ATDI

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A brief overview of 802.16e specific features and current developments for simulating a WiMAX Network with ICS telecom

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Solutions in Radiocommunications

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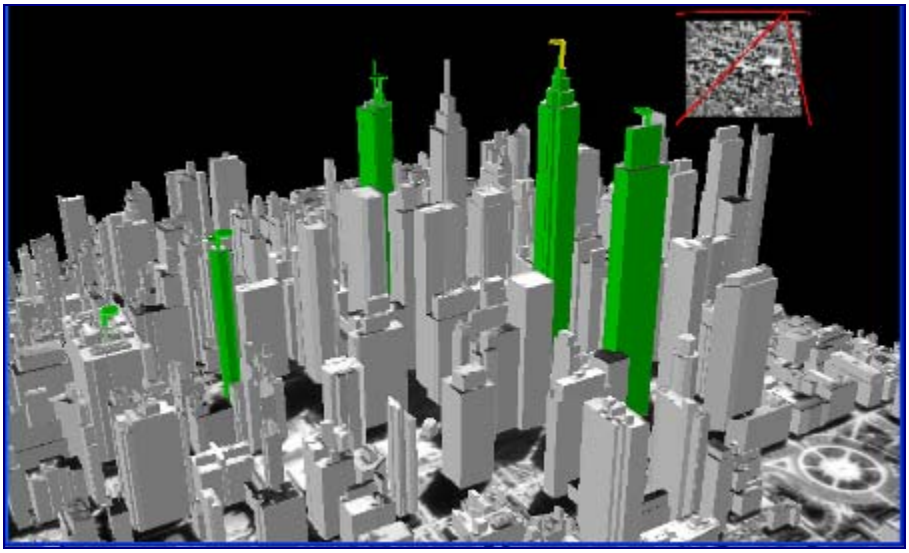
A brief overview of 802.16e specific features and current developments for simulating a WiMAX Network with ICS telecom

Abstract

This document provides a brief overview of the current developments specific to 802.16e standards for simulating a WiMAX style network. This document also reviews the future development plans for enhancing the QoS reporting and enhancing ICS telecom's options for simulating WiMAX mobility.

Currently, ATDI's research and development of ICS Telecom for WiMAX planning is focused in the following areas:

- WiMAX specific radio propagation
- Capacity management/analysis
- Interference analysis
- Functions specific to mobility



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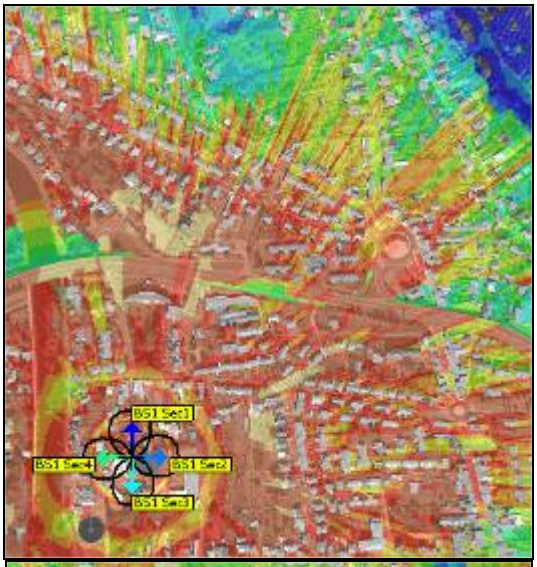
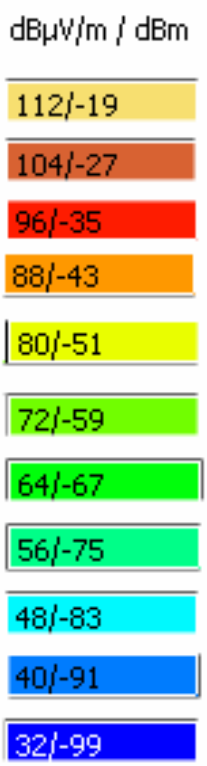
802.16 Propagation

A previously published white paper by Emmanuel Grenier on “3D Propagation Modeling in an Urban Environment” (June 2005) describes the changes implemented in ICS telecom over two years ago in anticipation of demands to simulate propagation specific to Fixed Wireless Access technologies. These developments include the ability to simulate outdoor to indoor propagation (via absorption), the InterSymbol Interference effects of multipath reflection specific to OFDM equipment (ray-tracing) and the “urban canyoning” effect, LOS, NLOS and nLOS characteristics of a radio profile analysis, power delay spread and so forth.

