Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Coverage/Capacity simulations for OFDMA PHY in ITU-T channel model including MRC, STC, AAS results**
Date Submitted	**2004-11-16**
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Re:	Task Group Review of IEEE 802.16e-03/07r5
Abstract	OFDMA PHY performance and coverage simulations
Purpose	Demonstrate performance of the OFDMA PHY in real coverage scenarios
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Coverage/Capacity simulations for OFDMA PHY using STC, MRC, and switching AAS simulation

1 Simulated system

Coverage simulations have been prepared using the channel ITU-R recommendation M.1225 [1]. The scenario analyzed is for the channel ITU-B, which presents more severe conditions than its ITU-A counterpart, and which accounts to about 50% of the SS in the cell according to the model. The simulation has been conducted under capacity limited conditions (i.e. smaller cells than possible with the available link budget).

All simulations where done for an OFDMA system with 2K FFT and 32 sub-channels. The mobile station transmit power is limited to 20dBm. To maintain bi-directional communication the base station transmit power has been set to the mobile transmit power plus the OFDMA concentration gain. The OFDMA concentration gain is up to 15dB (excluding mini-sub-channels, which provide additional 7dB). The BS transmission power has therefore been set at 35dB. The simulations show the effect of advanced options present in the standard on the coverage and capacity of the system. The results therefore apply for the downlink channel, or for a single OFDMA uplink channel. Capacity calculations do not include overhead for preambles, guard intervals, etc.

The simulated system summary is

- 10MHz ITU-B channel at 2.5GHz (Similar results were obtained for 5MHz channel)
- Convolutional Turbo Coding FEC scheme with threshold BER of 10^{-5}
- The SS antenna is omni-directional with gain of 0dBi
- Various antennas where used for the BS. Beam-width of 60 degrees for six sectors scenario, 120 degrees for 3 sectors scenario, and 30 or 15 degrees for switching AAS simulation scenario.
- Transmit power from the BS is 35dBm
- Receiver noise-figure of 4.5dB in the BS and 6.5dB in the UT

2 PHY performance graphs and explanations about the simulation

For the PHY sensitivity curves and explanation of the way the simulation works, see [2]. Note that the coverage statistics are given over time, not over the coverage area. ARQ is NOT used in these simulations, but if it had been used it would have improved the coverage at the cost of reducing capacity.

3 Simulation Results

Results summary:

Scenario	Coverage (% of time)	Bit/Sec/Hz per cell
6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 TX antenna, one RX (STC) (downlink)	97.3%	4.74
6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity (downlink)	100%	6.96
6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity (uplink)	97%	5.34
24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, Simulating AAS operation (downlink)	88.5%	18.96

Scenario: 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 TX antenna, one RX (STC)

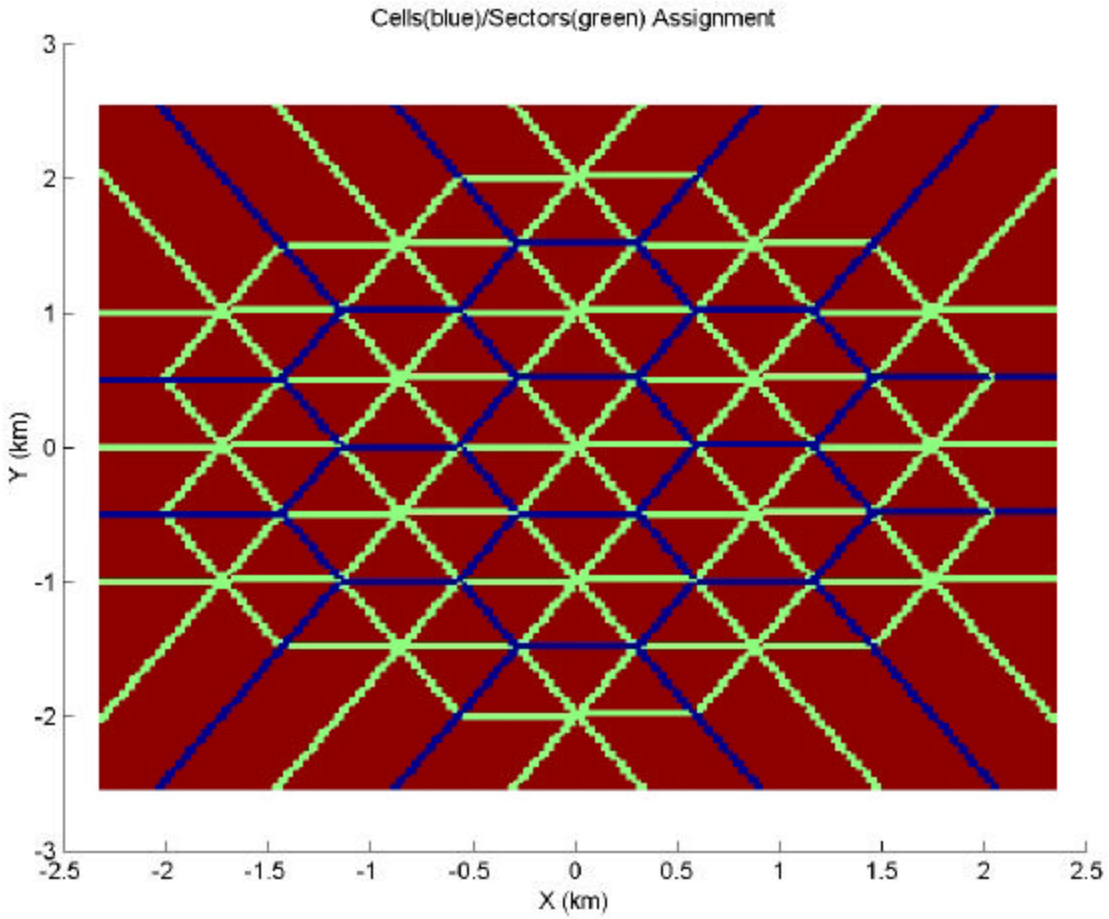

Figure 1: Cell/Sector Assignment - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 Antenna STC + 2 Antenna MRC

Coverage Statistics:

- Average DL throughput = 0.79 Bit/Sec/Hz per sector
- DL Coverage
  - **FADE - 2.70%**
  - **QPSK, 1/12 - 5.06%**
  - **QPSK, 1/8 - 17.48%**
  - **QPSK, 1/4 - 33.18%**
  - **QPSK, 1/2 - 23.55%**
  - **QPSK, 3/4 - 6.74%**
  - **16QAM, 1/2 - 10.48%**
  - **64QAM, 1/2 - 0.80%**
  - **64QAM, 2/3 - 0.00%**

