

RF Engineering for WiMax

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TechnoCom™

TechnoCom is a leading provider of performance management and wireless design services and solutions to North American wireless operators

- **Founded in 1995**
- **Experienced Management Team**
- **Consistent revenue growth**
- **Technology Fast 50**



Our Customers

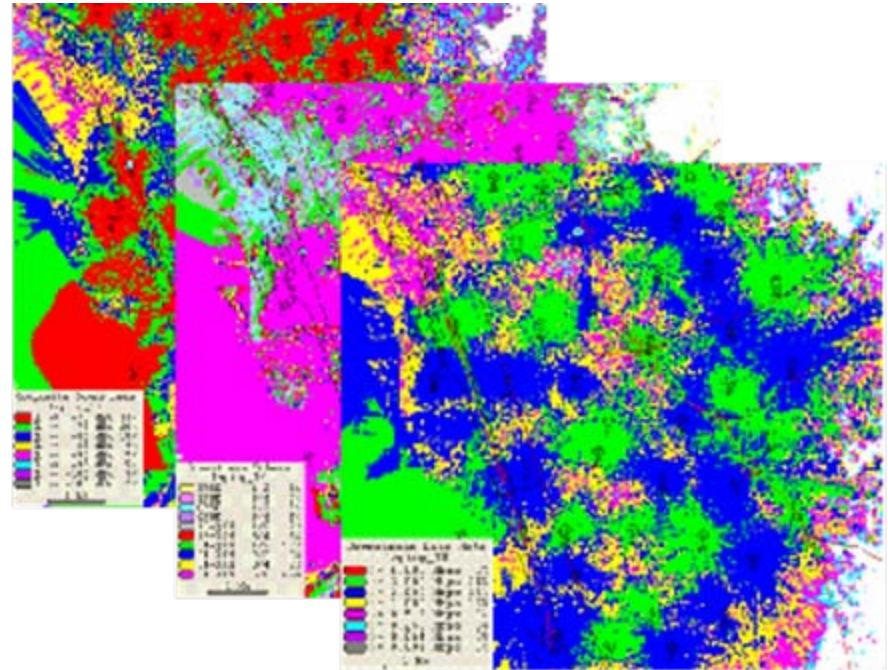


Our Services

TechnoCom provides expert RF planning, optimization, test, and deployment management services

Areas of Expertise

- Network Planning
- Network Deployment
- Network QOS
- Location Systems/E911
- System Design Trade-offs



TechnoCom's Team

- **TechnoCom's professional services team is lead by telecommunication systems and RF engineering experts with many years of practical wireless experience**
 - **Wireless carrier and broadband wireless technology vendor experience**
 - **Diverse industry experience including large and small wireless carriers, service providers, technology vendors, and state governments**
 - **Designed, developed and patented wireless location prediction system**
 - **Experienced in latest RF modeling tools and platforms for 3G/4G wireless**
- **TechnoCom's Team offers a best of class, highly responsive, customer intimate professional engineering service that is both very competitive and cost effective**

Air Interface Experience

- **TechnoCom's team possesses strong experience in a broad array of wireless air interfaces**
 - **Strong hands-on experience with traditional cellular air interfaces**
 - **CDMA2000, GSM, ANSI-136, AMPS, NAMPS**
 - **RF planning and system experience with 3G technologies**
 - **WCDMA/UMTS**
 - **In depth knowledge of the PHY and MAC of WiFi-class technologies**
 - **802.11a/b and adaptation of 802.11a to 802.11p (for high speed vehicular applications)**
 - **In depth development and test experience of MMDS and LMDS systems (802.16)**
 - **Hands-on WiMAX planning and design for large enterprise settings**
 - **In depth knowledge of mobile and fixed satellite systems and propagation**

Experience with RF Design Tools

- TechnoCom's engineers have extensive experience with a variety of RF planning platforms and software tools and have used them to design, test, optimize and maintain a variety of networks
 - RF prediction platforms:
 - CelPlan, PLANET EV, dB Planner, LocatePredict, GRANET
 - Field testing:
 - Comarco, IFR, Invex, TechnoCom's LocationAssurance Manager (LAM), spectrum and network analyzers
 - Mapping/GIS:
 - MapInfo, ArcGIS, TechnoCom's LocationAssurance Reporter (LAR), Google Earth

Team Leadership

- **Dr. Khaled Dessouky**
 - Co-founder of TechnoCom; 15 years of engineering management experience; expert on RF modeling and prediction; co-inventor of patented wireless location prediction system; co-inventor of 5 additional wireless benchmarking related patents; pioneer in the development and adoption of 802.11p; co-inventor of 5 patent applications related to 802.11p in mobile systems; expert on mobile and fixed satellite systems (member NASA Space Technology Hall of Fame)
- **Ray Brunet**
 - Ray Brunet, Director of RF Engineering at TechnoCom, has over 24 years of wireless industry experience and over 18 years of experience directly involved in the RF design and deployment of wireless systems. He has led design and deployment efforts of 802.16 LMDS, CDMA, NAMPS/AMPS, and aftermarket amplifier applications for GSM, TDMA, and CDMA networks.