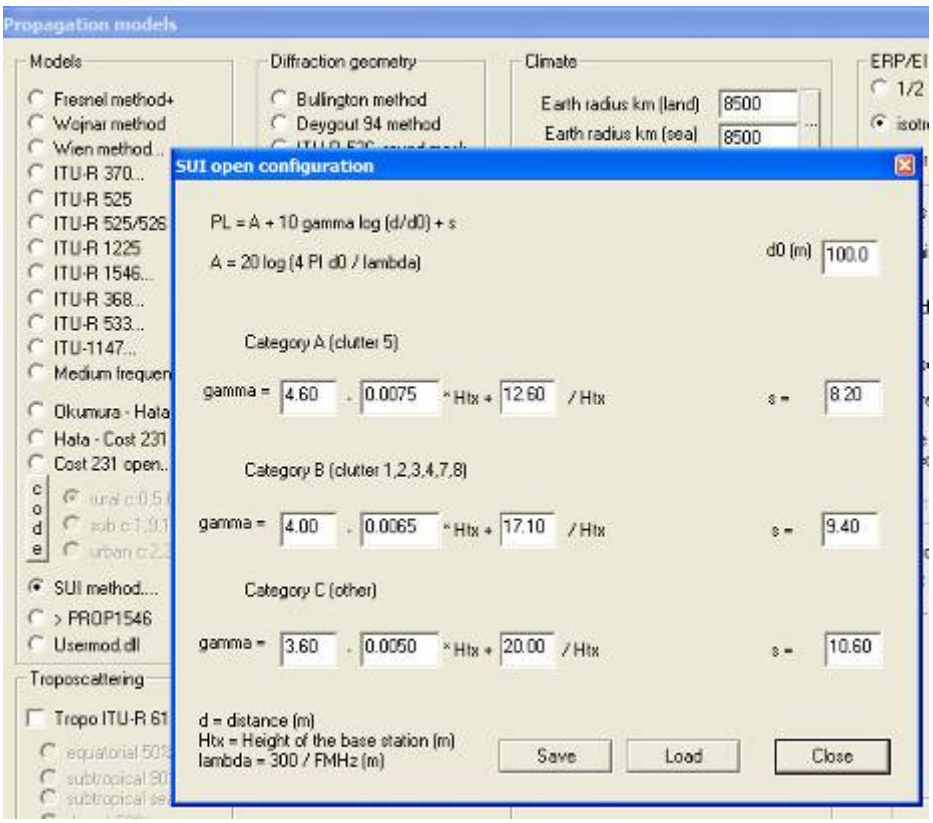




Deterministic simulation of the canyon effect in an urban setting without using ICS telecom’s ray-tracing engine. Each building along the direct path becomes a physical obstacle to the signal propagation. Cannot visualize the effects of reflection.

Deterministic simulation of the canyon effect in an urban setting with ICS telecom’s ray tracing engine. Each building along the possible paths (direct or not) become physical obstacles to the signal propagation. Some constructive field strength effects due to multipath reflection are highlighted with blue circles.

In addition to the features developed specific to deterministic planning in high resolution cartographic environments, several statistical algorithms (COST231, Okamura-Hata, ITM 122, ITU-R P.1225) have been integrated for propagation analysis over medium resolution environments (30m-90m). Given the prominence of the SUI Channel implementation of the Erceg model in the WiMAX Forum, an open configuration of this algorithm has been recently integrated for use with ICS telecom. However, the use of these models for accurate propagation analysis for FWA applications is still far from evident.



NEW!

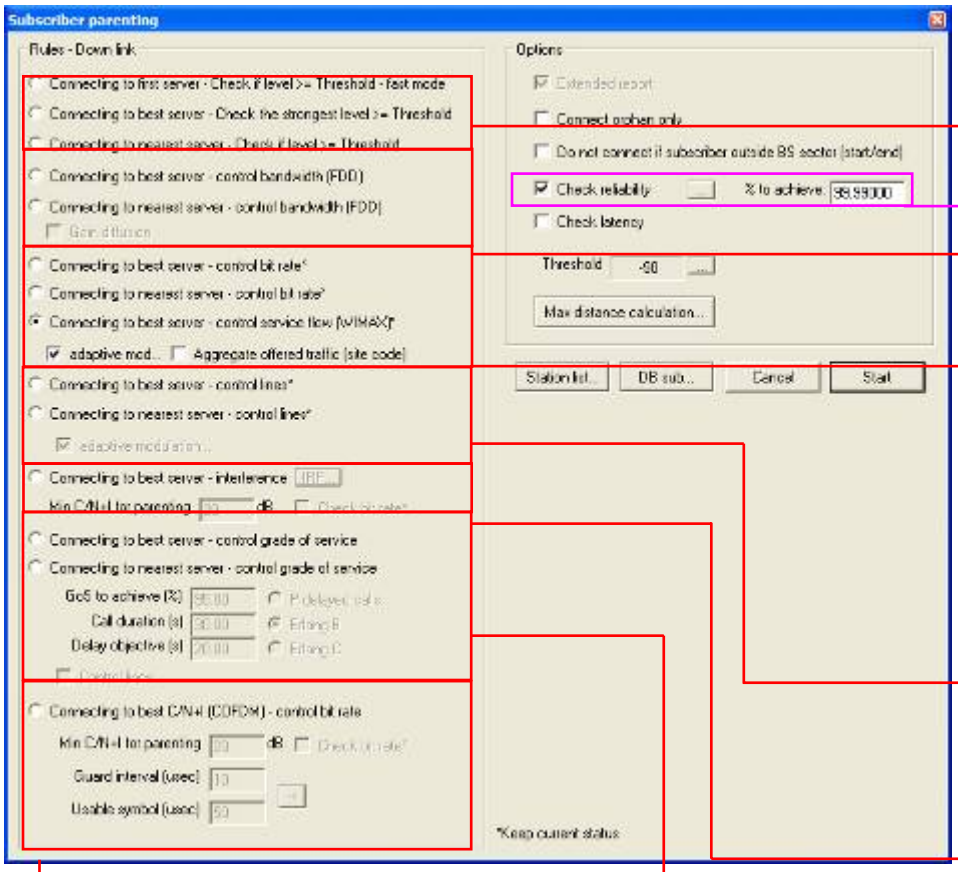
Additional developments to consider for 3D propagation analysis specific to mobility and calculation of jitter are under investigation and review.

