TTI4A3
Komunikasi Akses Nirkabel

CLO 3 Radio Access Network Dimensioning

Minggu 12:
COVERAGE PLANNING AND LINK BUDGET

Outline

CLO 3

Radio Access Network Dimensioning

Minggu 12 Coverage Planning & Link Budget

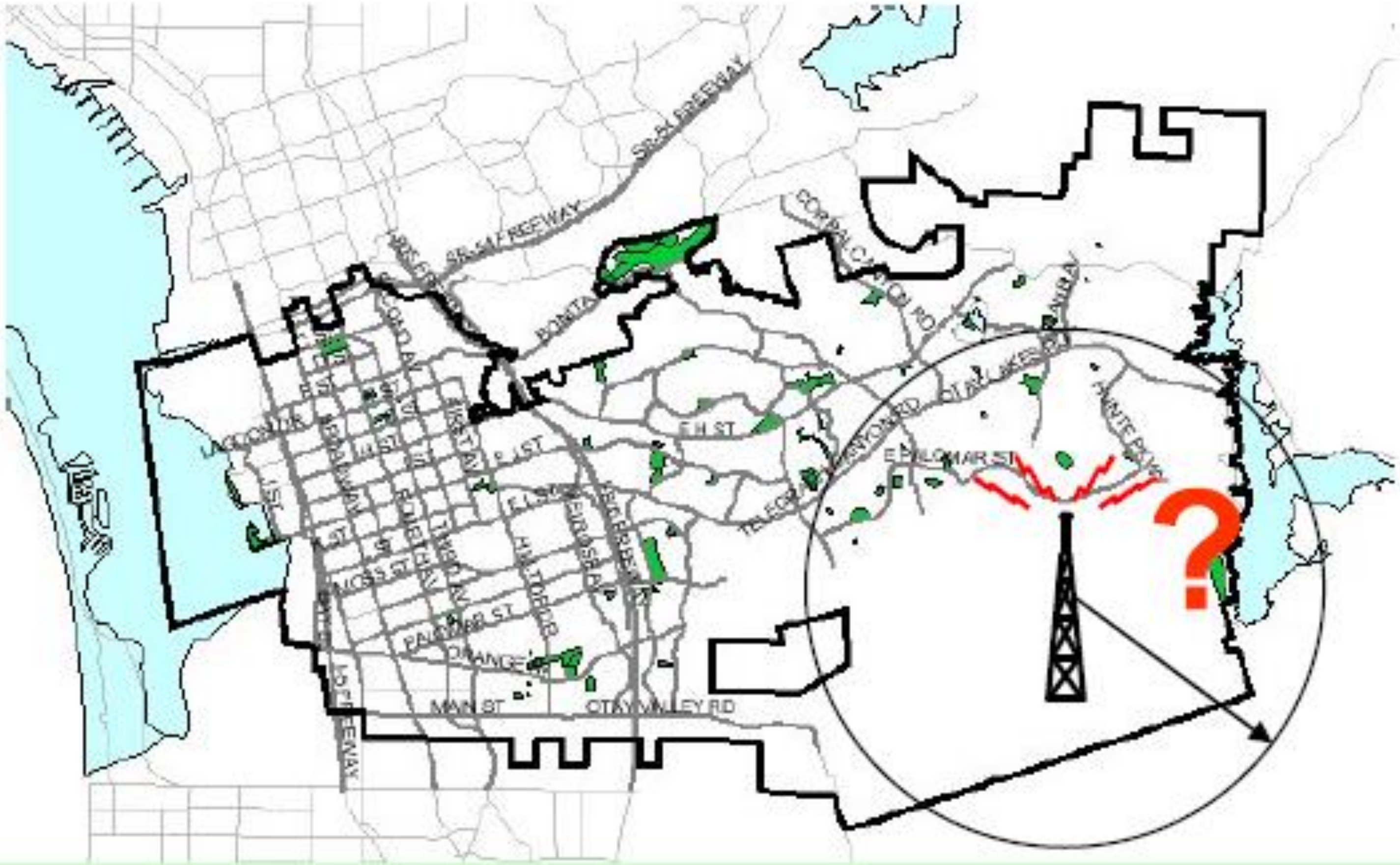
- Introduction: Coverage & Capacity Planning Approach
- Coverage Planning
- Link Budget

Introduction: Network Planning Processes

Outline

- Introduction
- Software environment
- Network planning processes
- Network planning scope
- Steps:
  - Preliminary network design
  - Initial network design
  - Detailed network design
  - Installation
  - Verification
  - Optimization

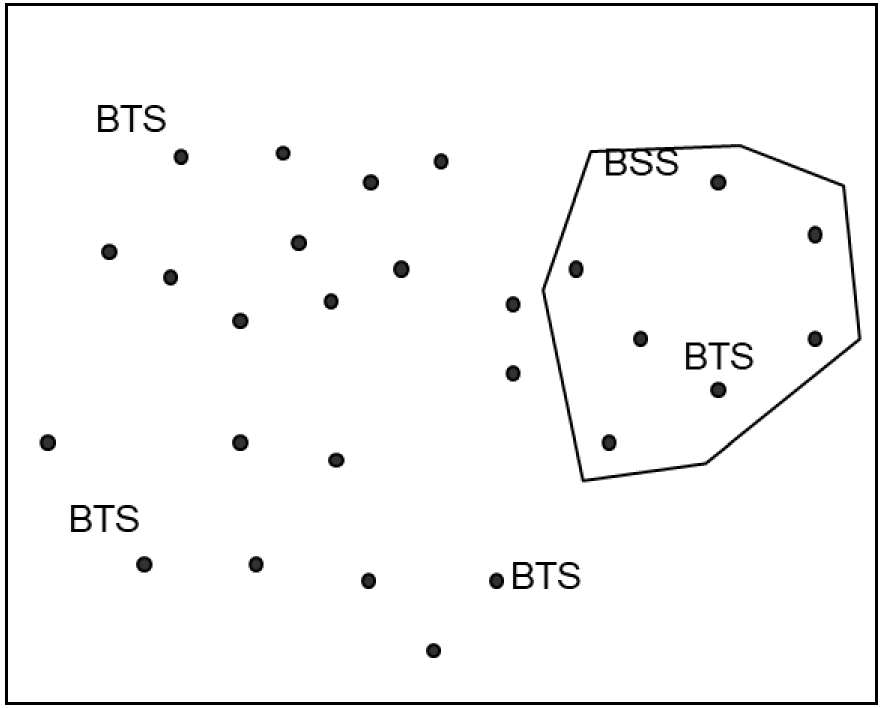
Introduction



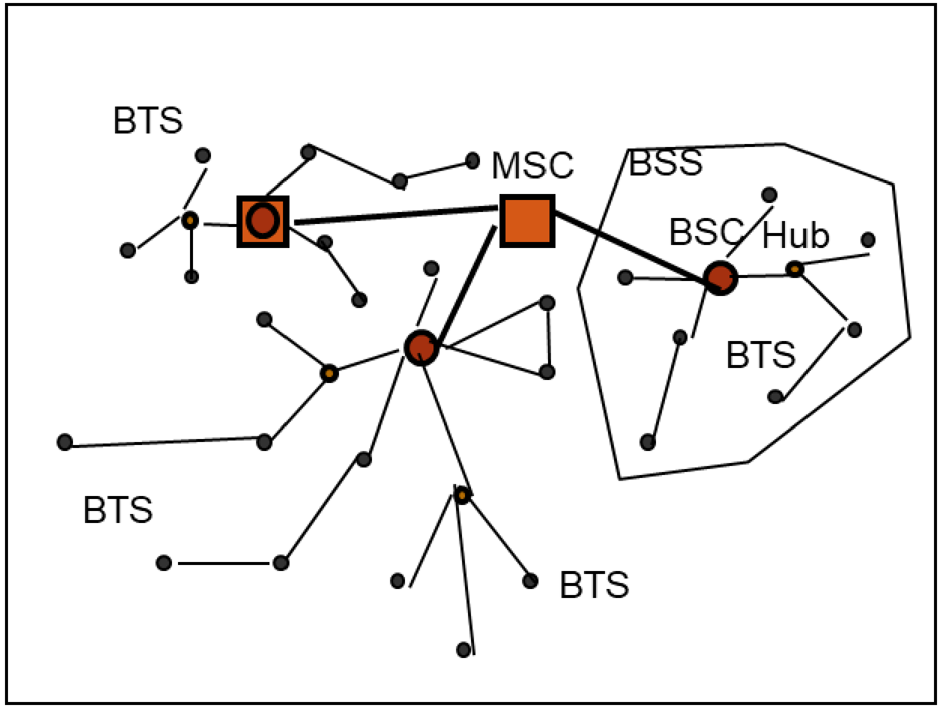
First Steps and Factors affecting Network Planning

Introduction: Cellular network planning

Radio part design



Fixed part design: planning transmission



Radio Network Planning

- evaluation of **expected traffic density**
- use of **CAD network planning tool**
- determination of suitable **MSC**, **BSC**, **BTS sites**

Transmission Planning

- **connection** points to the **PSTN**
- possible **leased lines**
- **frequencies** available for **microwave** links

Introduction: Operator Needs

OPERATOR NEEDS

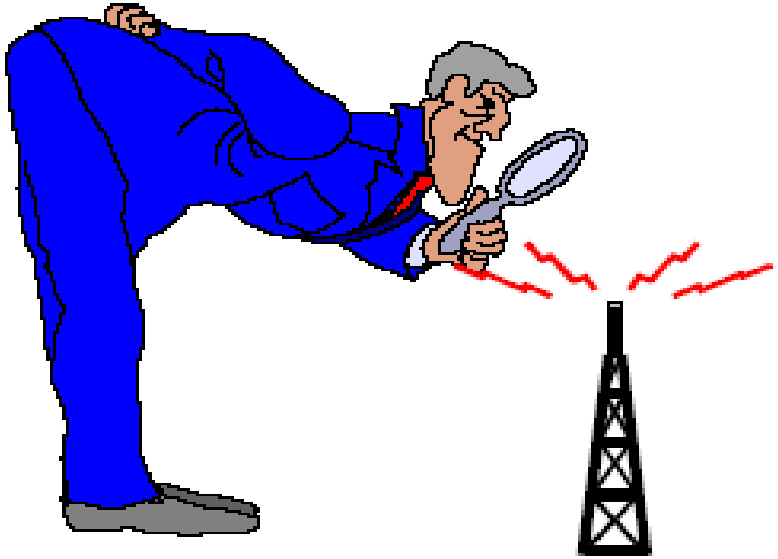
- Cost efficient total solution
- Enough capacity with optimized reserves
- Optimized network reliability
- Optimized network flexibility

NETWORK PLANNING

- Is the key to respond to the needs
- Has to deal with long term goals and short term targets
- Starts from existing network or from the scratch

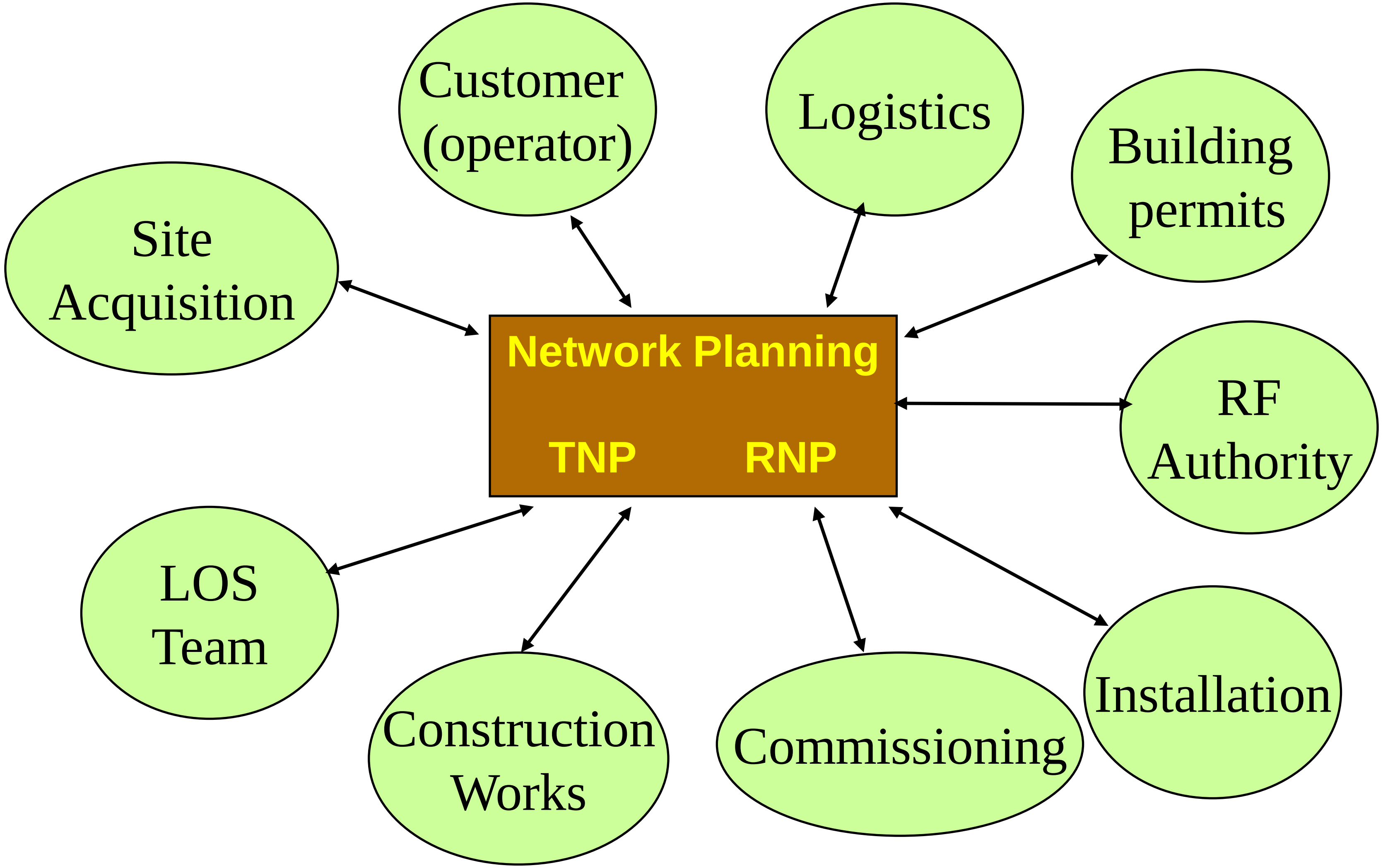
- Aim is to find the optimal network structure
- There usually is a tradeoff between
  - Cost
  - Network quality
  - Time

