Planning Fixed Broadband Wireless Access Networks based on WiMAX Technology

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A Case Study on Business Modeling and Planning Process

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LS telcom AG

ITU Regional Seminar on Broadband Wireless Access (BWA) for rural and remote areas for the Asia-Pacific Region

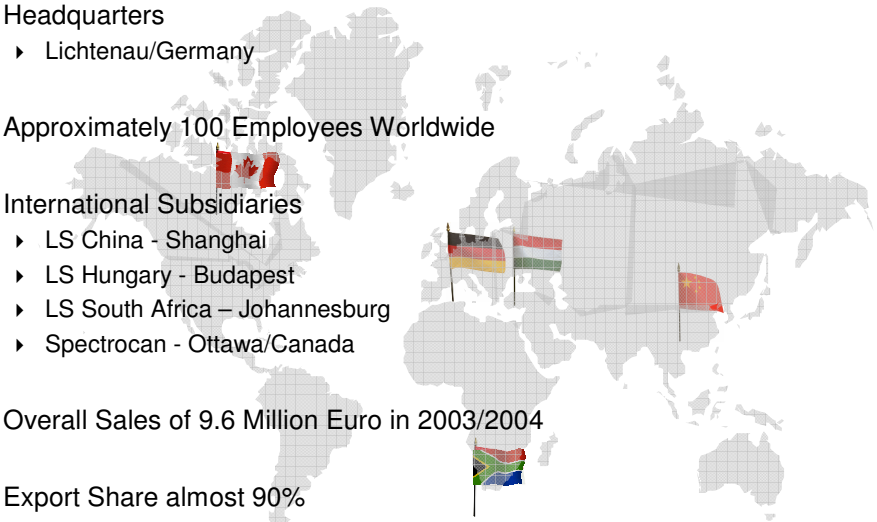
Shenzhen, P. R. China, 1-2 September 2005

Agenda

- Company Introduction
- Case Study
  - Definition of Scenarios
  - Comparison and Selection of Equipment
  - Planning Guideline
  - Tool-based Network Design
  - Results
- Lessons Learned

Short Company Introduction

- Headquarters
  - Lichtenau/Germany
- Approximately 100 Employees Worldwide
- International Subsidiaries
  - LS China - Shanghai
  - LS Hungary - Budapest
  - LS South Africa – Johannesburg
  - Spectrocan - Ottawa/Canada
- Overall Sales of 9.6 Million Euro in 2003/2004
- Export Share almost 90%



Lines of Business

Lines of Business

Spectrum Management Systems

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MULTIlink
- Planning / Coordination of Microwave Services

CHIRplus_LM
- Planning / Coordination of Landmobile Services

SPECTRAemc
- EMC Analysis Tool (9KHz – 100GHz)

CHIRplus_BC
- Planning / Coordination of Broadcasting Services

Other Tools...

SPECTRAplus
Application Processing
- License Procesing
- Equipm. Type Approva

Fee Calculation
- Invoicing
- Bookkeeping

Customized Licensing and Billing Forms
General Reports and Statistics

SPECTRAplus_db
Central Spectrum Management Database Containing all Relevant License Data
- System Administration
- Data Security Management
- Backup

SPECTRAplan
- Spectrum Planning
- Frequency Allocation Plan
- Channel Processing
- ITU Notification

SPECTRAweb
- License Data Entry via Internet
- Generation of Reports
- Display of Statistics

MONITORplus
- Interface to Radiomonitoring Systems
- Analysis of Monitoring Result Files

Radiomonitoring System
Rohde&Schwarz ARGUS, ...

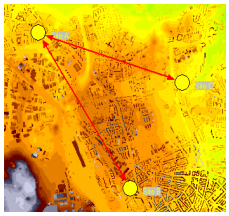
Lines of Business

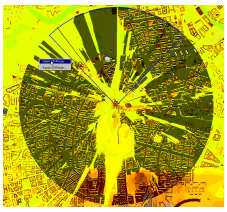
RF Engineering Software Tools

LS telcom

Software for Radio Network Planning and Engineering

- By use of LS telcom's comprehensive software solutions, clients can perform all essential planning, optimisation and management tasks, which there are:
  - Network calculations, dimensioning and analysis
  - Coverage, frequency and traffic planning as well as market opportunity simulations
  - Site planning for base stations; database for existing radio sites
  - Management of sites and network elements
  - Acquisition and maintenance of geo-data
  - Terrain and field-strength profiles





