3G Radio Network Planning for a Mobile Network Operator

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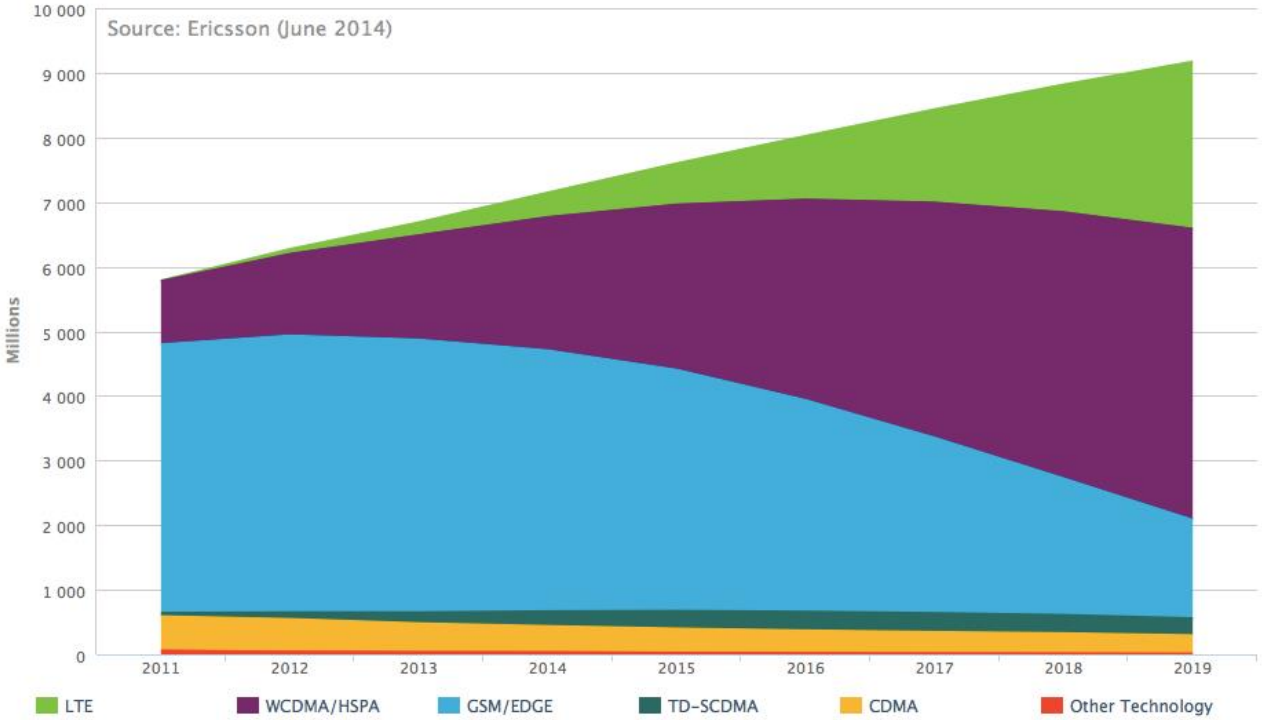
Agenda

- Motivation
- Objectives
- 3G Radio Network Planning
- Optimization Process
- Conclusions

Motivation

- By the end of 2019, 3G networks will represent 50% of worldwide mobile subscriptions



Motivation

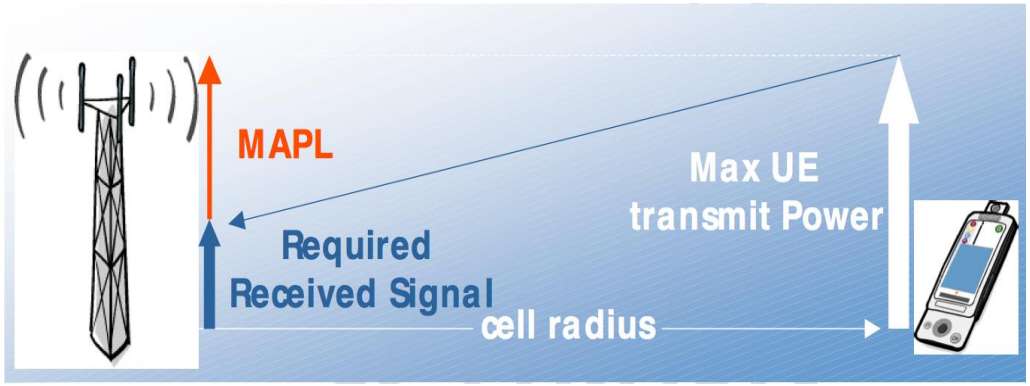
- Africa is one of the continents still dominated by 2G networks (90% of mobile subscriptions)
- By the end of 2013 Africa didn't have more than 100 million 3G subscribers
- The rising middle class and the introduction of new low cost Smartphones increased the need for a more robust and evolved network
- It is expected that by the end of 2019 the total 3G subscribers in Africa rise 600%

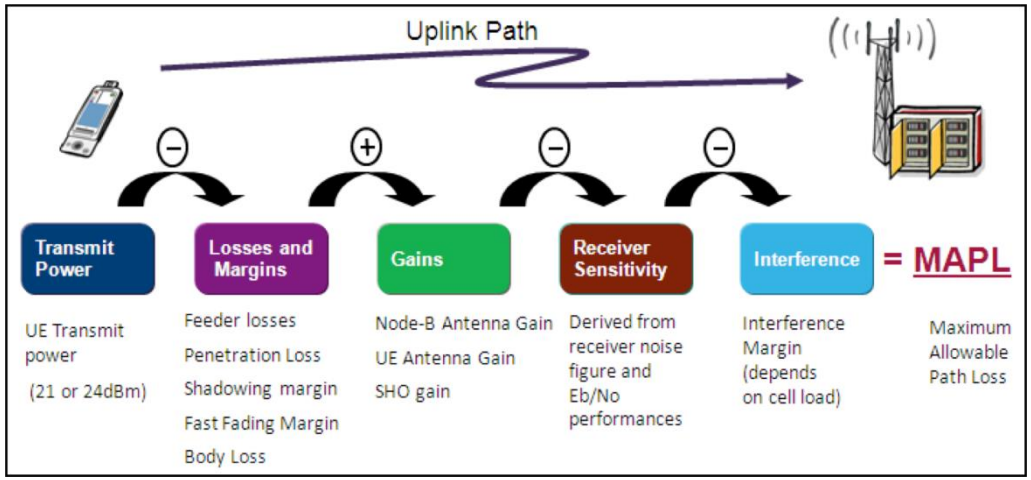
Objectives

- Provide a 3G Radio Network Planning (RNP) for a mobile operator in Cameroon
- Make predictions of coverage area by service, quality and interference based on the 2G network configurations (location of the sites and tilts)
- Optimize the network configurations to the new 3G network
- Further optimize the network to achieve the Alcatel-Lucent and the customer requirements