802.16 Capacity planning

ICS telecom allows a user to simulate point-to-point or multipoint technologies through a variety of dedicated menus and interfaces. As described in the previously published white paper by Vincent Roger-Machart & Emmanuel Grenier on “Planning a WiMAX network with ICS telecom nG” (December 2004), there have been several developments in ICS telecom specific to FWA applications over the past few years, and specifically for analysis of WiMAX style networks. For multipoint analysis specific to WiMAX the user can not only define the radio characteristics in terms of antenna pattern, polarization and type (Adaptive, RPE 2D or 3D) but also can select signal type profiles assignment specific to the evolving 802.16 standard. New developments for 802.16e are highlighted below:

- **802.16e Quality of Service analysis – Integrated Service flow assignment box – *NEW!***

ICS telecom can run the multipoint connectivity analysis with a PR threshold requirement to which additional traffic based or interference based constraints can set in order to achieve realistic parenting scenarios:



Reliability definition can be from ITU 530/837, Siemens method, Vigants-Barnett or Crain Rain tables

Connectivity based on FSR/PR threshold.

Connectivity based on bandwidth capacity (BS) demand (TS).

Connectivity based on bit rate capacity (BS) demand (TS), as well as options for adaptive modulation definition and service flow bit rate assignments specific to 802.16e. ***NEW!***

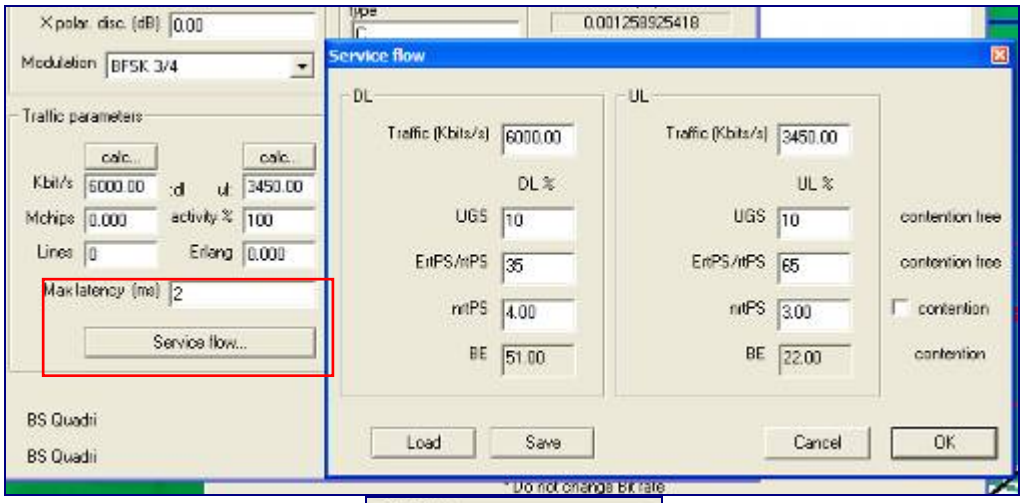
Connectivity based on communication line capacity (BS) demand (TS), as well as options for adaptive modulation

Connectivity with C/I or IRF interference constraints.

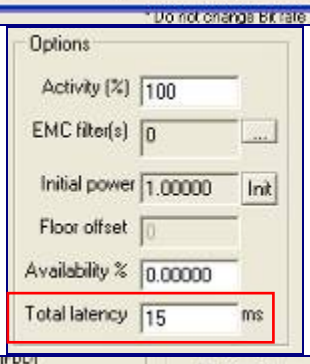
COFDM parenting for SFN with ability to define C/N+1 margin to account for interference of signal arriving after Guard interval definition (which can be defined from a drop down menu of WiMAX profiles).

Connectivity with performance base constraints based on GoS using Erlang B, C or P delayed calls definitions.

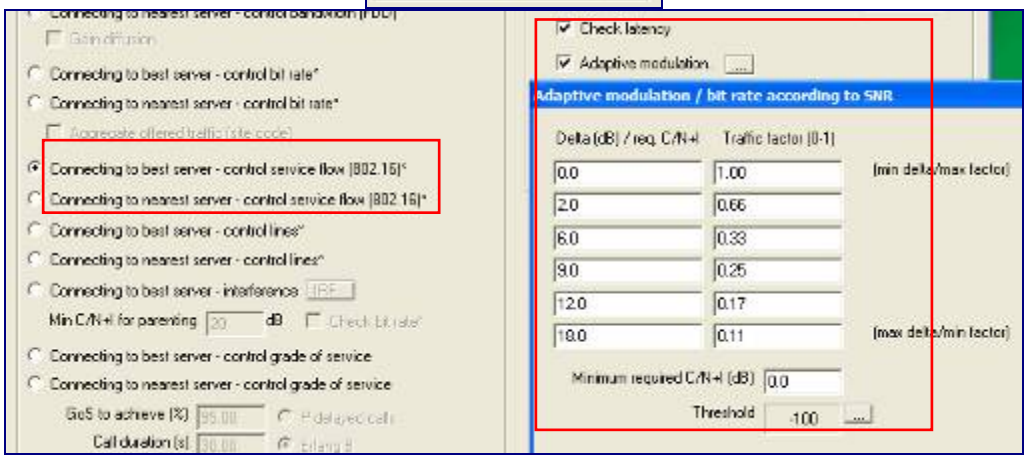
Currently, recent developments have identified the procedures for simulating the demand to the base station from a CPE according to the type of connection of the CPE (VoIP, Streaming Video, remote downloading, or simple surfing/best effort for Internet) as well as considering for latency assignments to CPE and also to entire network. This feature is still under a validation stage however the option is included in the current release of ICS telecom:



Latency and service flow definition at the CPE level. ***NEW!***



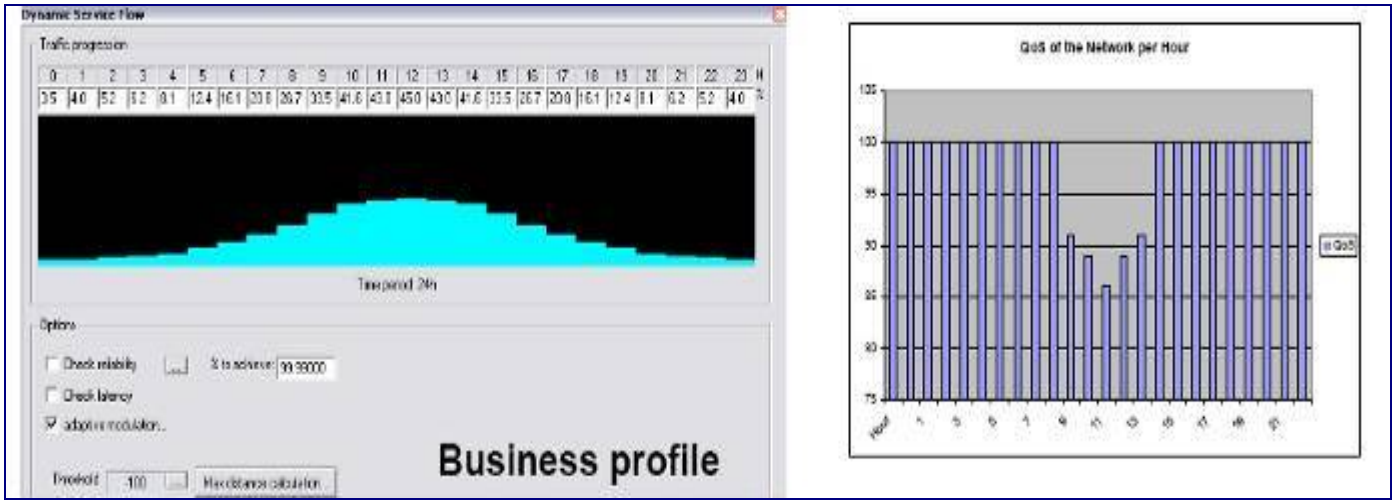
System Latency at the BS level. ***NEW!***



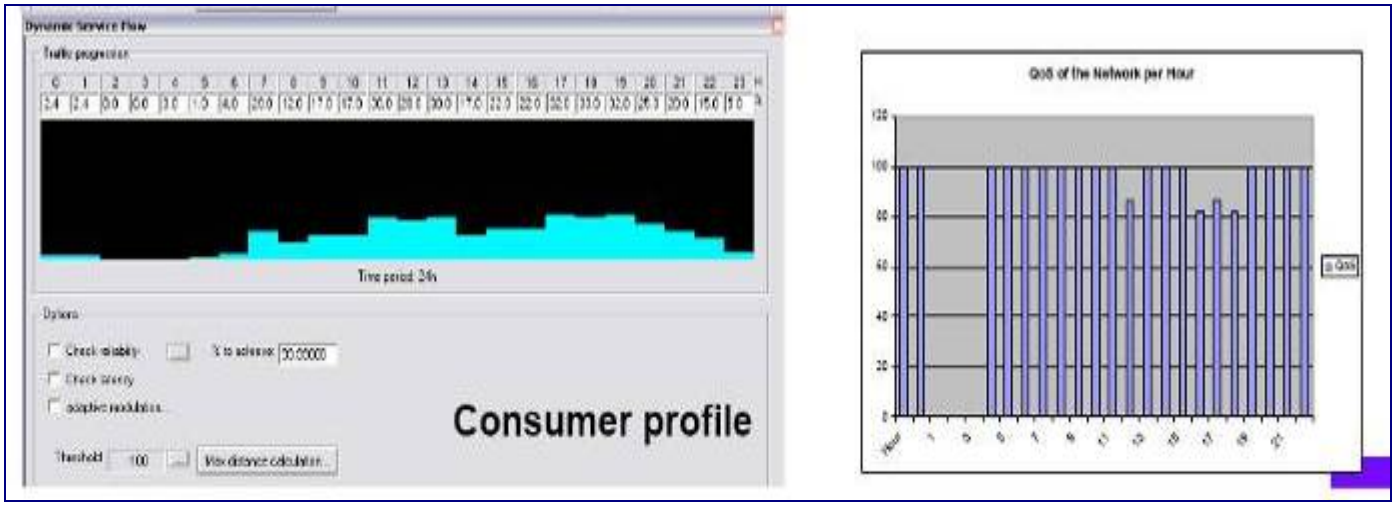
802.16e QoS parenting with options for setting Adaptive Modulation and Latency check. ***NEW!***

- **24 hour QoS activity reporting - *NEW!***

Option for determining the QoS of a network according to the real use of the WiMAX connection during the day:



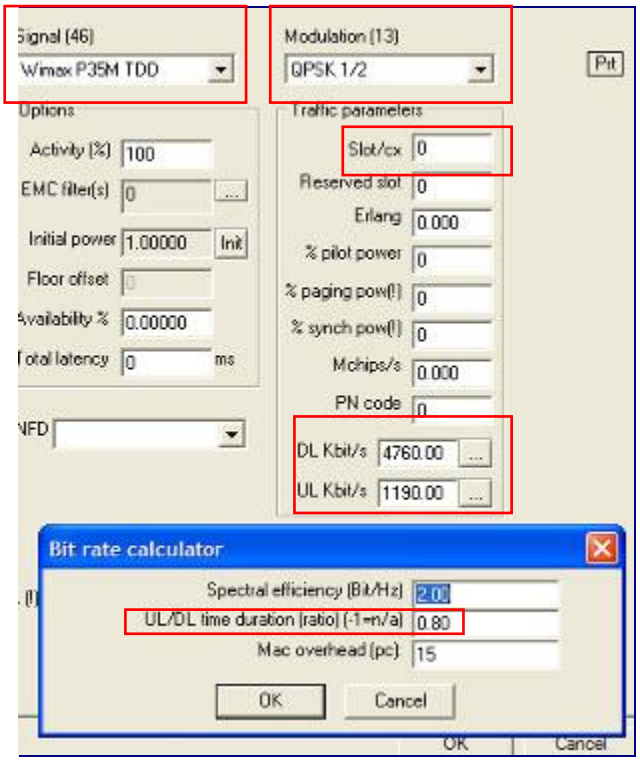
Service Flow report measuring QoS per hour in a 24 hour business day. On the left, ICS telecom can ouput a report reflecting increases in activity that correlate to decrease in QoS (right bar graph).



Service Flow report measuring QoS per hour in a 24 hour average consumer day. On the left, ICS telecom can ouput a report reflecting increases in activity that correlate to decrease in QoS (right bar graph).

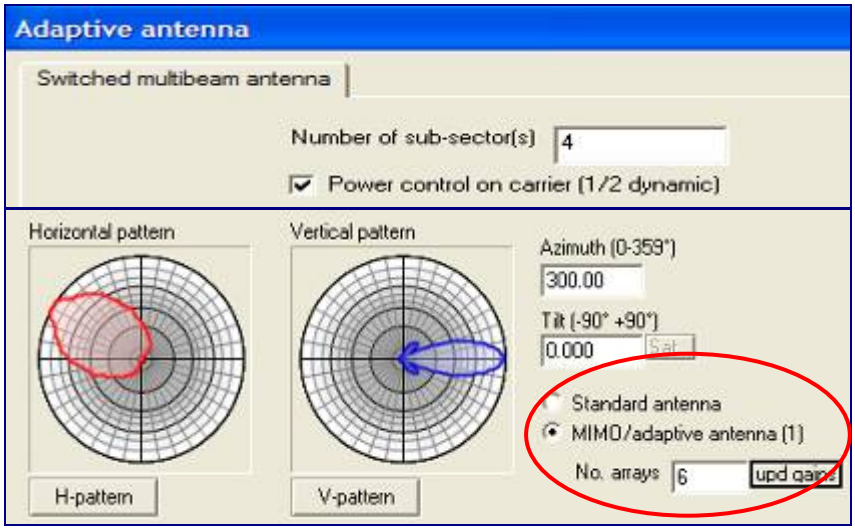
- **FDD/TDD capacity & interference analysis - *NEW!***

Specific to 802.16e standards, ICS telecom's BS Signal Type drop down menu now calls the documented FDD and TDD bandwidth profiles. In terms of traffic capacity/demand the user can define not only UL/DL asymmetry at the CPE but now also at the BS. Given the addition of assigning UL/DL [time] duration ratio for fixed and mobile WiMAX network analysis, the respective 802.16e TDD/FDD Signal Types have been included in the BS parameters interface as drop down menu options. Consequently, these will call the respective modulation that calls the appropriate integrated C/I table hard-coded in ICS telecom, but also opens the option to assign an asymmetrical time duration ratio for the purposes of minimizing interference:

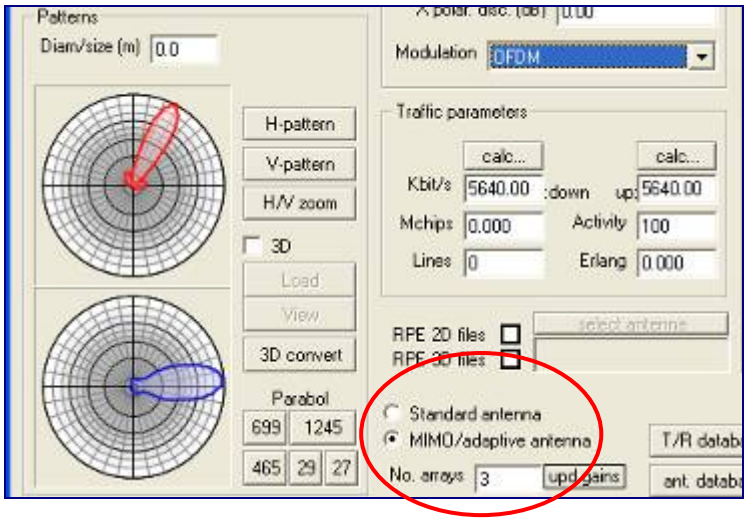


A variety of capacity/demand parameters can be set for a BS element in ICS telecom including asymmetrical UL/DL data rates, and communication line capacity (Slot/Cx). Users can select specific signal type assignments to define appropriate bandwidth and modulation parameters specific to WiMAX profiles defined by 802.16e. To the left are also examples of how a user can define time duration to the UL/DL analysis specific to WiMAX TDD. ***NEW!***