Software for Fast and Cost-Efficient Rollout and Operation of Wireless Networks

Lines of Business – RF Engineering Software Tools

LS telcom

Radio Network Planning Tools

Mobile Networks

Solutions for fast and cost-efficient rollout, operation and optimization of mobile communication networks

- Covers the whole range of mobile network planning aspects
- Multi Technology Support (TETRA, TETRAPOL, 2G, GSM, CDMA,2,5G, 3G, WCDMA)

Microwave Networks

Design tool for microwave links, WLL, PMP, WiMAX

- Interactive link engineering
- Interference analysis
- Channel assignment
- Availability calculation
- Flexible report generation
- Implemented ITU-R recommendations

Broadcast Networks

Design tool for the planning and coordination of analog (FM,TV) and digital (DAB, DVB, DRM) networks

- Frequency selections according to ITU recommendations and plans
- LF/MF and HF frequency coverage

Lines of Business

Engineering Services (Radio Network Planning)

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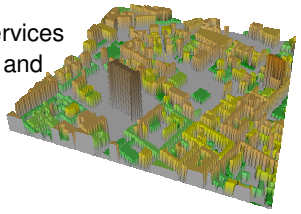
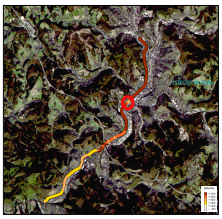
Radio Network Planning and Engineering Services

This comprises all sorts of engineering and planning services relevant to network operators, regulatory organisations and system suppliers, including:



- coverage analysis and studies
- frequency planning & coordination services
- network design (cellular and transmission)
- network implementation
- network optimisation: coverage, interferences, capacity
- geo data: consulting, generation, conversion and acquisition
- project management



Lines of Business

Consulting Services & Training

- Our Consulting Team includes Spectrum Managers and RF Specialists, who have managed Spectrum of various countries and assisted regulators worldwide.
- Several hundred person years of experience and capability in:
  - Feasibility Studies / Expert Surveys
  - Vendor Selection
  - Process / Workflow Development
  - Technical Concepts
  - Radio Policy
  - Frequency Planning
  - Spectrum Operations
  - Automated Tools
  - Radio Monitoring
  - Preparation of Tender Documents

Lines of Business – Consulting Services & Training

Trainings and Seminars

This comprises a wide variety of trainings in the whole field of telecommunications, including:

- Basic- and Expert-seminars for our Software Solutions
- Expert trainings for Radio Network Planning (mobile, microwave, WiMAX…)
- Seminars for Broadcast Planning (RRC04/06, TV, FM, ...DAB, DVB, DRM…)
- Spectrum Management Workshops
- Expert Trainings on Spectrum Monitoring

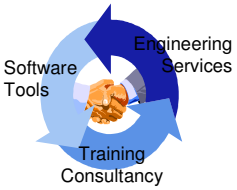
LS TrainingCenter, Germany

AIBD - Asia-Pacific Institute for Broadcasting Development, Malaysia

ITU Centers of Excellence

Why Customers Choose LS telcom?

- More Than 13 Years of Experience in the specific Market
- Successfully Completed Projects at More than 50 Coutries (Regulators and Operators) Wordwide
- Market Leader and Trendsetter in Spectrum Management Solutions
- One-Stop-Company (Consultancy, Software Solutions, Digital Mapping Data, Implementation, Support and After-Sales Services)
- Extensive Human Resources
- Stable and Reliable Partner



Case Study

Planning Fixed Broadband Wireless Access Networks

Case Study: Planning Fixed BWA Networks

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Project Description

- BWA Network to provide fast Internet
- 3,5 GHz band
- Three different Scenarios
  - Scenario 1: Rural Area
  - Scenario 2: Suburban Area
  - Scenario 3: Urban Area
- Basic Business Model and Coverage Criteria

Project Steps

- Definition of the “Scenarios”
- Comparison of available Hardware
- Definition of the Planning Guideline
- Tool-based Network Design

Scenario “Rural Area”

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- Valley, villages
- Lower average income
- Lower penetration of home computers
- Fewer business
- No DSL via cable available

- Residential-dominated market
- Outdoor coverage (using outdoor antenna)
- Large cell sizes
- Existing core network / microwave link for backhaul
- Data Rate: >1.0 Mbit/s

Scenario “Suburban Area”