3G Radio Network Planning

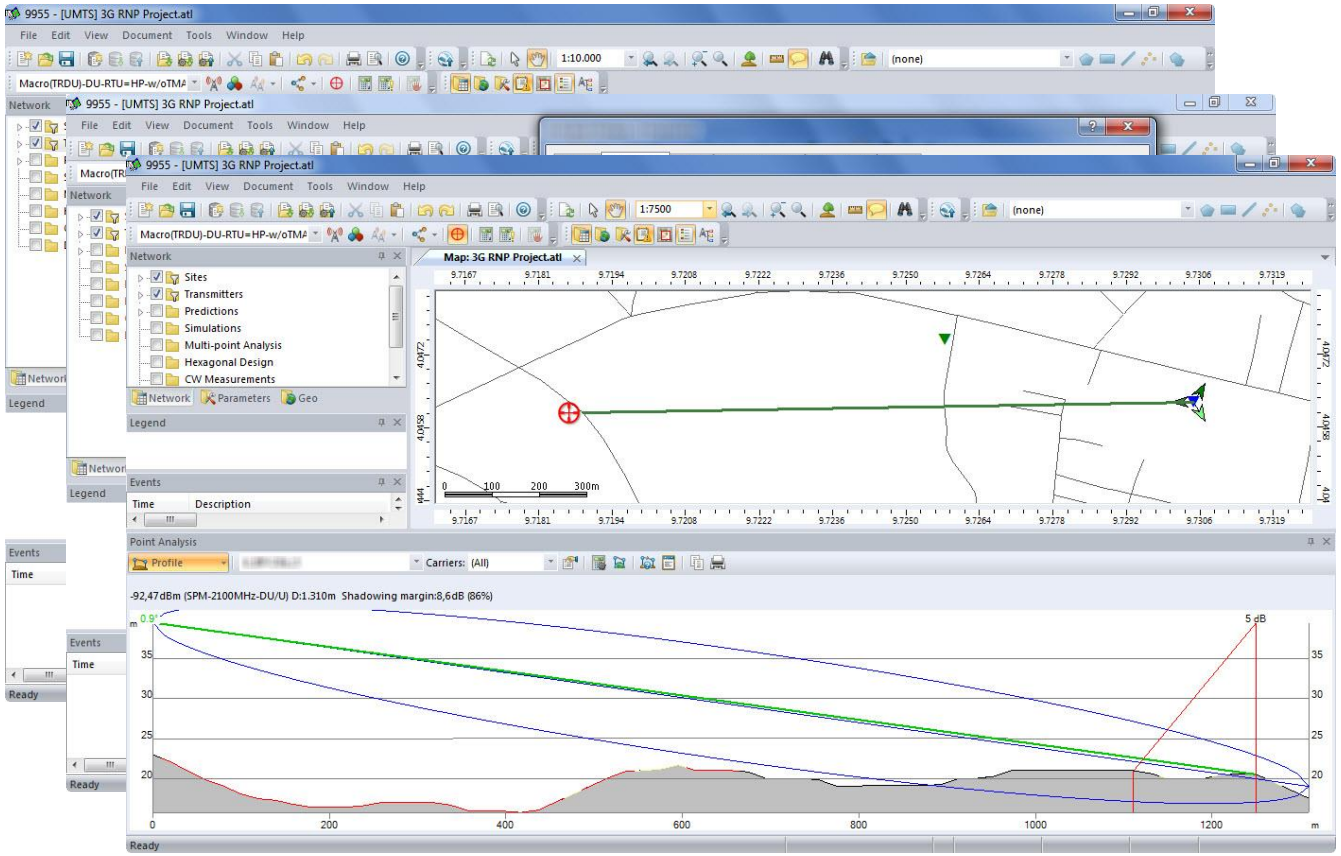
- Alcatel-Lucent Link Budget Tool





3G Radio Network Planning

- Alcatel-Lucent A9955 Tool



3G Radio Network Planning

- Alcatel-Lucent A9955 Tool
  - The propagation model adopted in the project was the Standard Propagation Model (SPM)
  - Is suited for predictions between 150 to 3500MHz over long distances
- SPM is given by the following formula:

$$P_R = P_{TX} - \left(\begin{array}{c} K_1 + K_2 \cdot \log d + K_3 \cdot \log H_{TX_{eff}} + K_4 \cdot DiffractionLoss + K_5 \cdot \log d \cdot \log H_{TX_{eff}} + \\ K_6 \cdot H_{RX_{eff}} + K_7 \cdot \log H_{RX_{eff}} + K_{clutter} \cdot f(clutter) + K_{hill,LOS} \end{array} \right)$$

3G Radio Network Planning

- Inputs and Assumptions

City	Total Sites	2G Only Sites	2G / 3G Sites
Douala	218	83	135
Yaoundé	180	75	105
Rest of the country	135	92	43
Total	533	250	283

NodeB Parameters	
Selected PA Type	60 W - RRH
NodeB RTU Power Step	20 W
Max NodeB Tx Power	43,0 dBm

