SIMULATIED MULTIPATH RESULTS OF PROPOSED TG3 OFDM SYSTEM

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Purpose:
This presentation is for improvement of phy proposals for 802.16.3 TG3

SCICOM

SIMULATIED MULTIPATH RESULTS OF PROPOSED TG3 OFDM SYSTEM
IEEE TG3 CONTRIBUTION 48

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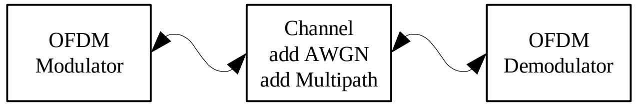
Bob Ward

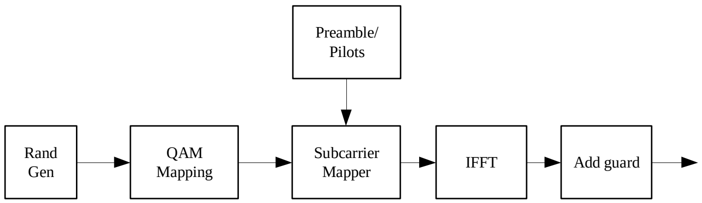
SUMMARY

- Objective
  - Preliminary evaluations of proposed TG3 OFDM system in multipath in support of the standardization process
  - Demonstrate the utility of flexible OFDM structures to various multipath scenarios

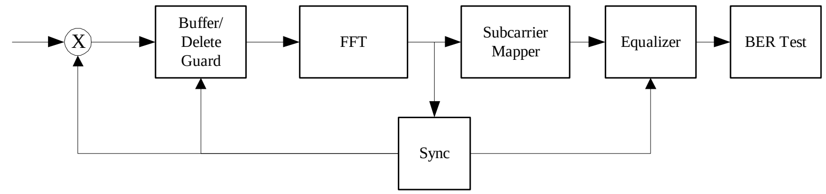
- System Description
  - OFDM modulation with various FFTsizes: 64, 256, 512, 1024, 2048
  - AWGN + Multipath channel
  - Self synchronizing burst demodulator
- Results
  - Preliminary at this point
    - Not all of modes have been tested against the SUI models yet
  - Conservative in some respects: “Pull in” of tracking mechanisms not yet employed
    - For example: Noisiness of initial channel estimate is reduced by LMS algorithm during tracking
  - Multipath delay of the SUI models are easily mitigated via the proposed OFDM system

SIMULATION CONFIGURATION





- 802.16.3 Multipath Model
- 6 Mhz Channel Bandwidth



- OFDM SYMBOL STRUCTURE
  - Preamble
    - Modified short/long structure with similar properties as 802.11a
    - Number of short symbols can be increased to more than 10 for tests
    - Two long symbols, equal in length to selected FFT size
  - Data Symbols
    - FFT size: 64, 256, 512, 1024, 2048, 4096
    - Guard ratios: 1/64, 1/32, 1/16, 1/8, 1/4, of active FFT part
    - QAM modes: BPSK, QPSK, 16QAM, 64QAM,
    - Data Subcarrier Mask
      - -M, -M+1, …, -1, 0, 1, …, +M
      - Generally the ratio of active subcarriers to FFT size is held constant
        - 2M/FFTsize = 52/64 for convenient comparisions
  - Packet Lengths
    - Max simulated: 6500 bytes

SYNCHRONIZATION: ACQUISITION ONLY

- Burst by burst
  - To be conservative, force acquisition in the multipath channel without benefit of prior synchronization knowledge based on framing and pilot mechanisms of proposed system
  - Thus, should expect improved performance when prior knowledge is used
- Short Symbols used for coarse synchronization
  - FFT timing
  - AGC
  - Frequency offset
    - Not estimated. Easy methods exist, based on experience from 802.11a
  - Long symbol identification
- Long Symbols used for channel estimation only
  - As shown in 802.11a system, can also refine coarse synchronization estimates
  - However, not performed here to make results more conservative

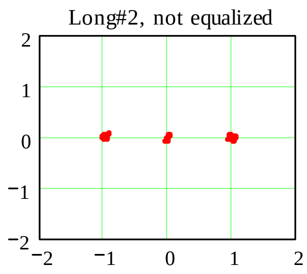
- Tracking not utilized at this point
  - "Pull in" of tracking mechanisms not yet employed. Thus improved performance can be expected
    - For example: Noisiness of initial channel estimate is reduced by LMS algorithm during tracking