Financial Aspects



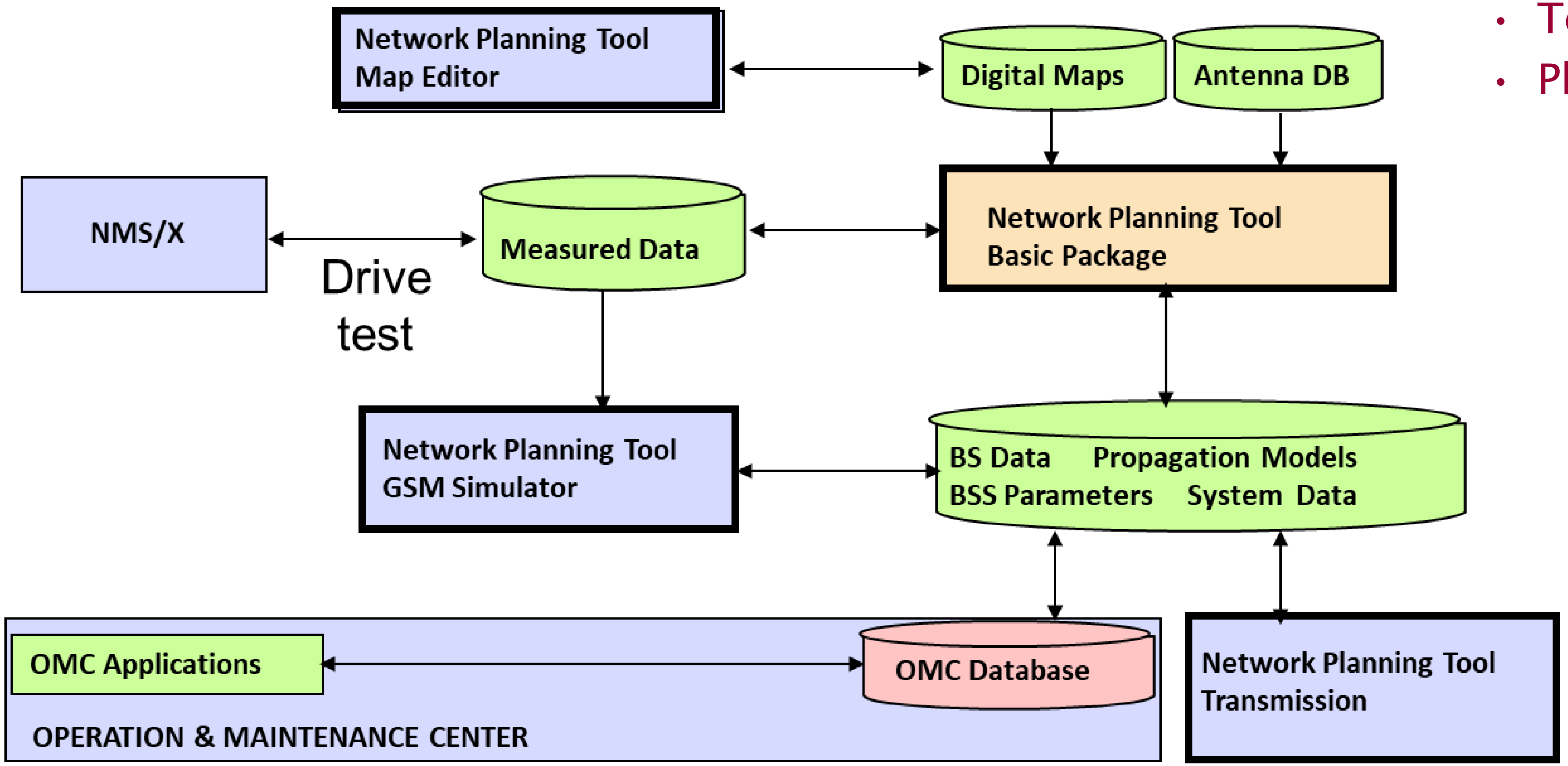
- cost of the base station
- engineers evaluation of the area
- local administration permission
- compensation to ground owner
- cablings (power, transmission)
- specialized workers

Introduction: Network Planning Role



Software Environment

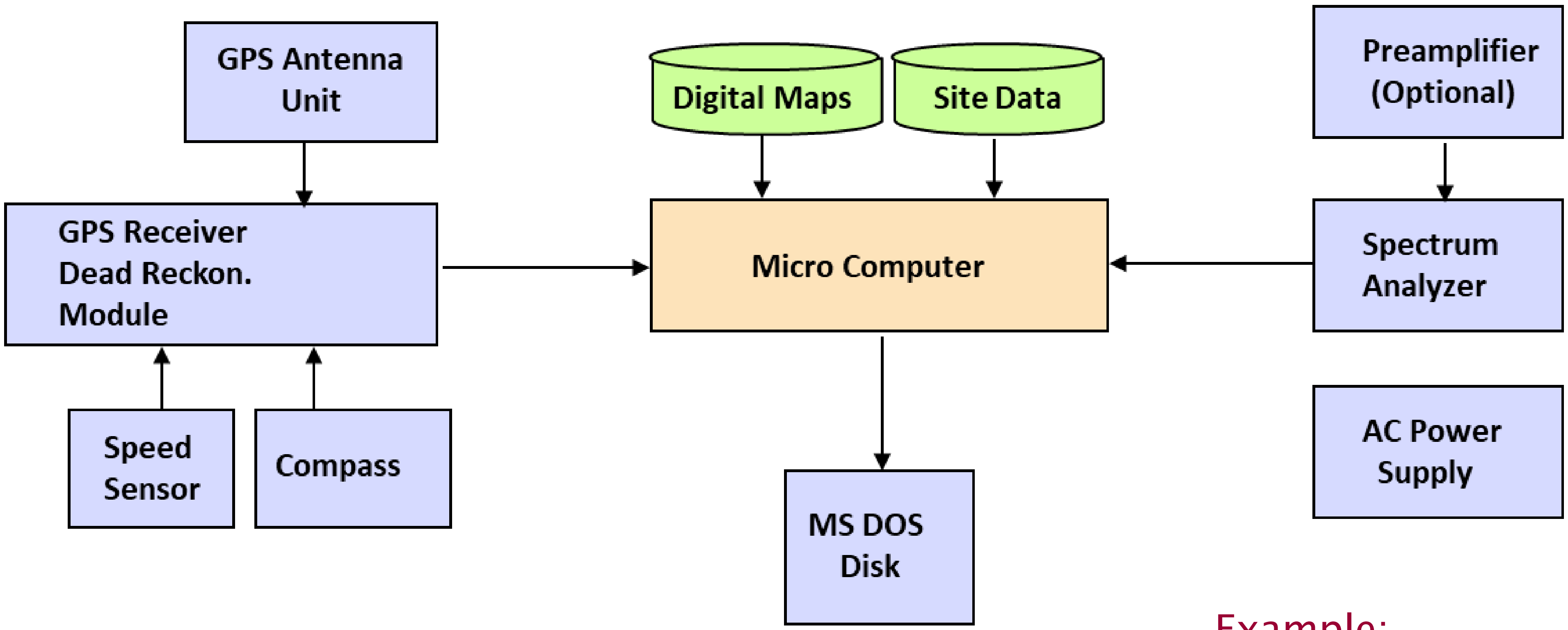
Software Environment: Network Planning Tool



Example:

- TEMS Cell Planner (Ericsson)
- NPS/X (Nokia)
- Tornado (Siemens)
- Planet EV

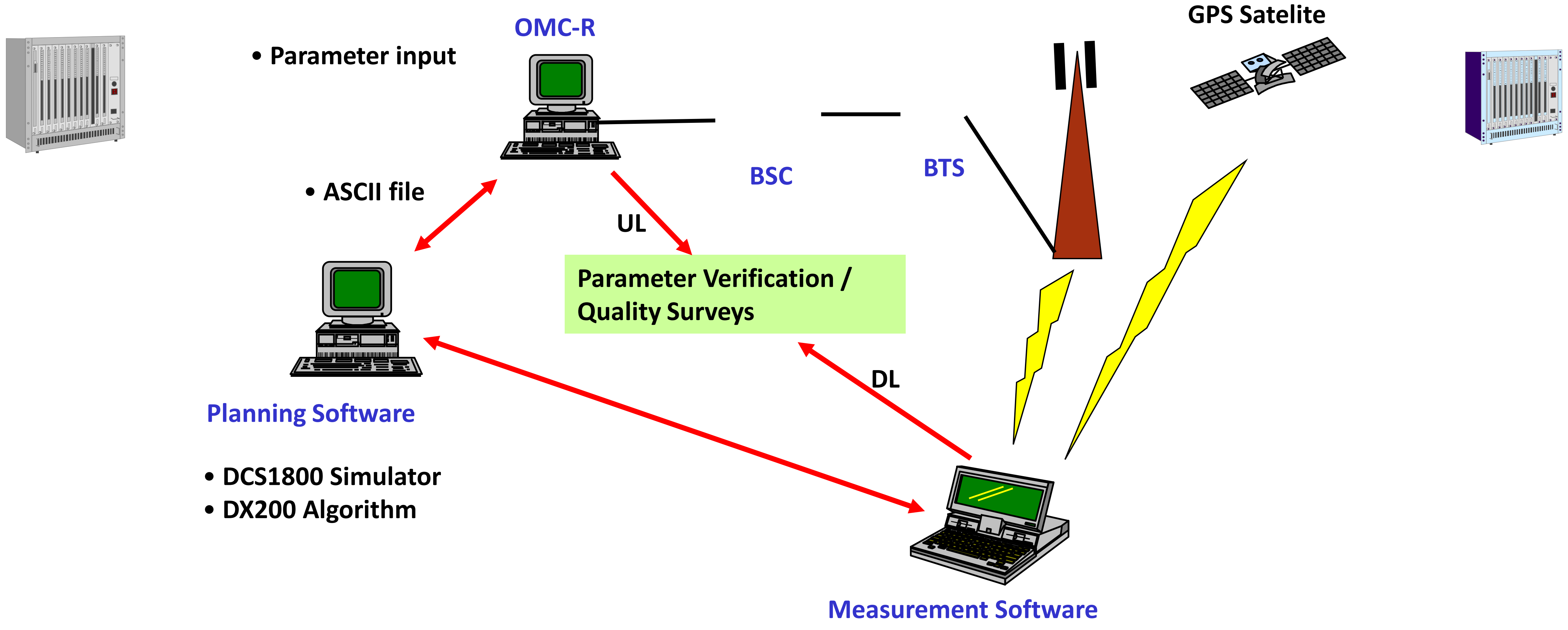
Software Environment: Measurement Software



Example:

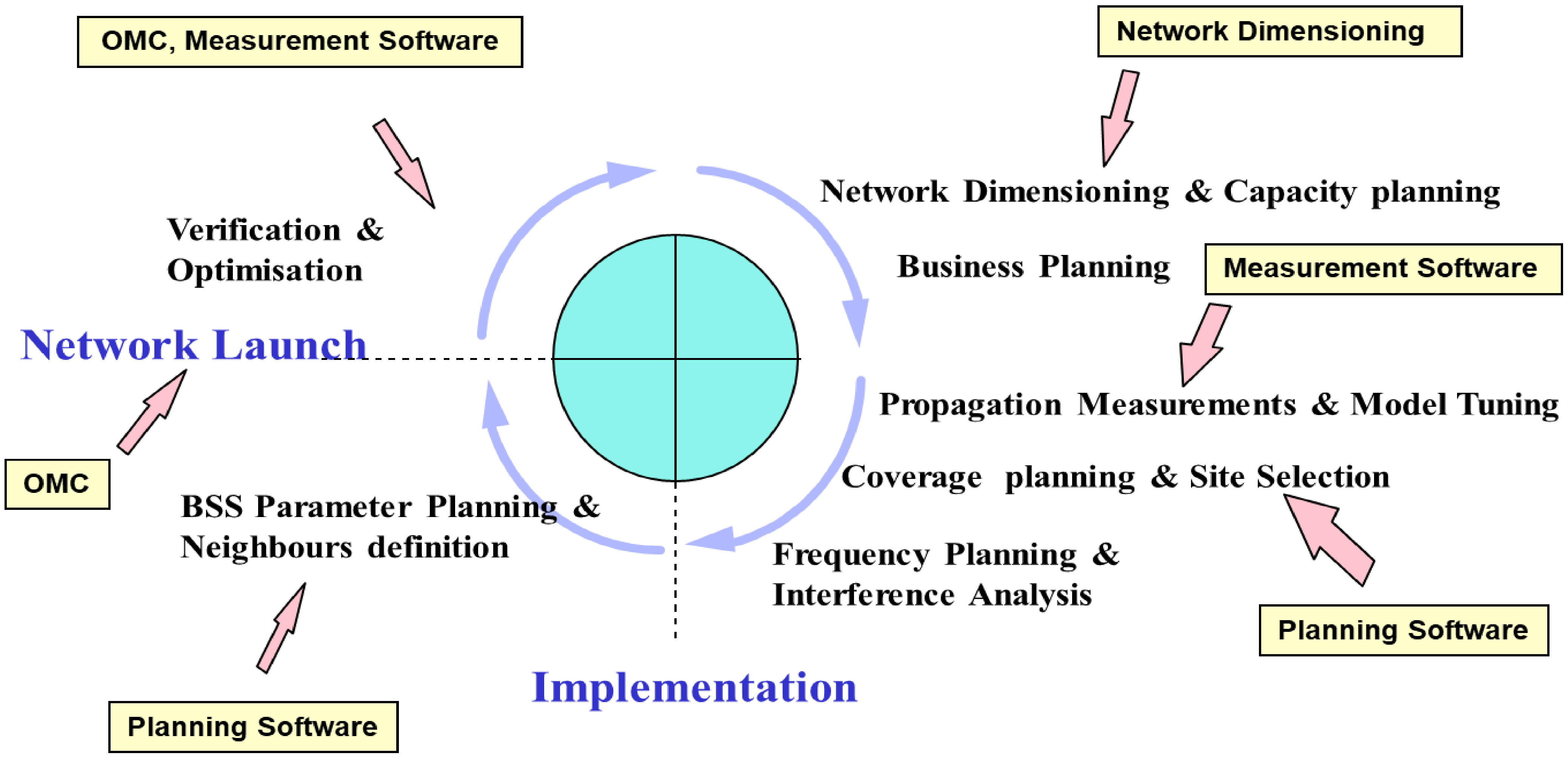
- TEMS Investigation (Ericsson)
- NMS/X (Nokia)