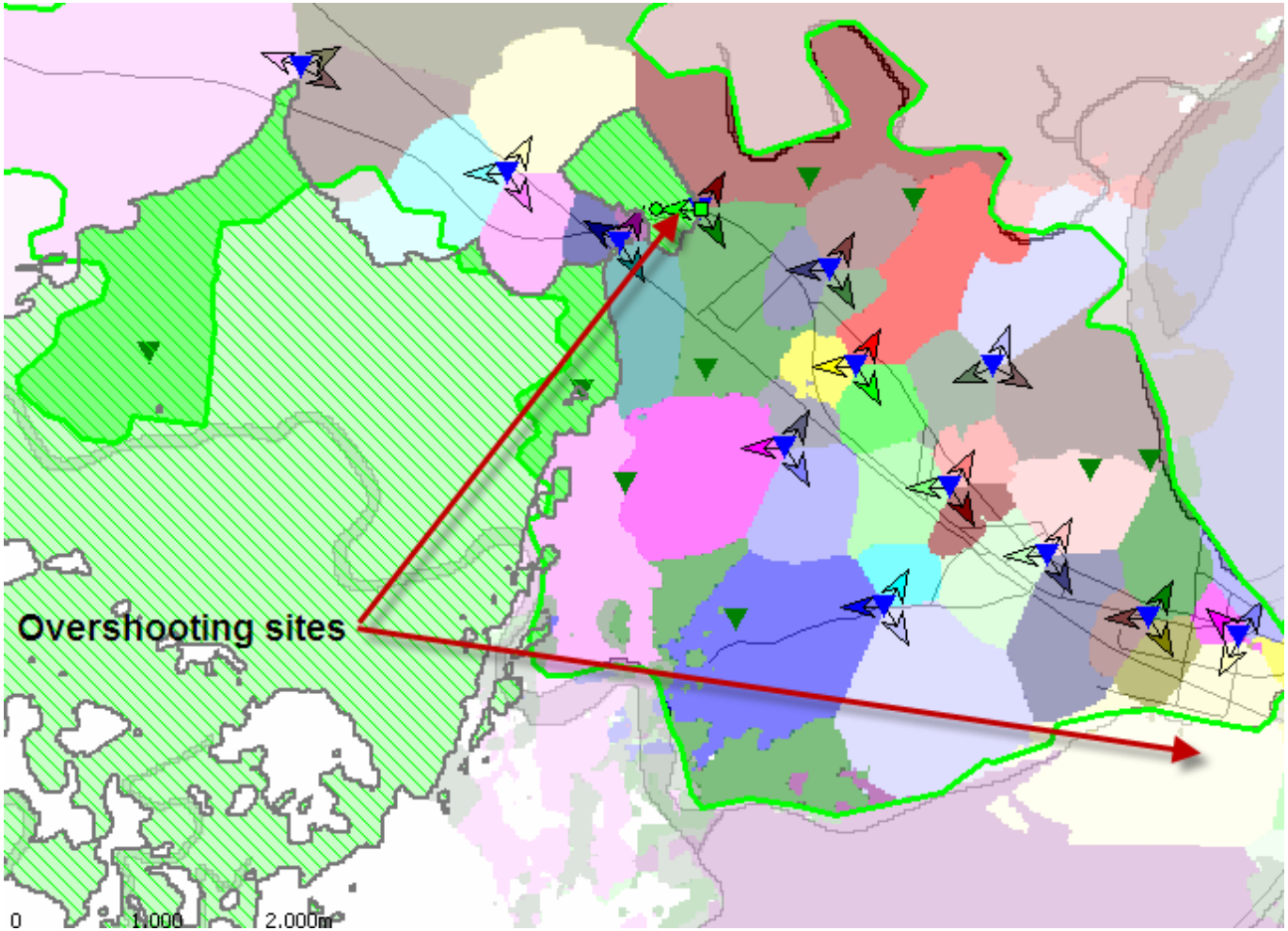
CPICH EiRP	
Max NodeB power	43 dBm
% CPICH Power	10%
CPICH Power	33 dBm
CPICH EiRP w/o TMA	50,6 dBm

Signal Coverage Color Scheme
Dense Urban (Deep Indoor)
Urban (Daylight Indoor)
Incar
Outdoor
Rest

3G Radio Network Planning

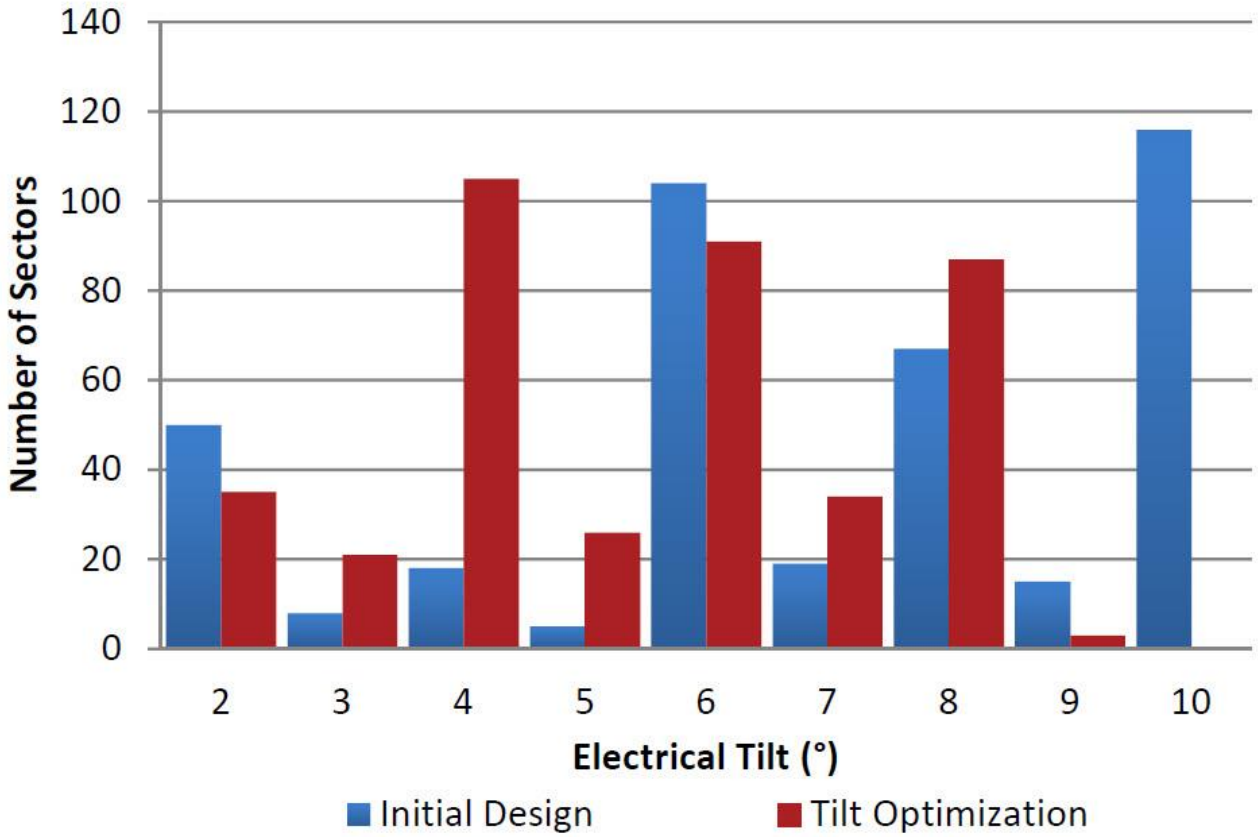
- Design Project Goals
  - Alcatel-Lucent design goals:
    - 95% covered area with outdoor RNP design level in PS128 service
    - 95% coverage area with Ec/I0 value of -15dB
    - Less than 2% of covered area with 4 servers within 4dB of the best server
  - Customer design goals:
    - 95% covered area with outdoor RNP design level in PS128 & HSDPA 2Mbps service
    - 70% covered area with urban RNP design level in PS128 & HSDPA 2Mbps service