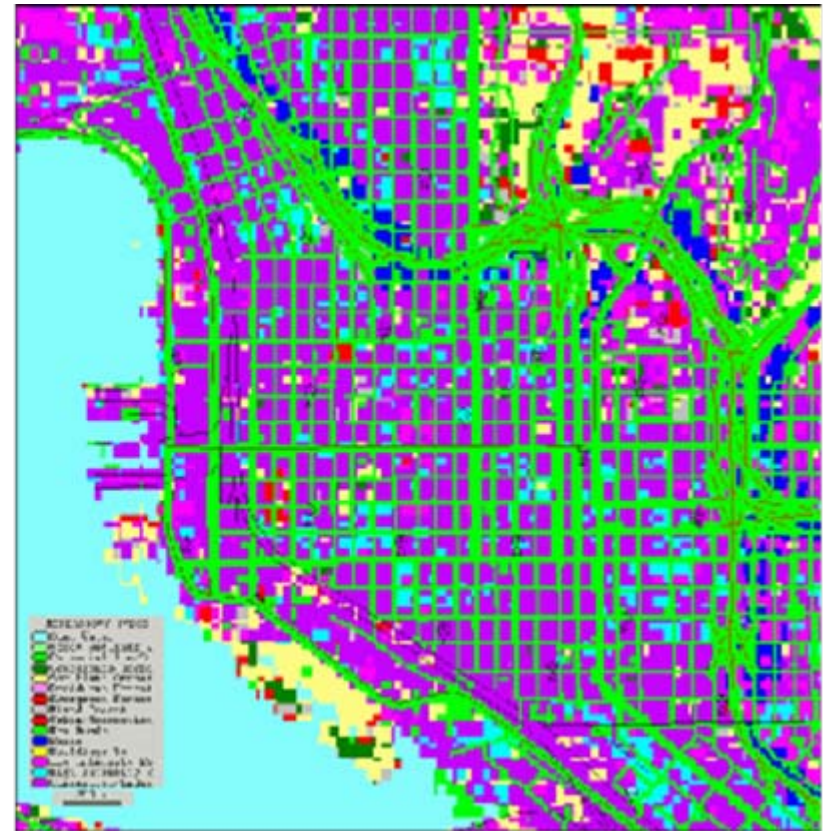
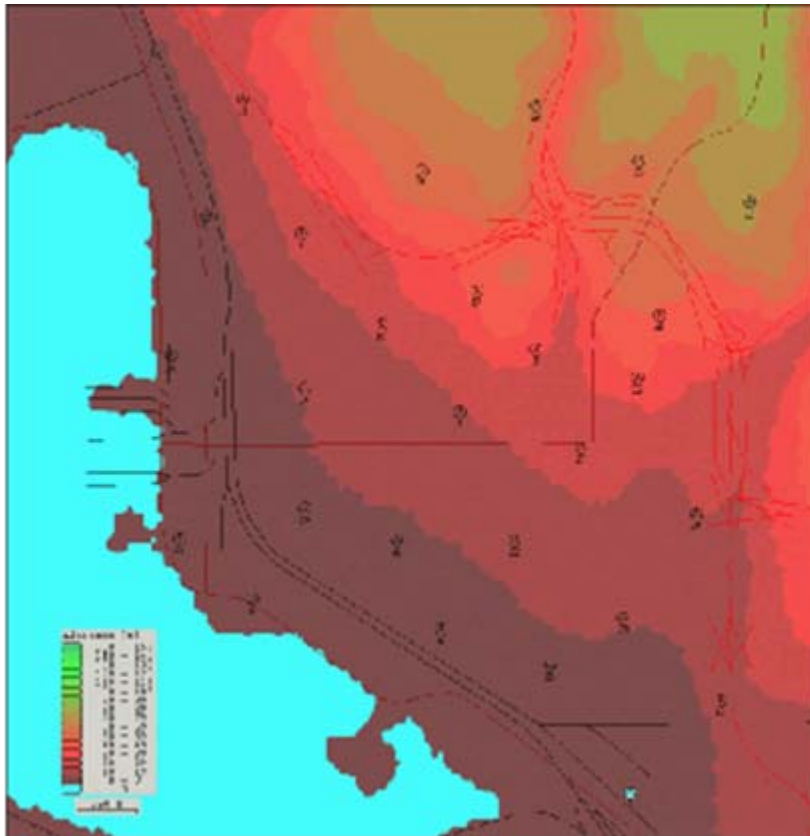
Network Planning: Initial Design

- **Design and network objectives identification and analysis**
 - Coverage, cost, capacity
 - Spectrum re-use planning
 - Traffic demand (Morphology, traffic corridors, population, income levels)
 - Link budget analyses
 - Coverage criteria, building penetration, fixed versus portable
 - Budgetary considerations (trade-offs)
 - Zoning considerations (impacts on deployment plan and mitigation)
 - Cell build-out options, capacity or coverage expansion
 - System growth considerations

Sample WiMax Project

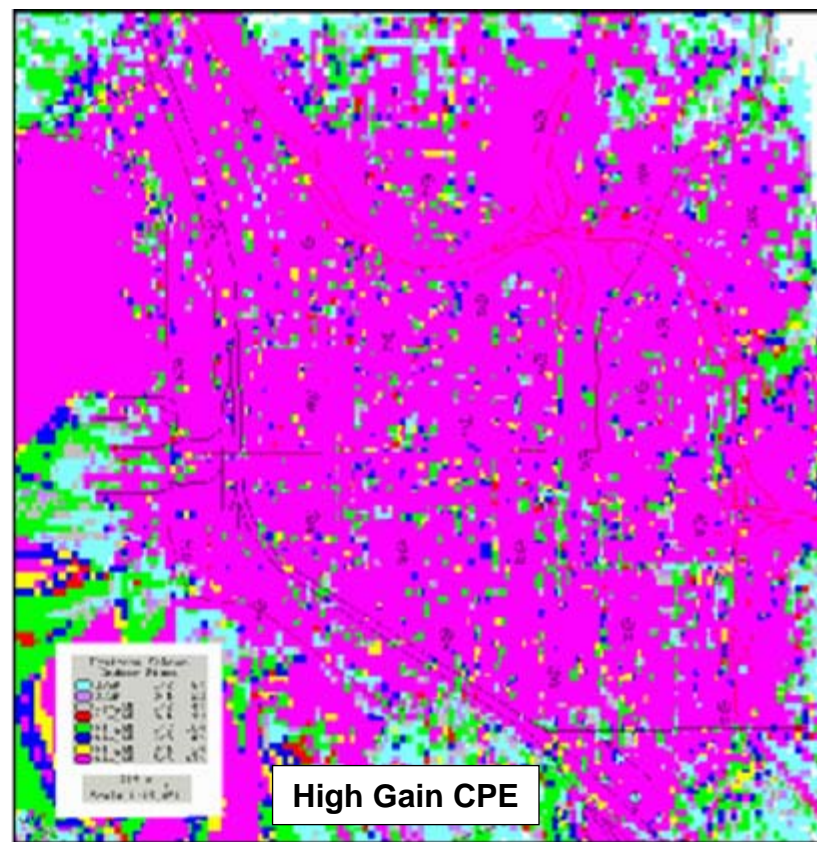
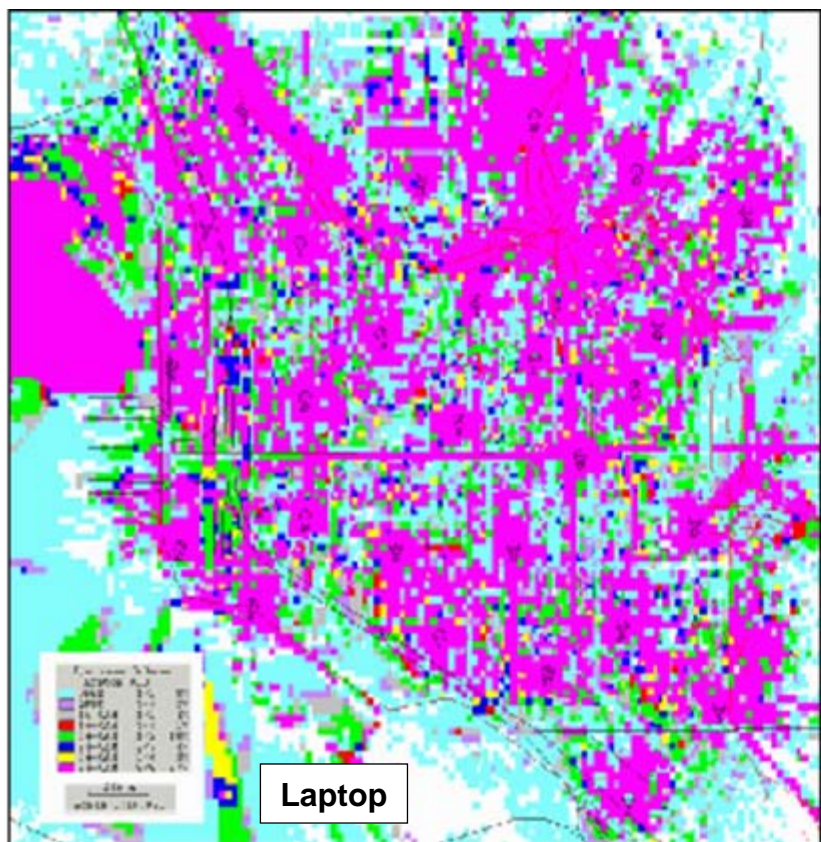
(Downtown San Diego)

