**	**10**	-61	-49	12	1781	0	2.5%	46	0	1268	1314	72%	0%	72%
7	**6**	**10**	-61	-48	13	1700	2	3.2%	56	0	1349	1407	80%	0%	80%
7	**6**	**10**	-61	-47	14	2100	80	2.9%	63	0	949	1092	50%	4%	47%
7	**6**	**10**	-61	-46	15	2100	1	3.0%	65	0	949	1015	47%	0%	47%
7	**6**	**10**	-61	-45	16	1700	2	3.8%	67	0	1349	1418	80%	0%	80%
7	**6**	**10**	-61	-44	17	1700	5	4.4%	78	0	1349	1432	81%	0%	80%
7	**6**	**10**	-61	-43	18	1700	5	3.4%	60	0	1349	1414	80%	0%	80%
7	**6**	**10**	-61	-42	19	1600	10	3.8%	63	0	1449	1522	92%	1%	91%

AGENDA

Beginning to Quantify the Impact of TLPS on Wi-Fi Channel 11

1) Analytical View of Adjacent Channel Interference (ACI) with and without TLPS

2) Adjacent Channel Rejection Testing with Ixia
   - 25MHz Spacing: Test with Channel 6 Desired & Channel 11 Adjacent Channel Interferer
   - 22MHz Spacing: Test with Channel 11 Desired & TLPS/Channel 14 Adjacent Channel Interferer
   - 20MHz Spacing: Test with Channel 6 Desired & Channel 10 Adjacent Channel Interferer

3) Results Summary and Implications

Results Summary and Implications:

Results show that, under precisely-controlled, identical conditions:

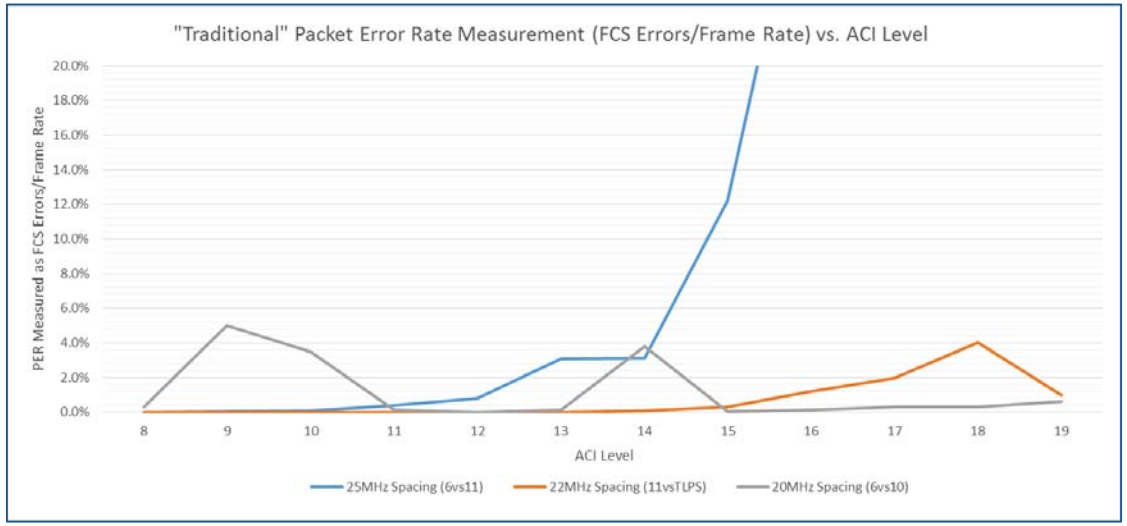
1) **ACI-induced errors with 22MHz channel spacing is materially worse than 25MHz**
   - **At the "packet level", 22MHz spacing is ~3dB worse than 25MHz spacing**
   - **"Packet level" results consistent with analysis showing ACI/Desired Power ratio of 22MHz vs 25MHz is ~2x (3dB) higher**

2) **Severity of 22MHz packet errors is materially higher than 25MHz. Understanding the full system-level implications requires more testing**
   - **25MHz: PER driven by least severe FCS errors. ACI test range does not encounter most severe "Lost" packets, and "Malformed" packets remain under 5% for most of the ACI range**
   - **22MHz: Minimal FCS errors because of earlier, more severe, sources of packet loss. Material "Lost" packets at upper ACI Levels, "Malformed" exceeds 5% for over 90% of the ACI range**
   - **20MHz: FCS and "Malformed" errors remain minimal, with vast majority due to most severe "Lost" packets**

Results Summary and Implications:

Results illustrate the importance of using the right test equipment

- For our test configuration, the “traditional” method of computing packet error rate showed negligible PER for 22MHz and 20MHz across all ACI levels…clearly not correct.



- Unlike test equipment used by Globalstar to produce their TLPS demonstration, Ixia’s IxVeriWave provides access to all PHY and MAC Wi-Fi statistics, allowing for precisely controllable test configurations. Without it, we would achieve inconsistent, unreliable results when trying to quantify the impact of 25MHz vs. 22MHz vs. 20MHz channel spacing.

Important notes regarding these tests:

- IxVeriWave's RF Hardware meets specifications significantly in excess of those for consumer-grade Wi-Fi equipment. Whatever ACI effects are observed using IxVeriWave as the emulated client, "real-world" consumer-grade client hardware will perform worse. Without including a representative set of "TLPS-enabled" client devices, it is impossible to know how much worse actual clients will perform with 22MHz channel spacing vs. results collected with the "Ixia-only" testbed.

- Testing was conducted on April 29th and 30th with total time spent configuring the testbed and conducting tests being ~12 hours. While this demonstrates the power and efficiency of using IxVeriWave as the core piece of test equipment, it was not sufficient to perform the breadth of tests necessary for the FCC to assess all technical risks related to the issue.