TEST PREAMBLE STRUCTURE

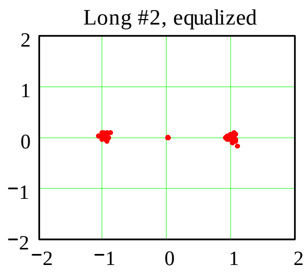
- Short/Long configuration similar to 802.11a
- Short Structure
  - 802.11a - Ten short symbols: 0.8 μsec
  - 802.16.3 Test model
    - Periodic every 16 samples, same as for base 64 point FFT 802.11a system for all FFT sizes
    - Spacing scales upward for larger FFT sizes
    - Programmable number of short symbols; eg more than ten short symbols selectable
    - QPSK 1+j
- Long Structure
  - 802.11a – 2 ½ Basic Long symbol of 64 points
  - 802.16.3 Test Model
    - 2 ½ times FFTsize of particular mode
    - BPSK: +/- 1
    - Masked to same length as data

EQUALIZER INITIALIZATION

- It is a noisy estimate based on two long symbols
- Example of noise effect,
  - EsNodb = 25
  - Long symbol #1 used to initialize equalizer. Then it is applied to #2. A comparison of the SNR on #2 before and after equalization demonstrates the potential noise degradation.

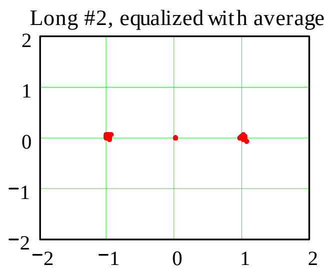


snra = 26.315



snrb = 23.463

- Simple averaging across the two long symbols reduces noise effect as shown with the averaged equalizer applied to Long #2



snrd = 29.484

MULTIPATH OVERVIEW

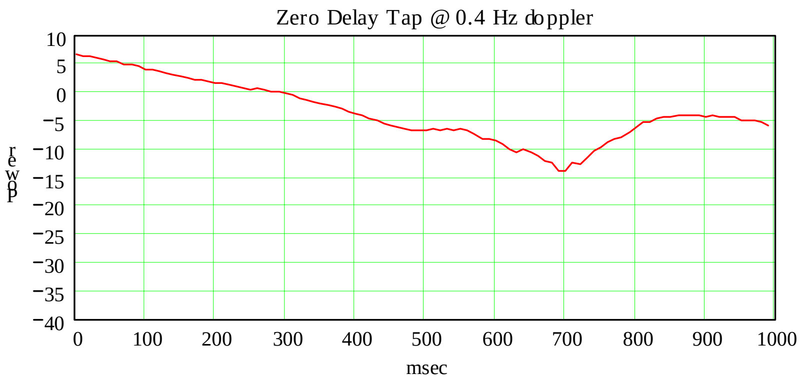
- From the reference model

SUI – 1 Channel				
	Tap 1	Tap 2	Tap 3	Units
Delay	0	0.4	0.8	µs
Power (omni ant.) K Factor (omni ant.)	0 4	-15 0	-20 0	dB
Power (30° ant.) K Factor (30° ant.)	0 16	-21 0	-32 0	dB
Doppler	0.4	0.4	0.4	Hz

- Multipath generation
  - Each of the three taps driven by low pass filtered complex AWGN process, with specified power relationships
  - Kfactor specifies presence of fixed tap value relative to noise processes
  - New tap values per burst; held constant for burst

DOPPLER EFFECT IS VERY SLOW

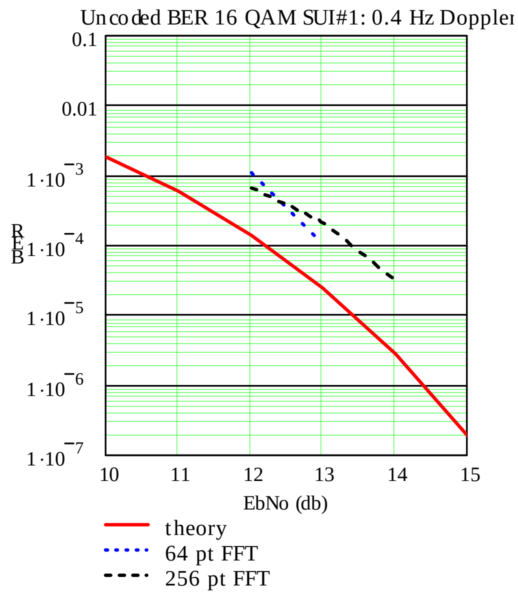
- SUI #6, omni, one instance



- Fades
  - Causes received SNR to drop below BER operating points needed for desired output coded error rates
  - Must be countered by a diversity scheme, such as included in proposed system, or other.
- BER simulations
  - Thus failed acquisition due to fade occur. Less frequent with Kfactor > 0