- Challenging mixture of dense clutter of varying size and height combined with terrain variation
 - Requirement for solid penetration in a strong potential co-interference environment



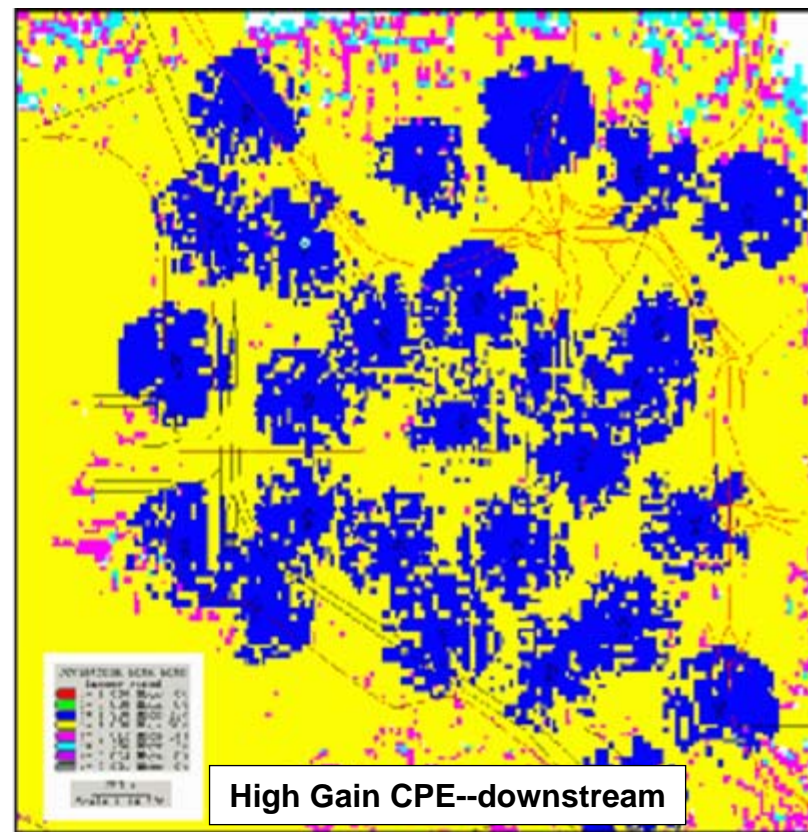
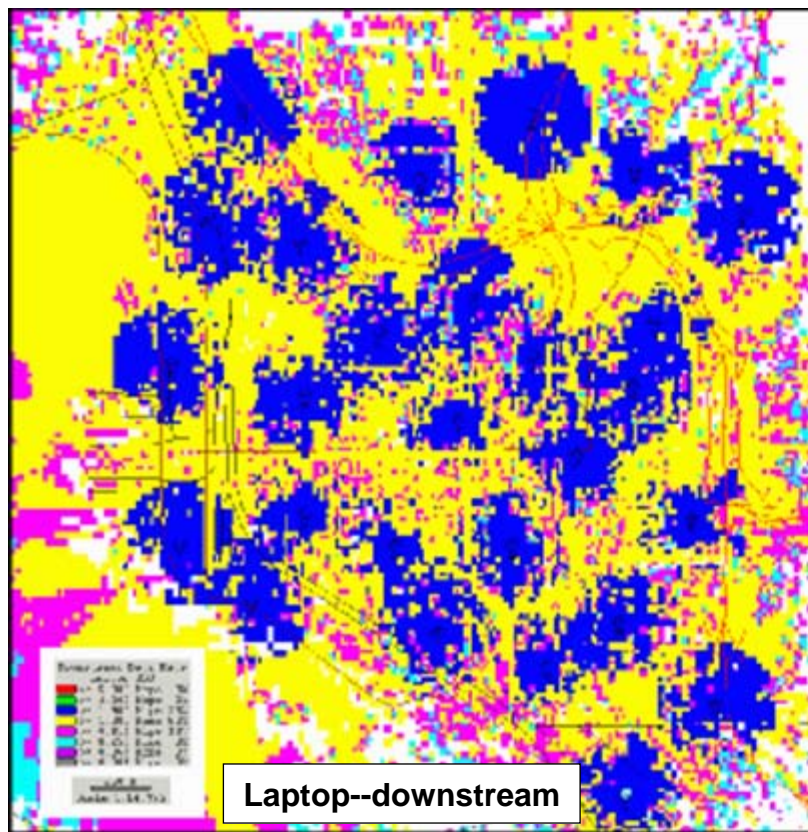
Detailed WiMax Prediction: e.g.: Modulation Schemes

- Indoor/outdoor laptop modem versus fixed indoor terminal uplink performance in an urban downtown setting
 - USB data card versus CPE with 13 dBi directional antenna
 - Coverage tends to be uplink limited indoor