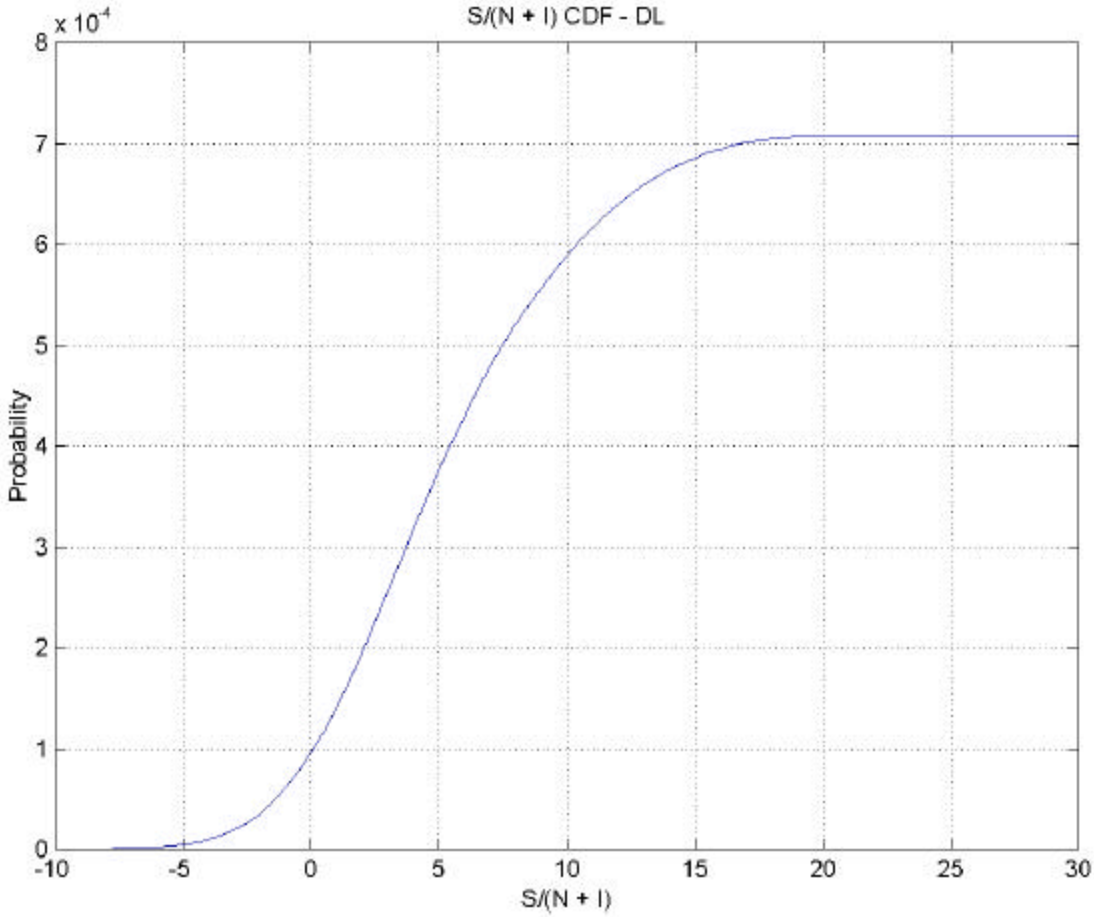

Figure 2: S/(N+I) Comulative Distribution Function (CDF) in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 Antenna STC + 2 Antenna MRC

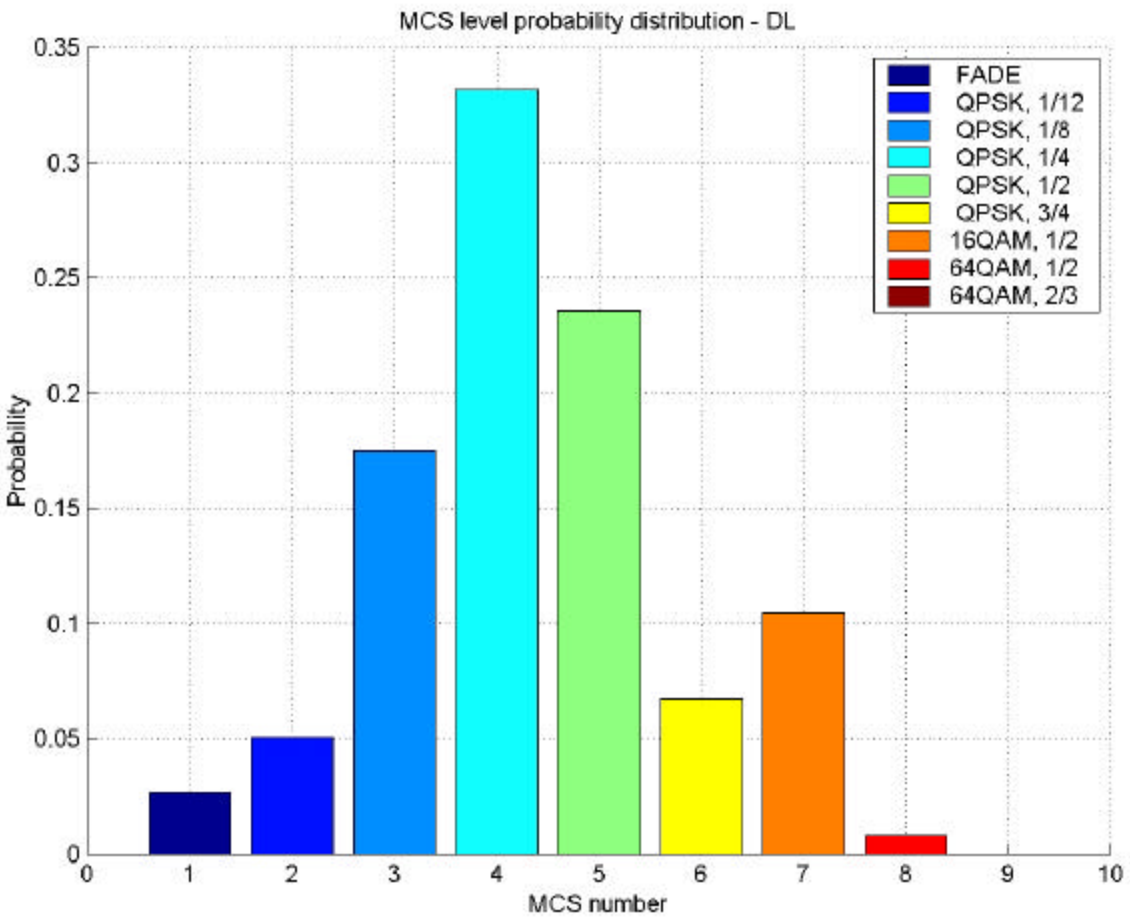

Figure 3: Modulation/Coding distribution in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 Antenna STC + 2 Antenna MRC

