



Adaptive Modulation in WG-3
Viewpoint of Selected NSMA WG-3 Participants
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Outline

- Background
- Why is Abuse a Concern?
- Summary of Concerns
- Conclusion

Adaptive Modulation in WG-3 - Background

- *Use of the Adaptive Modulation (A-Mod) feature is **not an issue***
 - Radios equipped with Adaptive Modulation are available today
 - Presumably, all modulation choices comply with Part 101.141 requirements
 - For bands <25.25 GHz, 101.141(a)(1) specifies spectral efficiency of 1 bps/Hz
 - For 4, 6, 10, 11 GHz bands, 101.141(a)(3) specifies more strict requirements
(Efficiency ranges from 2.5 bps/Hz to 4.5 bps/Hz, Band / Channel BW dependent)

 - *Use of the Adaptive Modulation (A-Mod) feature **is an issue***
 - For modulations that do not comply with Part 101.141 for bands <=11 GHz

 - *For convenience, Define:*
 - “Compliant Modulation”
Modulation meets or exceeds Part 101.141(a)(3) “Minimum Payload Capacity” (Spectral efficiency)
 - “Sub-Compliant Modulation”
Modulation does not meet Part 101.141(a)(3) (For applicable band, BW) (Spectral efficiency)

 - *WG-3 generally accepts use of sub-compliant modulations for frequency bands <= 11 GHz*
 - If used with restrictions, sub-compliant modulations can be beneficial
 - Some fear that, without specific restrictions **ABUSE** will result
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Adaptive Modulation in WG-3 – Why is Abuse a Concern?

- Scenario: User wants to implement highly-reliable 6 GHz Pt-Pt path
 - Long-term dedicated throughput of 32 Mbps required, cost is issue
 - A 6 GHz A-Mod radio model has choices of RF channel BW (7 to 28 MHz), varied modulations
(Because ETSI A-Mod radio specifications are available, ETSI RF channel BWs are used)
 - The “Compliant” 32 Mbps Option (7 MHz BW/64QAM) provides the desired throughput

| Band | Chan BW (ETSI) | Data Rate | Spectrum Efficiency | Modulation | System Gain |
|-------|----------------|-----------|---------------------|------------|-------------|
| 6 GHz | 7 MHz | 32 Mbps | 4.5 bps/Hz | 64QAM | 105 dB |
| 6 GHz | 28 MHz | 150 Mbps | 5.3 bps/Hz | 128QAM | 95 dB |
| 6 GHz | 28 MHz | 32 Mbps | 1.1 bps/Hz | QPSK | 116 dB |

For 32 Mbps, 28 MHz/QPSK has 11 dB advantage over 7 MHz/64QAM

- The 11 dB system gain advantage of the 28 MHz/QPSK is significant
 - Gain difference between 2-10 ft antennas and 2-6 ft antennas = ~9 dB
 - Extra 11 dB can overcome path design deficiencies (length, clearance, rain, interference, etc.)
 - In general, if channel is available, QPSK option will cost less
- For the application, “Sub-Compliant” 32 Mbps Option (28 MHz BW/QPSK) is “tempting”

Adaptive Modulation in WG-3 – Why is Abuse a Concern?

- *If QPSK/28 MHz Option selected, observers will assume 150 Mbps peak rate is required*
 - Long term average rate >4.5 bps/Hz, but path in reality is QPSK 1.1 bps/Hz lower-cost solution
 - Spectrum efficiency suffers (factor of 4), future band users harmed

A motive for abuse of sub-compliant modulations: Financial

Adaptive Modulation in WG-3 – Summary of Concerns

- ***Abuse of sub-compliant modulations can provide “First-Entrant Advantage”***
 - If wide-band channel successfully coordinated, excess spectrum is “warehoused”
 - Reliance on robust modulations improve system gain, can lower link cost
 - Path can be implemented with smaller size, lower-quality antennas
 - Use of space diversity may not be needed
 - Path short-comings may be tolerable, allow use of current sites/structures
- ***Longer-term, users attempting to implement new links will suffer***
 - Due to spectrum waste, co-channel conflicts more likely
 - Smaller/poorer antennas increase spectrum-sharing issues
 - In congested areas, potential band users likely “disadvantaged”
 - Spectrum may not be available
 - Higher-cost solutions required to co-exist with incumbents
- ***Without restrictions, abuse of sub-compliant modulations seems inevitable***
 - Lower cost links, spectrum warehousing will be tempting
 - Without suitable restrictions, technique can result in long-term spectral inefficiencies

Adaptive Modulation in WG-3 – Summary of Concerns

- *To prevent abuse, rules adopted to control use of A-Mod should be*
 - Specific, enforceable, enforced
- *Of special concern*
 - Any solution that assumes users will simply “self-police”
- *WG-3 Members Suggested and Discussed A-Mod Controls*
 - Limit sub-compliant operation time with timer integrated in radio equipment
 - Allow no modulation options at less than two-thirds efficiency of compliant value
 - Require path design to support limited duration of sub-compliant operation
 - Prevent transmit power/power densities from exceeding those of compliant modulations
- *WG-3 could not agree on potential FCC-imposed restrictions*
 - Viewpoints differed on the need for specific control measures
 - Without consensus in WG-3, endorsement of FWCC approach not obtained

Adaptive Modulation in WG-3 – Conclusion

- *The lower frequency bands are critical, only option for many longer paths*
 - With loss of 2 GHz bands, only 6 GHz suitable for many CC and OF paths
 - New and traditional users still require spectrum for high-reliability pt-pt links
- *Alterations affecting spectral efficiency should be considered carefully*
 - Existing FCC rules implemented to promote frequency reuse, spectrum availability
 - Spectral inefficiencies have long-term consequences, can affect users for decades
 - Without enforceable restrictions, abuse of any relaxation of rules can be anticipated
- *Despite lack of consensus, WG-3 activity has been valuable*
 - Viewpoints from a variety of microwave interests accommodated
 - Dialogue on adaptive modulation issues timely, and important

Adaptive Modulation, when used with compliant modulations, is not a controversial topic in WG-3. However some WG-3 members feel that use of sub-compliant modulations in the lower frequency bands, like any other change affecting spectral efficiency in the Fixed Service, should be considered cautiously and carefully.