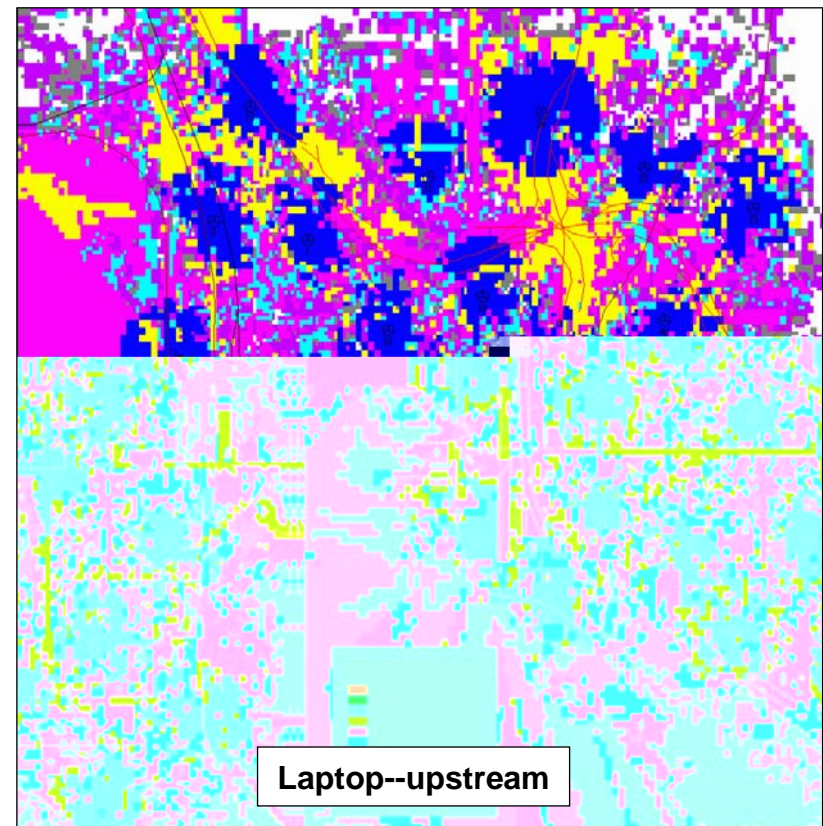
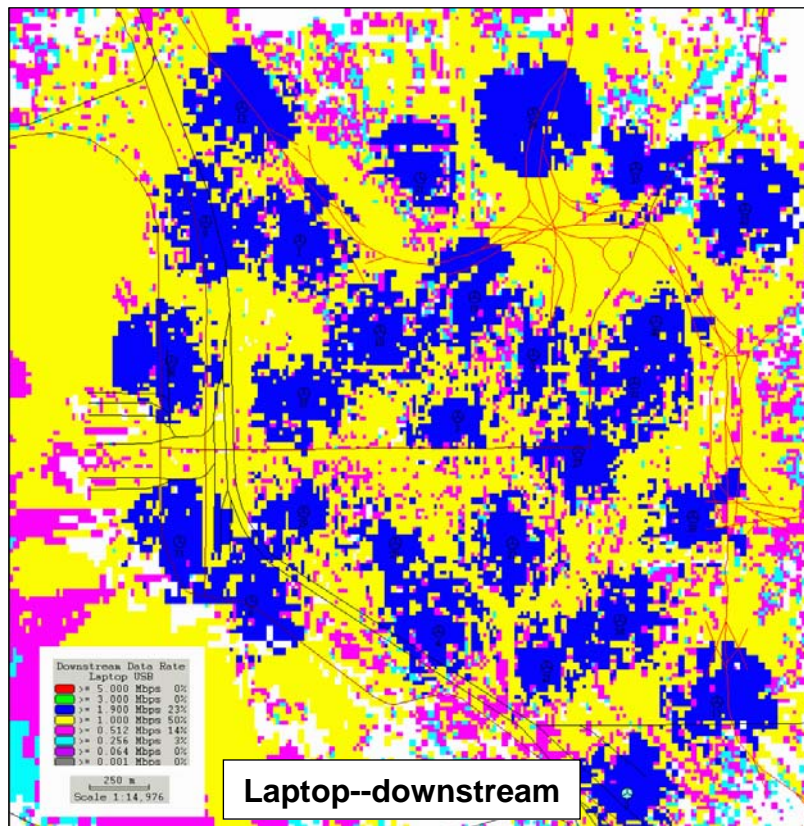
Data Rate Prediction for Different User Equipment

- Delicate balance of offered service throughputs and interference created
 - Intelligent use of subcarrier permutation zones to protect more vulnerable users



Data Rate Planning for Different Link Requirements

- Careful use of prediction models, scenario characteristics, and WiMAX features to reflect link differences and meet their requirements



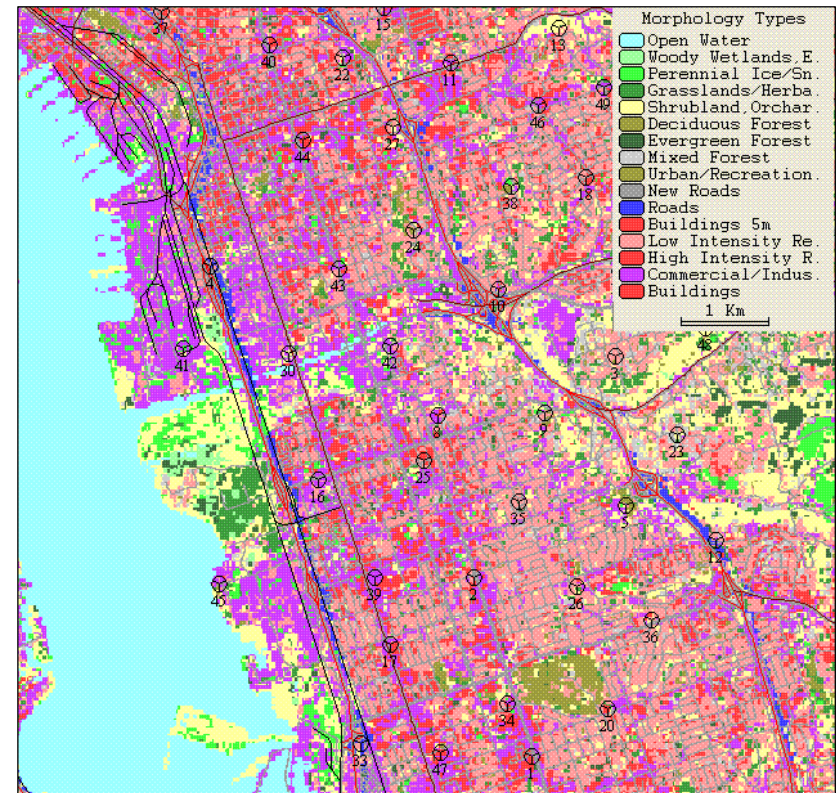
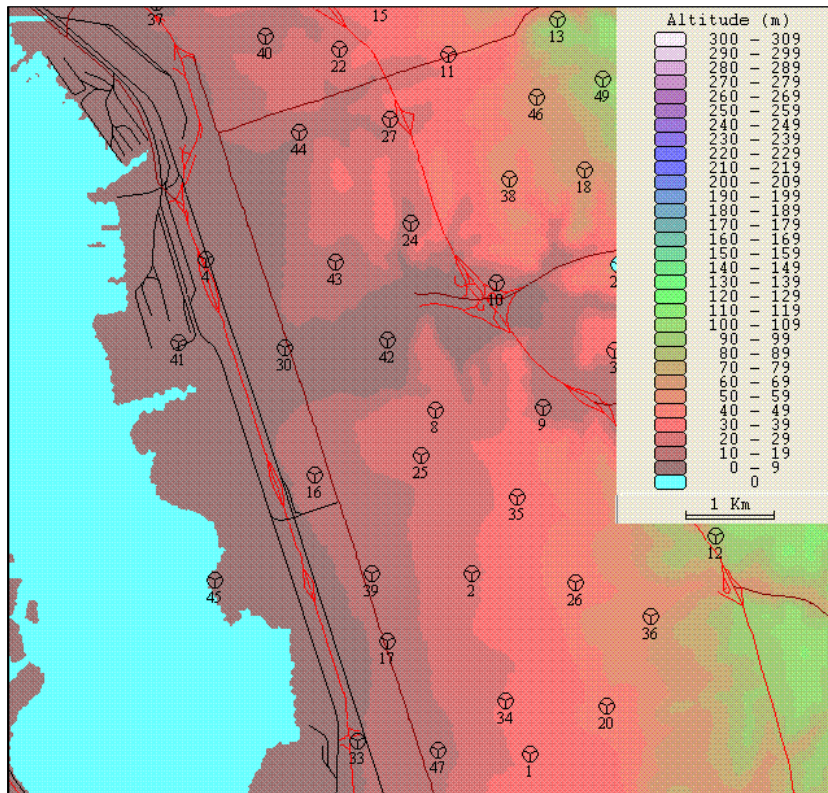
Network Planning: Resource Deployment