Network Planning Environment in Practice

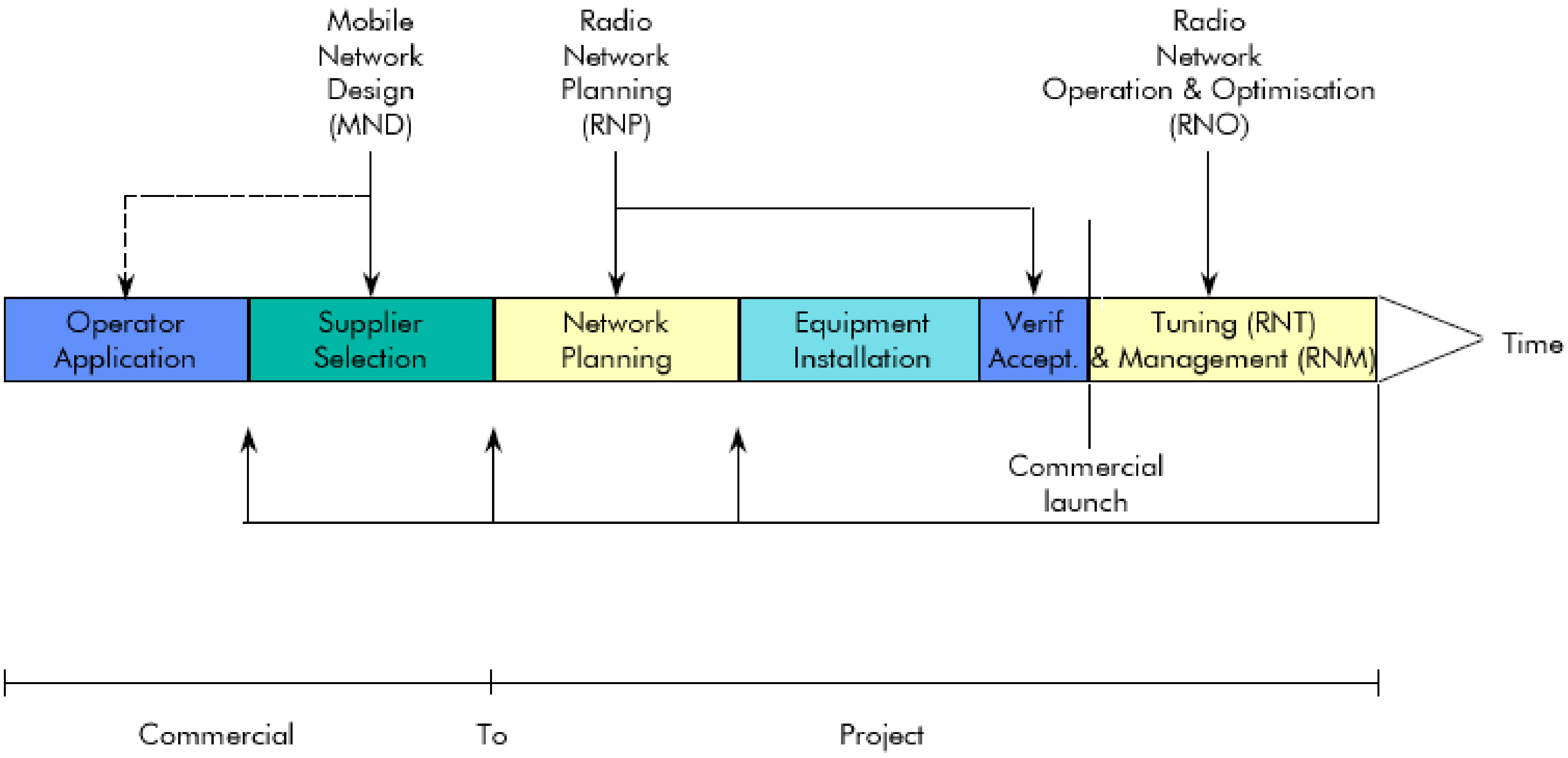


Network Planning Process

Radio Network Planning Process



Introduction Cellular Network Life Cycle



Network Planning Targets

- To achieve required radio **coverage**
- To maximise the network **capacity**(Erl/km2) with limited frequency band (MHz)
- To reach good **Quality** of Service (QOS)
- To minimize the number of network elements and **costs**

Keywords:
Coverage,
Capacity, Quality,
and Cost

Network Planning Scope

- **Customer requirements**
  - subscriber forecasts
  - coverage requirements
  - quality of service
  - recommended sites

- **External information sources**
  - terrain & morphological data
  - population data
  - bandwidth available
  - frequency co-ordination constraints

- Network planning team
  - data acquisition
  - site survey and selection
  - field measurement evaluation
  - NW design and analysis
  - transmission planning

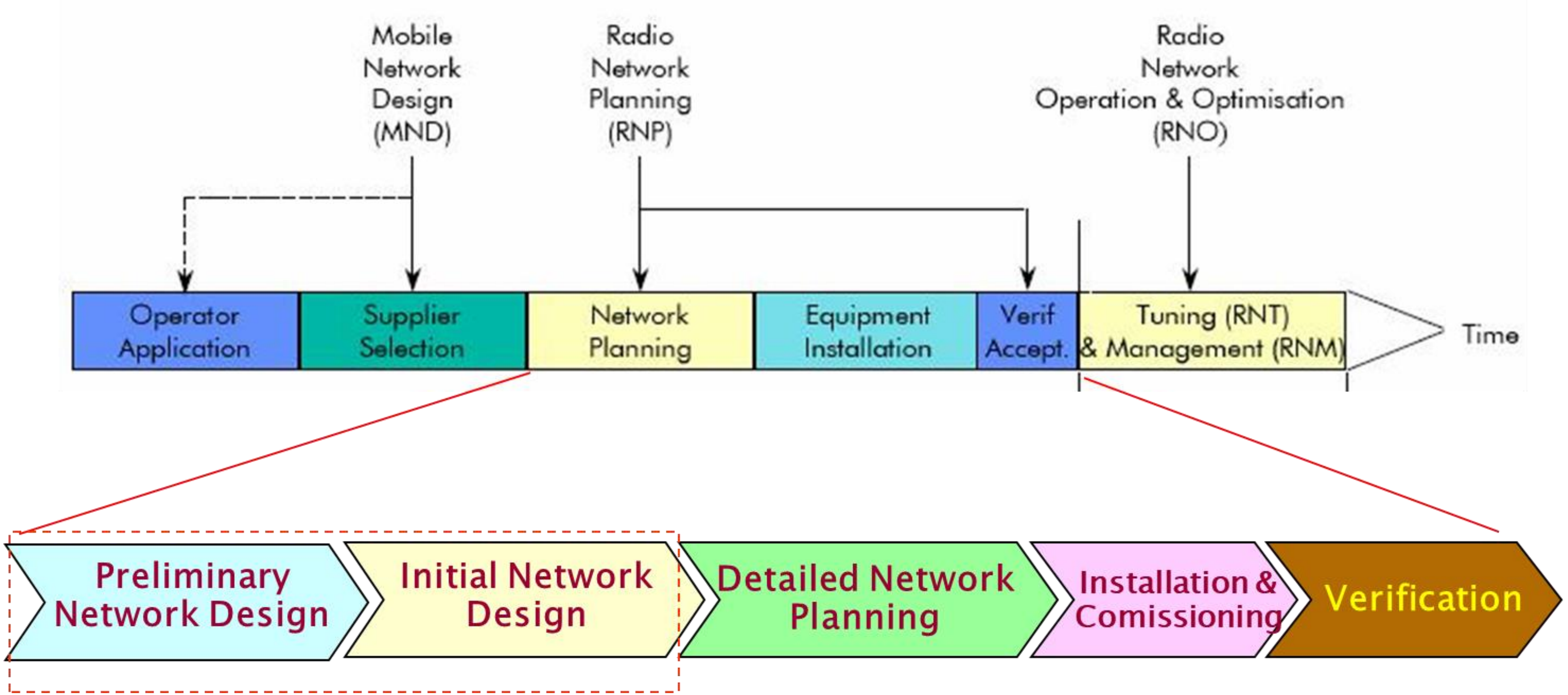
Interactions with

- ⇔ external subcontractors
- ⇔ site hunting teams
- ⇔ measurement teams
- ⇔ operator
- ⇔ switch planning engineers (Core Network engineers)

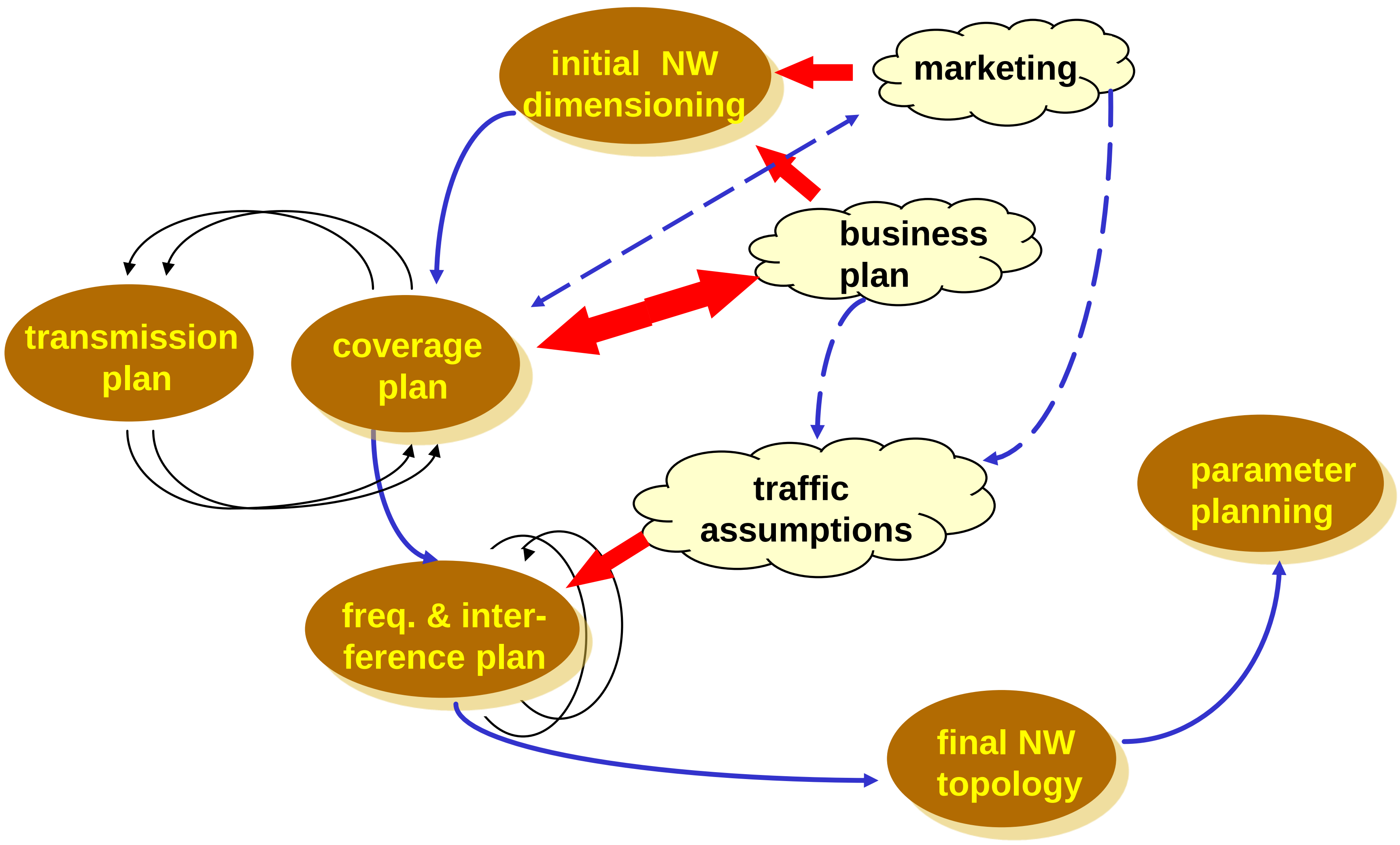
- **Network design**
  - number and configuration of BS
  - antenna systems specifications
  - BSS topology
  - dimensioning of transmission lines
  - frequency plan
  - network evolution strategy

- **Network performance**
  - grade of service (blocking)
  - outage calculations
  - interference probabilities
  - quality observation

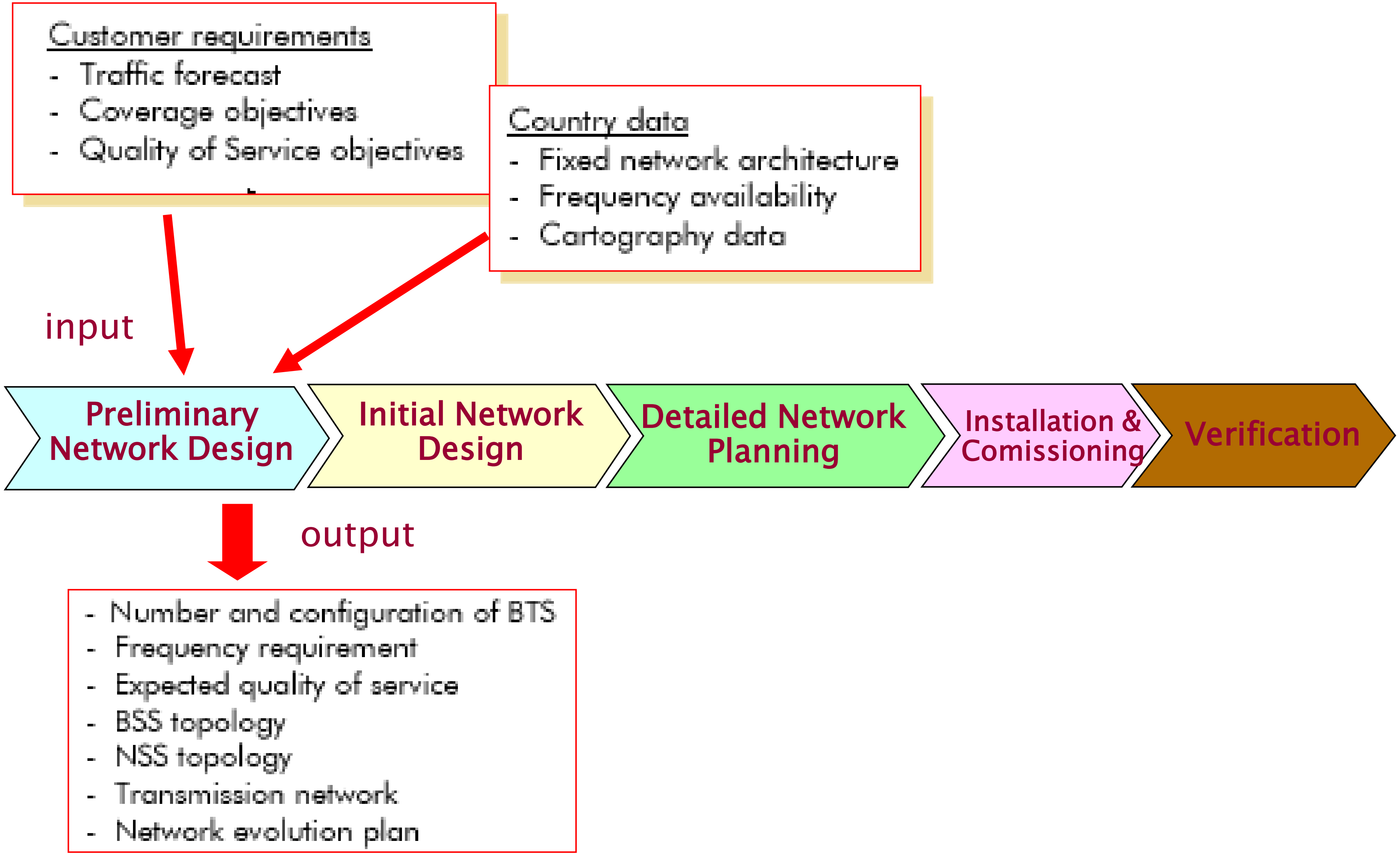
Network Planning Phases



Cellular Planning Principle



1. Preliminary Network Design



First Step: System requirements

Important input data:

- Cost
- Capacity
- Coverage
- Grade Of Service (GOS)
- Available frequencies
- Speech quality
- System growth capability

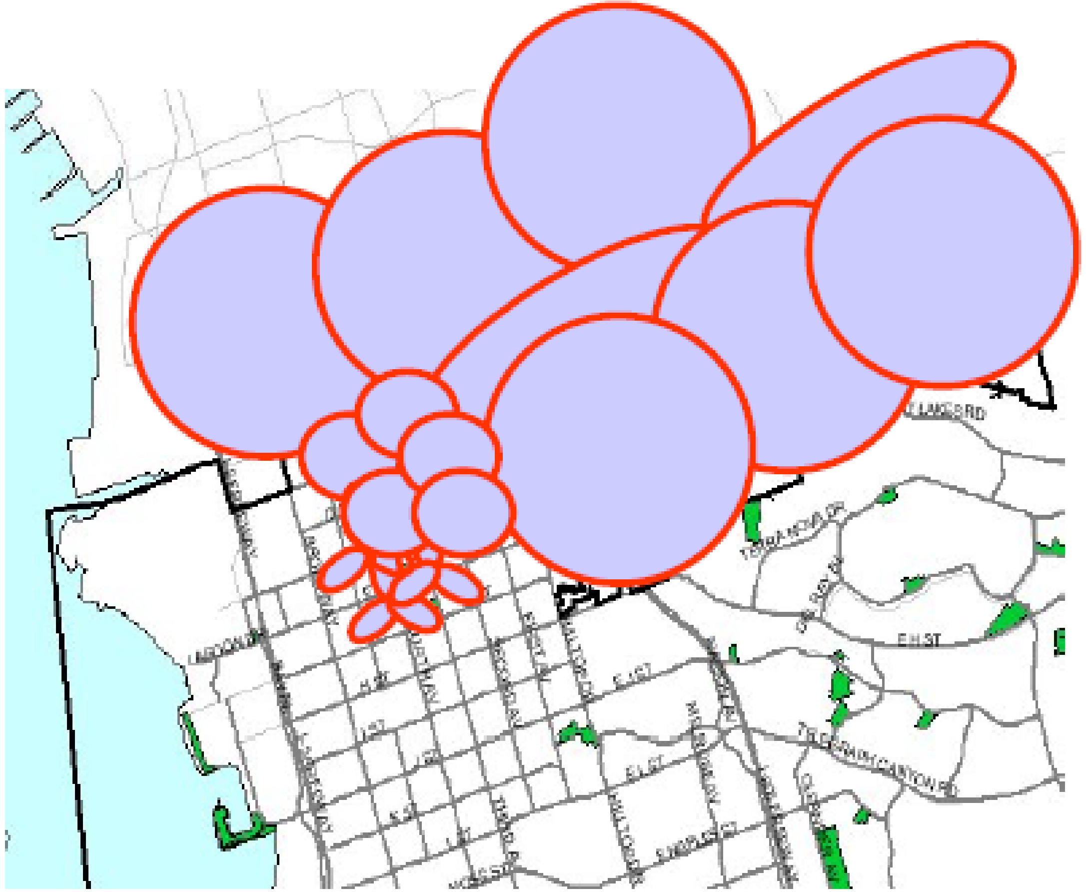
Geographical distribution of traffic demand can be calculated by the use of demographical data, such as:

- **Population distribution**
- **Car usage distribution**
- **Income level distribution**
- **Land usage data**
- **Telephone usage statistics**
- **Other factors, like subscription/call charge and price of mobile stations**

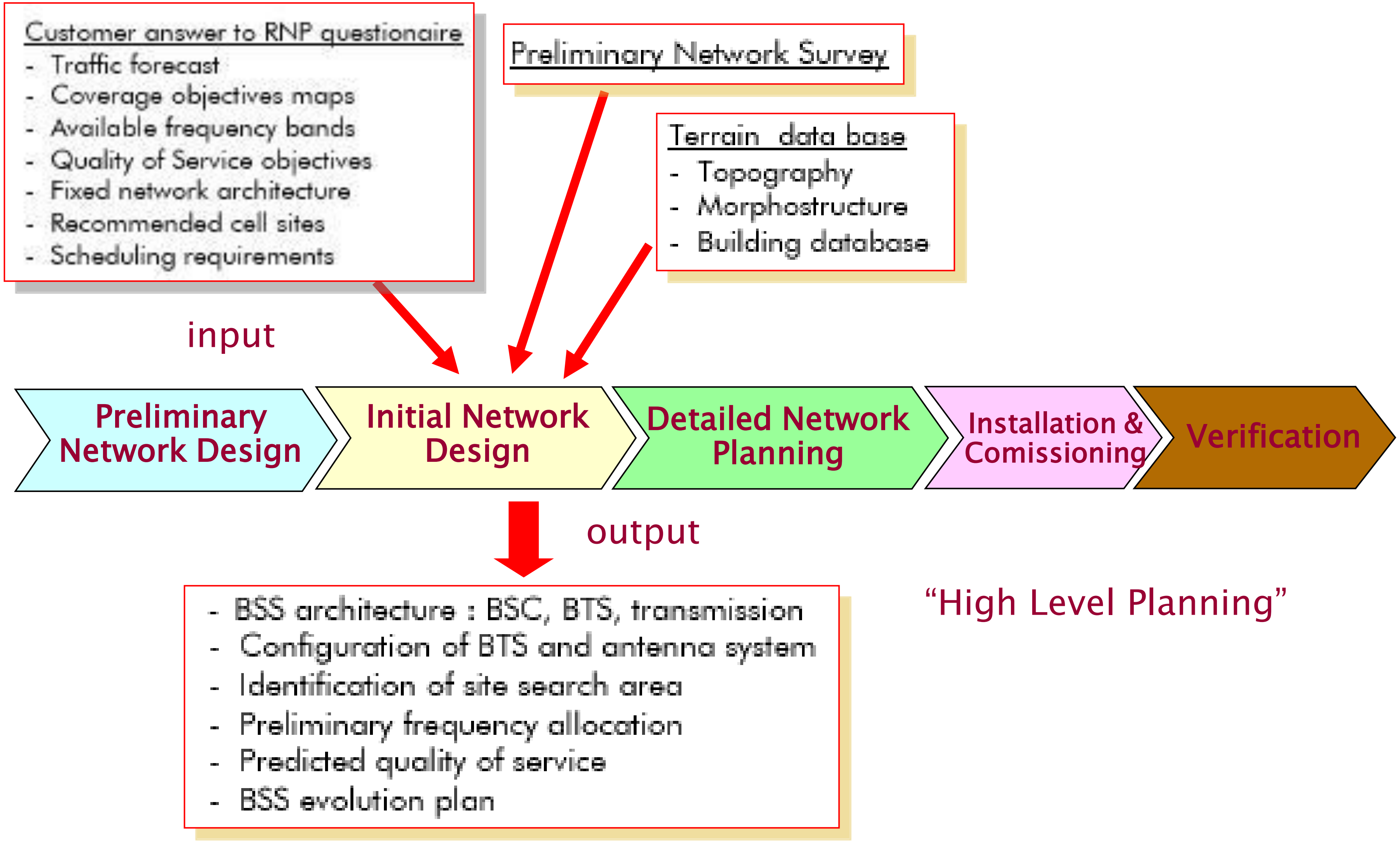
Topography

Relevant Topographical Factors:

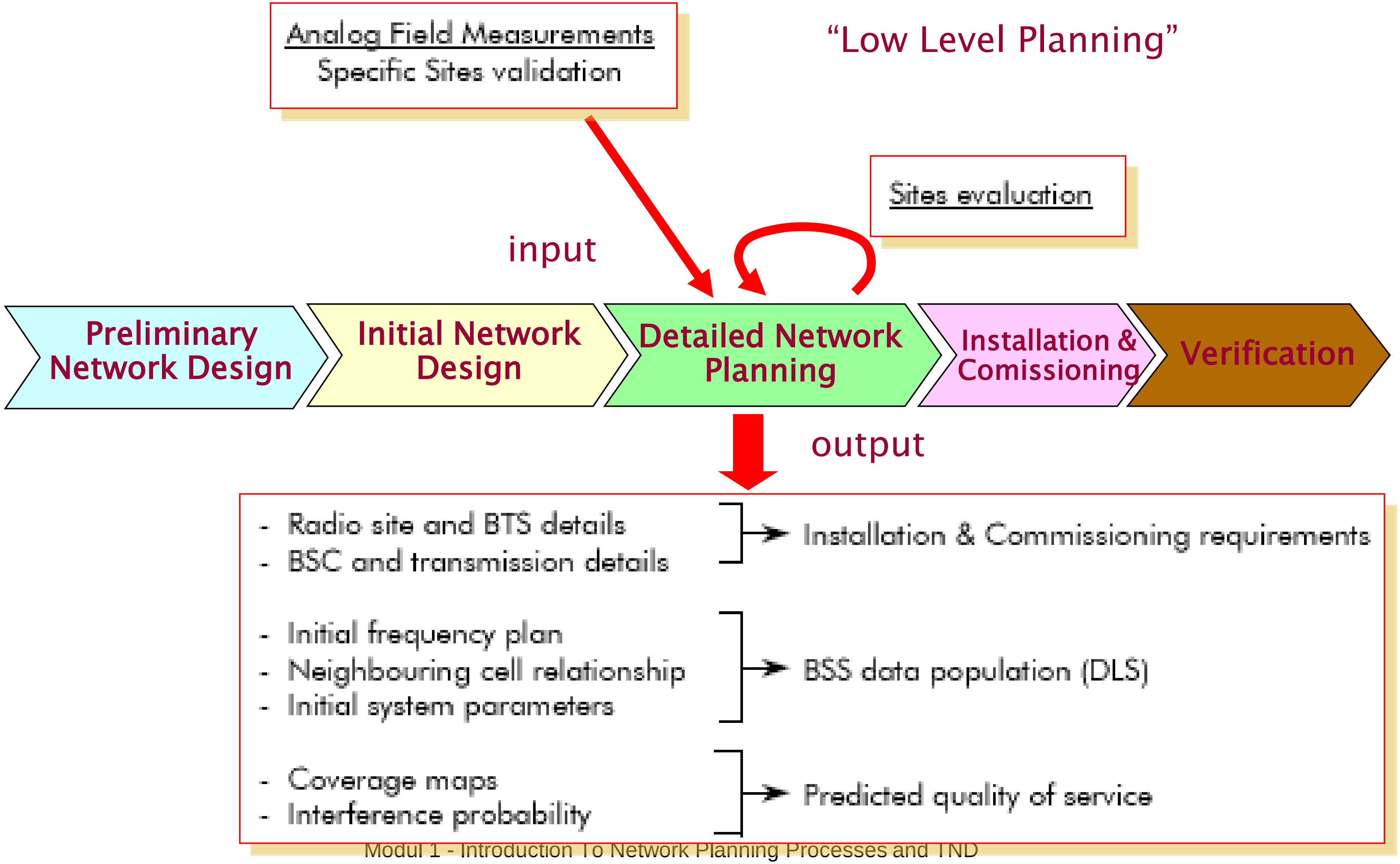
- Obstacles (mountains,forests,...)
- reflections (mountain walls, water...)
- Traffic density (population density)
- streets, bridges
- local regulations