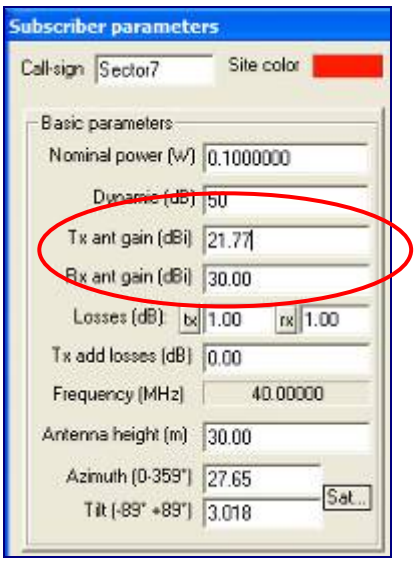
- **Adaptive antenna patterns**



MS or BS can have defined MIMO/adaptive antenna system.



CPE/subscriber can have a defined MIMO/adaptive antenna system.

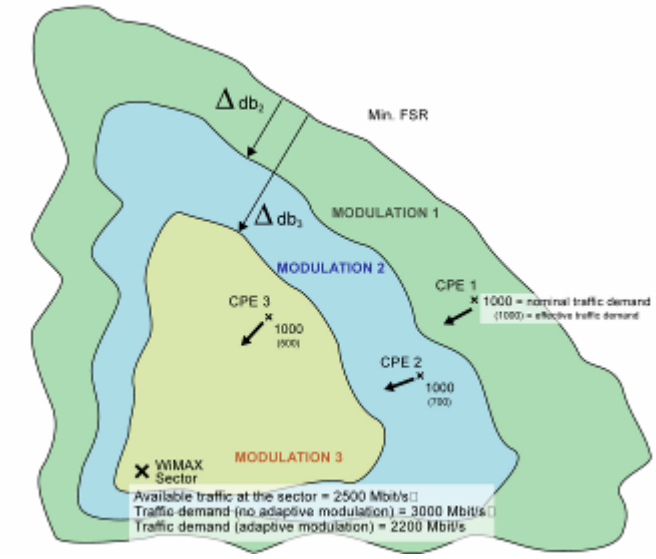


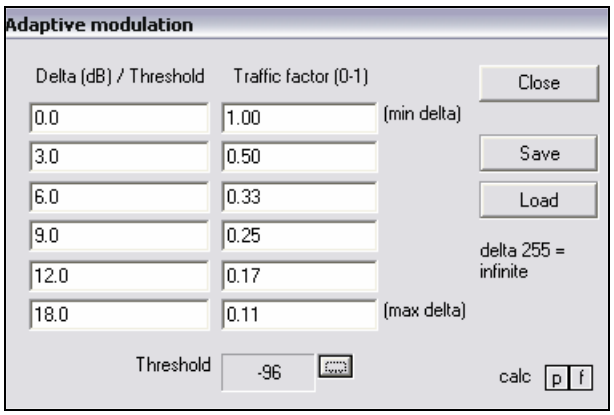
MS, BS or CPE/subscriber parameters can have asymmetrical gains in order to simulate the effects of subchannelization.

- **Adaptive modulation**

As described in Section 2.3.4 of the white paper “Planning a WiMAX network with ICS telecom nG”, there are methodologies for parenting by traffic factor assignment per Δ above the Rx sensitivity (network threshold). Given a bit rate that can be offered for a given received signal level, traffic demand can be modelled in a way reflecting the bit rate demand from CPE for different modulations:

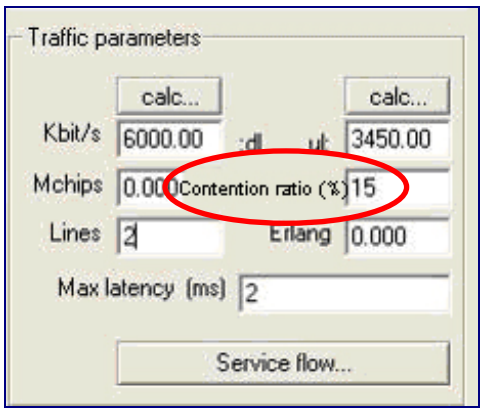
Modulation	Bit rate	Sensitivity [dBm]	dBs above the threshold	Bit rate ratio
BFSK ½	1.41Mbps	-100	0	1
BFSK ¾	2.12Mbps	-98	2	0.66
QPSK ½	2.82Mbps	-97	3	0.5
QPSK ¾	4.23Mbps	-94	6	0.33
QAM16 ½	5.64Mbps	-91	9	0.25
QAM16 ¾	8.47Mbps	-88	12	0.17
QAM64 $^{2}/_{3}$	11.29Mbps	-83	17	0.12
QAM64 ¾	12.71Mbps	-82	18	0.11