- Valley, medium-sized city
- Average income
- Medium penetration of home computers
- Small business
- Partly cable or DSL, limited competition

- Residential & small business market
- Outdoor coverage (using outdoor antenna) dominant
- Medium cell sizes
- Extension (more capacity) of existing core network necessary
- Data Rate: >2.5 Mbit/s 40%
  >1.0 Mbit/s: 60%

Scenario “Urban Area”

- Major city, high-rise buildings
- Many potential WiMAX customers
- High penetration of home computers
- Many business users
- Cable or DSL available, strong competition

- Residential & business market
- Indoor coverage dominant
- Small cell sizes
- Extension (more capacity) of existing or new core network necessary
- Data Rate: >2.5 Mbit/s 60%
  >1.0 Mbit/s: 40%

Hardware Comparison & Selection

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- Technical Data Base Stations

Vendor	Vendor 1	Vendor 2	Vendor 3
Multiple access scheme	CDMA (MC-SCDMA)	PPMA	256 FFT OFDM / TDMA
Duplex Mode	TDD	TDD/FDD	HD- FDD/TDD
Ausgangsleistung	max. 47 dBm (EIRP)	max. 27 dBm	max. 33 dBm
Bandbreite	5 Mhz, 10 x 500 kHz sub-channels	1 MHz sub-channel spacing	3,5 / 7 / 14 MHz channel spacing
Antennengewinn	max. 17 dBi	max. 18 dBi (15°-Antenne)	max. 12 dBi (60°-Antenne)
Modulationsarten	QPSK / 8BPSK / 16 QAM	2 / 4 / 8 CPFSK	BPSK, QPSK, 6QAM, 64QAM
max. Kapazität pro Sektor (5 MHz)	4.2 Mbit/s (16 QAM)	4 Mbit/s	35 Mbit/s (64QAM)
max. Sektoranzahl pro BS	3	24 BSRs	12

...

- Technical Data User Terminals

Vendor	Vendor 1	Vendor 2	Vendor 3
Output Power	31 dBm (EIRP)	27 dBm	20 dBm
Antenna Gain	6 dBi	max. 18 dBi /externe Antenne	max. 6 dBi (internal; integrated)
Bandwidth	5Mhz, 10x500 kHz sub-channels	1 MHz sub-channel spacing	3,5 MHz channel spacing
Modulation	QPSK	2 / 4 / 8 CPFSK	BPSK, QPSK, 16QAM, 64QAM
Capaity (max.)	2,2 Mbit/s (QPSK)	4 Mbit/s (8CPFSK)	13,1 Mbit/s (3,5 MHz,FDD)

...

Hardware Comparison & Selection

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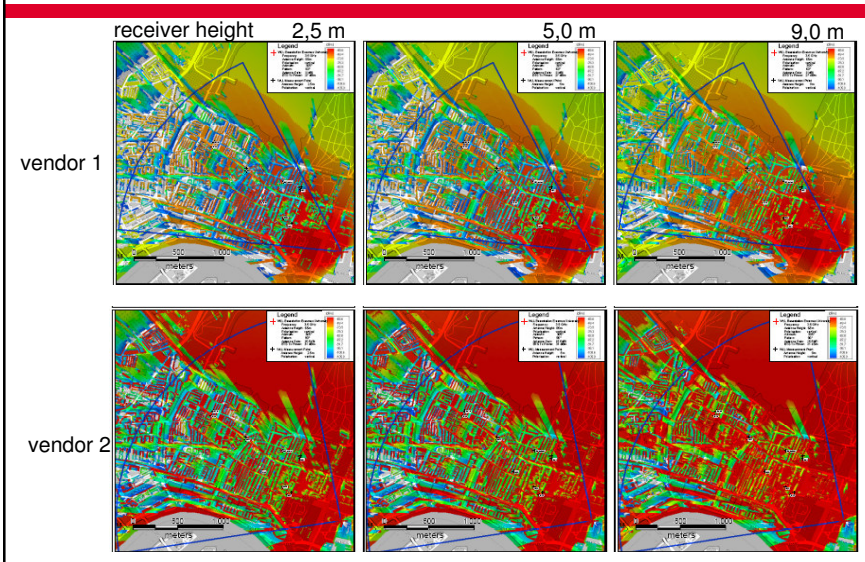
	Vendor valuation ratios		
			Sum
4	**Analysis of the Technical Data (Data Sheet) for vendor: _____**		1500
4.1	Base-Station and Terminal Output-Power	200	
4.2	Antenna Pattern , Gain, F/B Ratio	200	
4.3	Link Budget	100	
4.4	Carrier to Interference Ratio (C/I)	100	
4.5	Carrier to Noise Ratio (C/N)	100	
4.6	Base-Station, Receiver Sensitivity	100	
4.7	Throughput, Terminal per cell	200	
4.8	Type of Terminal	100	
4.9	Transmitting / Modulation System	100	
4.10	Availability	100	
4.11	Power Consumption	100	
4.12	Mechanical Size Base – Station / Terminal	100	
5	**Coverage calculation for vendor: _____**		1500
5.2	Coverage plot for 2.5 m receiver height	500	
5.3	Coverage plot for 5 m receiver height	500	
5.4	Coverage plot for 9 m receiver height	500	
6	**Analysis of Measurements field test for vendor: _____**		7000
6.3	Fieldstrength depending of the Distance and max. link distance	1500	
6.4	Throughput	2000	
6.5	Influence of Load	1500	
6.6	System Performance	1000	
6.7	System - Stability	1000	
			10000