Optimization Process



Tilt Optimization Phase

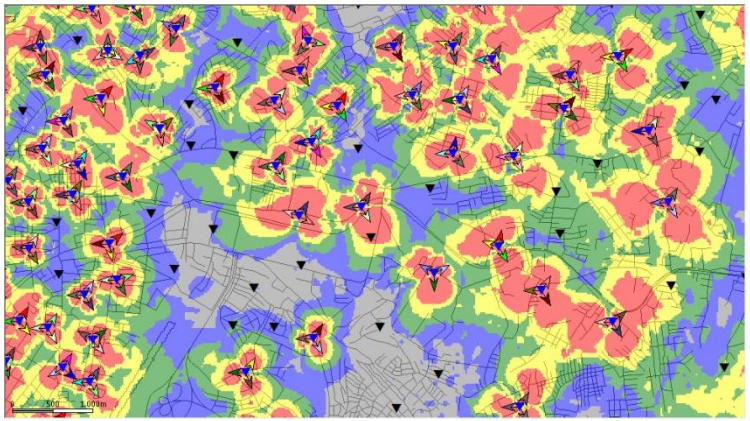
- Tilt optimization phase



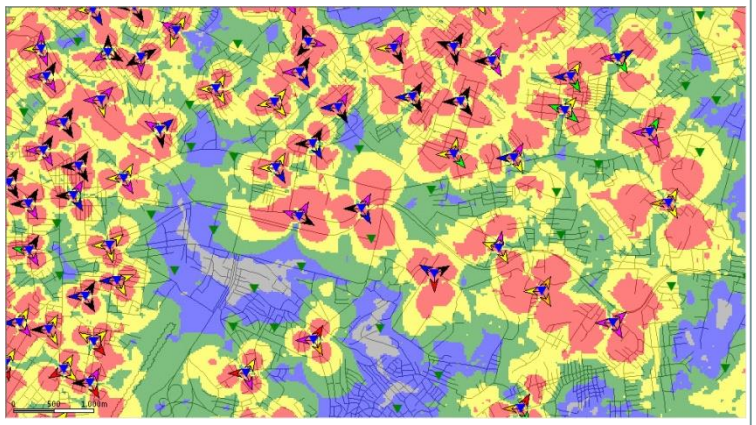
Tilt Optimization Phase

- PS128 & HSDPA 2Mbps Coverage Prediction

Initial Design



Tilt Optimization



Initial Design	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	18,5	40,082
Best Signal Level (dBm) ≥ -74,45	40,6	87,9144
Best Signal Level (dBm) ≥ -81,45	66,5	144,0924
Best Signal Level (dBm) ≥ -89,45	91	197,0208
Best Signal Level (dBm) ≥ -110	100	216,5188

Tilt Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	20,8	45,0452
Best Signal Level (dBm) ≥ -74,45	46,2	100,1504
Best Signal Level (dBm) ≥ -81,45	72,8	157,7644
Best Signal Level (dBm) ≥ -89,45	94,4	204,4764
Best Signal Level (dBm) ≥ -110	100	216,5188