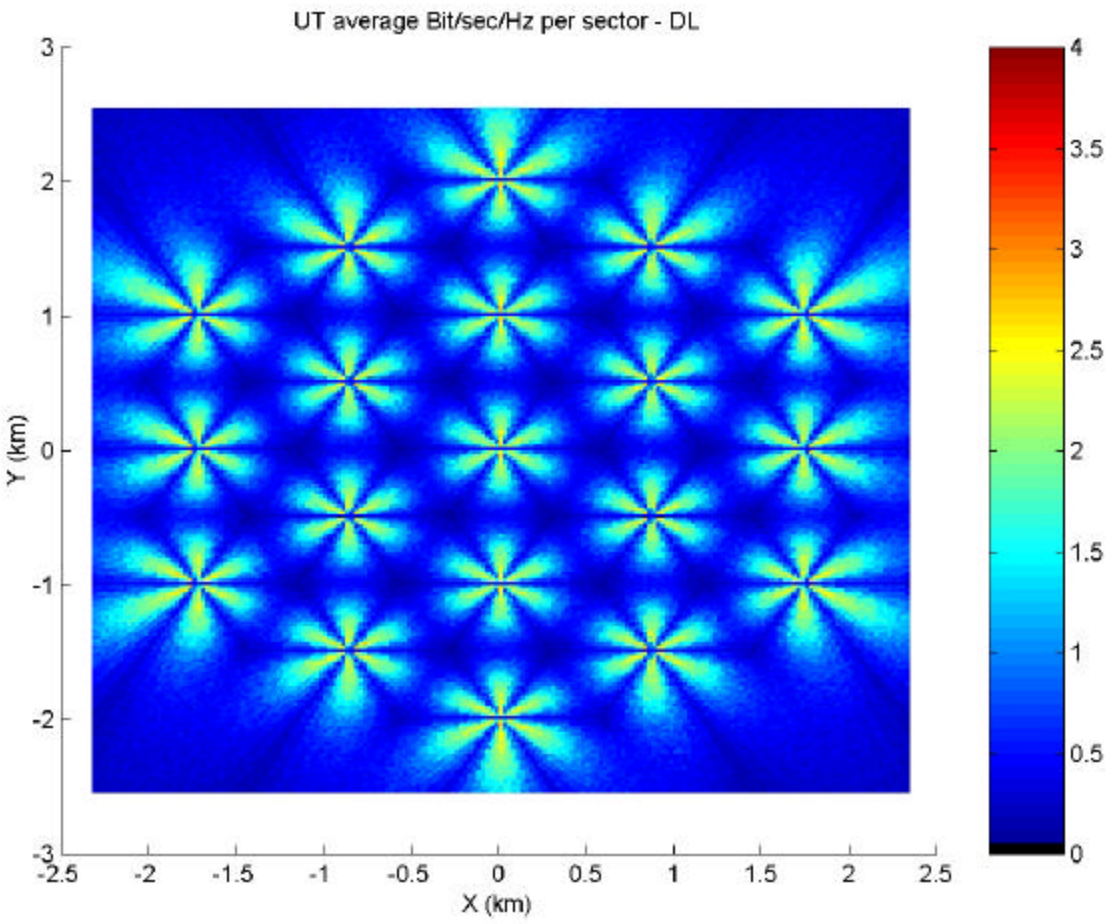

Figure 4: Average bit/sec/Hz per sector in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2 Antenna STC + 2 Antenna MRC

Scenario: 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

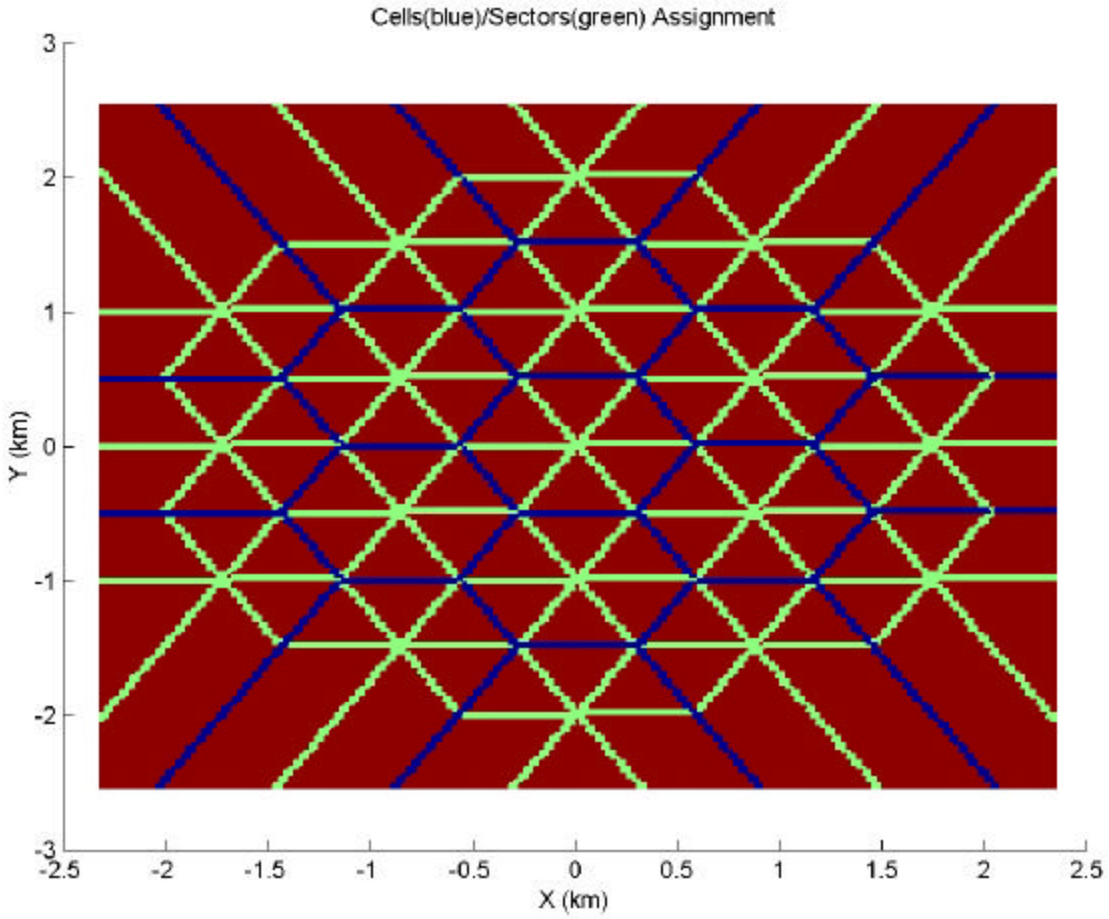

Figure 1: Cell/Sector Assignment - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

Coverage Statistics:

- Average DL throughput = 1.16 Bit/Sec/Hz per sector
- DL Coverage
    - **FADE - 0.03%**
    - **QPSK, 1/12 - 0.36%**
    - **QPSK, 1/8 - 5.26%**
    - **QPSK, 1/4 - 26.65%**
    - **QPSK, 1/2 - 33.03%**
    - **QPSK, 3/4 - 10.72%**
    - **16QAM, 1/2 - 19.92%**
    - **64QAM, 1/2 - 3.83%**
    - **64QAM, 2/3 - 0.21%**

- Average UL throughput = 0.89 Bit/Sec/Hz per sector
- UL Coverage
    - **FADE - 2.97%**
    - **QPSK, 1/12 - 3.71%**
    - **QPSK, 1/8 - 12.01%**
    - **QPSK, 1/4 - 29.10%**
    - **QPSK, 1/2 - 29.67%**
    - **QPSK, 3/4 - 9.23%**
    - **16QAM, 1/2 - 12.51%**
    - **64QAM, 1/2 - 0.75%**
    - **64QAM, 2/3 - 0.05%**