Hardware Comparison & Selection



Hardware Comparison & Selection

Results (for suburban scenario):

9. Vendor valuation matrix

			Vendor			
		Sum (max)	1	2	3	4
4	**Analysis of the Technical Data**					
4.X.1	Base-Station and Terminal Output-Power	200	150,00	130,00	80,00	180,00
4.X.2	Antenna Pattern , Gain, F/B Ratio	200	70,00	100,00	150,00	190,00
4.X.3	Link Budget	100	60,00	80,00	60,00	80,00
4.X.4	Carrier to Interference Ratio (C/I)	100	50,00	70,00	50,00	70,00
4.X.5	Carrier to Noise Ratio (C/N)	100	60,00	70,00	60,00	70,00
4.X.6	Base-Station, Receiver Sensitivity	100	50,00	90,00	50,00	90,00
4.X.7	Throughput, Terminal per cell	200	150,00	80,00	130,00	130,00
4.X.8	Type of Terminal	100	60,00	80,00	60,00	80,00
4.X.9	Transmitting / Modulation System	100	50,00	80,00	40,00	80,00
4.X.10	Availability	100	-	-	-	-
4.X.11	Power Consumption	100	60,00	60,00	60,00	40,00
4.X.12	Mechanical Size Base – Station / Terminal	100	60,00	60,00	60,00	60,00
5	**Coverage calculation**					
5.X.2	Coverage plot for 2.5 m receiver height	500	200,00	420,00	200,00	420,00
5.X.3	Coverage plot for 5 m receiver height	500	250,00	440,00	250,00	440,00
5.X.4	Coverage plot for 9 m receiver height	500	300,00	450,00	300,00	450,00
6	**Analysis of Measurements**					
6.X.3	Fieldstrength depending of the Distance and max. link	1500	800,00	1000,00	700,00	1500,00
6.X.4	Throughput	2000	1400,00	1400,00	1600,00	1500,00
6.X.5	Influence of Load	1500	1300,00	100,00	1300,00	1300,00
6.X.6	System Performance	1000	600,00	600,00	500,00	950,00
6.X.7	System - Stability	1000	800,00	100,00	800,00	990,00
	Sum:	**10000**	**6470**	**5410**	**6450**	**8620**

System Crash with increasing cell load

Measurement Points probably not in the main beam of the antenna elevation pattern. (MP to close to the BS)

System became instable when the number of connections in the cell has been increased

Hardware Comparison & Selection

Different scenarios

Different requirements

Different business cases

One equipment type will not be the winner for all scenarios

Each scenario could have his „own“ favourite equipment

Planning Guideline
WiMAX Network Planning Issues

Sufficiently high Reliability and Accuracy of the Prediction required

- To decide whether service can be provided at all
- To distinguish between various service classes

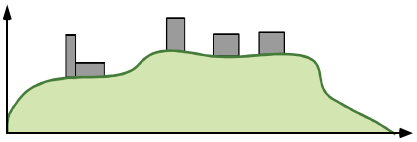
Under the constrains

- Often NLOS radio channels
  - Prediction of received signal levels (wanted and interferer) extremely difficult and require expensive 3D terrain and building data
- Different user terminals in use
  - Indoor (quasi omni antenna)
  - User mounted antenna at window (directive antenna)
  - (Roof antenna)

