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April 29, 2011

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: WT Docket No. 10-153, *Amendment of Part 101 to Facilitate Wireless Backhaul*

Dear Ms. Dortch:

On behalf of the Fixed Wireless Communications Coalition (FWCC), pursuant to Section 1.1206(b)(1) of the Commission's Rules, I am electronically filing this written *ex parte* communication in the above-referenced docket.

We thank the Commission staff who met with us to discuss wireless backhaul issues on March 31, 2011.

Below are our responses to questions raised in the meeting. We welcome any requests for additional clarification.

Question 1: Should the use of adaptive modulation be restricted to links designed to operate at a specific availability, and if so, what model should be used to calculate availability?

Specifying a particular minimum availability as a prerequisite for adaptive modulation entails regulatory risks. In particular, writing a minimum number into the rules will limit the freedom of link designers to specify parameters appropriate to a particular objective.

For example, systems that use path-diverse networks, such as ring or mesh/lattice deployments, are emerging as preferred design topologies compatible with the increasing use of packet technology. The availability, in these systems, of some links at full payload may be less important than maintaining backhaul continuity. Although most links should be designed to high availability, there will be cases where a link in the lattice is properly designed to a lesser availability at full payload. In some parts of mesh networks, designs for 99.9% are appropriate, but must deliver uninterrupted service even if at a temporarily reduced payload. This approach still provides for the efficient use of spectrum so long as the *average* payload meets the minimum requirement specified in the rules.

There are other applications, moreover, in which it may not make economic or technical sense to insist on a high signal availability number simply to bring backhaul or broadband transport to a community, particularly rural areas and Native American lands.[1]

Furthermore, as Commission staff pointed out in our meeting on March 31, specifying a particular minimum availability may raise the question whether a specific model should be required for the calculation. The assumptions used in the model may also have to be addressed, since they can significantly affect the results. The more detail subsumed by the rules, the more limited are a designer's options when addressing a specific transport requirement, and the less resilient the rules will be in the face of technological and market evolution.

For all of these reasons, the FWCC urges less specificity in the rules. ***In order of decreasing preference***, the FWCC proposes the Commission invoke one of the following conditions for the use of adaptive modulation:

1. Links may operate below the minimum specified payload for short periods of time in order to maintain link continuity when the microwave link is experiencing a deep fade condition.

2. The average payload must be maintained at or above the minimum specified in the rules.[2]

3. Links designed to operate temporarily below the minimum specified payload must be designed to high availability in accordance with good engineering practice.

If the Commission is determined to specify a particular numerical availability, the FWCC suggests the following approach:

4. For links using adaptive modulation, the minimum design availability must be 99.95% for calculations in the aggregate of both directions in a two-way link.

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1 *See, e.g.*, *Improving Communications Services for Native Nations by Promoting Greater Utilization of Spectrum over Tribal Lands*, Notice of Proposed Rulemaking, 26 FCC Rcd 2623, 2626 (2011) (discussing low penetration rates on Tribal lands); Julius Genachowski, *The FCC's Broadband Acceleration Initiative: Reducing Regulatory Barriers to Spur Broadband Buildout*, *available at* http://www.fcc.gov/Daily_Releases/Daily_Business/2011/db0209/DOC-304571A2.pdf (2011) (announcing national Broadband Acceleration Initiative, a national goal to bring broadband to all areas, including hard-to-reach rural areas and Native American lands).

2 47 C.F.R. § 101.141(a)(3).

As used here, the design availability objective is the percentage of time the link is expected to operate at a modulation level at or above the minimum payload capacity. The specified objective should apply only to links that are subject to the Section 101.141(a)(3) minimum payload capacity limits, and which use adaptive modulation to operate temporarily below those limits.

Rather than mandating any particular computational model, the Commission should consider requiring that availability be determined according to good engineering practice. This will preserve efficiency while allowing design flexibility. Because technical parameters are published in the coordination process, there will be ample opportunity to flag and correct any problems pertaining to specific systems.

We note that several technical provisions of Part 101 cite to Telecommunications Industry Association Bulletin TSB 10-F.[3] We propose that use of this standard, while not required, be taken as presumptive of good engineering practice.

Question 2A: Is sharing between the Fixed Service and BAS technically feasible at 7 GHz?