2. Initial Network Design



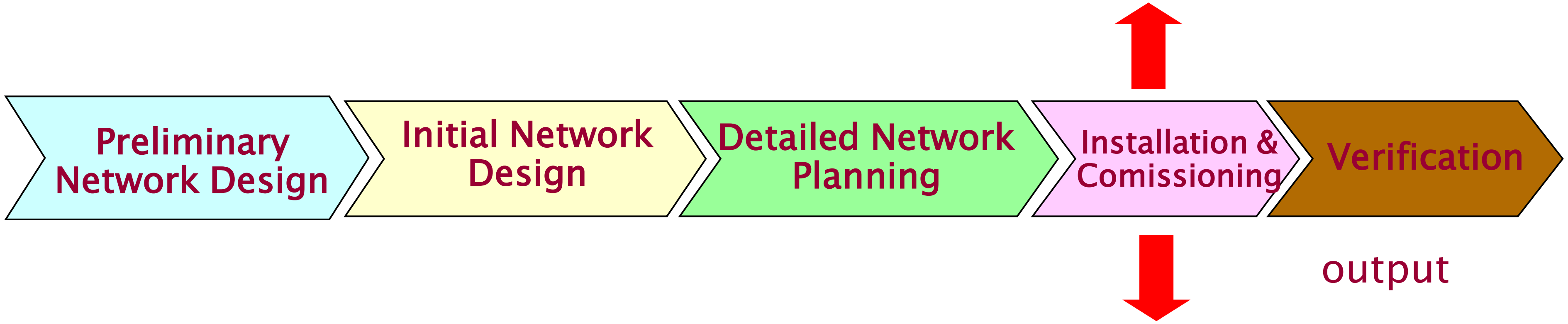
3. Detailed Network Planning



4. Installation & Commissioning

Installation → <u>cabling job & see you manual :</u>

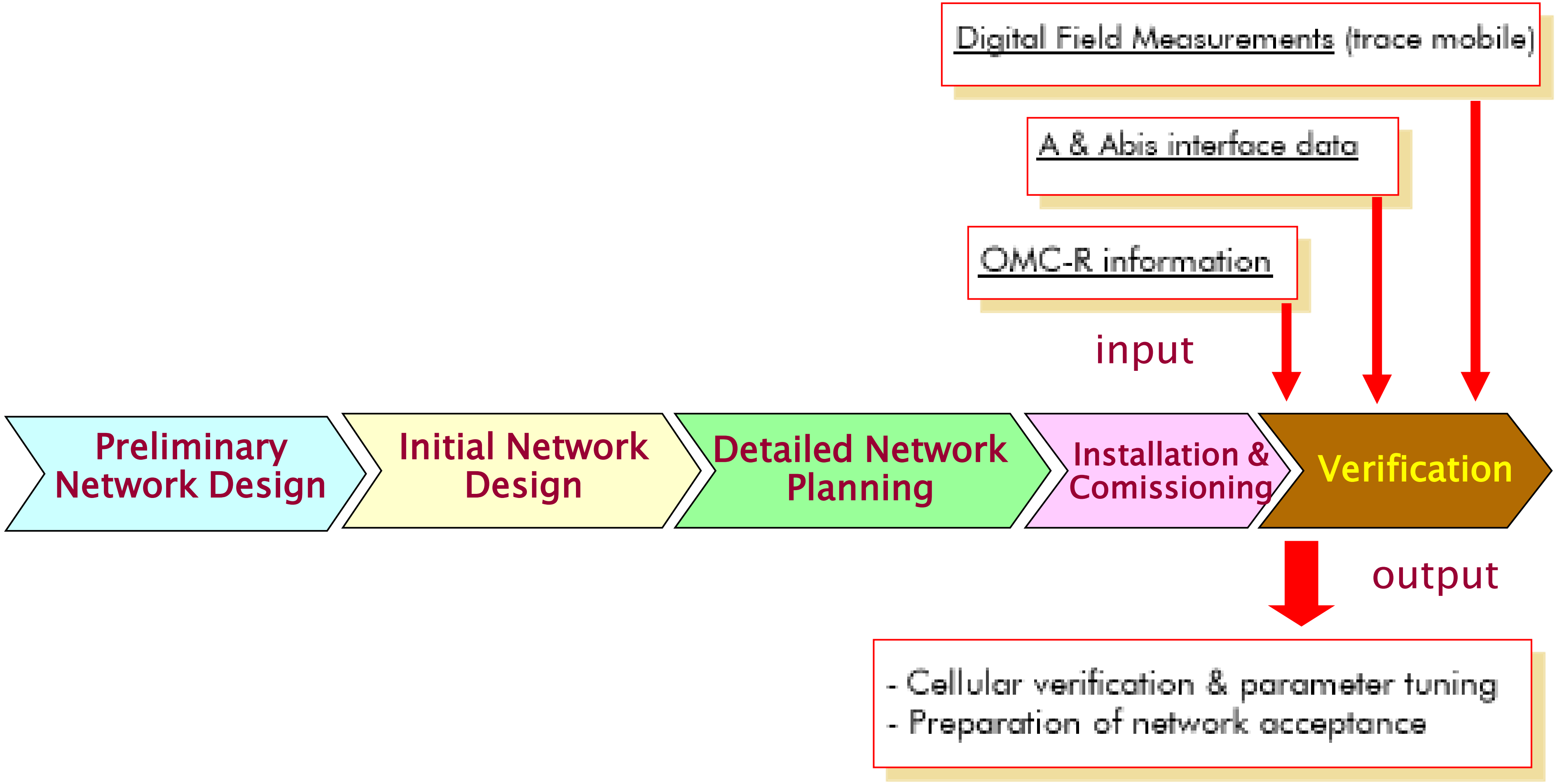
- BTS, BSC, MSC installation
- Power supply installation, …etc



But, the network has not optimal yet…

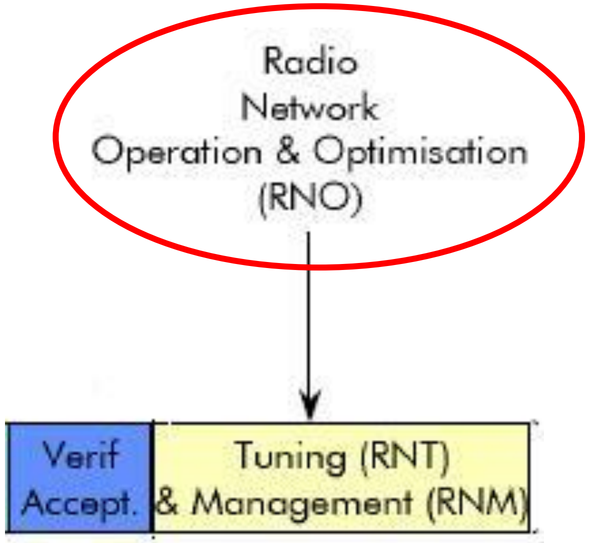
Commisioning → <u>at the first phase:</u> to ensure network function, normal call and data processing

5. Verification



Integration !!

6. Optimization



At the second phase:

Radio Network Optimization

It is about drive test to collect data, and radio network parameter optimization:

•at the RF side, …

•RAN side … via OMC → adjust some UMTS RAN parameters

Commisioning →
at the first phase:
to ensure network function, normal call and data processing

But, the network has not optimal yet…

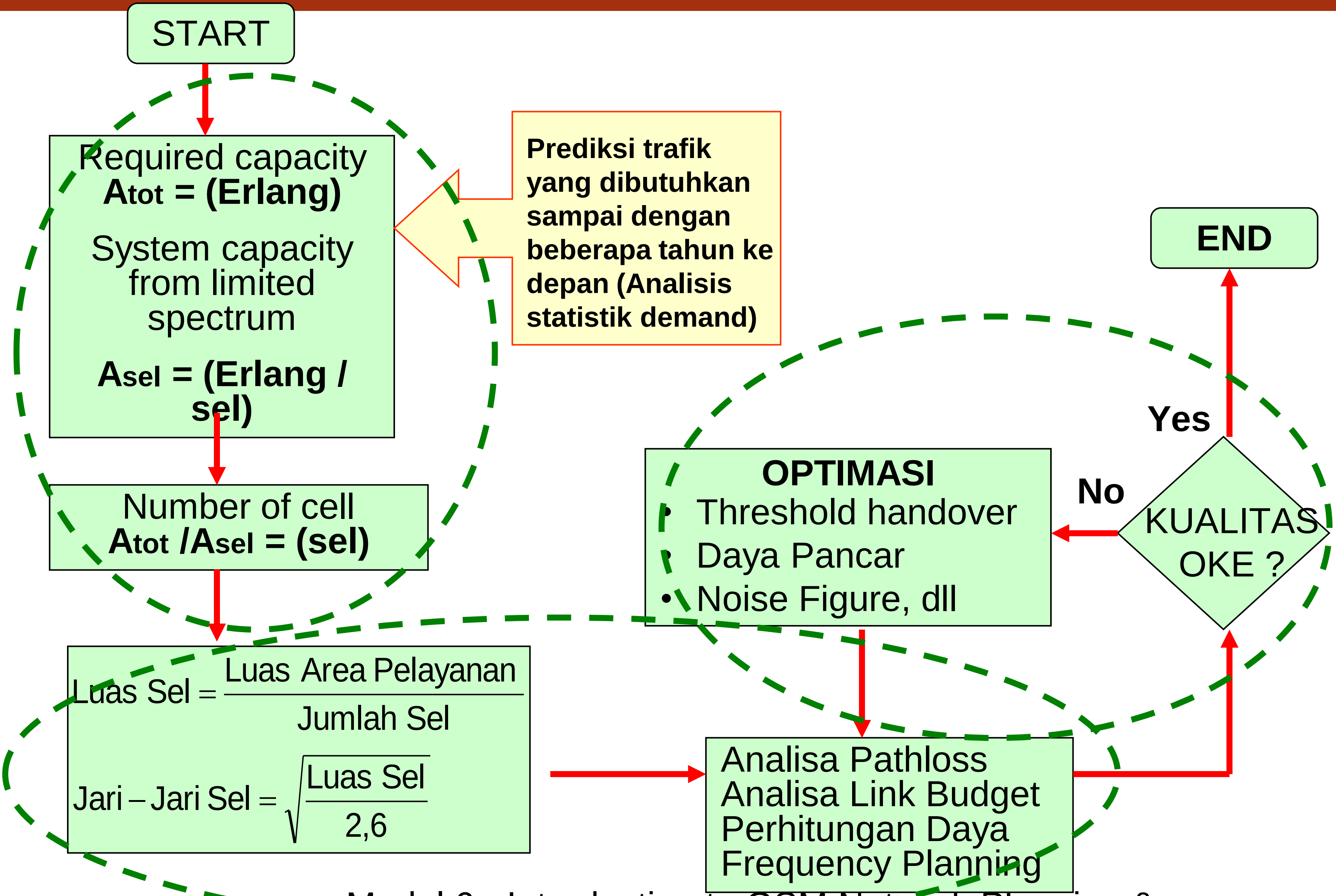
Cell Dimensioning

Coverage & Capacity Approach

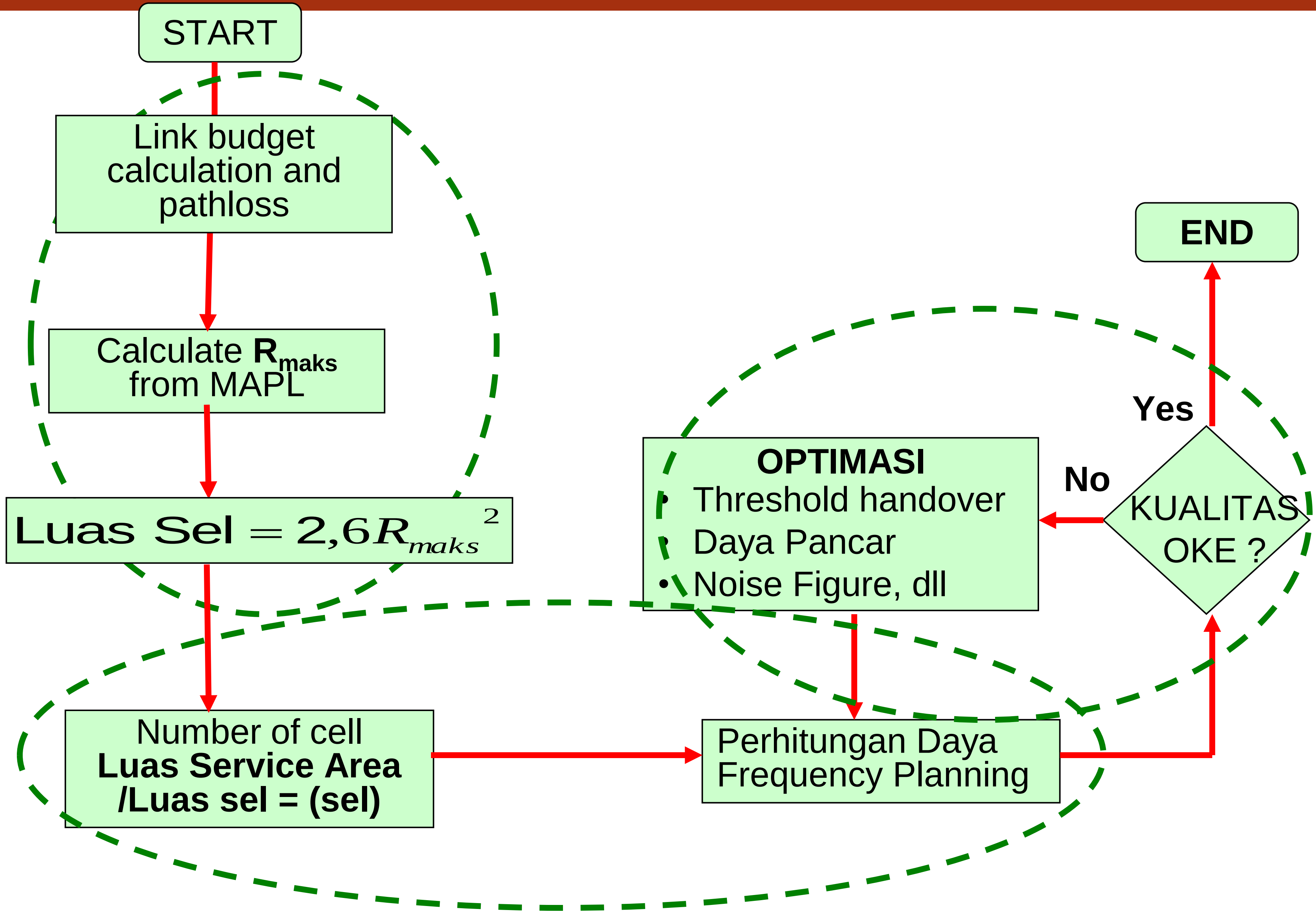
Definisi

- Dimensioning:
  - menghitung "dimensi' atau ukuran
- Network Dimensioning
  - Menghitung dimensi / ukuran jaringan → jumlah elemen-elemen jaringan dalam suatu jaringan
- Radio Network Dimensioning
  - Menghitung jumlah elemen-elemen jaringan pada sisi jaringan radio akses → menghitung jumlah BTS, jumlah cell/sector

Cell Dimensioning Principle from Capacity Requirement



Cell Dimensioning Principles from Coverage Requirements



Capacity Calculations

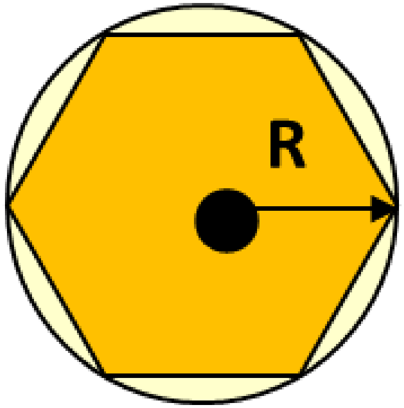
Erlang-B Table

	Blocking Probability					Blocking Probability			
Channels	1%	2%	3%	5%	Channels	1%	2%	3%	5%
1	0,01	0,02	0,03	0,05	21	12,80	14,00	14,90	16,20
2	0,15	0,22	0,28	0,38	22	13,70	14,90	15,80	17,10
3	0,46	0,60	0,72	0,90	23	14,50	15,80	16,70	18,10
4	0,87	1,09	1,26	1,52	24	15,30	16,60	17,60	19,00
5	1,36	1,66	1,88	2,22	25	16,10	17,50	18,50	20,00
6	1,91	2,28	2,54	2,96	26	17,00	18,40	19,40	20,90
7	2,50	2,95	3,25	3,75	27	17,80	19,30	20,30	21,90
8	3,13	3,63	3,99	4,54	28	18,60	20,20	21,20	22,90
9	3,78	4,34	4,75	5,37	29	19,50	21,00	22,10	23,80
10	4,46	5,08	5,53	6,22	30	20,30	21,90	23,10	24,80
11	5,16	5,84	6,33	7,08	31	21,20	22,80	24,00	25,80
12	5,88	6,61	7,14	7,95	32	22,00	23,70	24,90	26,70
13	6,61	7,40	7,97	8,83	33	22,90	24,60	25,80	27,70
14	7,35	8,20	8,80	9,73	34	23,80	25,50	26,80	28,70
15	8,11	9,01	9,65	10,60	35	24,60	26,40	27,70	29,70
16	8,88	9,83	10,50	11,50	36	25,50	27,30	28,60	30,70
17	9,65	10,70	11,40	12,50	37	26,40	28,30	29,60	31,60
18	10,40	11,50	12,20	13,40	38	27,30	29,20	30,50	32,60
19	11,20	12,30	13,10	14,30	39	28,10	30,10	31,50	33,60
20	12,00	13,20	14,00	15,20	40	29,00	31,00	32,40	34,60