Tilt Optimization Phase

Motivation

Objectives

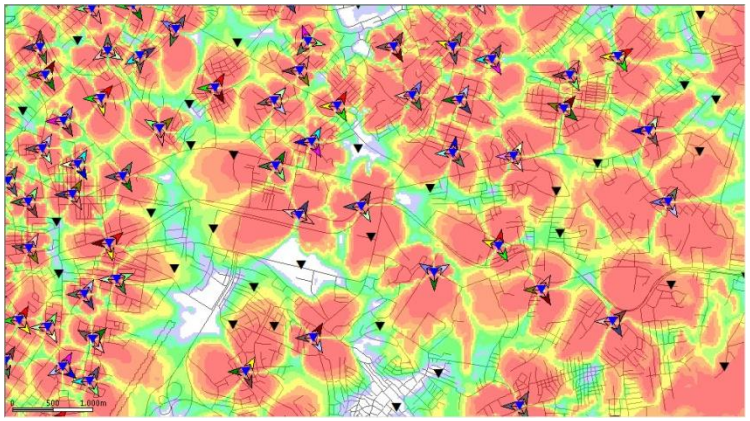
3G RNP

Optimization Process

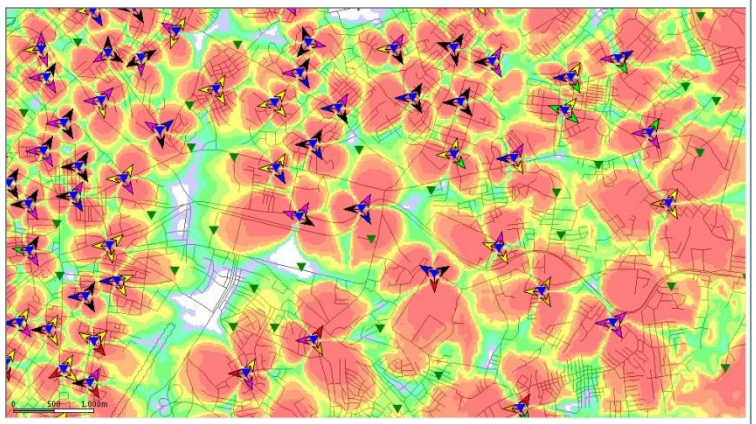
Conclusions

- PS128 Pilot Quality Prediction

Initial Design



Tilt Optimization



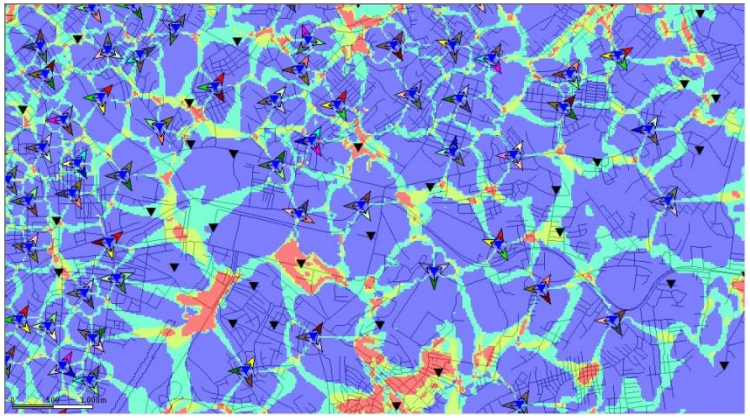
Inital Design	% Focus Zone Surface (km²)	
	98,2	212,8124
Ec/I0 (dB) ≥ -8	30,8	66,8236
Ec/I0 (dB) ≥ -9	46,3	100,2276
Ec/I0 (dB) ≥ -10	59,2	128,32
Ec/I0 (dB) ≥ -11	73,3	158,726
Ec/I0 (dB) ≥ -12	84,4	182,8644
Ec/I0 (dB) ≥ -13	91,9	199,116
Ec/I0 (dB) ≥ -14	96,3	208,5684
Ec/I0 (dB) ≥ -15	98,2	212,8124

Tilt Optimization	% Focus Zone Surface (km²)	
	98,8	214,1232
Ec/I0 (dB) ≥ -8	30	64,984
Ec/I0 (dB) ≥ -9	46,5	100,7204
Ec/I0 (dB) ≥ -10	60,6	131,234
Ec/I0 (dB) ≥ -11	74,5	161,4596
Ec/I0 (dB) ≥ -12	85,3	184,6708
Ec/I0 (dB) ≥ -13	92,7	200,7492
Ec/I0 (dB) ≥ -14	96,9	209,9544
Ec/I0 (dB) ≥ -15	98,8	214,1232

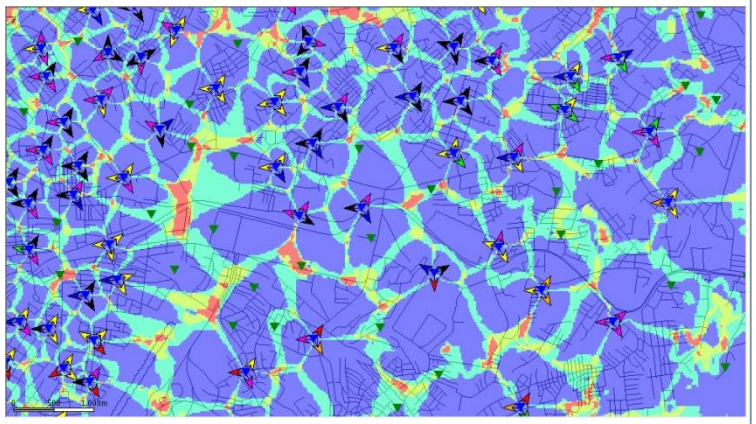
Tilt Optimization Phase

- Overlapping Areas 4dB Criteria

Initial Design



Tilt Optimization



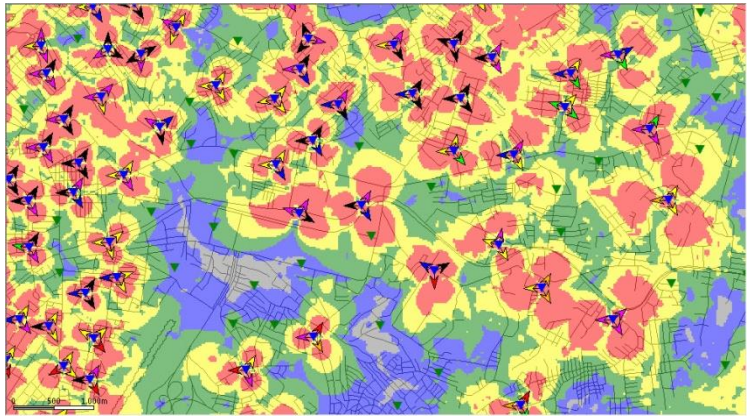
Initial Design	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	3,5	7,636
Number of Servers ≥ 3	10,4	22,582
Number of Servers ≥ 2	32,8	70,9928
Number of Servers ≥ 1	100	216,5188

Tilt Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	1,9	4,1136
Number of Servers ≥ 3	8,1	17,5552
Number of Servers ≥ 2	30,2	65,4936
Number of Servers ≥ 1	100	216,5188

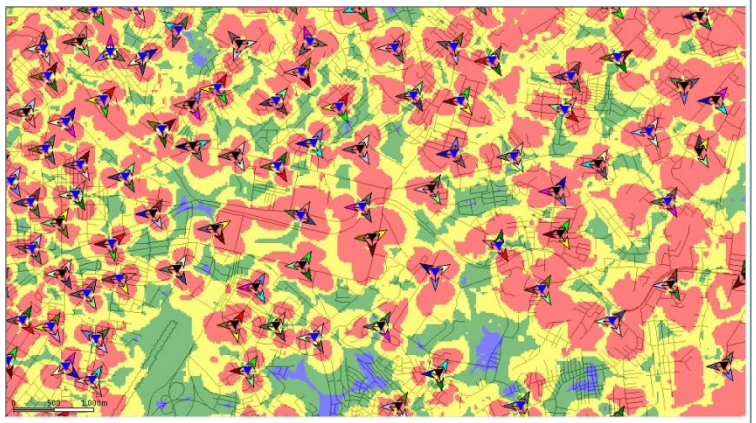
New Sites Proposal

- PS128 & HSDPA 2Mbps Coverage Prediction

Tilt Optimization



New Sites Proposal



Tilt Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	20,8	45,0452
Best Signal Level (dBm) ≥ -74,45	46,2	100,1504
Best Signal Level (dBm) ≥ -81,45	72,8	157,7644
Best Signal Level (dBm) ≥ -89,45	94,4	204,4764
Best Signal Level (dBm) ≥ -110	100	216,5188