16 QAM UNCODED BER EXAMPLE SUI#1

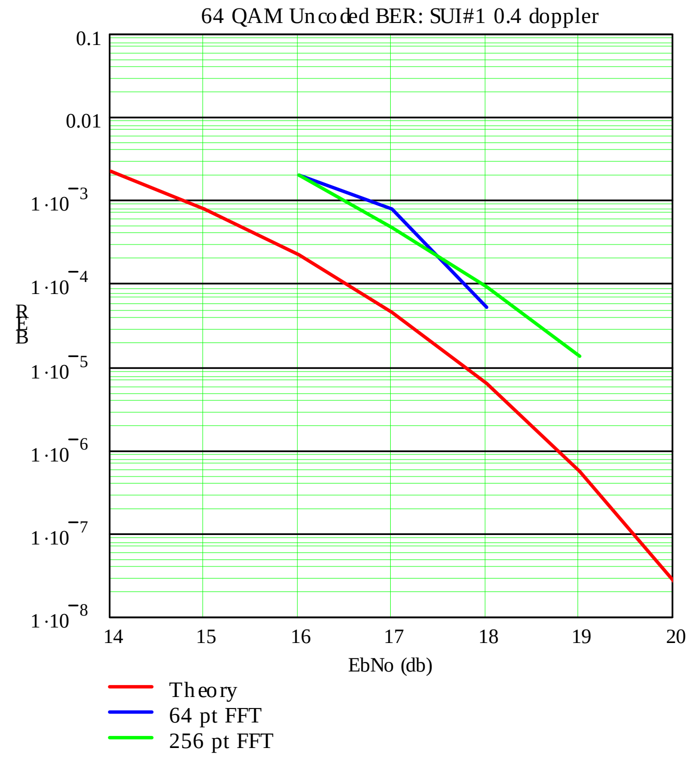
- 6 Mhz channel
- SUI#1
  - -15 db @ 0.4 and –20 db @ 0.8 μsec
  - 0.4 hz doppler
  - K factor = 4
- OFDM characteristics
  - 64 pt FFT
    - ¼ guard
    - 52 subcarriers
  - 256 pt FFT
    - ¼ guard
    - 208 subcarriers
  - Preamble based synchronization



- Observations
  - Multipath within guard of both FFTs so similar performance
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent
  - Both 64 and 256 point FFT have same data throughput