Typical Site Configurations

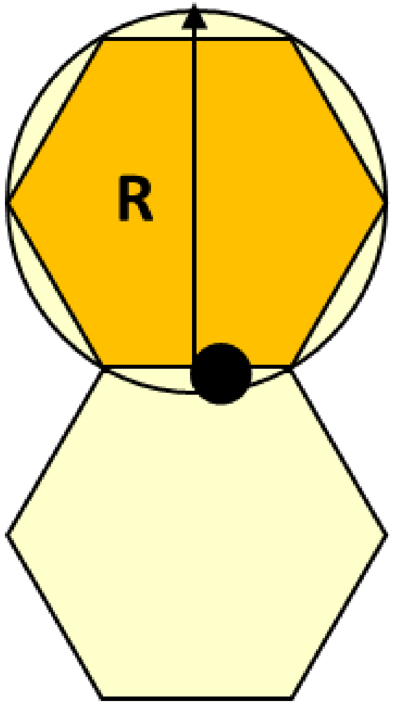
R = Cell Range
S = Site Area

Omni



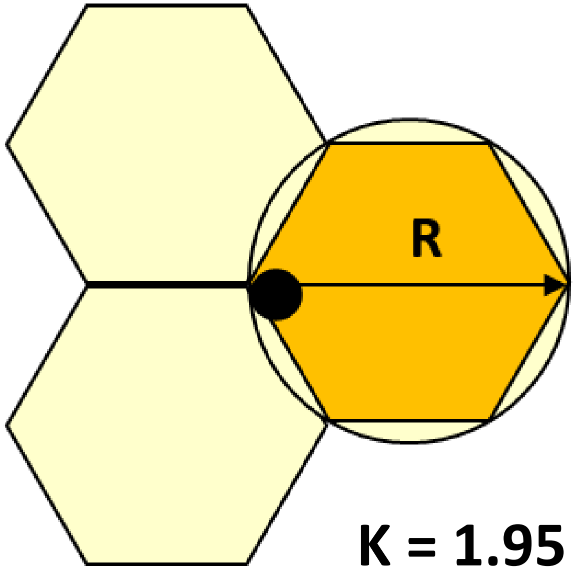
K = 2.6

Road



K = 1.3

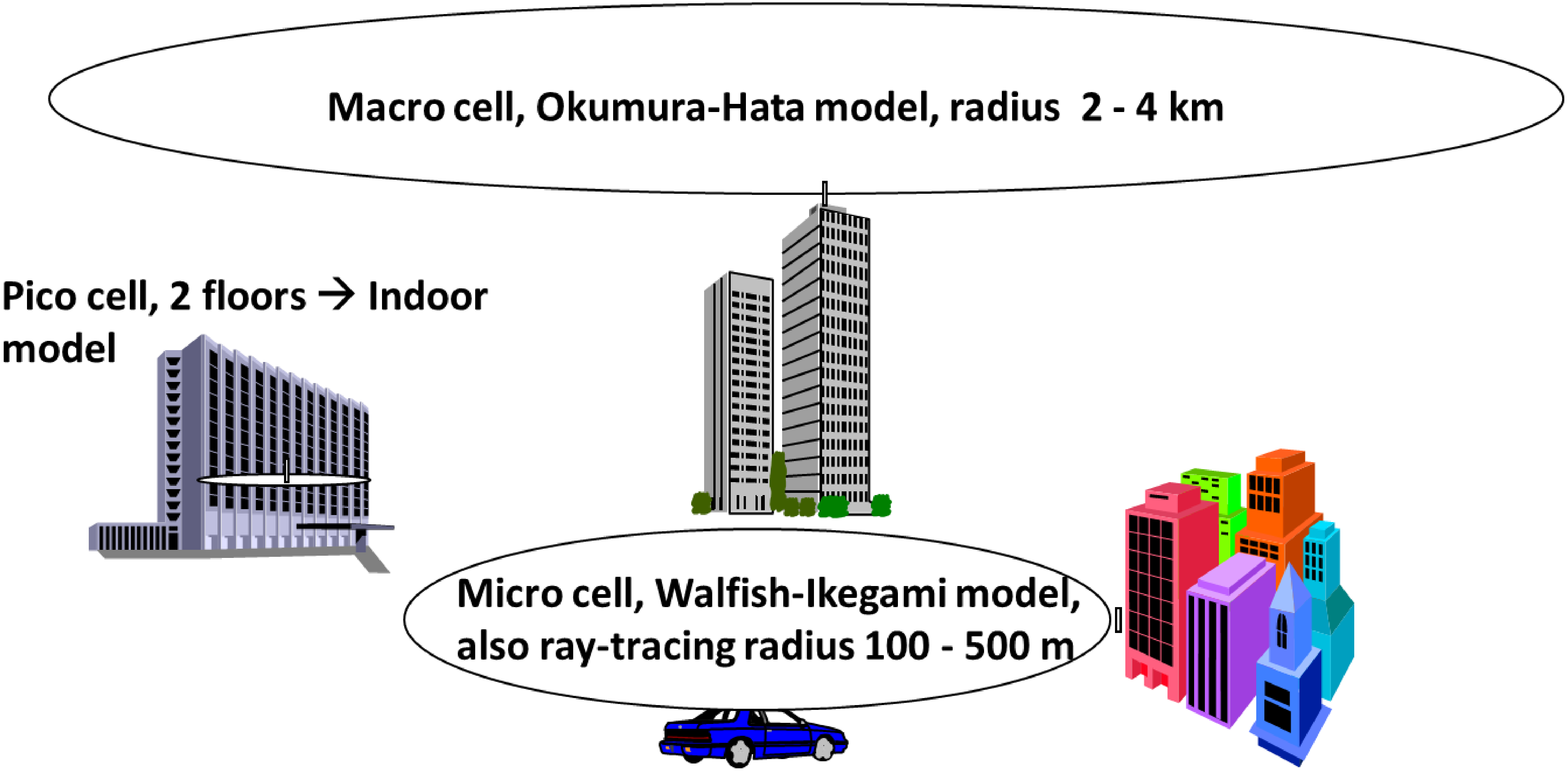
Three Sectorized



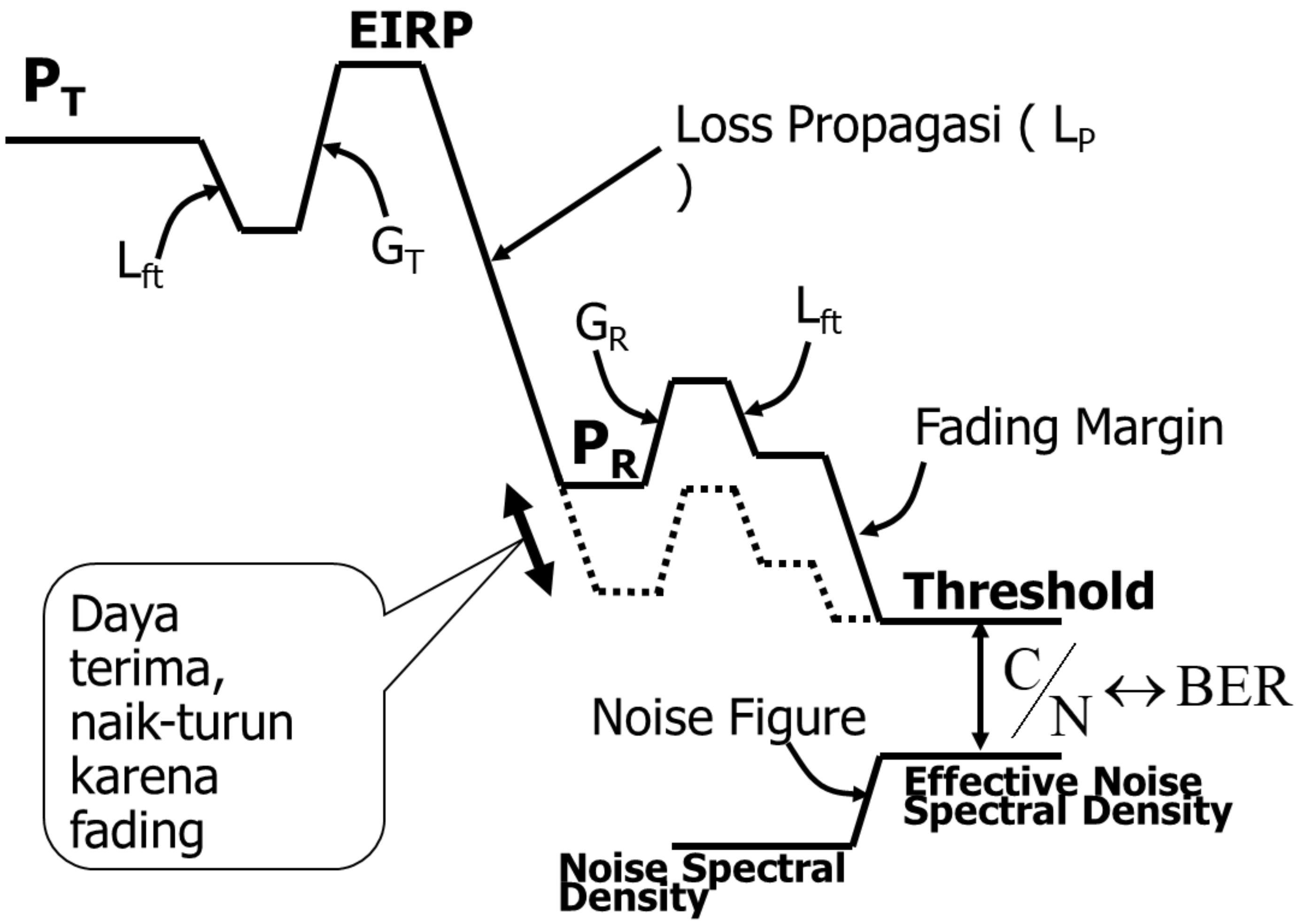
K = 1.95

$$\text{Luas Sel} = K \times R^2$$

Basic Cell Types and Models



Power Budget (PBGT) Principles



$$P_T = Threshold + FM + L_{fR} - G_R + L_P - G_T + L_{fT}$$

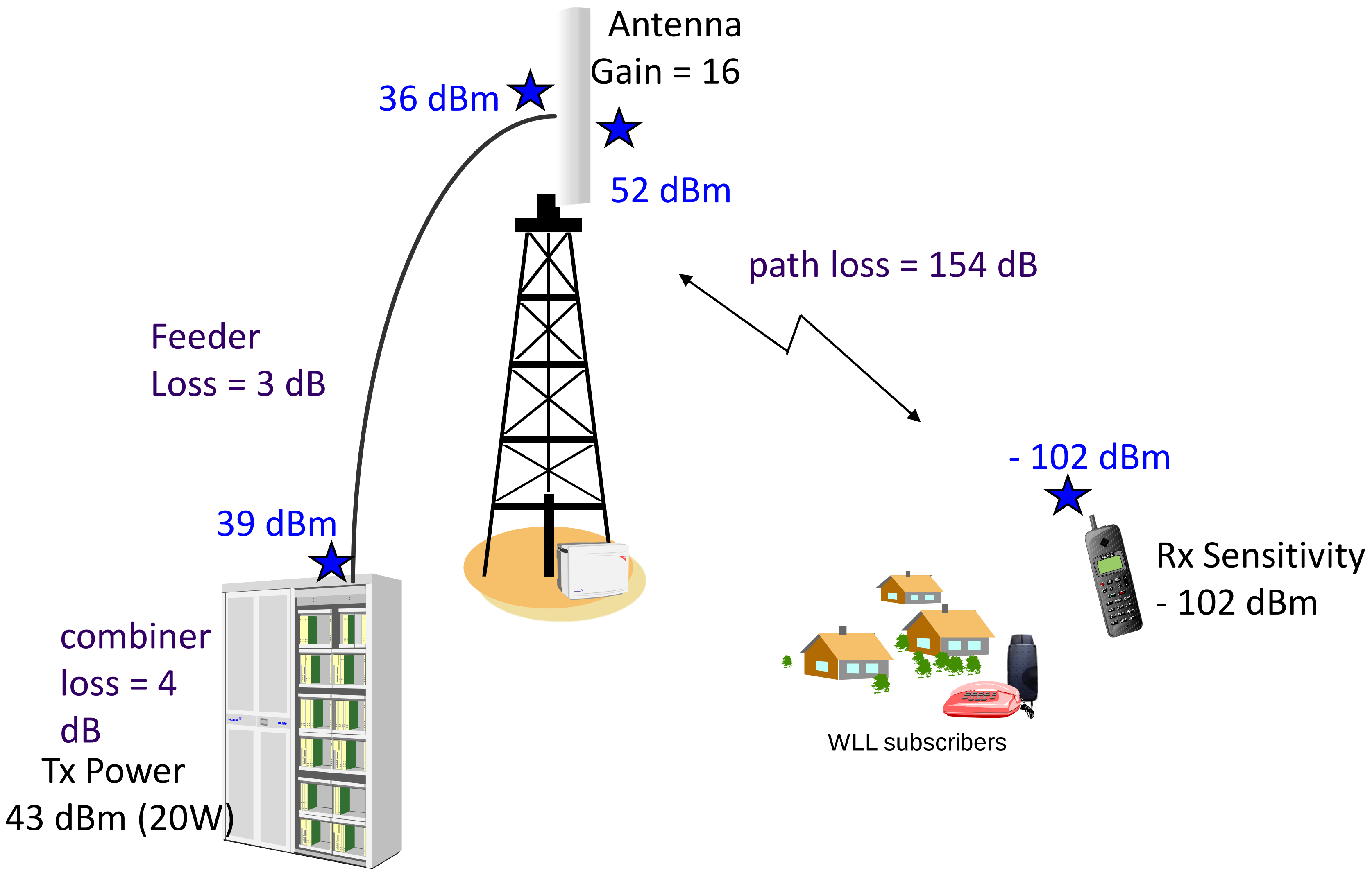
Ukuran sel didesain

MAPL = Maximum Allowable PathLoss

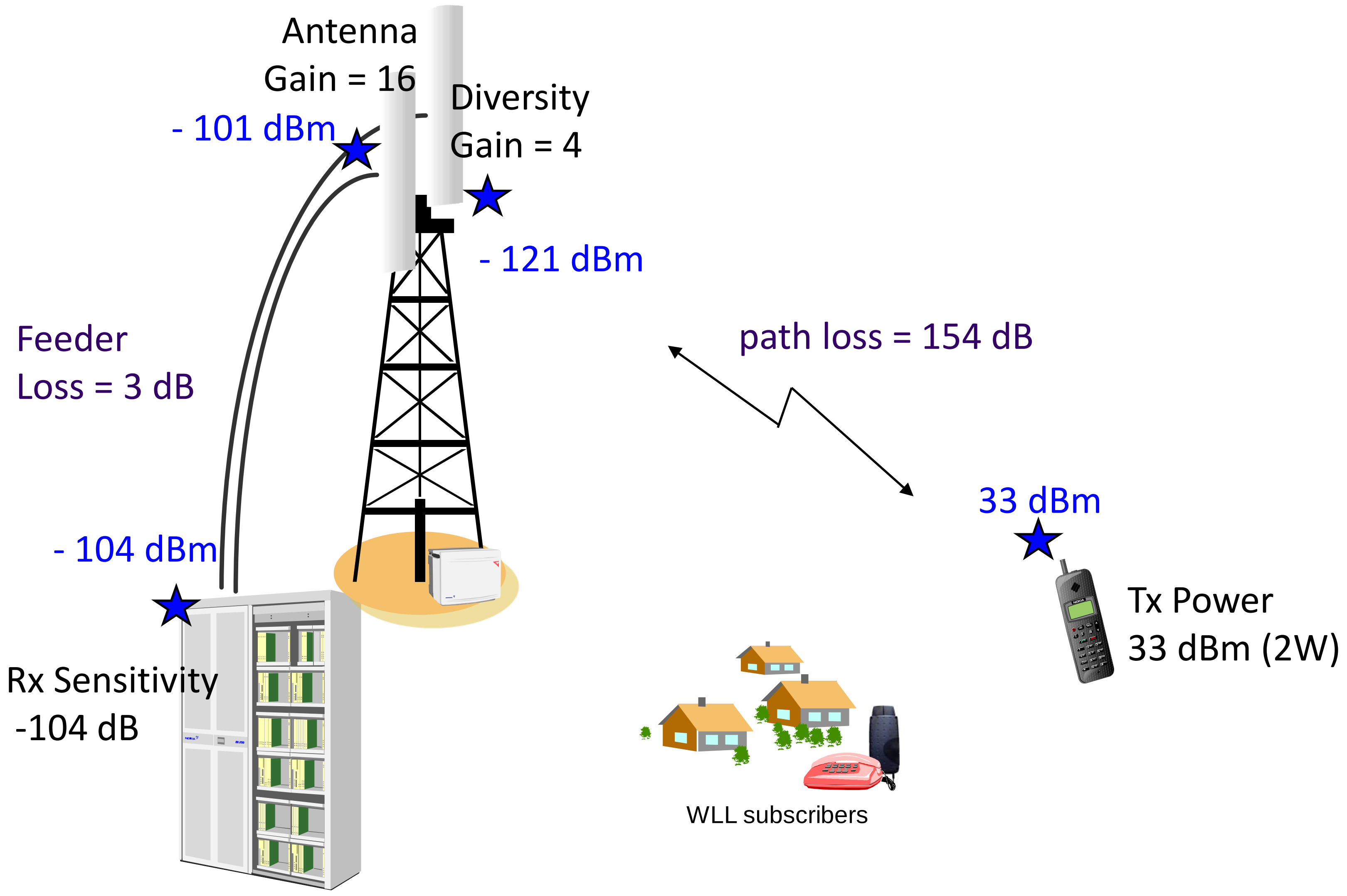
$$MAPL = EIRP_{maks} - P_{R\_Min}$$

Ukuran sel maksimum

Power Budget: Downlink



Power Budget: Uplink



Power Budget & Cell Sizes

RADIO LINK POWER BUDGET
GENERAL INFO
Frequency (MHz):
RECEIVING END:
RX RF-input sensitivity
Interference degrad. margin
Cable loss + connector
Rx antenna gain
Diversity gain
Isotropic power
Field strength
TRANSMITTING END:
TX RF output peak power
(mean power over RF cycle)
Isolator + combiner + filter
RF-peak power, combiner output
Cable loss + connector
TX-antenna gain
Peak EIRP
(EIRP = ERP + 2dB)
Isotropic path loss

RF LINK BUDGET

RF LINK BUDGET	UL	DL
TRANSMITTING END	MS	BTS
Tx RF Output	33 dBm	43 dBm
Body Loss	-2.0dB	0dB
Combiner Loss	0dB	0dB
Feeder Loss (@2dB/100m)	0dB	1.5dB
Connector Losses	0dB	2dB
Tx Antenna Gain	0dB	17.5dB
EIRP	31dBm (A)	57dBm (C)
RECEIVING END	BTS	MS
Rx sensitivity	-107 dBm	-102 dBm
Rx. Antenna gain	17.5dB	0dB
Diversity Gain	3dB	0dB
Connector Loss	2dB	0dB
Feeder Loss	1.5dB	0dB
Interference Degradation Margin	3dB	3dB
Body Loss	0dB	3dB
Duplexer Loss	0dB	0dB
Rx Power	-121dBm	-96dBm
Fade Margin	4dB	4dB
Required Isotropic Rx .Power	-117dBm (B)	-92dBm (D)
Maximum Permissible Path	148dB	149dB

	DU	U	SU	F	O
	1.5	1.5	1.5	1.5	1.5
	30.0	30.0	30.0	45.0	45.0
	7.0	7.0	7.0	7.0	7.0
	15.0	12.0	10.0	6.0	6.0
	10.0	10.0	10.0	10.0	10.0
	DU	U	SU	F	O
	3.0	0.0	-6.0	-10.0	-15.0
	DU	U	SU	F	O
	30.0	30.0	30.0	30.0	30.0
	90.0	90.0	90.0	90.0	90.0
	40.0	40.0	40.0	40.0	40.0
	30.0	30.0	30.0	30.0	30.0
	DU	U	SU	F	O
	OH	OH	OH	OH	OH
	22.8	19.8	17.8	13.8	13.8
	65.1	62.1	60.1	56.1	56.1
	-77.2	-80.2	-82.2	-86.2	-86.2
):	90.0%	90.0%	90.0%	90.0%	90.0%
ange (km):	0.37	0.55	0.94	1.89	2.65
	DU	U	SU	F	O
	OH	OH	OH	OH	OH
	4.5	4.5	4.5	4.5	4.5
	46.8	46.8	46.8	46.8	46.8
	-95.5	-95.5	-95.5	-95.5	-95.5
):	90.0%	90.0%	90.0%	90.0%	90.0%