New Sites Proposal	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	32,6	70,6008
Best Signal Level (dBm) ≥ -74,45	63,6	137,8568
Best Signal Level (dBm) ≥ -81,45	85,7	185,6224
Best Signal Level (dBm) ≥ -89,45	97,6	211,4736
Best Signal Level (dBm) ≥ -110	100	216,5188

New Sites Proposal

Motivation

Objectives

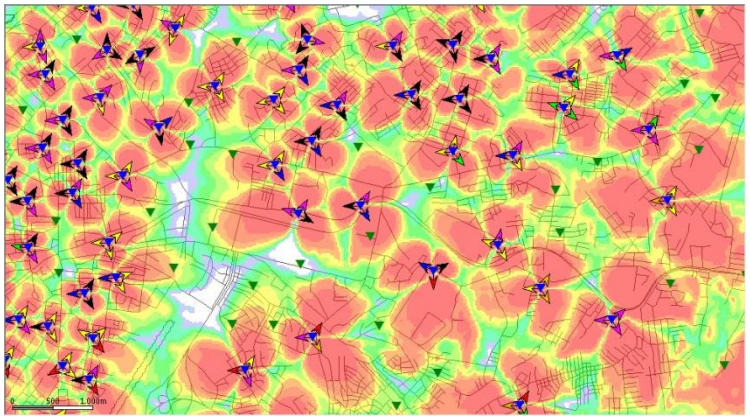
3G RNP

Optimization Process

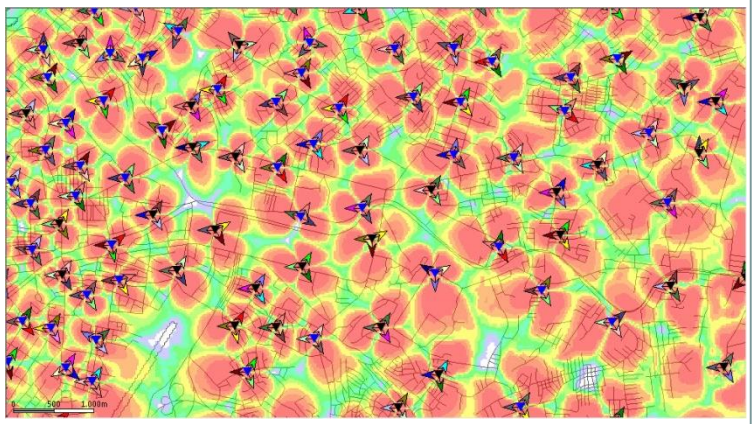
Conclusions

- PS128 Pilot Quality Prediction

Tilt Optimization



New Sites Proposal



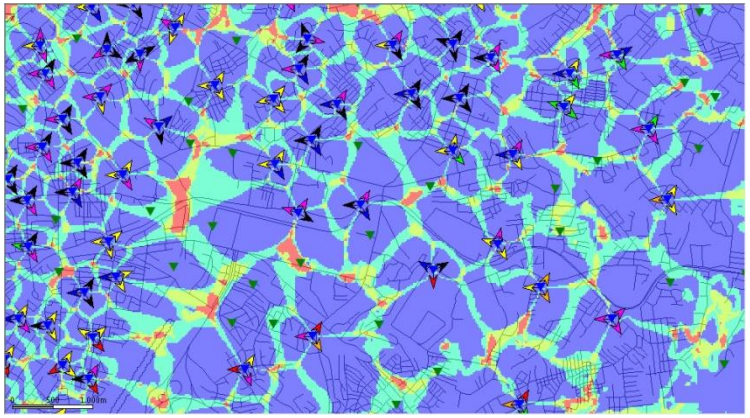
Tilt Optimization	% Focus Zone Surface	(km²)
	98,8	214,1232
Ec/I0 (dB) ≥ -8	30	64,984
Ec/I0 (dB) ≥ -9	46,5	100,7204
Ec/I0 (dB) ≥ -10	60,6	131,234
Ec/I0 (dB) ≥ -11	74,5	161,4596
Ec/I0 (dB) ≥ -12	85,3	184,6708
Ec/I0 (dB) ≥ -13	92,7	200,7492
Ec/I0 (dB) ≥ -14	96,9	209,9544
Ec/I0 (dB) ≥ -15	98,8	214,1232

New Sites Proposal	% Focus Zone Surface	(km²)
	99	214,4516
Ec/I0 (dB) ≥ -8	30,1	65,2312
Ec/I0 (dB) ≥ -9	48	103,9096
Ec/I0 (dB) ≥ -10	61,9	134,0752
Ec/I0 (dB) ≥ -11	76	164,5296
Ec/I0 (dB) ≥ -12	86,7	187,7072
Ec/I0 (dB) ≥ -13	93,7	203,0356
Ec/I0 (dB) ≥ -14	97,3	210,7644
Ec/I0 (dB) ≥ -15	99	214,4516