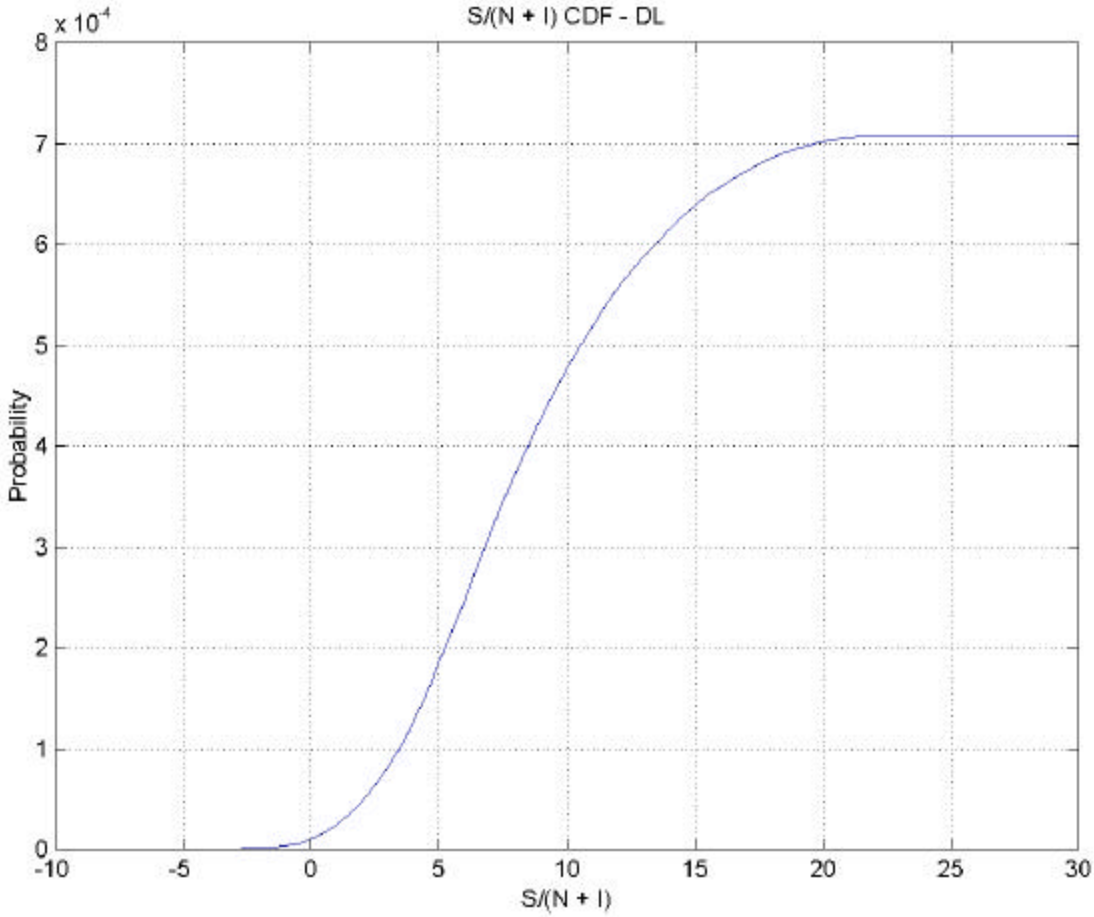

Figure 2: S/(N+I) Comulative Distribution Function (CDF) in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

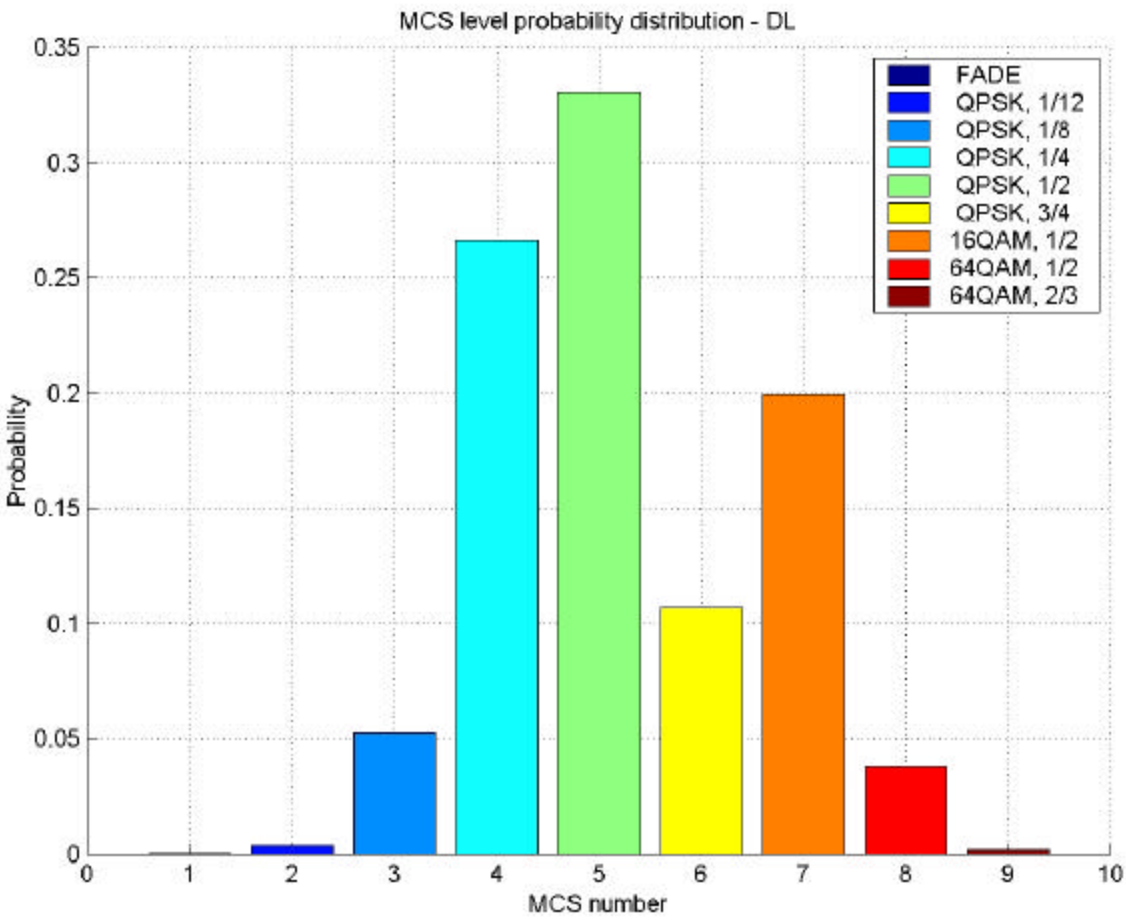

Figure 3: Modulation/Coding distribution in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