- **QoS activity management**

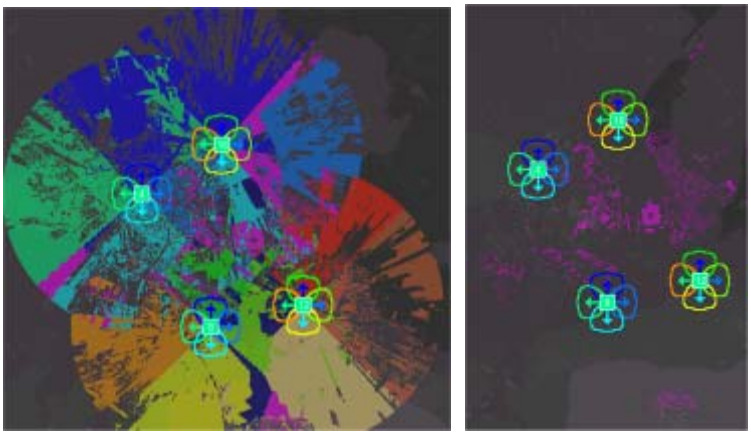
ICS telecom currently allows for the assignment of an "activity factor" or “contention ratio” to consider the reality that the WiMAX customer does not use 100% of the capacity of their connection all day long. This activity factor can attenuate the connection as much as required.



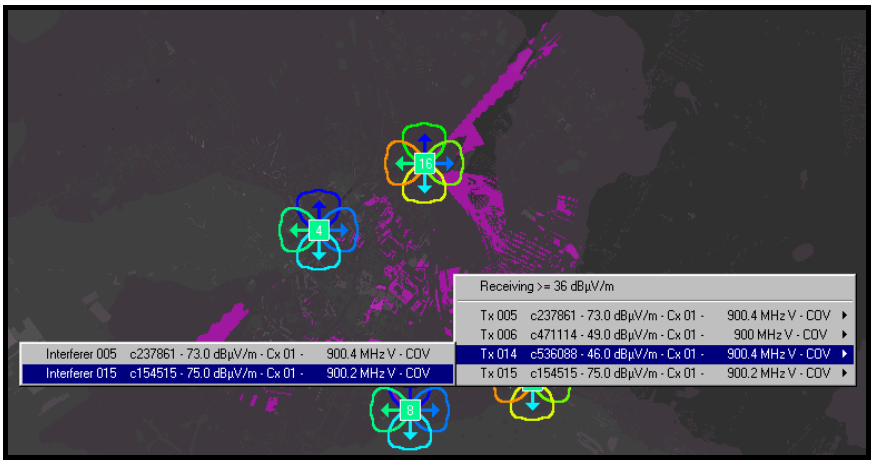
802.16 Interference

Previous white papers and training documentation detail the various options for calculating interference according to C/I or IRF rules with ICS telecom, as well as displaying interference on map and in reports as C/I or SNR values:

Result of interference calculation.
Interfered areas are displayed in pink
Interfered areas filtered on rooftops (right)

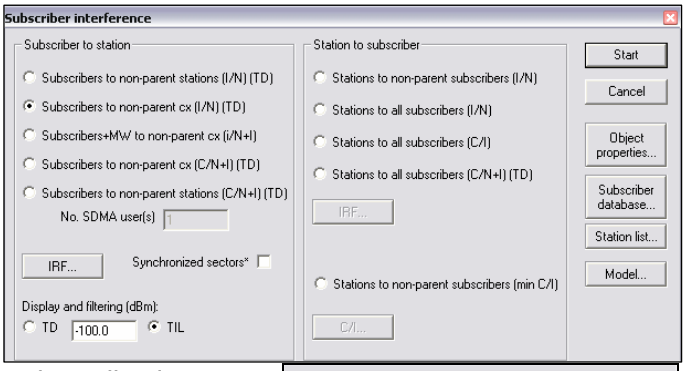


The interference results can also be analyzed in point mode, in order to check what are the field strength received, what are the interfering channels (pilot or not…) at a particular location.

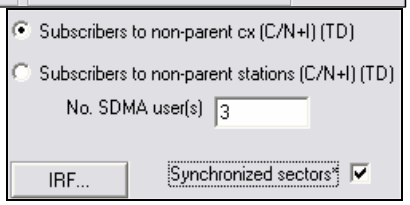


List of received transmitters at a particular location, and for each one, the interferer

ICS telecom nG features an interference calculation engine specially dedicated to the Point to Point connections that allow for easy analysis for uplink and downlink interference cases.

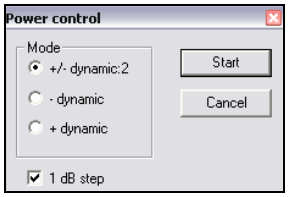


In addition to the previous features, for SDMA systems, the radio planner can specify the maximum number of terminals that can be simultaneously connected to a given base station for uplink interference calculations (from terminals to base stations).



- **Power control**

To improve the overall performance of the system. The transmitted power of the CPEs is regulated so that the power received at the base station is at a pre-determined level. ICS telecom adjusts the uplink radiated power at the CPE side, thereby limiting cases of interference.