ange (km):	1.24	1.51	2.24	3.55	4.97

Coverage Planning

Coverage Mindset

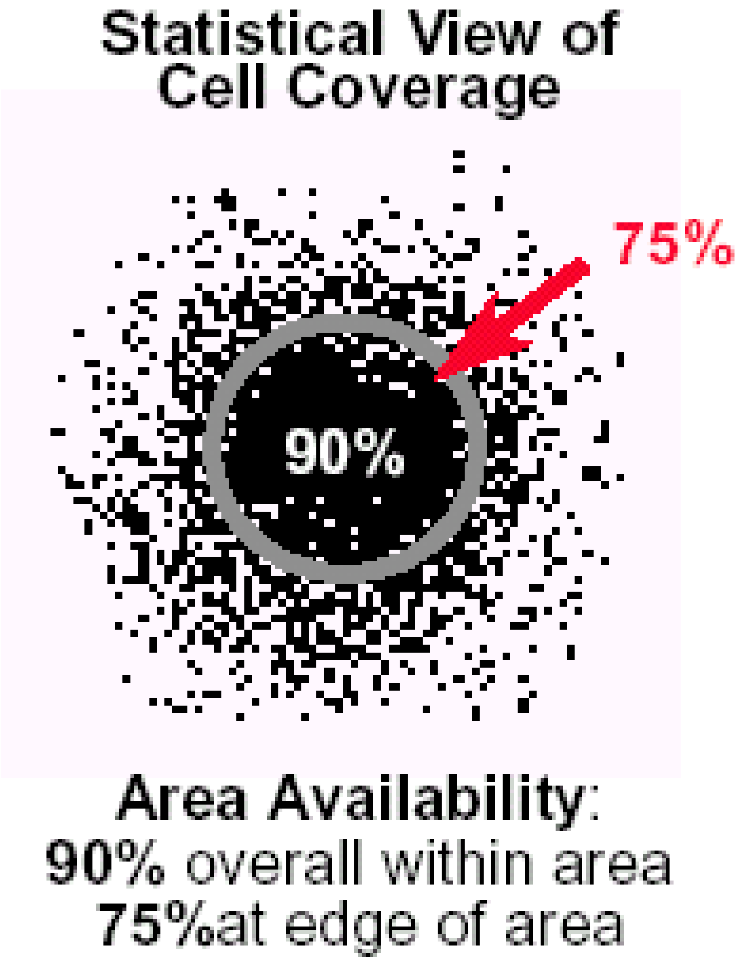
RADIO PARAMETERS → **FORMULA PATHLOSS** →

- MAXIMUM ALLOWABLE PATHLOSS (MAPL)
- MAXIMUM COVERAGE

<u>Design requirements:</u>

- Coverage availability /Cell Edge Reliablity
- Karakteristik propagasi: Urban, Sub-urban, Rural

Coverage Parameters: Coverage Availability vs Cell Edge Reliability



- Titik-titik disamping adalah lokasi yang mendapatkan sinyal di atas threshold
- Untuk mencapai 90% cakupan sel memiliki sinyal di atas level threshold (coverage availability), maka cell edge reliability yang harus dicapai adalah 75%
- Angka 90% / 75% tersebut umum dipakai sebagai obyektif perencanaan

Catatan: Coverage Availability sebagai fungsi Cell Edge Reliability akan kita lihat pada slide berikutnya

Cell Edge Reliability Vs Coverage Availability

Cell Edge Reliability

Probabilitas sinyal terukur ditepi sel (jarak R) mendapatkan sinyal di atas level threshold, dinyatakan oleh fungsi berikut:

$$P_{Th}(R) = P(m \geq Th) = \int_{Th}^{\infty} p(m)dm = \frac{1}{2} - \frac{1}{2}\operatorname{erf}\left(\frac{Th - \overline{m}}{\sigma_m \sqrt{2}}\right)$$

Coverage Availability

Prosentase daerah sel yang menerima sinyal lebih besar dari level threshold. Jika misalkan availabilitas cakupan dinyatakan sebagai $\mathbf{F_u}$, maka :

$$F_u = \frac{1}{\pi R^2} \int P_{Th}(R)dA$$

$$P_{Th}(R) = \frac{1}{2} - \frac{1}{2}\operatorname{erf}\left(\frac{Th - \overline{m}}{\sigma_m \sqrt{2}}\right)$$

dimana sinyal rata-rata $\overline{m}$ dinyatakan :

$$\overline{m} = \alpha - 10\gamma \log \frac{d}{R}$$

$$P_{Th}(R) = \frac{1}{2} - \frac{1}{2}\operatorname{erf}\left(\frac{Th - \alpha + 10\gamma \log\left(d/R\right)}{\sigma_m \sqrt{2}}\right)$$

Jake's Curves

- Jika dimisalkan $\overline{m} = Th$ pada d = R, maka :
  didapatkan persamaan untuk ***Jake's Curves*** yang sering digunakan untuk prediksi availabilitas cakupan :

$$F_u = \frac{1}{2}\left\{1 + e^{\left(\frac{1}{b}\right)^2}\left[1 - \operatorname{erf}\left(\frac{1}{b}\right)\right]\right\}$$

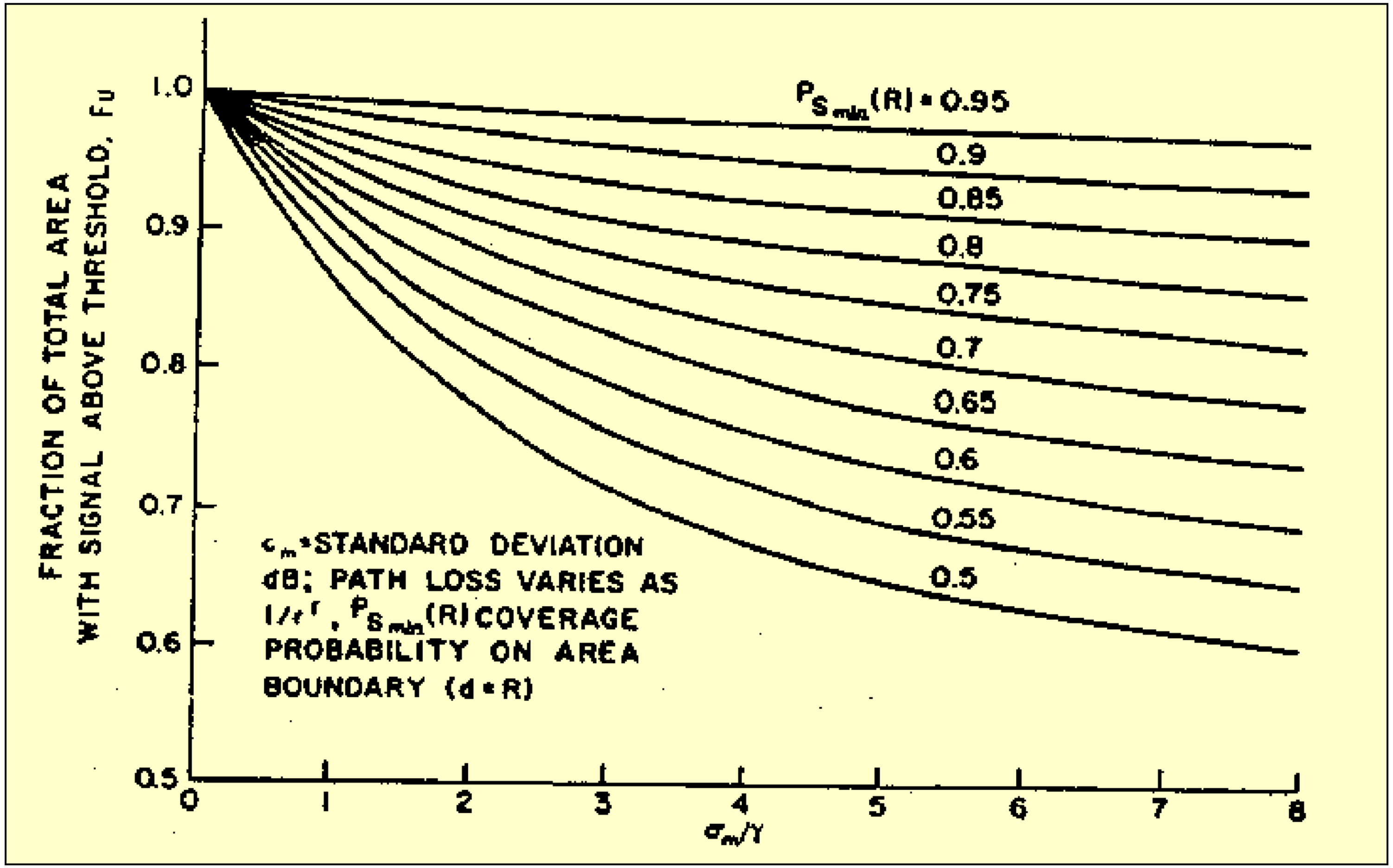
dimana,

$$b = \frac{10\gamma \log\left(\frac{d}{R}\right)}{\sigma_m \sqrt{2}}$$

<u>Catatan</u> : penurunan lengkap dapat dilihat pada buku Vijay K Garg, Wilker, E Joseph, " ***Principles and Applications of GSM*** " , Prentice Hall , 1999