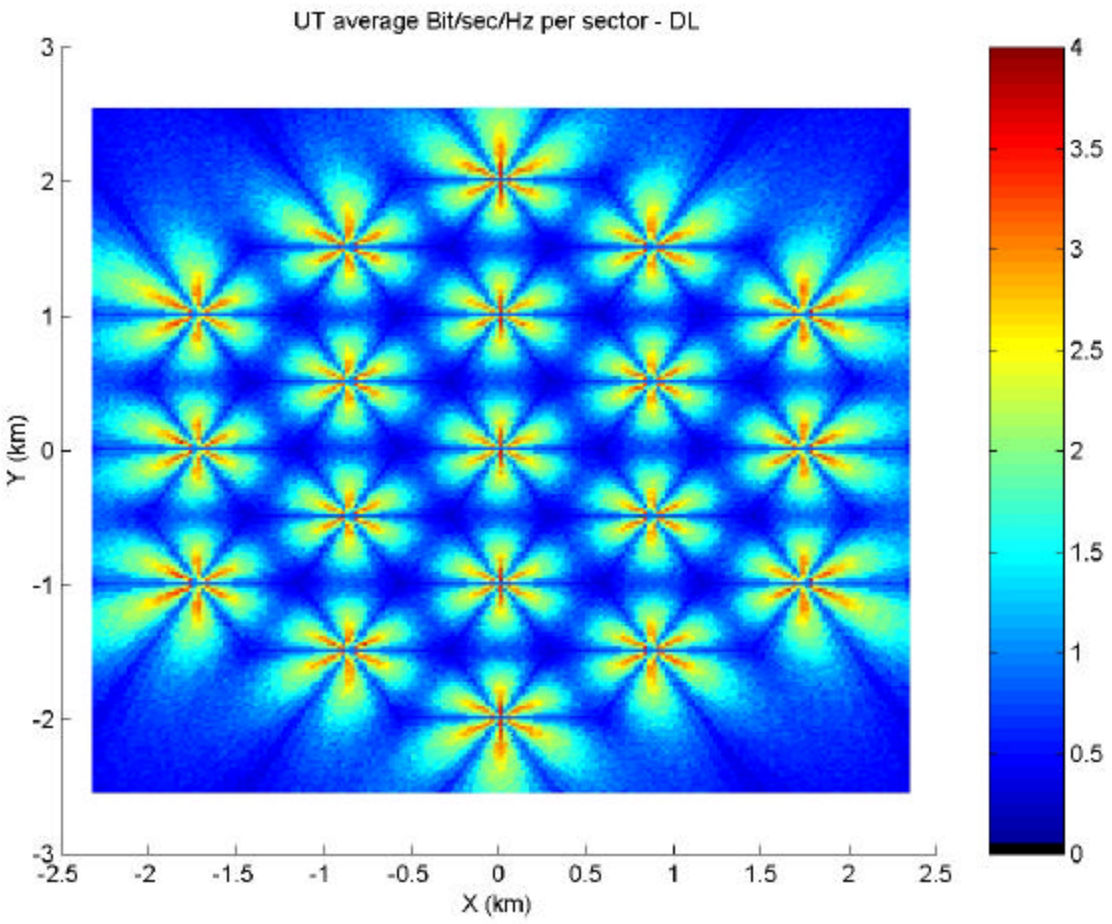

Figure 4: Average bit/sec/Hz per sector in the downlink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

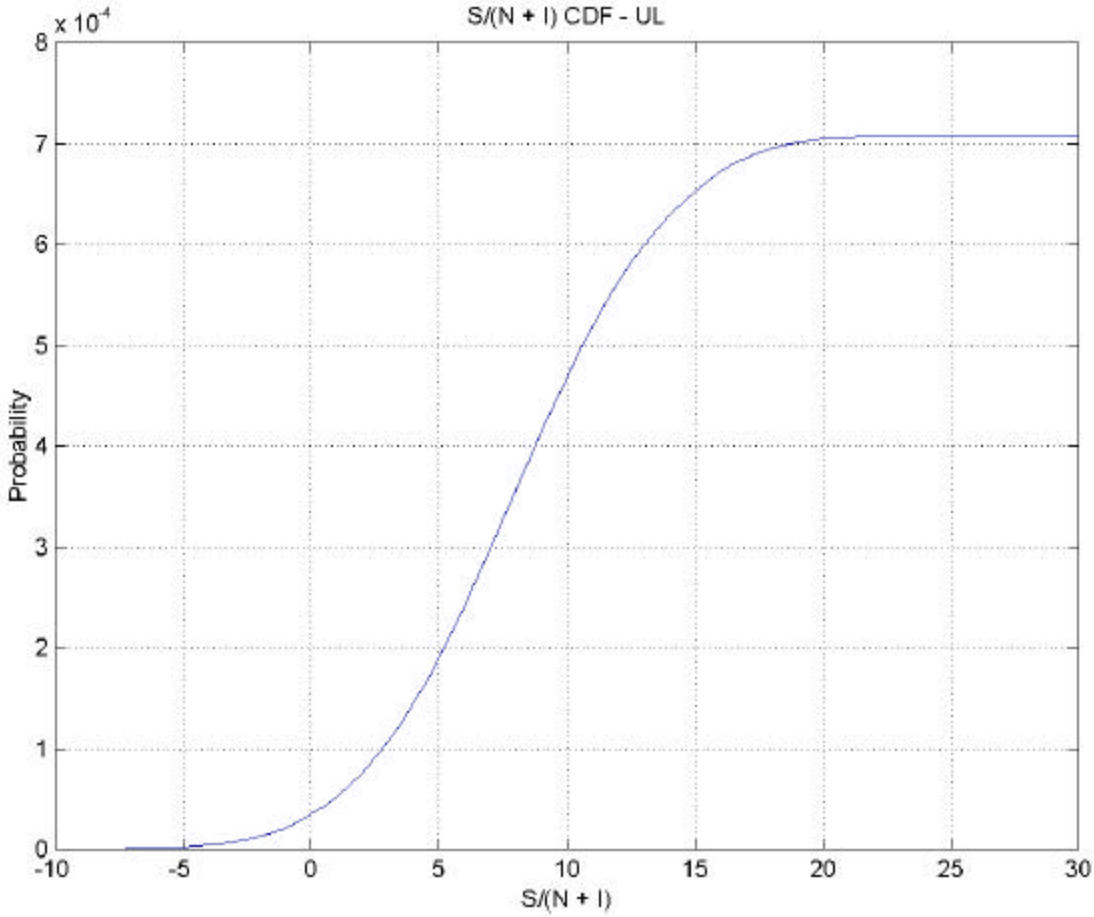

Figure 5: S/(N+I) Comulative Distribution Function (CDF) in the uplink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