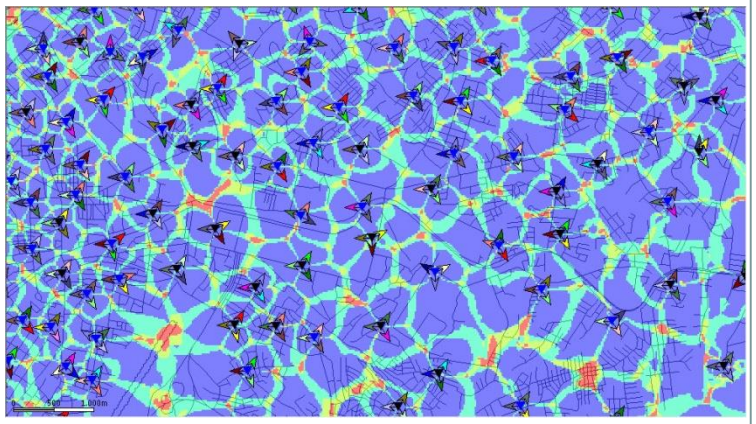
New Sites Proposal

- Overlapping Areas 4dB Criteria

Tilt Optimization



New Sites Proposal



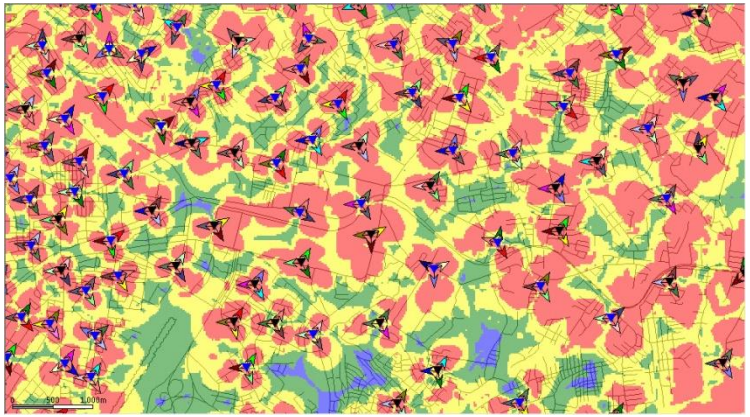
Tilt Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	1,9	4,1136
Number of Servers ≥ 3	8,1	17,5552
Number of Servers ≥ 2	30,2	65,4936
Number of Servers ≥ 1	100	216,5188

New Sites Proposal	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	1,9	4,2204
Number of Servers ≥ 3	7,3	15,8804
Number of Servers ≥ 2	28,9	62,6196
Number of Servers ≥ 1	100	216,5188

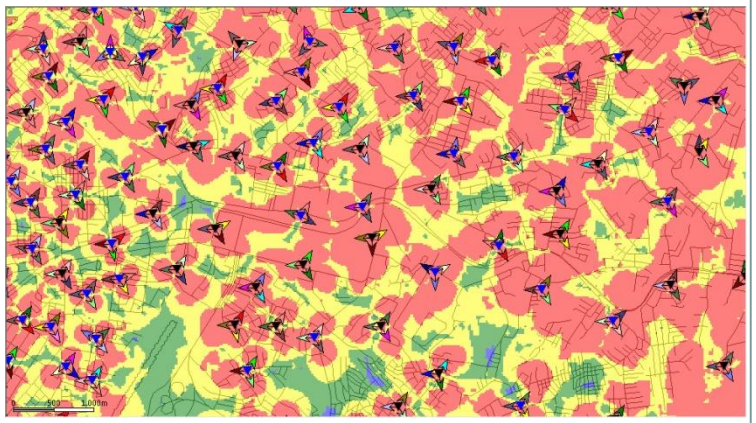
Power Optimization Phase

- PS128 & HSDPA 2Mbps Coverage Prediction

New Sites Proposal



Power Optimization



New Sites Proposal	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	32,6	70,6008
Best Signal Level (dBm) ≥ -74,45	63,6	137,8568
Best Signal Level (dBm) ≥ -81,45	85,7	185,6224
Best Signal Level (dBm) ≥ -89,45	97,6	211,4736
Best Signal Level (dBm) ≥ -110	100	216,5188

Power Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Best Signal Level (dBm) ≥ -67,56	43,6	94,548
Best Signal Level (dBm) ≥ -74,45	73,1	158,2728
Best Signal Level (dBm) ≥ -81,45	91,6	198,3528
Best Signal Level (dBm) ≥ -89,45	99	214,4644
Best Signal Level (dBm) ≥ -110	100	216,5188

Power Optimization Phase

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3G RNP

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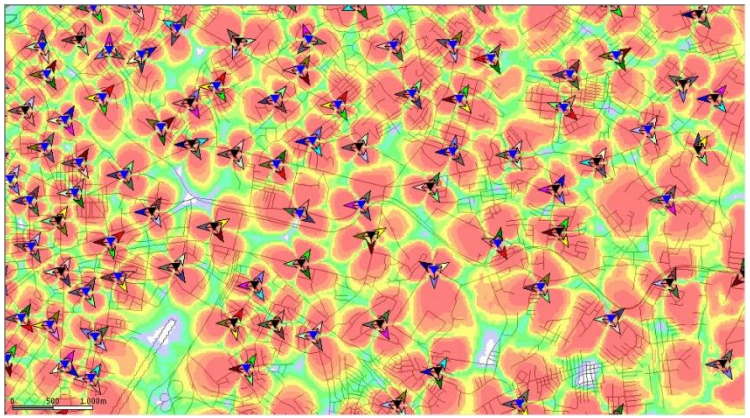
Conclusions

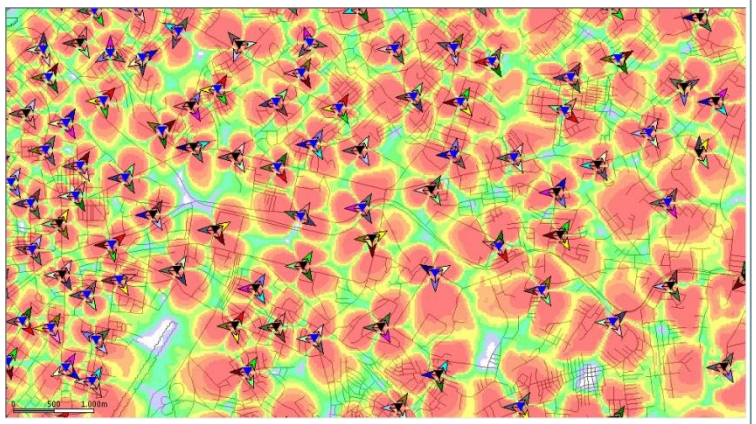
- PS128 Pilot Quality Prediction

New Sites Proposal



New Sites Proposal	% Focus Zone Surface (km²)	
	99	214,4516
Ec/I0 (dB) ≥ -8	30,1	65,2312
Ec/I0 (dB) ≥ -9	48	103,9096
Ec/I0 (dB) ≥ -10	61,9	134,0752
Ec/I0 (dB) ≥ -11	76	164,5296
Ec/I0 (dB) ≥ -12	86,7	187,7072
Ec/I0 (dB) ≥ -13	93,7	203,0356
Ec/I0 (dB) ≥ -14	97,3	210,7644
Ec/I0 (dB) ≥ -15	99	214,4516