- Given time constraints, "desired" and "interferer" signals were combined using simple RF splitters/combiners. The passive analog component topology described in the paper "Adjacent Channel Interference in 802.11a: Modeling and Testbed Validation" [1] and/or "Adjacent Channel Interference in 802.11a is Harmful"[2](modified for testing in the 2.GHz band) might provide a better "cabled RF environment".

- Collection of "Desired Channel Receiver Total Frame Rate" and "Desired Channel Receive FCS Errored Frames" was done by observing values over a 30-second time period, and picking a median value. This method is obviously susceptible to human entry error, and should be automated.

[1] http://www.eu-mesh.eu/files/publications/RWS2008.pdf
[2] http://www.aueb.gr/users/vsiris/publications/p16_IEEECommMag_ACI_draft.pdf

Important notes regarding these tests (continued):

- Both desired and adjacent channels were configured as a single AP/single client pair simulating a continuous streaming download (e.g.: Netflix scenario). Relative to a multi-client configuration with the same aggregate throughput, this was a relatively benign environment. A multi-client configuration would produce far more "overhead" traffic, especially as a rising ACI level causes retransmission requests across all clients.

- Changing from a single client to multi-client environment requires only a software change in IxVeriWave. The existing hardware configuration would remain the same.

Ixia's IxVeriWave product is a leading tool for testing Wi-Fi systems. With a representative set of TLPS-enabled clients and Bluetooth devices, Ixia test equipment could be used to execute comprehensive testing that would quantify virtually all key technical risks associated with Globalstar's TLPS Proposal. Based on our experience, such testing could be designed and executed in a matter of weeks.

SUPPORTING MATERIAL

Supporting Links:

- Link to IEEE 802.11-2012 Specification: https://standards.ieee.org/findstds/standard/802.11-2012.html
  - Click on "Access via the IEEE Get Program", enter "User Type" and "Email Address" and click "ACCEPT"

- Link containing explanation of different "clause numbers" of 802.12-2012 and changes from 802.11-2007: http://blogs.aerohive.com/blog/the-wi-fi-security-blog/why-did-80211-2012-renumber-clauses

- Links regarding Ixia:
  - http://ixiacom.com/
  - http://www.ixiacom.com/products/ixveriwave
  - http://en.wikipedia.org/wiki/Ixia_(company)
  - http://en.wikipedia.org/wiki/VeriWave
  - http://www.crn.com/news/networking/231000577/network-testers-unite-ixia-buys-veriwave.htm
  - http://www.onwindows.com/Article/microsoft-selects-ixia-to-ensure-lync-application-reliability-on-mobile-devices-12560#.VU6IhPlVhBc
  - http://legacy-www.ixiacom.com/news_and_events/customer_reference/
  - Mentions Ixia as the "Gold Standard": *: http://davidhoglund.typepad.com/integra_systems_inc_david/2015/01/ixia-comprehensive-solutions.html*
  - *EE Times article: http://www.eetimes.com/document.asp?doc_id=1164318*
  - http://webcache.googleusercontent.com/search?q=cache:Myl4f5odZKQJ:www.edn.com/Pdf/ViewPdf%3FcontentItemId%3D4378047+IxVeriWave+Cisco&cd=7&hl=en&ct=clnk&gl=us
  - http://www.reuters.com/article/2012/04/30/idUS114394+30-Apr-2012+MW20120430
  - LinkedIn Job Search on "VeriWave": https://www.linkedin.com/vsearch/j?orig=TRNV&rsid=1729511143121036265 0&keywords=VeriWave&trk=vsrp_jobs_sel&trkInfo=VSRPsearchId%3A1729511143121036265 0%2CVSRPcmpt%3Atrans_nav

Technical Papers relevant to Wi-Fi Adjacent Channel Interference Studies:

- Effect of adjacent-channel interference in IEEE 802.11 WLANs (http://upcommons.upc.edu/e-prints/bitstream/2117/1234/1/CrownCom07_CReady.pdf)
  - Describes method for computing ACI in a given desired channel.
  - Also addressed the reduction in "offered throughput" when channels overlap.
  - Conclusions focus on 802.11b. Subsequent research clearly highlights ACI for OFDM-based Wi-Fi is worse than DSSS-based.

- Adjacent Channel Interference in 802.11a: Modeling and Testbed Validation (http://www.eu-mesh.eu/files/publications/RWS2008.pdf)
  - Demonstrates the effect of adjacent channel utilization, not only adjacent channel spacing.
  - Effect of channel utilization on interference (whether adjacent or co-channel) is directly relevant to the analysis of "Fact #1: TLPS Will Increase Co-Channel Interference with Bluetooth" given in the April 14,2015 Ex Parte presentation. The low channel utilization in Globalstar's March TLPS demonstration had the effect of lowering interference with adjacent Wi-Fi channels and Bluetooth devices versus higher, more realistic, utilization (i.e. traffic) levels.

- Adjacent Channel Interference in 802.11a is Harmful. Testbed validation of a simple quantification model. (http://www.aueb.gr/users/vsiris/publications/p16_IEEECommMag_ACI_draft.pdf)
  - Presents a possible improved "cabled RF environment" for further testing.

- Susceptibility of IEEE 802.11n networks to adjacent-channel interference in the 2.4GHz ISM band (http://pe.org.pl/articles/2012/9b/73.pdf)
  - Specific to 802.11n networks.
  - Scenario 2 shows material degradation in 802.11n throughput for all channel spacings < 25MHz. Validates full rates only achieved when channels are non-overlapping.

- Diagnosing Wireless Packet Losses in 802.11: Separating Collision from Weak Signal (http://pages.cs.wisc.edu/~suman/pubs/diagnose.pdf)