- **Coverage Evaluation**
 - Area goals – urban, suburban, rural, highway
 - Services goals – Data services for fixed indoor, laptop
- **Frequency planning and interference analysis**
 - Frequency re-use, sub-channel allocation
 - Localized interference identification and mitigation
 - Coexistence Interference measurement, modeling and coordination with adjacent markets
- **Detailed traffic analysis and capacity planning**
 - Individual site analysis and channel requirements (subchannel utilization, zone and segment planning)

Example: WiMax Suburban Deployment

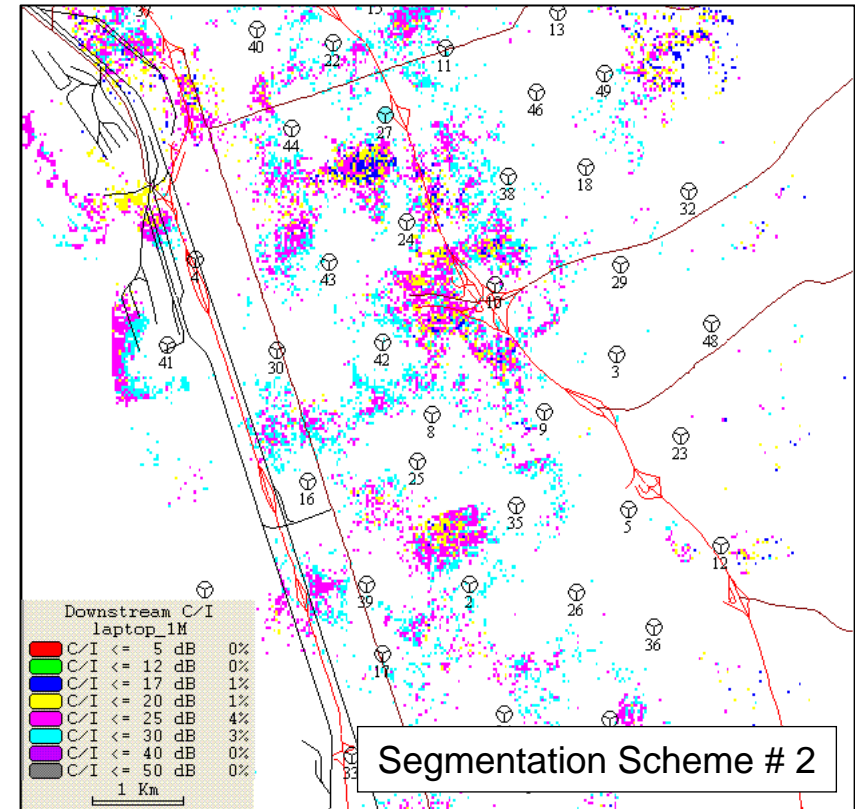
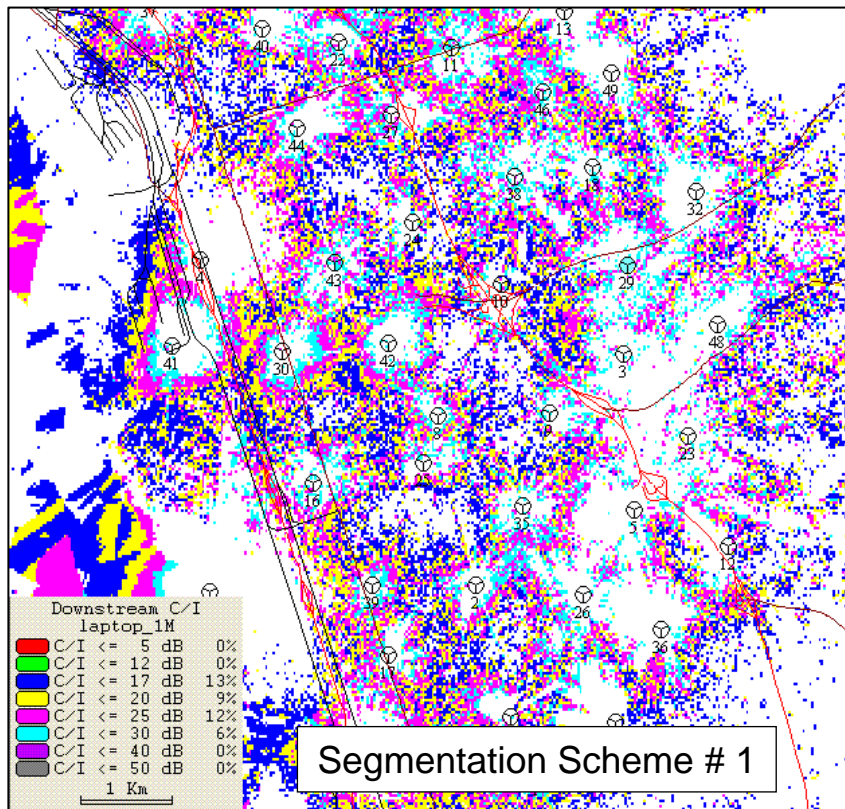
Freq., Segmentation & Bandwidth Planning

- South San Diego
 - Mixture of residential and light urban
 - Average clutter heights approximately 12 meters
 - Low customer density; high residential usage
 - Lighter site deployment to manage costs



Interference Analysis and Planning

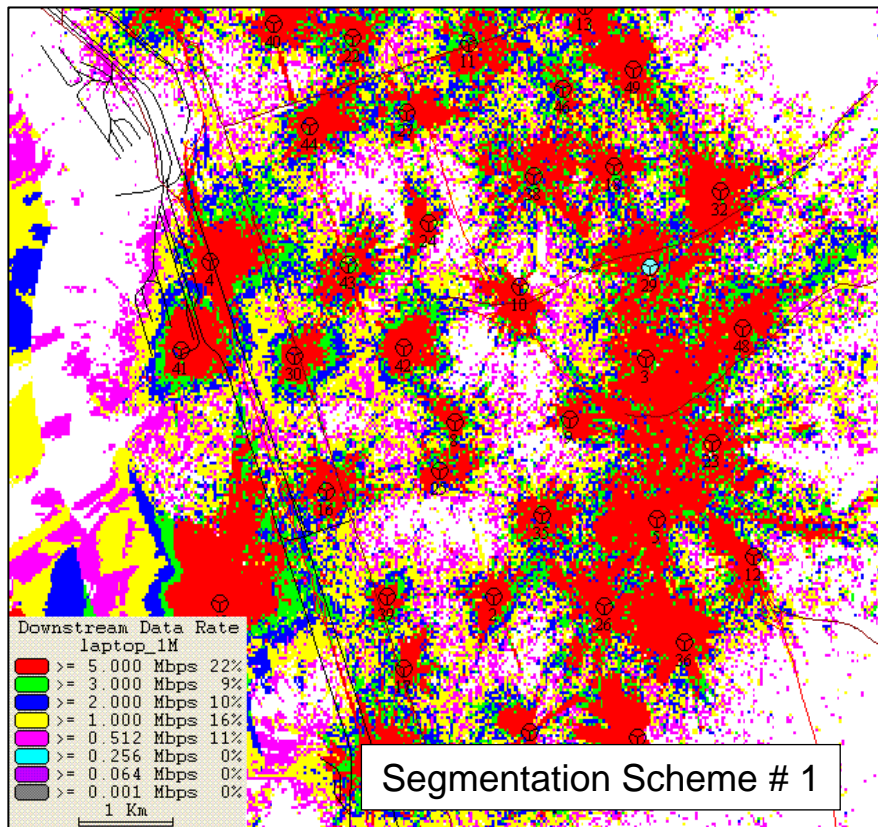
- Careful segmentation reuse minimizes interference and improves coverage in interference limited network
- Allows for targeted growth in high capacity areas with segment and spectrum conservation