Power Optimization

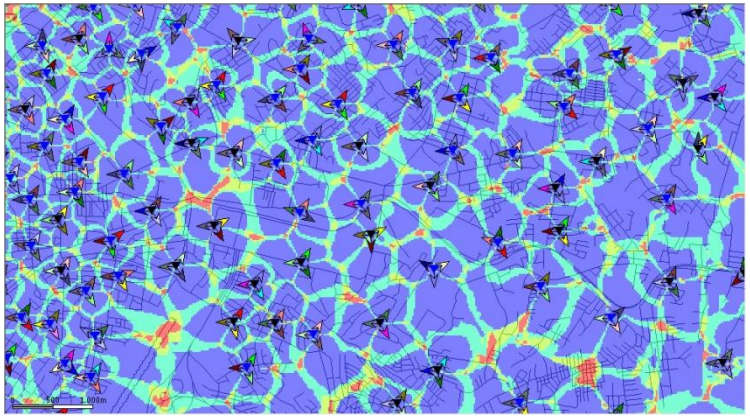


Power Optimization	% Focus Zone Surface (km²)	
	99	214,4984
Ec/I0 (dB) ≥ -8	30,4	65,8376
Ec/I0 (dB) ≥ -9	48,3	104,5928
Ec/I0 (dB) ≥ -10	62,2	134,7284
Ec/I0 (dB) ≥ -11	76,2	165,0032
Ec/I0 (dB) ≥ -12	86,9	188,1468
Ec/I0 (dB) ≥ -13	93,8	203,1872
Ec/I0 (dB) ≥ -14	97,3	210,7956
Ec/I0 (dB) ≥ -15	99	214,4984

Power Optimization Phase

- Overlapping Areas 4dB Criteria

New Sites Proposal



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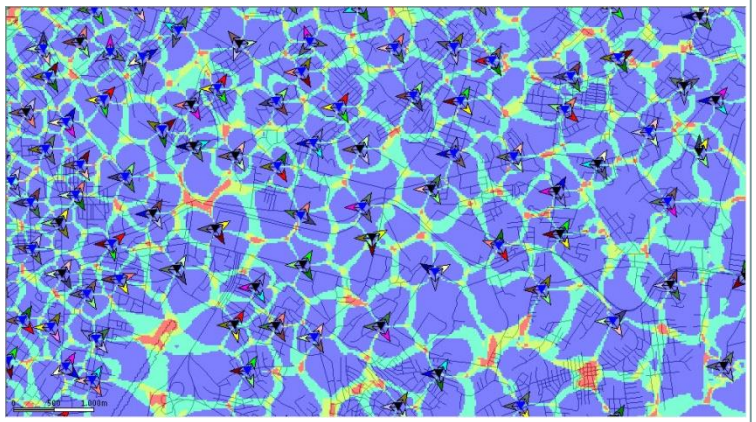

New Sites Proposal	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	1,9	4,2204
Number of Servers ≥ 3	7,3	15,8804
Number of Servers ≥ 2	28,9	62,6196
Number of Servers ≥ 1	100	216,5188

Power Optimization	% Focus Zone Surface (km²)	
	100	216,5188
Number of Servers ≥ 4	2	4,2608
Number of Servers ≥ 3	7,4	16,0068
Number of Servers ≥ 2	28,9	62,5896
Number of Servers ≥ 1	100	216,5188

Conclusions

- Both customer and Alcatel-Lucent project requirements were fulfilled, regarding coverage, quality and interference

- The work was done for the entire country with a total of 533 sites and 1301 sectors optimized

- At the end of the project was developed a document with the lessons learned with the RNP project

- Deployment of the network is scheduled for the end of 2014/beginning of 2015, the future work is to perform a QoS follow-up to address network issues

Backup

- Link Budget calculations per service

Link Budget - 2100 MHz					
RNP Design Level	**Speech**	**PS128**	**PS128 & HSDPA**	**PS128 & HSDPA 2Mbps**	**PS128 & HSDPA 1Mbps**
Dense Urban (Deep Indoor)	-82,5 dBm	-78,7 dBm	-81,2 dBm	-67,56 dBm	-70,9 dBm
Urban (Daylight Indoor)	-85,4 dBm	-81,7 dBm	-84,1 dBm	-74,45 dBm	-77,8 dBm
Incar	-94,4 dBm	-90,7 dBm	-93,1 dBm	-81,45 dBm	-84,8 dBm
Outdoor	-102,4 dBm	-98,7 dBm	-101,1 dBm	-89,45 dBm	-92,8 dBm
Rest	-110 dBm	-110 dBm	-110 dBm	-110 dBm	-110 dBm

Backup

- A9955 UMTS main parameters

UMTS Inputs	Values
Frequency Band	2100 MHz
Main Propagation Model (Dense-Urban / Urban)	SPM-2100MHz-DU/U
Main Propagation Model (Sub-Urban / Rural)	SPM-2100MHz-SU/RU
Main Calculation Radius (m)	15 000
Main Resolution (m)	20
Max Power (dBm)	43
Transmission Loss (dB)	0,6
Reception Loss (dB)	0,6
Noise Figure (dB)	2
NodeB Antenna	APXVERR26_2110
Body Loss Speech (dB)	3
Body Loss Data (dB)	0
UE Antenna Gain (dB)	0
UE Noise Gain (dB)	7
HSDPA Mobile Categories	8 (Max 7,2 Mbps)
	24 (Max 42 Mbps)
HSUPA Mobile Categories	6 (Max 5,7 Mbps)

Backup

- Carriers Parameters Definition

Carrier 0 (R99 & HSDPA)	Values
Total Power for Common Channels and R99 traffic Load (50%)	40 dBm
Remain power for HSDPA	39 dBm
UL Load Factor	50%
UL Load Factor due to HSUPA	25%
Max UL Load Factor	75%

Carrier 1 (Dedicated HSDPA)	Values
Total Power for Common Channels Load (20%)	36 dBm
Remain power for HSDPA	41,8 dBm
UL Load Factor	0%
UL Load Factor due to HSUPA	25%
Max UL Load Factor	75%