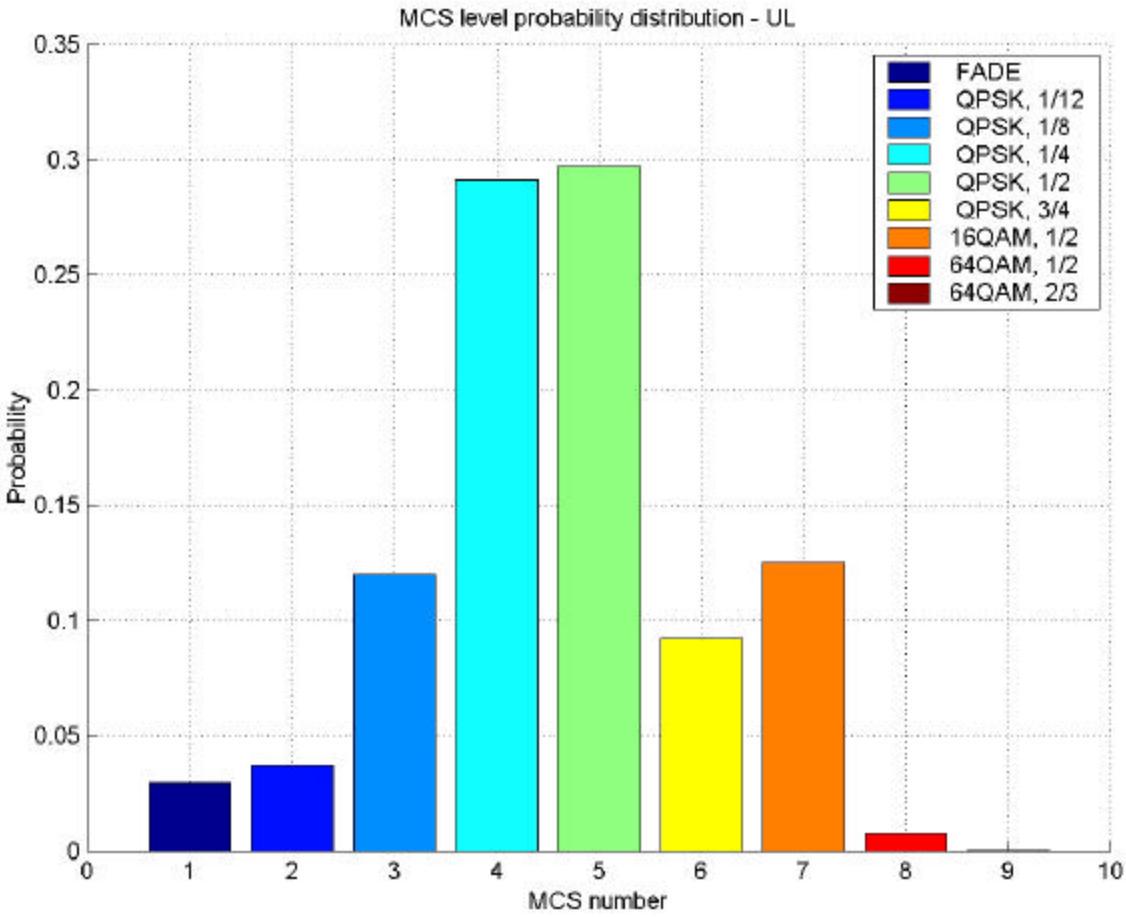

Figure 6: Modulation/Coding distribution in the uplink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

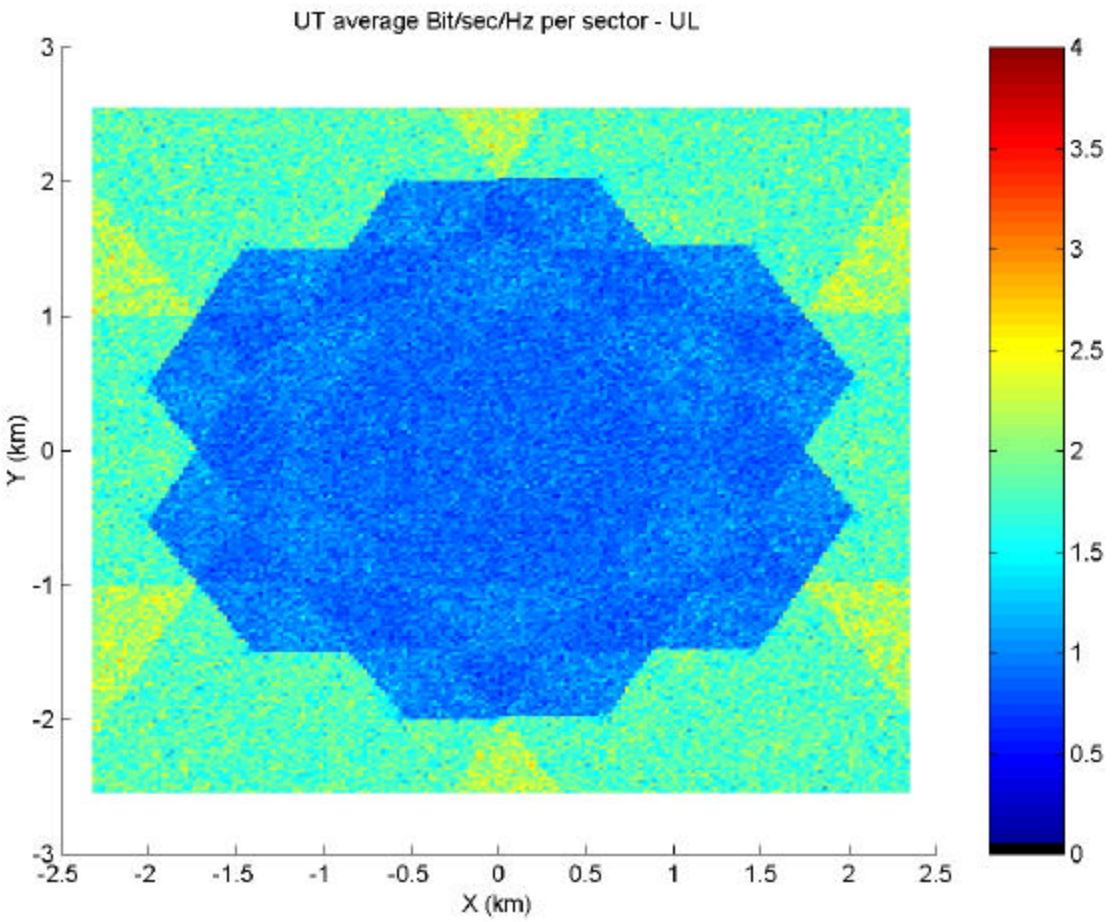

Figure 7: Average bit/sec/Hz per sector in the uplink - 6 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH, 2x2 Antenna diversity

Scenario: 24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH (Simulating AAS operation)