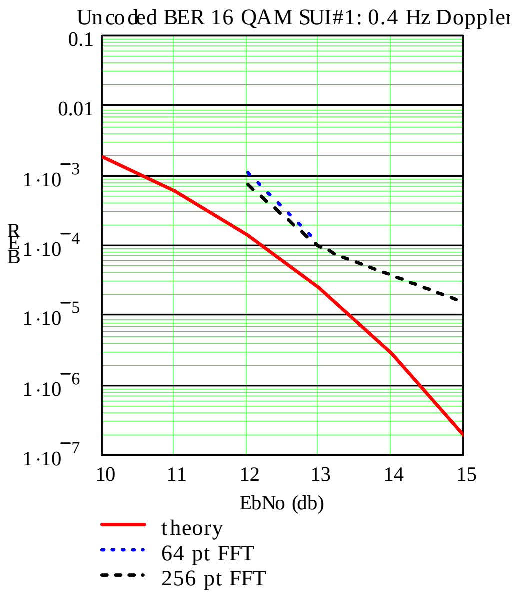
64 QAM UNCODED BER EXAMPLE SUI#1

- Same as 16 QAM
- Observations
  - Very Similar performance to 16 QAM



16 QAM EXAMPLE REVISITED BUT WITH REDUCED GUARD

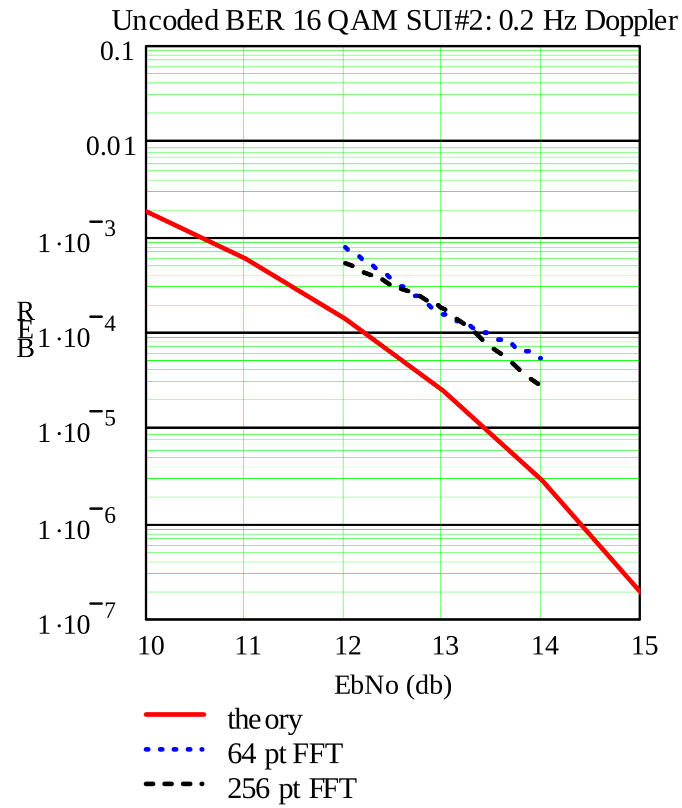
- For the 256 point FFT case, 0.8 μsec max delay permits reducing guard from ¼ to 1/8
  - Slightly better efficiency with reduced guard
  - Similar performance (close again to 64 point FFT curve), but indications that performance may not be as good as ¼ guard for lower BERs
  - Again could expect FEC to reduce the error rate



SUI#2 16 QAM

- 6 Mhz channel
- SUI#2
  - -12 db @ 0.5 and –15 db @ 1 μsec
  - 0.2 hz doppler
  - K factor = 2
- OFDM characteristics
  - 64 pt FFT
    - 1/8 guard
    - 52 subcarriers
  - 256 pt FFT
    - 1/8 guard
    - 208 subcarriers
  - Preamble based synchronization

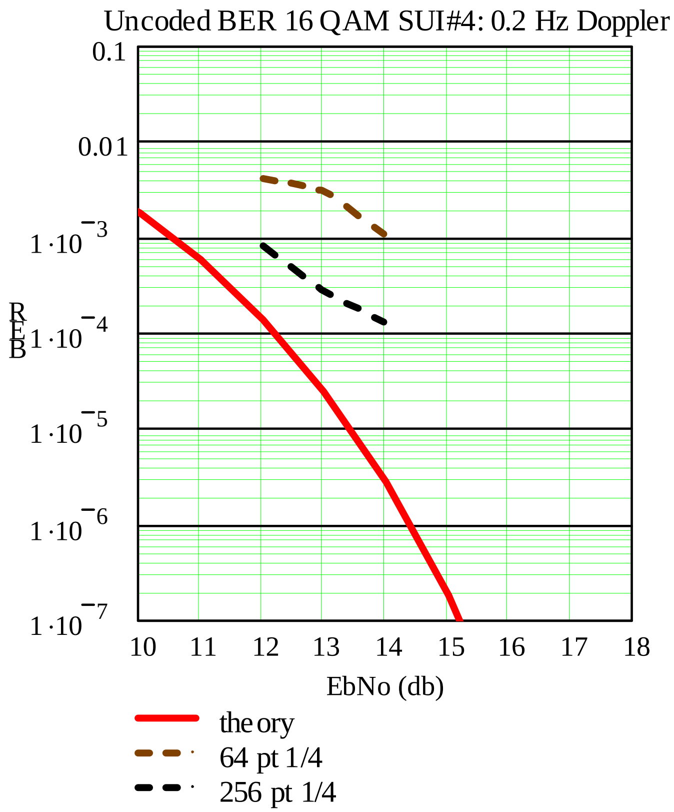
On the 64 point FFT, two failed acquisitions due to deep fade not included



- Observations
  - Multipath of similar length, but reduced guard of both FFTs
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent
  - Both 64 and 256 point FFT have same data throughput