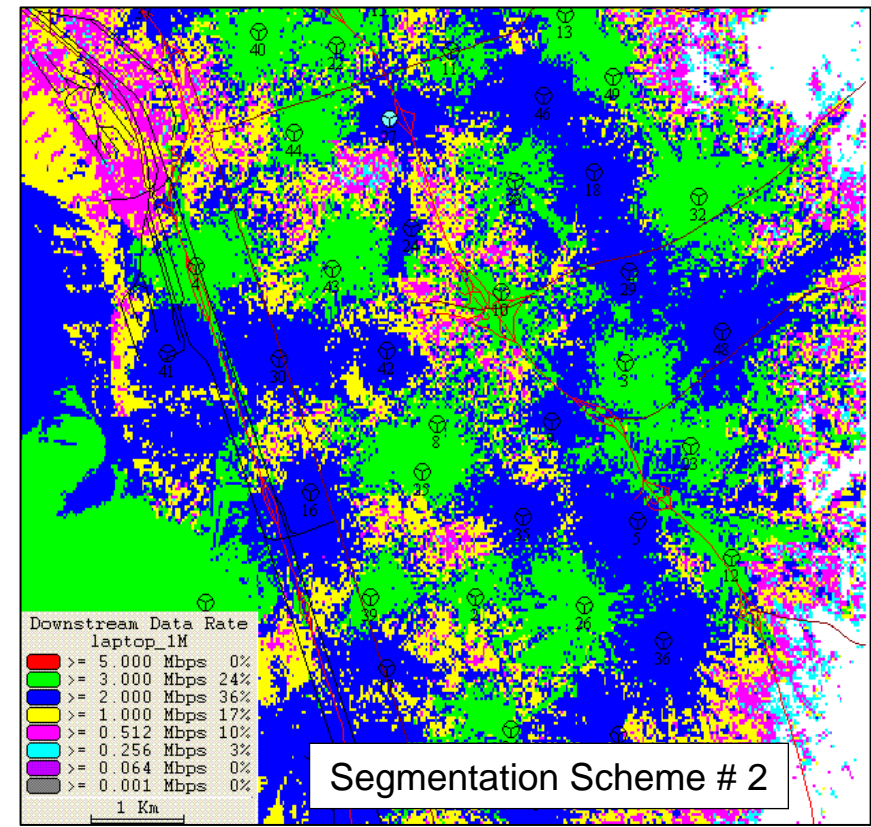
System with 30 MHz Total Bandwidth and Frequency Reuse of 1 (1/3/3)

Bandwidth Utilization Optimization

- Indoor/Outdoor laptop model data service comparing the two freq reuse 1 segmentation schemes (3x and 6x) suiting different needs



Focused "hot spot" areas with very high data rates

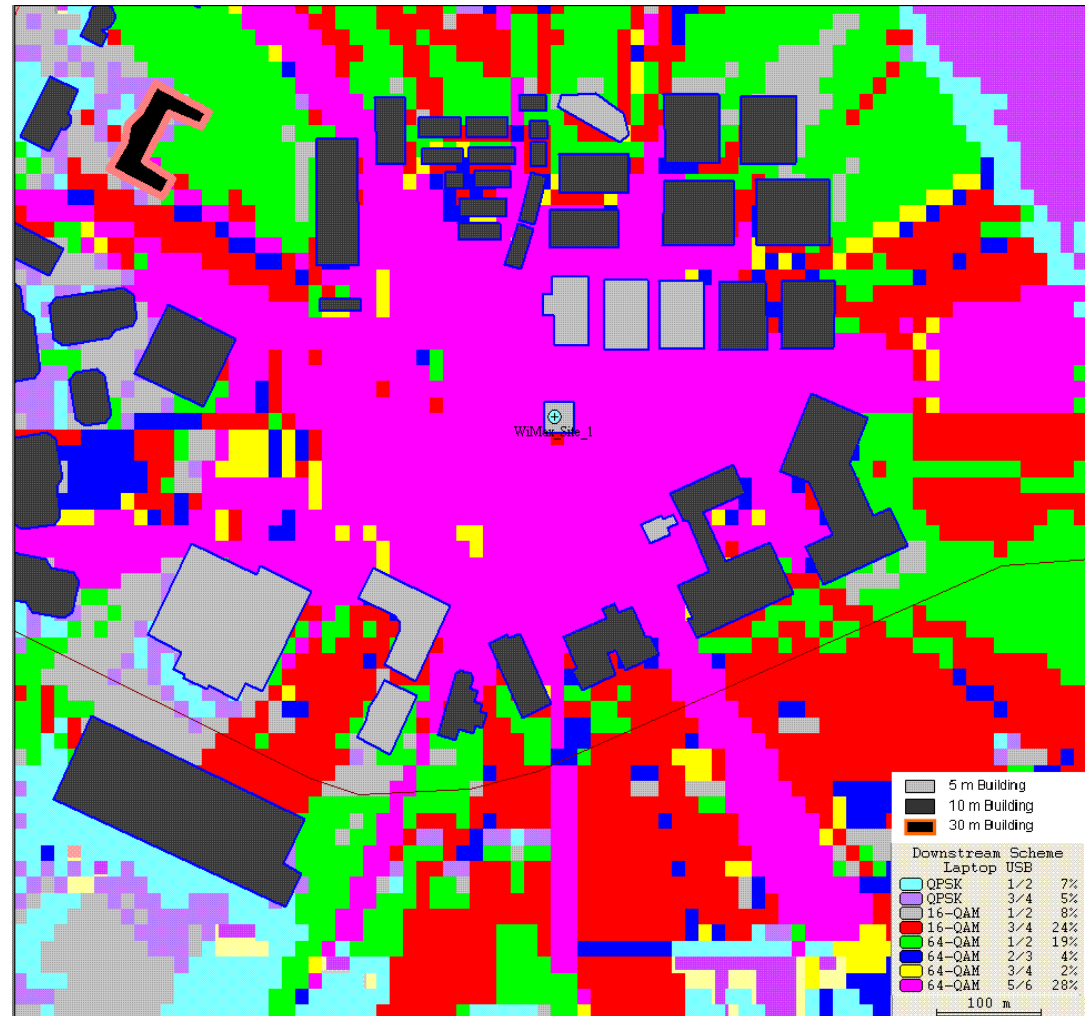


Broader coverage with lower but still high data rates

System with 30 MHz Total Bandwidth and Frequency Reuse of 1 (1/3/3)