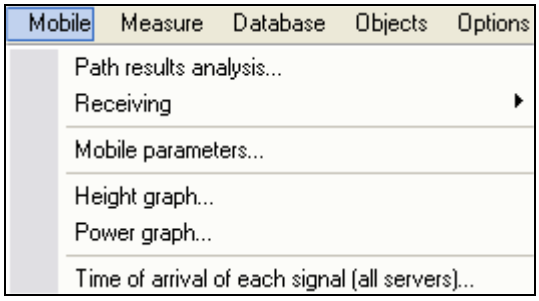


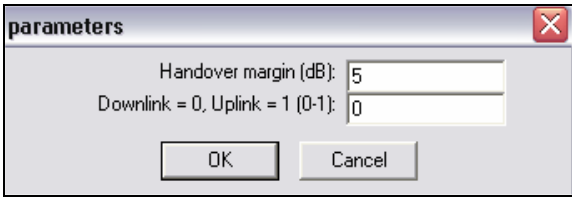
- **Destructive Field Strength effects due to multipath**

ICS telecom's OFDM parameters box for simulating multipath reflection can also highlight the cases where the signal is degraded due to the reflected signal being greater (by a user-defined margin in dB) than the direct path threshold and with a ToA outside of the OFDM receiver Guard interval:

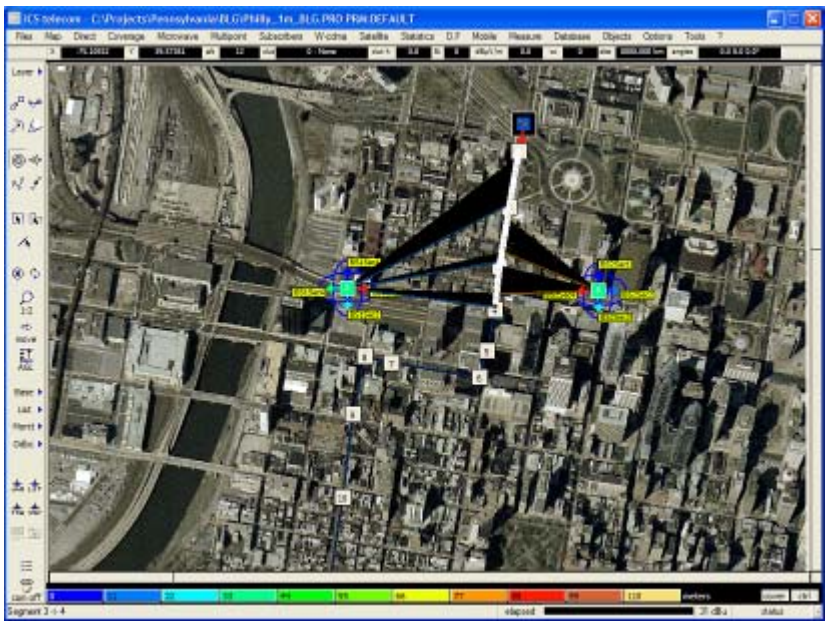
802.16e Mobility

Features for mobility analysis including handover path analysis, waypoint coverage and ToA analysis have been available in ICS telecom for some time now. ATDI's experience in working with vendors in the deployment of WiBRO networks in Korea, have led to additional developments over the years specific to enabling outdoor-to-indoor propagation analysis.

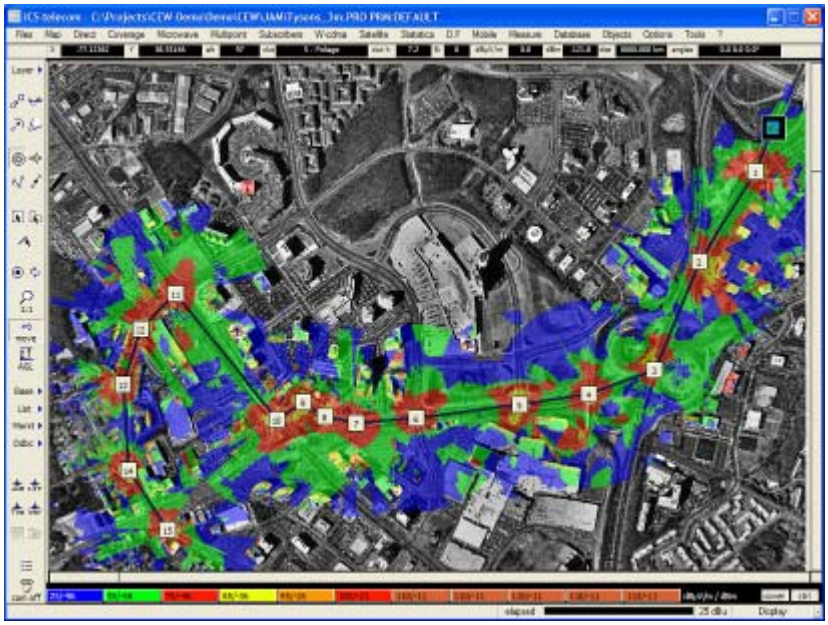




Currently these developments along with additional options for statistical reports (Monte-Carlo analysis) allow ICS telecom to simulate the nomadic and mobile movement of a WiMAX end-user. Several enhancements to these options specific to 802.16e are currently under investigation with development to commence in mid 2006.



UL handover path analysis of a mobile between to base stations in a dense urban environment. The list of BSs involved in hand off with the MS can be output to a report to give the user a report of Active Sets per mobile path.



Mobile coverage analysis along various waypoints allowing for penetration/diffusion analysis of the mobile's signal into the surrounding buildings. Attenuation effect is defined as a value in dB/km to the specific building clutter codes.

Future works

(Currently under investigation with development to commence in the coming months…)

802.16e mobility dedicated features

The key topics of investigation are as follows:

- Distinction of hard and soft handover zones. Additional features for defining anchor base station during FBSS analysis.
- Enhancement of delay spread calculation to consider Doppler effect thus allowing for calculation of "jitter", and option to define a jitter max value that when exceeded will warn the user that a real time mobile application cannot be assured.
- Integration of the concept of speed to the mobility features: to take into account that in reception, mobility will degrade the static coverage. The concept of speed will also be applied to the calculation of jitter.