Operation of Fixed Service links within Part 74 BAS spectrum at 7 GHz presents unique challenges.

Foremost among these is the problem of coordinating with links used for electronic news gathering (ENG) operations. Although ENG has traditionally been a temporary-fixed application, recent applications of COFDM (coded orthogonal frequency division multiplexing) have allowed mobile ENG transmission from news helicopters as well as mobile land vehicles. An ENG transmitter's having unlimited and unpredictable possibilities for location and azimuth makes coordinating fixed service links on the same channel effectively impossible. Merely allocating specific channels for uniform ENG use in all markets probably would not resolve the problem, as the requirements for ENG vary widely from market to market.

While television broadcasters are able to coordinate temporary ENG links with fixed BAS links, they do so through local frequency coordinators interacting with only a limited community of their fellow television broadcast engineers. To expand this local coordination process to include the entire Fixed Service industry would put an unmanageable burden on the local frequency coordinator and the BAS operators in each market. Moreover, to place frequency coordination of ENG links under the 30-day prior coordination notice process used by the Fixed Service[4] would conflict with the essential needs of ENG, which requires rapid deployment in real time as news events develop.

For all of these reasons, the FWCC strongly doubts that sharing between the Fixed Service and BAS at 7 GHz is technically feasible. We nonetheless encourage the Commission to gather additional information to reach a more informed decision. Much of the information needed is not easily available to the FWCC and its members. Broadcasters, however, may be able to identify how the band is currently used in various markets, what capacity is needed to sustain

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3 *E.g.*, 47 C.F.R. § 101.105(c) (interference protection criteria).

4 47 C.F.R. § 101.103(d).

their operations (particularly mobile operations), and what disadvantages would accrue if their band use is changed.

Question 2B: Is sharing between the Fixed Service and BAS/CARS technically feasible at 13 GHz?

We believe that sharing is feasible, although with limitations, in part because use of 13 GHz by BAS and CARS has been declining over the last decade.

Comsearch data on path and channel licensing shows the following usage trend for 13 GHz BAS and CARS:

Year	Channels	Paths	Channels per Path
2000	131,761	3,686	35.7
2010	35,849	2,638	13.6

The Part 78 CARS service has tended to license a large number of 6 MHz channels (up to about 80) per link, while Part 74 BAS licenses a single channel per link. While the number of paths dropped considerably over the decade, the even faster drop in number of channels suggests that reduced CARS usage is the major factor in the decline.

We offer the following proposed band plan of 28 MHz bandwidth channels from ITU as a starting point for discussion:

Low		High	
Lower Edge (MHZ)	**Upper Edge (MHZ)**	**Lower Edge (MHZ)**	**Upper Edge (MHZ)**
12,751	12,779	13,017	13,045
12,779	12,807	13,045	13,073
12,807	12,835	13,073	13,101
12,835	12,863	13,101	13,129
12,863	12,891	13,129	13,157
12,891	12,919	13,157	13,185
12,919	12,947	13,185	13,213
12,947	12,975	13,213	13,241

This plan allows for protection of the 13.15-13.2 GHz ENG priority channels.[5] Specifically, it offers four channel pairs that avoid the ENG priority channels, and provides a total of eight channel pairs without that exclusion, for use in smaller television markets. The 266 MHz transmit-receive separation should be acceptable to equipment manufacturers.

[5] There is a 50 MHz ENG exclusion zone in the top markets, which should be adequate for ENG applications. *See* 47 C.F.R. § 76.602(a) (table) n.2 ("The band 13.15–13.20 GHz is reserved for television pickup and CARS pickup stations inside a 50 km radius of the 100 television markets delineated in § 76.51 of this chapter. . . .") Section 76.602(a) (table) contemplates 25 MHz bandwidth transmitters. Tighter efficiency standards may be able to reduce this value.

In addition, BAS has access to the 13.2-13.25 GHz segment subject only to sharing with secondary CARS ENG in 13.2-13.2125 within 50 km of the top 100 markets, and sharing with NGSO FSS gateway earth stations elsewhere. In practice, BAS has good access to 13.15-13.25 for ENG almost everywhere.

Question 3: Do manufacturers for the Fixed Service market have any interest in producing equipment with 25 MHz channel spacing, so as to suit the BAS/CARS band plan?