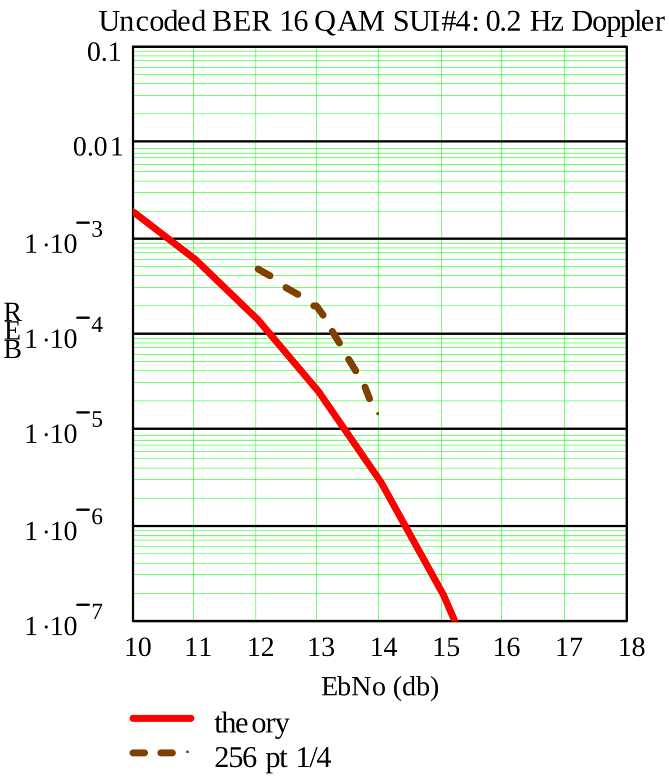
SUI#4 16 QAM OMNI Antenna

- 6 Mhz channel
- SUI#4 - Hot
  - -4 db @ 2 and –8 db @ 4 μsec
  - 0.2 hz doppler
  - K factor = 0
- OFDM characteristics
  - 64 pt FFT
    - 1/4 guard (on the order of 2.6 μsec)
    - 52 subcarriers
  - 256 pt FFT
    - 1/4 guard (on the order of 9.3 μsec)
    - 208 subcarriers
  - Preamble based synchronization
- Observations
  - 64 point FFT suffering
  - 256 point FFT about 2 db off
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent



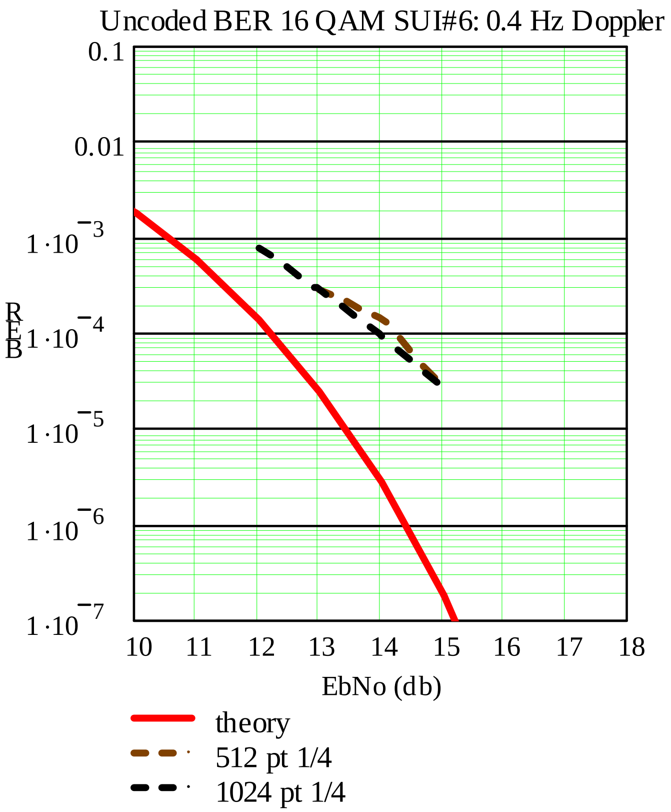
SUI#4 16 QAM 30 degree Antenna

- 6 Mhz channel
- SUI#4 - Cooler
  - -10 db @ 2 and –20 db @ 4 μsec
  - 0.4 hz doppler
  - K factor = 0
- OFDM characteristics
  - 256 pt FFT
    - 1/4 guard (on the order of 9.3 μsec)
    - 208 subcarriers
- Observations
  - 256 point FFT performance is better as expected
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent



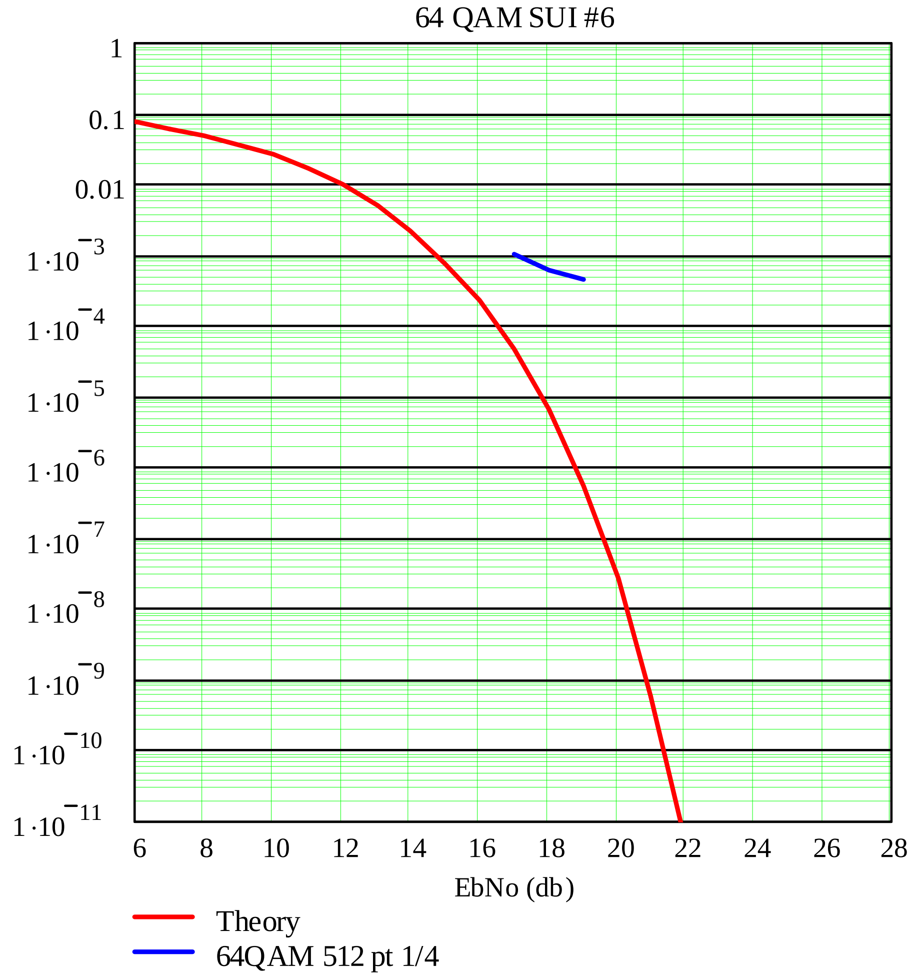
SUI #6: 16 QAM OMNI

- 6 Mhz channel
- SUI#6
  - -10 db @ 10 and –14 db @ 20 μsec
  - 0.4 hz doppler
  - K factor = 0
- OFDM characteristics
  - 512 pt FFT
    - 1/4 guard (on the order of 18.6 μsec)
    - 416 subcarriers
  - 1024 pt FFT
    - 1/4 guard (on the order of 37.3 μsec)
    - 832 subcarriers
  - Preamble based synchronization
- Observations
  - Note 512 can mitigate effectively beyond its guard length
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent



SUI #6: 64 QAM OMNI

- 6 Mhz channel
- SUI#6
  - -10 db @ 10 and –14 db @ 20 μsec
  - 0.4 hz doppler
  - K factor = 0
- OFDM characteristics
  - 512 pt FFT
    - 1/4 guard (on the order of 18.6 μsec)
    - 416 subcarriers
- Observations
  - Uncoded operating point below 10^{-3} is achievable. Thus, coded performance will be excellent



CONCLUSIONS & NEXT STEPS

- Conclusions
  - OFDM flexible structure vs multipath scenarios was demonstrated as a good approach
- Next Steps
  - Other modes to be included
  - More detailed models as they develop. For example
    - Framing concepts and preamble design as they relate to synchronization
    - Diversity method
      - Considered critical, for K = 0 cases
    - FEC