Network Planning: Campus Environment

- Detailed propagation analysis & model tuning
 - Customized morphologies
 - Quasi-microcell environments
 - Cost effective building/obstacle creation over campus areas
- Drive testing and candidate site evaluation
 - Validation of coverage performance
- Modeling refinement
 - Future cell expansion and interference/retuning/sub-channel segmentation
 - Planning adjacent system interference or co-existence with identical or divergent air-interfaces



Network Deployment

- **Project planning and management**
 - From inception through conclusion and handover to customer
- **Provide support to customer as early as real estate acquisition through negotiation and subsequent network roll out**
 - Identify suitable compromises and negotiation driven configuration changes
 - Support zoning and permits process
 - Preliminary and detailed site surveys
 - Exact location, space for equipment, antennas, cable runs, power facilities, backhaul, etc.
 - BTS or subsystem installation, commissioning and testing
 - Site integration and acceptance
 - Market-wide drive test planning and execution
- **Perform cell design data management**
 - Maintain extensive database of cell configuration
 - Floor plans, cell locations and parameters, dimensioning, antennas, RF interconnections, expansion, etc.

RF Network Optimization

- **Pre and post launch system performance analysis and parameter optimization**
 - Maximize coverage, data capacity
 - Verify indoor/outdoor coverage, modulation schemes
 - Antenna pattern adjustments and evaluations
 - Identify traffic related interference growth
 - Refine coverage relating to power budget, traffic levels, sub-channel segmentation, freq re-use

Optimization Example—Pre-Launch

- Careful adjustment of electrical and mechanical tilts for key sites 2 and 3 rings out to improve SNIR

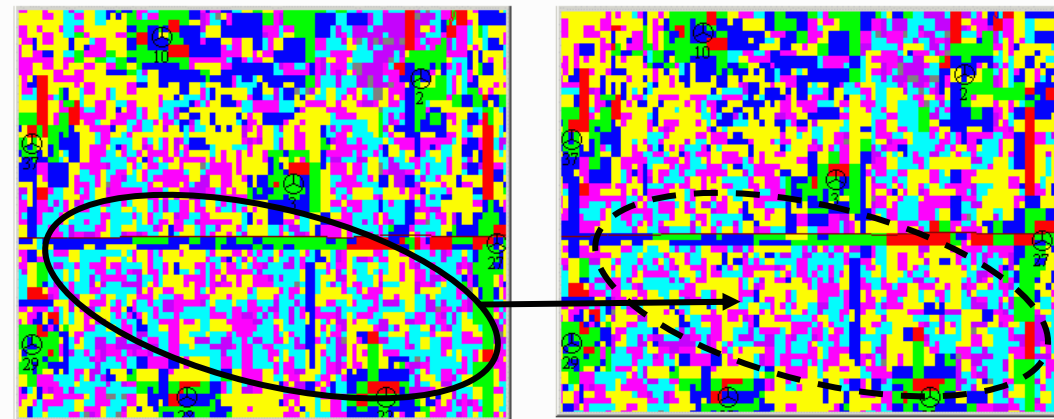
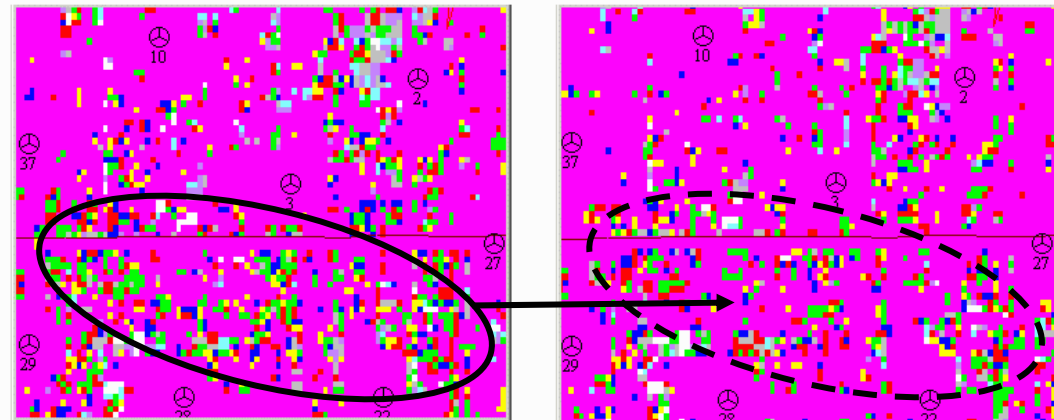
- Balance with sacrificing their local coverage and supported service

- When needed, subcarrier segmentation readjustment

Downstream Scheme Laptop USB	
Schm QPSK	1/2
Schm QPSK	3/4
Schm 16-QAM	1/2
Schm 16-QAM	3/4
Schm 64-QAM	1/2
Schm 64-QAM	2/3
Schm 64-QAM	3/4
Schm 64-QAM	5/6

Composite Downstream Laptop USB	
S/N >= 60.0 dB	
S/N >= 50.0 dB	
S/N >= 40.0 dB	
S/N >= 30.0 dB	
S/N >= 25.0 dB	
S/N >= 20.0 dB	
S/N >= 15.0 dB	
S/N >= 0.0 dB	

Modulation scheme (and subsequent data rate)



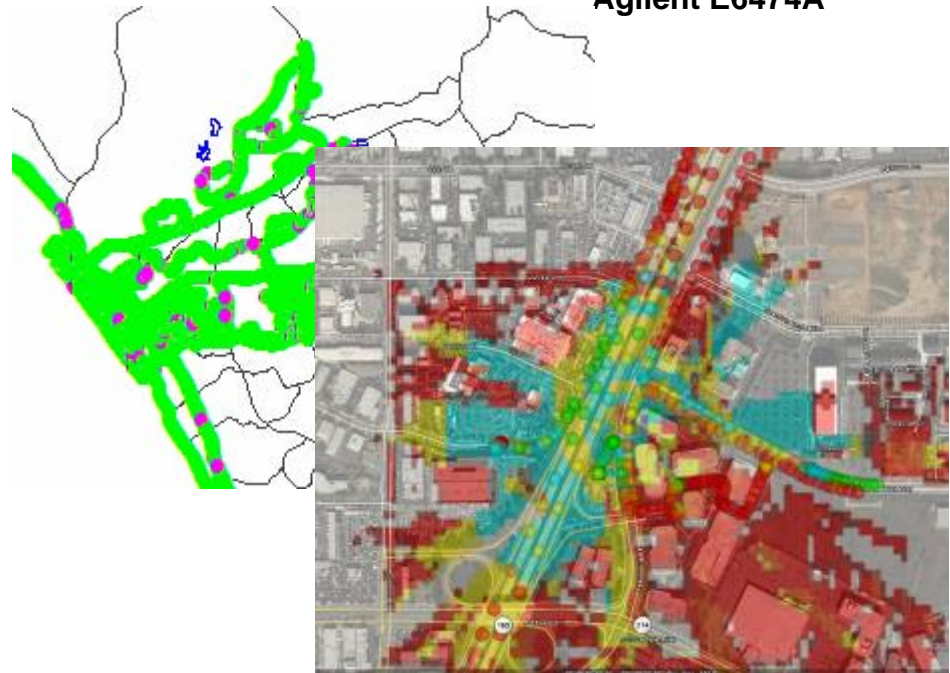
Underlying signal to noise plus interference ratio