We consulted with the two leading global manufacturers of Fixed Service equipment, both active FWCC members.

One advises that it formerly marketed 25 MHz equipment, did not recover its costs, and has no plans to repeat the experiment. That manufacturer adds that the BAS market is supported by a group of small radio manufacturers with a long history of designing and customizing radio equipment to the BAS operators' requirements at competitive pricing. It would be costly for the larger radio manufacturers to design and support radios with 25 MHz channel plans and other unique requirements for BAS, without the sales volume needed to make the investment worthwhile.

The other manufacturer responded more positively, saying it would consider introducing 25 MHz channel equipment if the Commission were to open sufficient spectrum in the BAS/CARS bands to create a viable Fixed Service band and if there were a sufficient business case to do so.

Question 4: By what amount would the use of adaptive modulation increase the useful length of a Fixed Service link?

NOTE: See the Appendix for alternative responses to Questions 4 and 5.

In the FWCC's proposal, adaptive modulation trades off temporarily lower payload for improved availability.

As the Commission's question implies, however, design availability could be held constant, and reduced payload traded off for increased path length instead. The increase in path length would depend on the amount of time the path is allowed to operate with reduced payload, and the allowable depth of the reduction in payload.

To examine this approach, first consider the application of adaptive modulation as envisioned by the FWCC: to temporarily increase the link budget (and temporarily lower the payload) on a path so that link continuity and synchronization can be maintained (and availability increased, albeit at a temporarily lower payload).[6] For example, a decrease in the modulation order from 64 QAM to QPSK would add about 16 dB to the link budget, thus decreasing outage time and

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6 Link budget is generally calculated using transmitter output at one end of a link, and receiver threshold at the other end; it includes network losses, waveguide losses, and antenna gains at both ends of the link, along with free space loss. Unavailability calculations include these factors along with multipath and rain fading factors and a number of environmental factors to arrive at a path availability figure. The multipath and rain factors increase unavailability rapidly as path length increases.

increasing availability.[7] If the additional link budget (and decreased payload) are used to increase path length instead, the following variables come into play:

- amount of time the link is allowed to operate at reduced payload;
- amount the payload is allowed to be reduced;
- as distance is increased, the additional fade margin required to maintain a specified availability, including increased outages from multipath and rain fade (above 10 GHz);
- as distance is increased, the additional antenna height needed to assure adequate ground clearance;
- as antenna height increases, additional transmission line (waveguide) losses (usually at both ends of the link).

Below are illustrative examples of these two applications of adaptive modulation. Both assume adaptive modulation reductions from 64 QAM to QPSK, for an additional 16 dB in the link budget.

Adaptive modulation used to increase availability:

Assumed time the link is allowed to operate below required payload: .01%

For paths where multipath fading is the predominant cause of reduced signal level, the entire 16 dB gleaned from adaptive modulation may be applied to the link fade margin, thus decreasing outage by a factor of approximately 40. Therefore, a link that will operate with an availability of 99.99% at full payload may be expected to achieve an availability of 99.99975%, including the period with temporarily reduced payload.

Adaptive modulation used to increase path length:

Many more variables apply to this calculation, so a specific idealized path will be assumed for study. The relevant technical parameters are assumed to be as follows:

- Time link is allowed to operate below required payload: .01%
- Initial path length: 15 miles
- 6 GHz band, smooth earth, equal height towers at each end of path
- Mid-path clearance 1.0 F_1, waveguide loss 1.35 dB per 100 feet, K= 4/3
- The 16 dB of additional link budget is distributed as follows:
  - 2.5 dB for additional waveguide loss (total)
  - 8.1 dB for additional fade margin to hold availability unchanged over the longer path
  - 5.4 dB for additional free space loss due to increased path length

[7] The link budget increases at lower modulation levels because receivers can detect less complex signals at a lower threshold.

Result for this path: New path length: 28 miles
(Tower height must increase from 85 feet to 176 feet.)

(All links are different; this path is for illustration purposes only.)

* * * *

Again, there are at least two ways in which adaptive modulation technology can be applied to improve microwave link operation: (1) by *increasing the payload* during times of adequate receive signal strength, *i.e.*, when deep fades are not present, which is well over 90% of the time; and (2) by *maintaining link continuity* by temporarily decreasing the payload when adequate receive signal strength is not available, during deep fading conditions.[8] These techniques together increase both the capacity and survivability of Fixed Service links without the need for excessively large antennas.