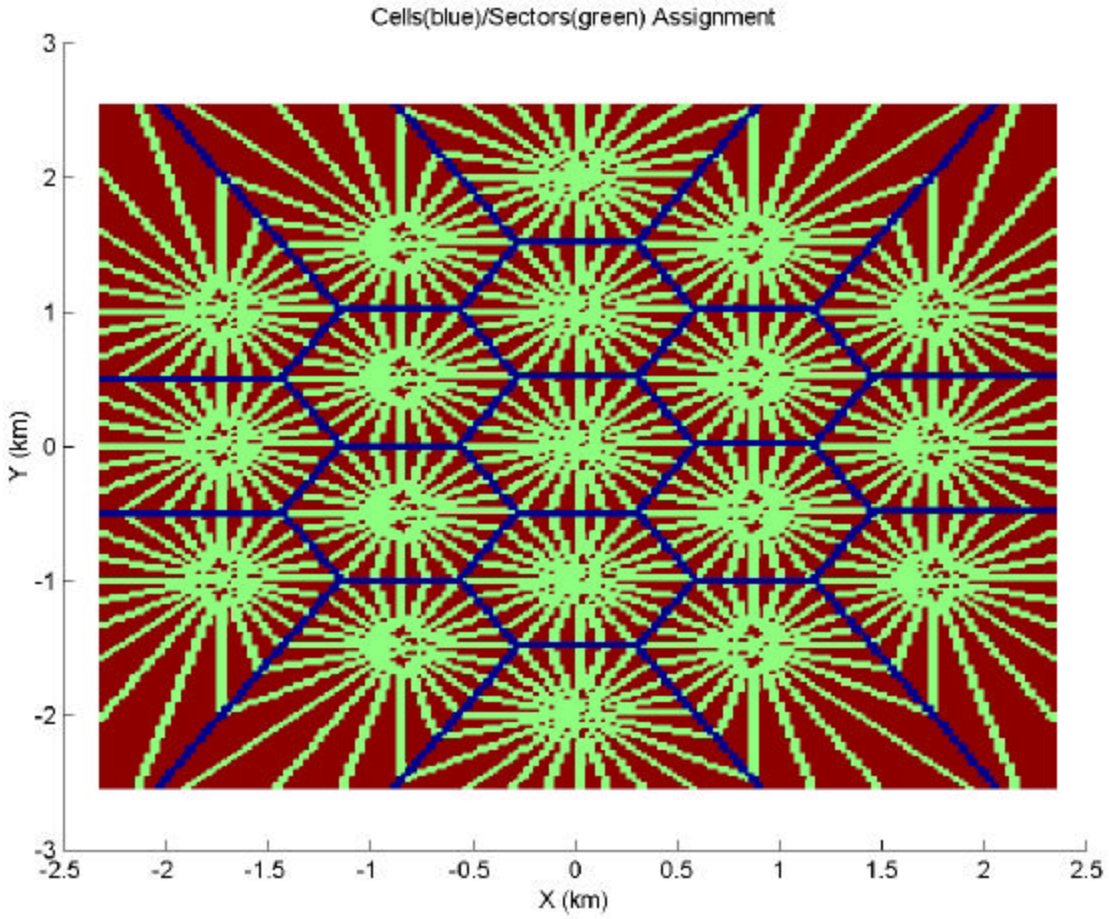

Figure 1: Cell/Sector Assignment - 24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH (Simulating AAS operation)

Coverage Statistics:

- Average DL throughput = 0.79 Bit/Sec/Hz per sector
- DL Coverage
  - **FADE - 11.50%**
  - **QPSK, 1/12 - 8.45%**
  - **QPSK, 1/8 - 17.54%**
  - **QPSK, 1/4 - 21.41%**
  - **QPSK, 1/2 - 16.76%**
  - **QPSK, 3/4 - 7.11%**
  - **16QAM, 1/2 - 16.66%**
  - **64QAM, 1/2 - 0.57%**
  - **64QAM, 2/3 - 0.00%**

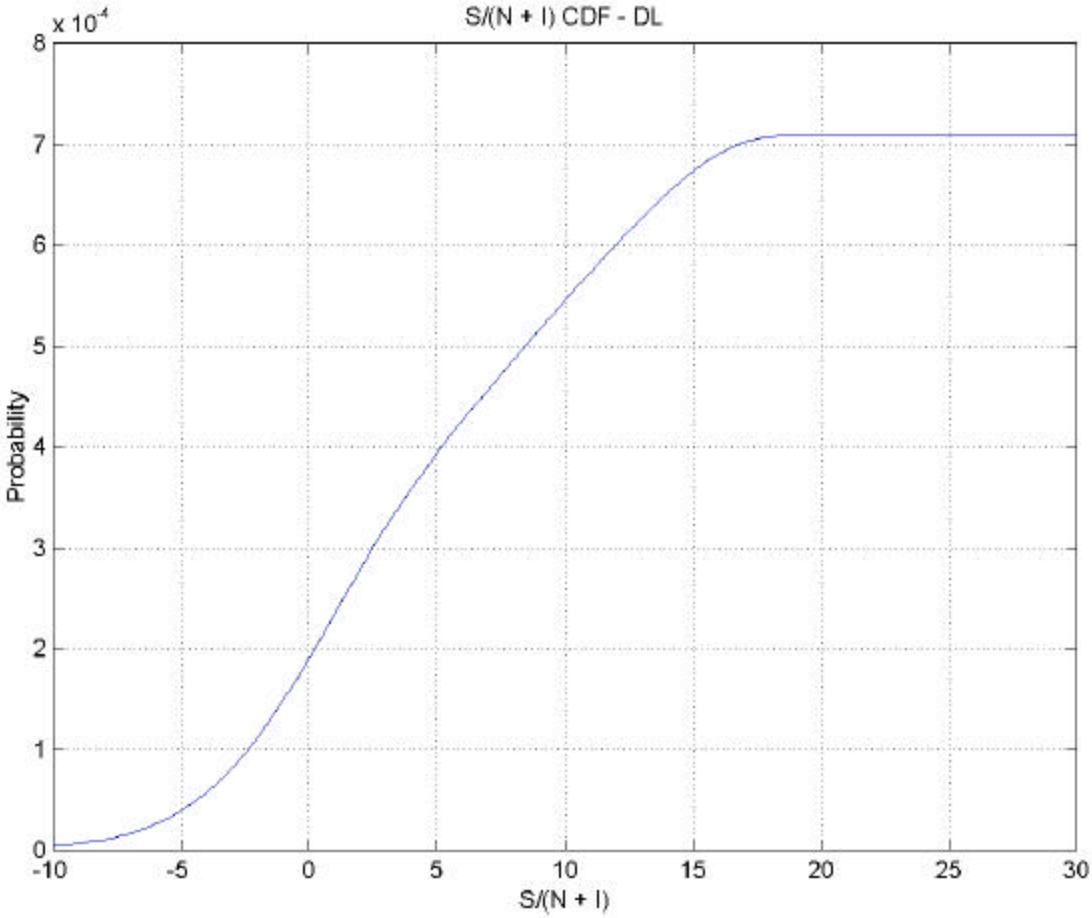

Figure 2: S/(N+I) Comulative Distribution Function (CDF) in the downlink - 24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH (Simulating AAS operation)