Network QoS

- TechnoCom deploys and manages teams which monitor, test, and evaluate market performance
- Network performance analysis of WiMax networks
 - Received signal level
 - Data throughput (average, max, min)
 - Effects of Segmentation on data capacity
 - Effects of PermBase usage on interference
 - Performance statistics (mapped, statistics by region, area, custom boundary)
 - Guidance for areas of improvement based upon empirical results
 - Identification or verification of possible “hot spots” – areas of high profile performance issues

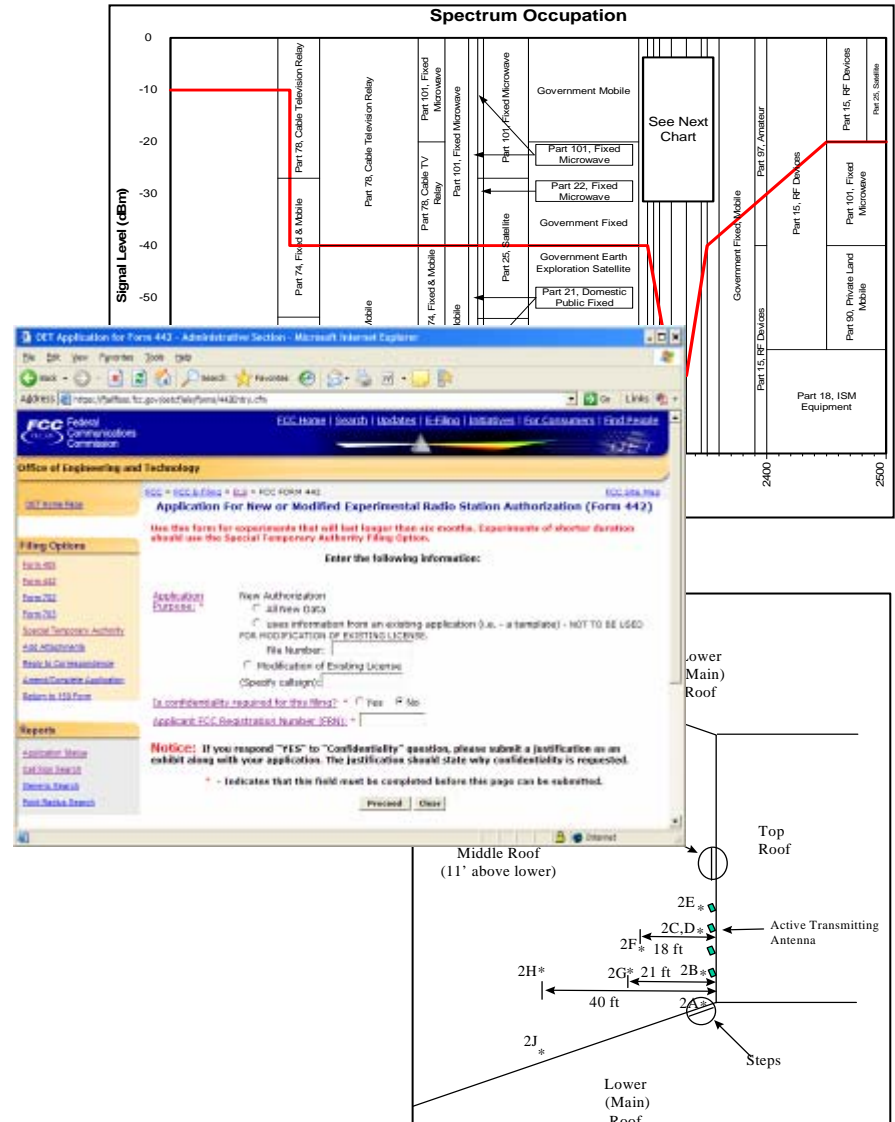


Agilent E6474A



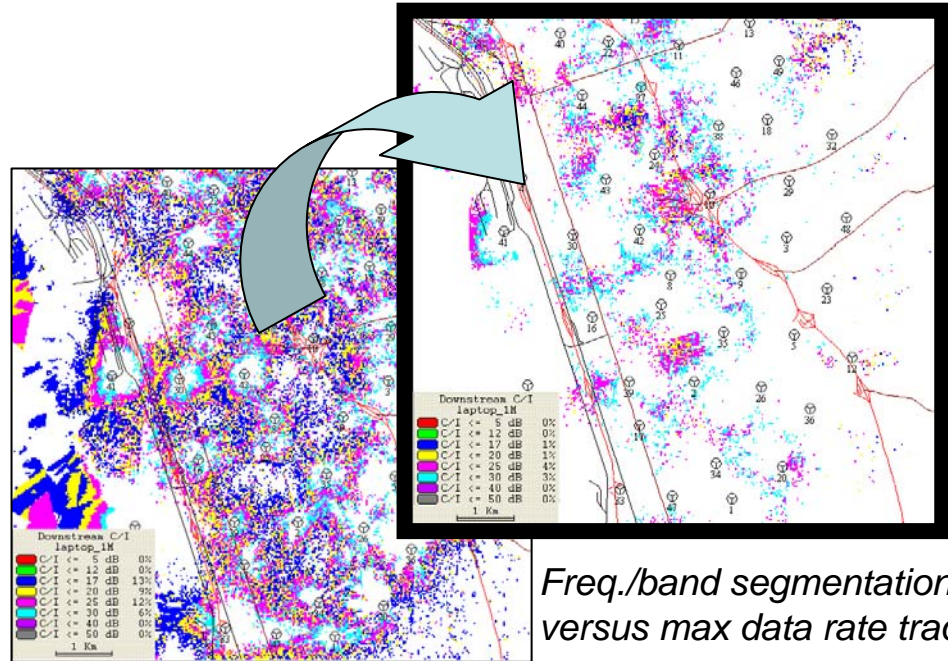
Regulatory Support

- **Regulatory (FAA/FCC) compliance**
 - RF Exposure reports and documentation
 - Interference analysis and mitigation plans
 - International Coordination
 - Adjacent market coordination
 - Rule interpretation
 - E911 accuracy compliance
- **FCC License applications**
 - Experimental
 - Other
- **Permit renewal**
 - Expert testimony



RF Design Tradeoff Studies

- **Capacity enhancements**
 - New sites vs. increased sub-channel segmentation
 - Frequency plan expansion
 - Interference reduction to increase available modulation scheme
- **Co-existence with adjacent networks and/or divergent technologies**
 - Coordination versus additional sites
 - 3.65 GHz licensed band co-existence evaluations of non-contention based air-interfaces in non-exclusive deployments
 - Coordination with FSS



Freq./band segmentation versus max data rate trade