With the first technique above, an operator can use adaptive modulation to substantially increase link payload, as shown in the following table. This does not cause any reduction in availability at lower modulations, which meet the minimum requirements in the rules. (See columns titled "Without Adaptive Modulation.")

Frequency Band	Channel bandwidth	Without Adaptive Modulation		With Adaptive Modulation		% Capacity Growth
		Modulation	Capacity	Peak Modulation	Capacity	
6 GHz	30 MHz	64 QAM	135 Mb/s	256 QAM	190 Mb/s	41%
11 GHz	30 MHz	16 QAM	90 Mbps	256 QAM	190 Mb/s	111%
	40 MHz	64 QAM	180 Mb/s	256 QAM	253 Mb/s	41%
18 & 23 GHz	30 MHz	4 QAM	50 Mb/s	64 QAM	135 Mb/s	170%
	30 MHz	16 QAM	90 Mb/s	256 QAM	190 Mb/s	111%
	40 MHz	4 QAM	67 Mb/s	64 QAM	180 Mb/s	170%
	40 MHz	16 QAM	120 Mb/s	256 QAM	253 Mb/s	111%
	50 MHz	16 QAM	150 Mb/s	256 QAM	317 Mb/s	111%

In most cases, the peak capacity gain is better than 100%, which is comparable to adding a second radio channel. This increase in capacity comes without the need to construct new links. This approach can be beneficial in rural areas and particularly in rough terrain, where building additional links can be difficult and costly.

This technique, in essence, mines excess spectrum capacity from the link fade margin during the large percentage of time it is not needed to offset a deep fade.

Question 5: By what amount would a reduction in availability increase the useful length of a Fixed Service link?

NOTE: See the Appendix for alternative responses to Questions 4 and 5.

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[8] Increasing the payload under favorable atmospheric conditions does not require a change in the rules.

For the same example used in Question 4 (and using the same assumptions), a reduction of the availability from 99.999% to 99.99% would allow an increase in path length from 15 miles to about 22 miles.

Question 6: What alternative Category B standards does the FWCC propose?

The FWCC supports the proposed Category B standards set out by Comsearch in its *ex parte* filing of April 15, 2011, in Docket 10-153, available at

h**ttp://fjallfoss.fcc.gov/ecfs/document/view?id=7021238104.**

* * * *

We hope this helps to clarify the issues presented in this proceeding. Please do not hesitate to contact us with any further questions.

Respectfully submitted,

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APPENDIX

The following is an alternative response to Questions 4 and 5 in text.

Question 4: By what amount would the use of adaptive modulation increase the useful length of a Fixed Service link?

The answer depends on the highest and lowest modulations used. Assuming the highest modulation is 256-QAM, and the lowest is QPSK, and subject to other assumptions described below, then the use of adaptive modulation could extend the length of a link as follows:

Frequency (GHz)	Rain Region	Without Adaptive Modulation (km)	With Adaptive Modulation (km)
6.2	N/A	24.56	66.45
11.2	F (dry)	9.83	26.40
11.2	E (rainy)	6.55	17.04

Question 5: By what amount would a reduction in availability increase the useful length of a Fixed Service link?

This answer likewise is subject to assumptions listed below.

Frequency (GHz)	Rain Region	Link Length at 99.999% Availability (km)	Link Length at 99.995% Availability (km)
6.2	N/A	33.02	45.35
11.2	F (dry)	14.85	20.67
11.2	E (rainy)	9.44	16.20

Assumptions for Question 4

6.2 GHz Link

- Multipath outage model: Vigants
- Model assumptions
  - Average path roughness: 15.24 meters (50-feet)
  - Average mean annual temperature: 10°C (50°F)
  - Average geo-climate region: x=1
- Radio Equipment Parameters
  - Channel bandwidth: 30 MHz
  - Modulation range: 256 QAM to QPSK
  - Radio equipment system gain
    - 256 QAM: 95.5 dB
    - QPSK: 117.5 dB
  - Antenna size: 6-ft Class A (minimum required to meet 101.115)

Based on these assumptions, a 24.56 km link using 256-QAM will achieve an objective of 99.999%. Using the same assumptions, a 66.45 km link using QPSK will achieve an objective of 99.999%.