Planning Guideline Parameters

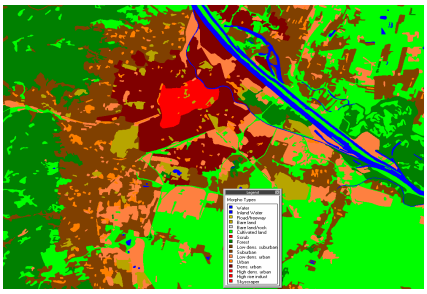
Rural Area

- Based on existing sites
- Antenna height: 20m above ground
- Receiver height: 2.5 / 5.0 / 9.0 m



Medium Resolution Data (25m / 50m)
based on 2 different files:

- Digital Terrain Model, elevation of earth-surface
- Digital Clutter Model, describing land use above terrain
- Provide no building heights



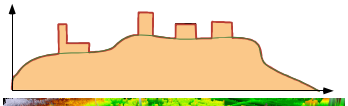
Deterministic or empirical prediction model

Planning Guideline Parameters

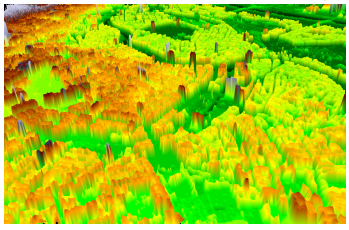
Suburban and Urban Area

- "greenfield" planning, fictive sites
- Antenna height: 3m above rooftop
- Receiver height: 2.5 / 5.0 / 9.0 m

High Resolution Data (1m / 5m)



- Digital Elevation Model, elevation of earth surface + building heigths
- Sat-Image, 1m resolution
- Provide details of buildings



Deterministic, empirical prediction model or 3D ray-tracing model

Planning Guideline

Based on the system data of the selected equipment, the link budgets for the different scenarios

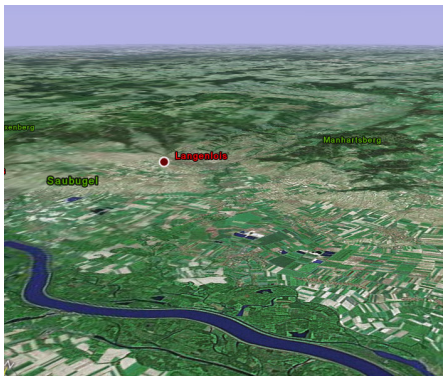
- rural, suburban, urban
- outdoor, indoor
- data rate

have been generated

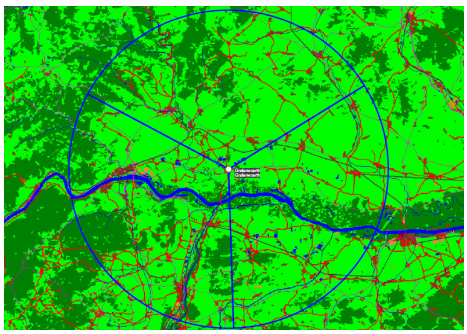
Linkbilanz	3.5 GHz / 2.5 Mbit/s / Indoor		
Downlink		**Uplink**	
Sender (WLL Basisstation)		**Sender (WLL Terminal)**	
Max. Sendeleistung	1600,0 mW	Max. Sendeleistung	316,0 mW
Anzahl parallel genutzter Codes	200,0	Anzahl parallel genutzter Codes	30,0
Max Sendeleistung pro Code	8,0 mW	Max Sendeleistung pro Code	10,5 mW
Max. Sendeleistung pro Code in dBm	9,0 dBm	Max. Sendeleistung pro Code in dBm	10,2 dBm
Kabelverluste	2,0 dB	Kabelverluste	0,0 dB
Antenna Gain	17,0 dB	Antenna Gain	6,0 dB
EIRP pro Code	24,0 dBm	EIRP pro Code	16,2 dBm
Empfänger (WLL Terminal)		**Empfänger (WLL Basisstation)**	
Rauschdichte Thermisches Rauschen	-174,0 dBm/Hz	Rauschdichte Thermisches Rauschen	-174,0 dBm/Hz
Rauschzahl Empfänger	5,0 dB	Rauschzahl Empfänger	5,0 dB
Rauschdichte Empfänger	-169,0 dBHz	Rauschdichte Empfänger	-169,0 dBHz
Effektive Bandbreite pro Subcarrier	400,0 kHz	Effektive Bandbreite pro Subcarrier	400,0 kHz
Rauschleistung am Empfänger	-113,0 dBm	Rauschleistung am Empfänger	-113,0 dBm
Noise Rise (50% Zellast)	3,0 dB	Noise Rise (50% Zellast)	3,0 dB
Interferenzleistung am Empfänger	-113,0 dBm	Interferenzleistung am Empfänger	-113,0 dBm
Rauschen + Interferenz Empfänger	-110,0 dBm	Rauschen + Interferenz am Empfänger	-110,0 dBm
Spreizfaktor	32	Spreizfaktor	32
Processing Gain	15,1 dB	Processing Gain	15,1 dB
benötigtes Eb/N0	6,0 dB	benötigtes Eb/N0	6,0 dB
Min. Empfangspegel	-119,0 dBm	Min. Empfangspegel	-119,0 dBm
Antennengewinn	6,0 dBi	Antennengewinn	17,0 dBi
Kabelverluste	0,0 dB	Kabelverluste	2,0 dB
Max. Funkfelddämpfung (50%)	149,1 dB	Max. Funkfelddämpfung (50%)	190,3 dB
Zuschlag Versorgungswahrsch. 95 %	12,0 dB	Zuschlag Versorgungswahrsch. 95 %	12,0 dB
Reflektionsdämpfung	9,0 dB	Reflektionsdämpfung	9,0 dB
Gebäudedämpfung	20,0 dB	Gebäudedämpfung	20,0 dB
Designwert Funkfelddämpfung (95 %)	190,1 dB	Designwert Funkfelddämpfung (95 %)	190,3 dB
Maximale Linklänge	1,733 km	Maximale Linklänge	1,990 km