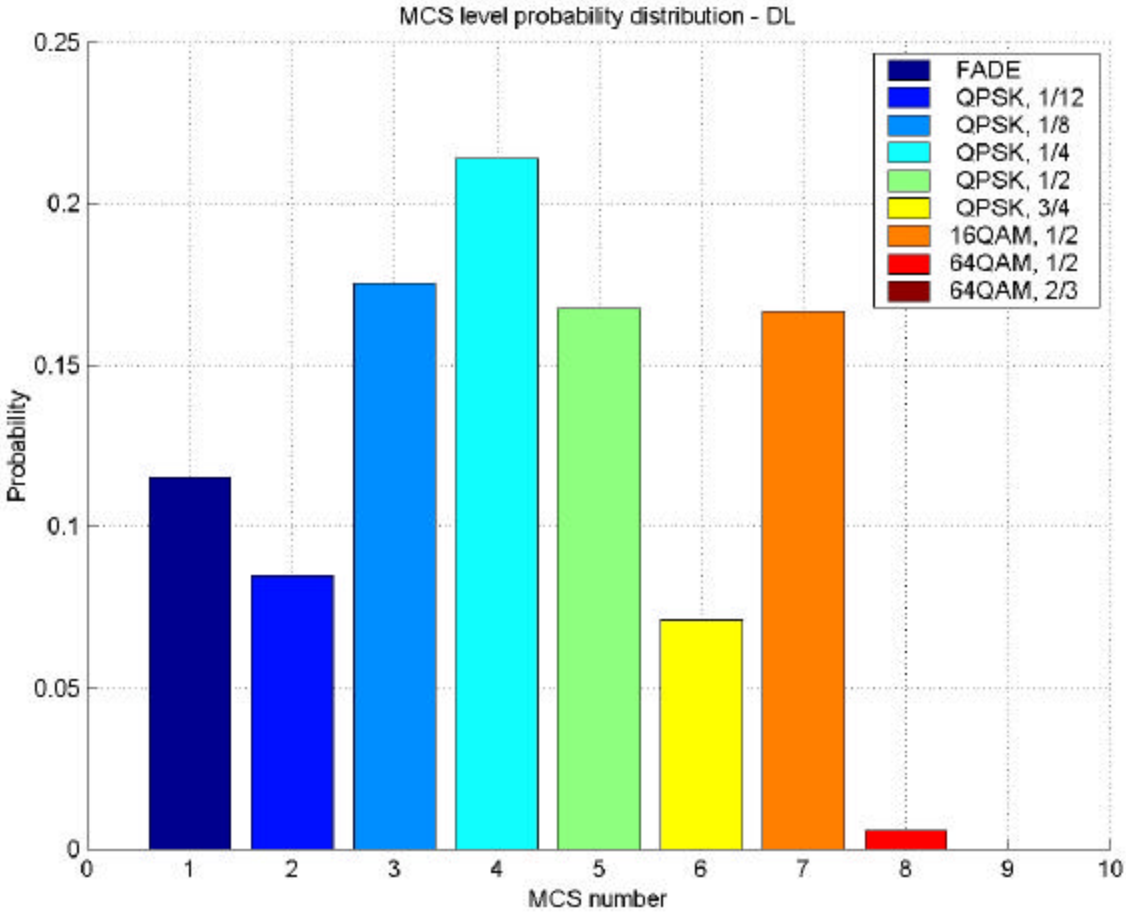

Figure 3: Modulation/Coding distribution in the downlink - 24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH (Simulating AAS operation)

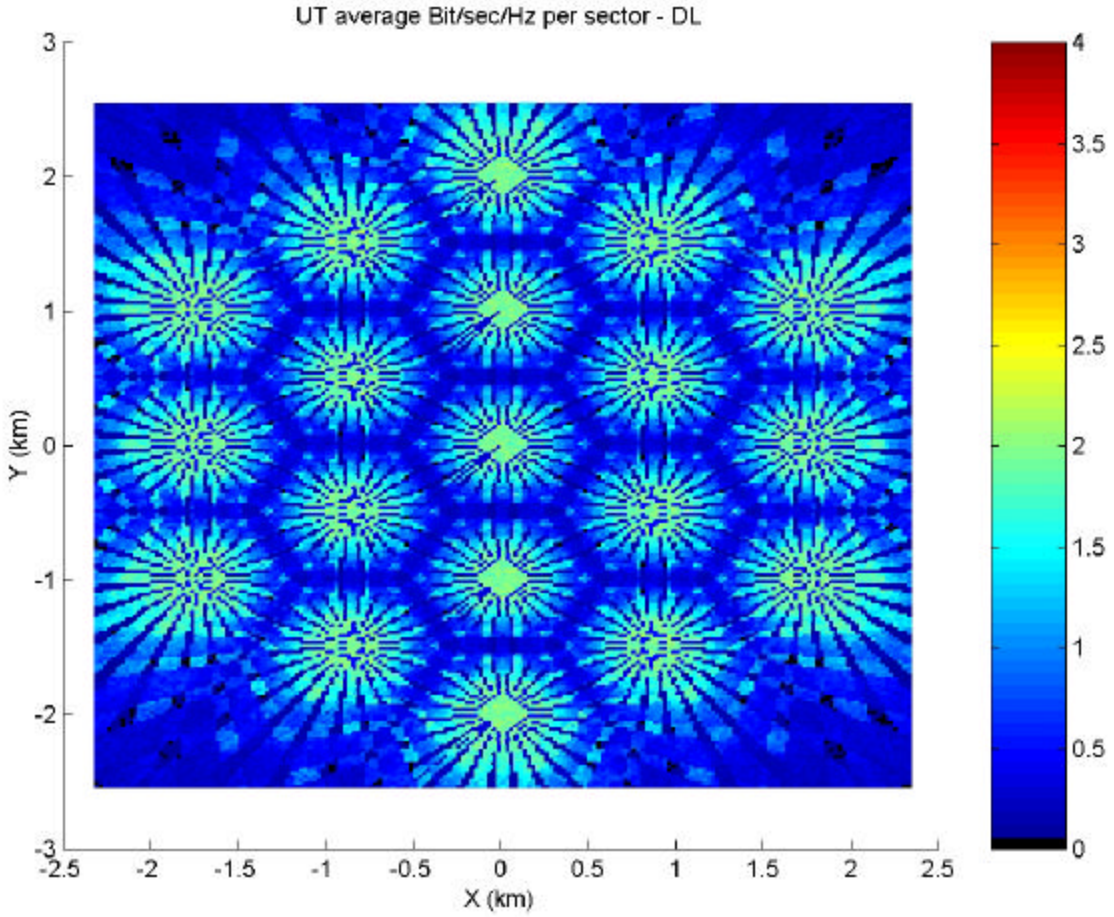

Figure 4: Average bit/sec/Hz per sector in the downlink - 24 Sectors, Reuse 1/1, IEEE-802.16d ITU-B 10MHz@120KmpH (Simulating AAS operation)

References

[1] RECOMMENDATION ITU-R M.1225, GUIDELINES FOR EVALUATION OF RADIO TRANSMISSION TECHNOLOGIES FOR IMT-2000

[2] IEEE C802.16d-03/78r1, “Coverage/Capacity simulations for OFDMA PHY in with ITU-T channel model”, Yigal Leiba, Yossi Segal, Zion Hadad, and Itzik Kitroser