11.2 GHz Link

- Multipath outage model: Vigants
- Rain outage model: Crane

- Model assumptions
    - Average path roughness: 15.24 meters (50-feet)
    - Average mean annual temperature: 10°C (50°F)
    - Average geo-climate region: x=1
    - Crane rain region
        - Rain region F: mild rain rate
        - Rain region E: heavy rain rate
- Radio Equipment Parameters
    - Channel bandwidth: 40 MHz
    - Modulation range: 256 QAM to QPSK
    - Radio equipment system gain
        - 256 QAM: 91.0 dB
        - QPSK: 112.5 dB
    - Antenna size: 2-ft Class B (minimum required to meet 101.115)

Based on these assumptions, a 9.83 km link in rain region F using 256-QAM will achieve an objective of 99.999%. Using the same assumptions, a 26.40 km link using QPSK will achieve an objective of 99.999%.

Similarly, a 6.55 km link in rain region E using 256-QAM will achieve an objective of 99.999%. Using the same assumptions, a 17.04 km link using QPSK will achieve an objective of 99.999%.

The increase in system gain realized when shifting modulation down from 256-QAM to QPSK can translate into greater path length. As noted in text, adaptive modulation can also allow critical traffic to survive a larger percentage of time during adverse fading conditions. For example, a 33.02 km, 6.2 GHz link operating on the assumptions given above and designed to meet 99.999% using the minimum modulation allowed by 101.141, which is 64-QAM, critical traffic will survive a greater percentage of time as shown in the table below:

Survivability of Critical Traffic		
Modulation Rate	**Throughput (Average Packet Size)**	**Availability**
256-QAM	208 Mbps	99.99556%
128-QAM	185 Mbps	99.99822%
64-QAM	161 Mbps	99.99900%
32-QAM	134 Mbps	99.99944%
16-QAM	104 Mbps	99.99980%
8-PSK	71 Mbps	99.99992%
QPSK	45 Mbps	99.99997%

The table above illustrates how a 33.02 km link will carry 161 Mbps of traffic 99.999% of the time, and under adverse fading conditions when adaptive modulation reduces the modulation to QPSK, 45 Mbps of traffic will continue to be passed for 99.99997% of the time. Furthermore, under unfaded or more favorable propagation conditions, the same link is capable of passing up to 208 Mbps of traffic using 256-QAM for up to 99.99556% of the time.

Assumptions for Question 5

6.2 GHz Link

- Multipath outage model: Vigants
- Model assumptions
    - Average path roughness: 15.24 meters (50-feet)

- Average mean annual temperature: 10°C (50°F)
    - Average geo-climate region: x=1
- Radio Equipment Parameters
    - Channel bandwidth: 30 MHz
    - Modulation: 64 QAM (minimum required to meet 101.141)
    - Radio equipment system gain at 64-QAM: 102 dB
    - Antenna size: 6-ft Class A (minimum required to meet 101.115)

Based on these assumptions, a 33.02 km link will achieve an objective of 99.999%. Using the same assumptions, a 45.35 km link will achieve an objective of 99.995%.

<u>11.2 GHz Link</u>

- Multipath outage model: Vigants
- Rain outage model: Crane
- Model assumptions
    - Average path roughness: 15.24 meters (50-feet)
    - Average mean annual temperature: 10°C (50°F)
    - Average geo-climate region: x=1
    - Crane rain region
        - Rain region F: mild rain rate
        - Rain region E: heavy rain rate
- Radio Equipment Parameters
    - Channel bandwidth: 40 MHz
    - Modulation: 32 QAM (minimum required to meet 101.141)
    - Radio equipment system gain at 32-QAM: 100 dB
    - Antenna size: 2-ft Class B (minimum required to meet 101.115)

Based on these assumptions, a 14.85 km link in rain region F will achieve an objective of 99.999%. Using the same assumptions, a 20.67 km link will achieve an objective of 99.995%.

And a 9.44 km link in rain region E will achieve an objective of 99.999%. Using the same assumptions, a 16.20 km link will achieve an objective of 99.995%.