Vendor	Vendor 1	Vendor 2	Vendor 3
Indoor 2,5 Mbit/s	1480 m	140 m	1120 m
Indoor 1,0 Mbit/s	1890 m	170 m	1360 m
Outdoor 2,5 Mbit/s	18400 m	2600 m	19600 m

Network Design Rural Scenario



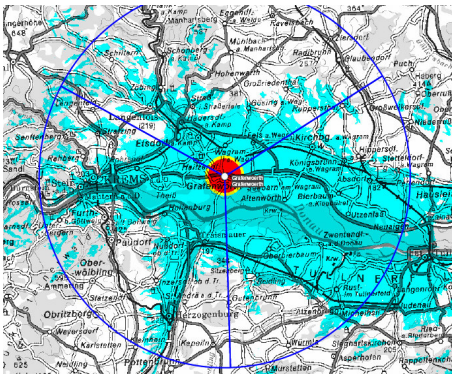
- 1 Base Station
- 3 Sectors, 3 Channels
- Microwave link as backhault



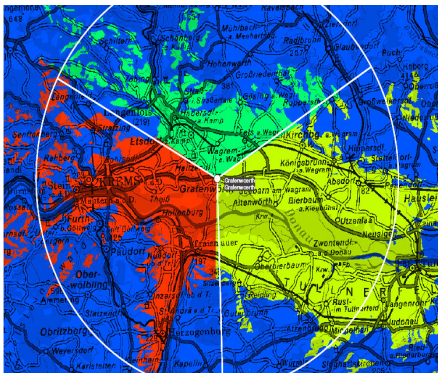
Network Design Rural Scenario

- Rural Area

Coverage Plot



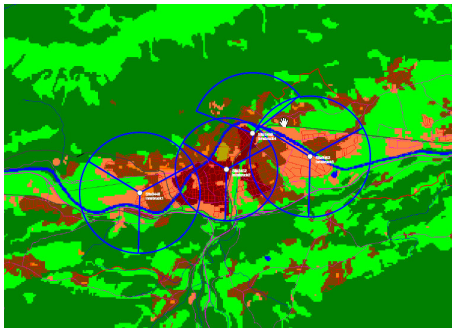
Best Server



blue: outdoor 1Mbit/s
yellow: indoor 1Mbit/s
red: indoor 2,5 Mbit/s

Network Design Suburban Scenario

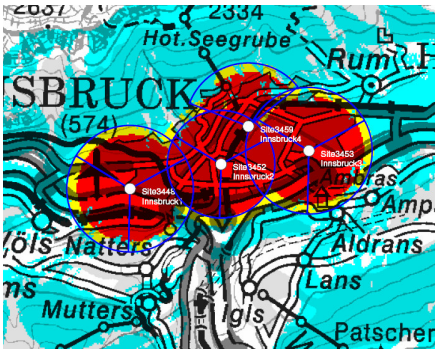
- 4 Base Station
- 10 Sectors



Network Design
Suburban Scenario

Suburban Area

Coverage Plot



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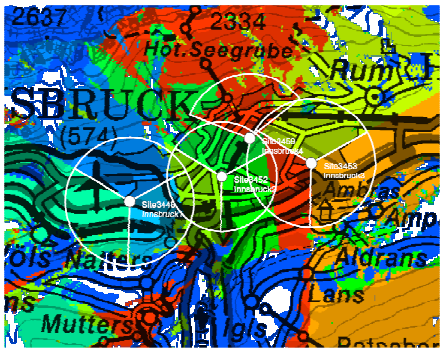
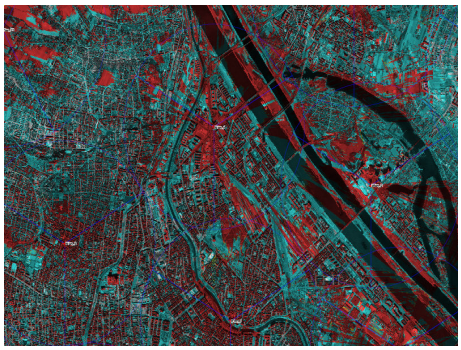


blue: outdoor 1Mbit/s
yellow: indoor 1Mbit/s
red: indoor 2,5 Mbit/s

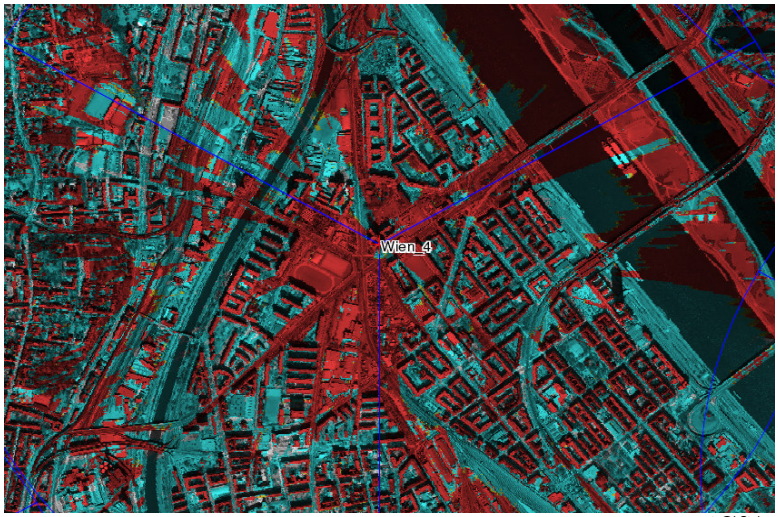
Network Design
Urban Scenario

- 24 Base Station
- 72 Sectors



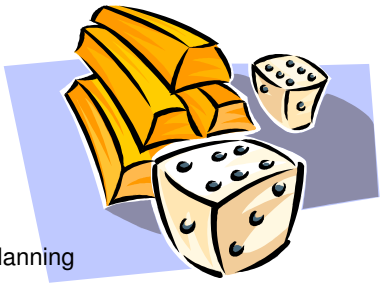
Network Design
Urban Scenario

- Zoom In



Results

- 3 scenarios have been defined
- For each scenario the following tasks have been done:
  - Development of basic business plan
  - Definition of the planning guideline
    - Link budgets
    - Terrain data sets
    - Calculations algorithms
    - Planning procedure
  - Selection of the hardware
  - Network design
  - Creation of input data for business case planning
    - Number of base stations
    - Covered area
    - Necessary bandwidth
    - Services to be offered



Results

- Exact statement whether a NLOS subscriber can be reached with a defined quality of service is extremly difficult and requires highest standar on terrain data and planning algorithms
- Basic LOS and NLOS analysis allows rough statement about subscriber coverage

- Different scenarios (environments) need different business cases
- The „rural scenario“, has lowest investment, a short payback period, low competition -> reduced investment risk
- Selected cherry-pick-regions could be used by new operators to build up qualitiy standards, operation concepts, reputation in a low risk environment (technical & finacial)

Thank you for your attention !

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