Jake's Curves

Didapatkan kurva berikut ini, yang biasa disebut ***Jake's Curves***, dari kurva dapat diketahui nilai *Coverage Availability* yang dicapai dengan *Cell Edge Reliability* tertentu



Dari kurva disamping diketahui, bahwa *Coverage Availability* adalah **fungsi dari** ***mean pathloss exponent*** dan ***SDEV*** untuk *Cell Edge Reliability* tertentu

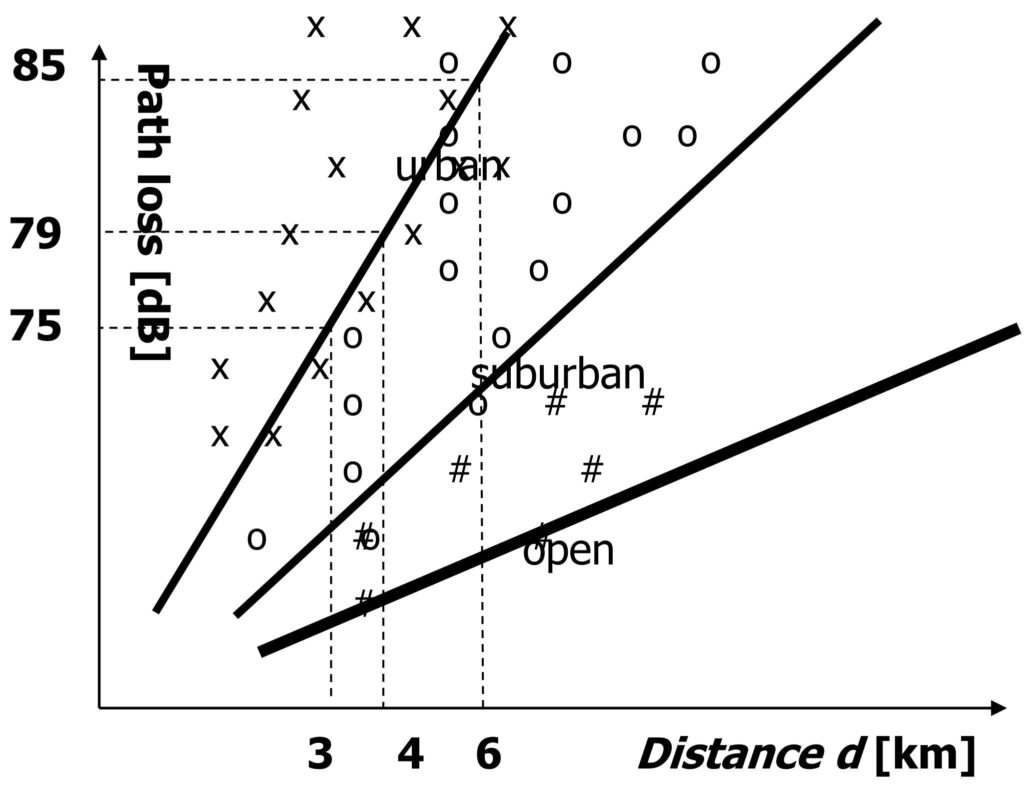
Meningkatkan Coverage Probability Dengan Fade Margin

Review Pengukuran Pathloss: Mendapatkan *Mean* dan Standar Deviasi

- Pengukuran dilakukan pd tipe-tipe daerah:
  - Urban, suburban, dan open / rural area
- Pengukuran pada radius konstan dari BTS menghasilkan *pathloss* yang berbeda (random) → terdistribusi Lognormal
- Dengan regresi linear, didapatkan trend *mean pathloss* dan *standar deviasi* disekitar nilai rata-rata
- Contoh untuk urban *path loss*

  → Slope = 33.2 (dB/decade) dan

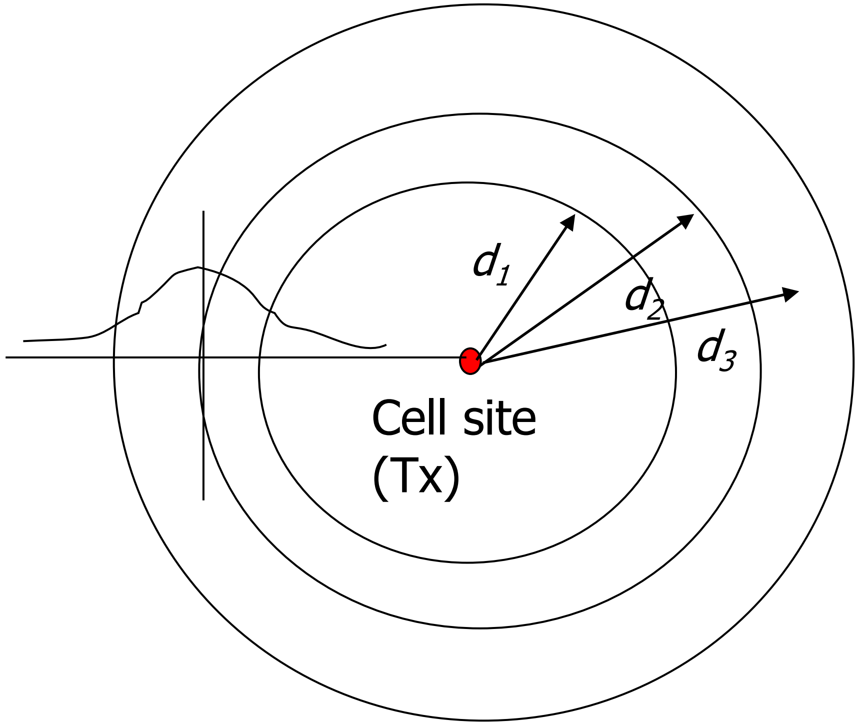
  → Std dev. = 7 dB



Distribusi Lognormal Pada Pathloss

- **Contoh** misalkan untuk jarak d_2 = 4 km (urban area). Misal path loss pada 4 km adalah 79 dB → Pathloss ini didesain untuk suatu nilai rata-rata dengan tingkat keyakinan 50 %
- Dengan STDev untuk urban adalah 7 dB,

  Maka, untuk mendapatkan tingkat keyakinan (*confidence level*) 84 % (1σ) membutuhkan margin 7 dB , dan untuk tingkat keyakinan 97.7 % (2σ) membutuhkan margin 14 dB



Rumus distribusi Lognormal

$$p(m) = \frac{1}{\sigma_m \sqrt{2\pi}} e^{-\left[\frac{(m-\overline{m})^2}{2\sigma_m^2}\right]}$$

m = normal random variabel kuat sinyal (dBm)

$\overline{m}$ = rata-rata (mean) kuat sinyal (dBm)

σ_m = standar deviasi

Review: Okumura-Hata Model

$$L = A + B \times \log(f) - 13.82 \times \log(Hb) - a(Hm)$$
$$+ (44.9 - 6.55 \times \log(Hb)) \times \log(R)$$

f [MHz]	A	B
150-1500	69.55	26.16
1500-2000	46.30	33.90

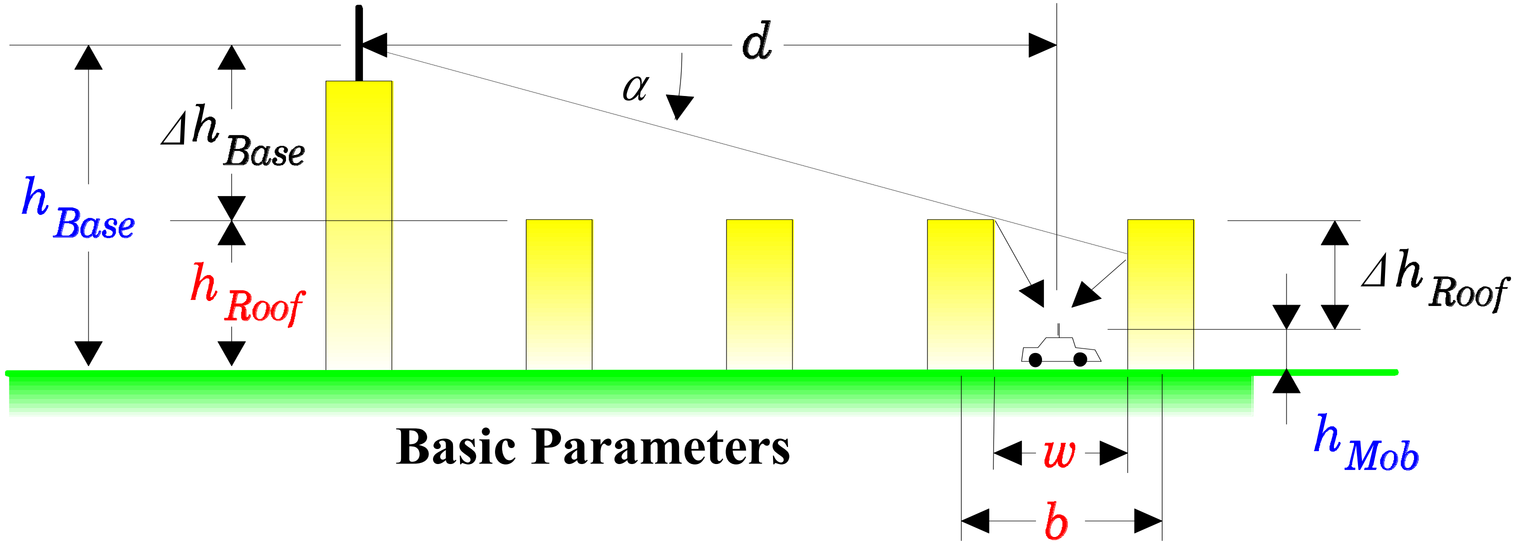
f	Frequency [MHz], range 150-2000
Hb	BS effective antenna height [m], range 30-200
Hm	MS antenna height [m], range 1-10
R	Distance [km], range 1-20
a(Hm)	Correction factor for MS antenna height
a(Hm)	$1.1 \times \log(f) - 0.7) \times Hm - (1.56 \times \log(f) - 0.8)$, large city
	$3.2 \times (\log(11.75 \times Hm))^2 - 4.97$, small city

Review: COST-231 Walfish-Ikegami

$$L = 42.6 + 26 \times \log(d) + 20 \times \log(f) \qquad , \text{LOS}$$

$$L = 32.4 + 20 \times \log(d) + 20 \times \log(f) + L_{rts} + L_{msd}, \text{NLOS}$$

- **Frequency Range = 800 - 2000 MHz**
- **0.02 - 0.2 km for LOS**
- **0.02 - 5 km for NLOS**

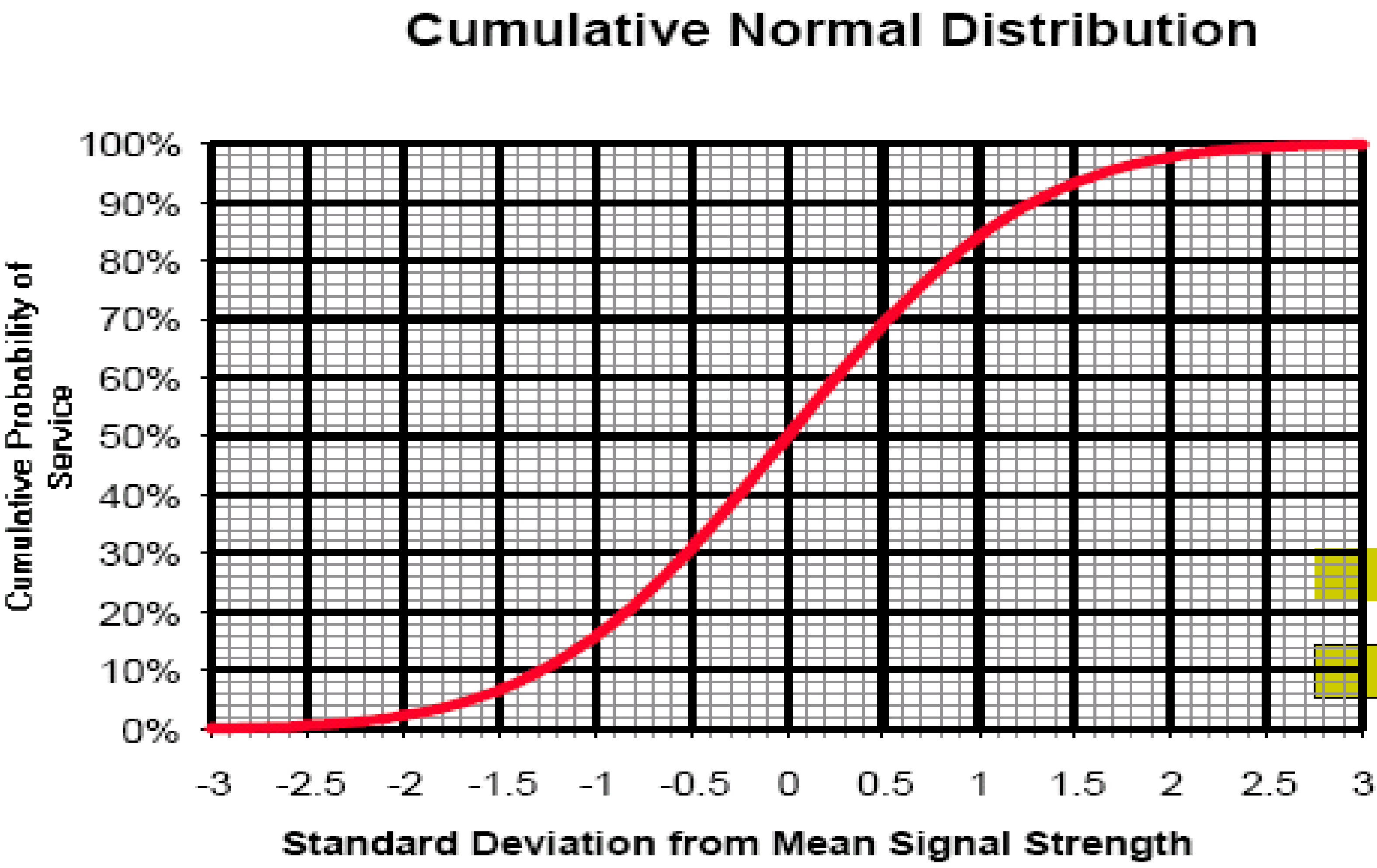


Basic Parameters

Coverage Threshold (MAPL) Basics

- Based on the calculated maximum allowed path loss in PBGT, the coverage threshold can be defined
- Coverage threshold depends on margins related to
  - Location probability (= slow fading)
  - Fast fading / Interference degradation
  - Polarization / Antenna orientation loss
  - Body loss
  - Penetration losses (vehicle or building)

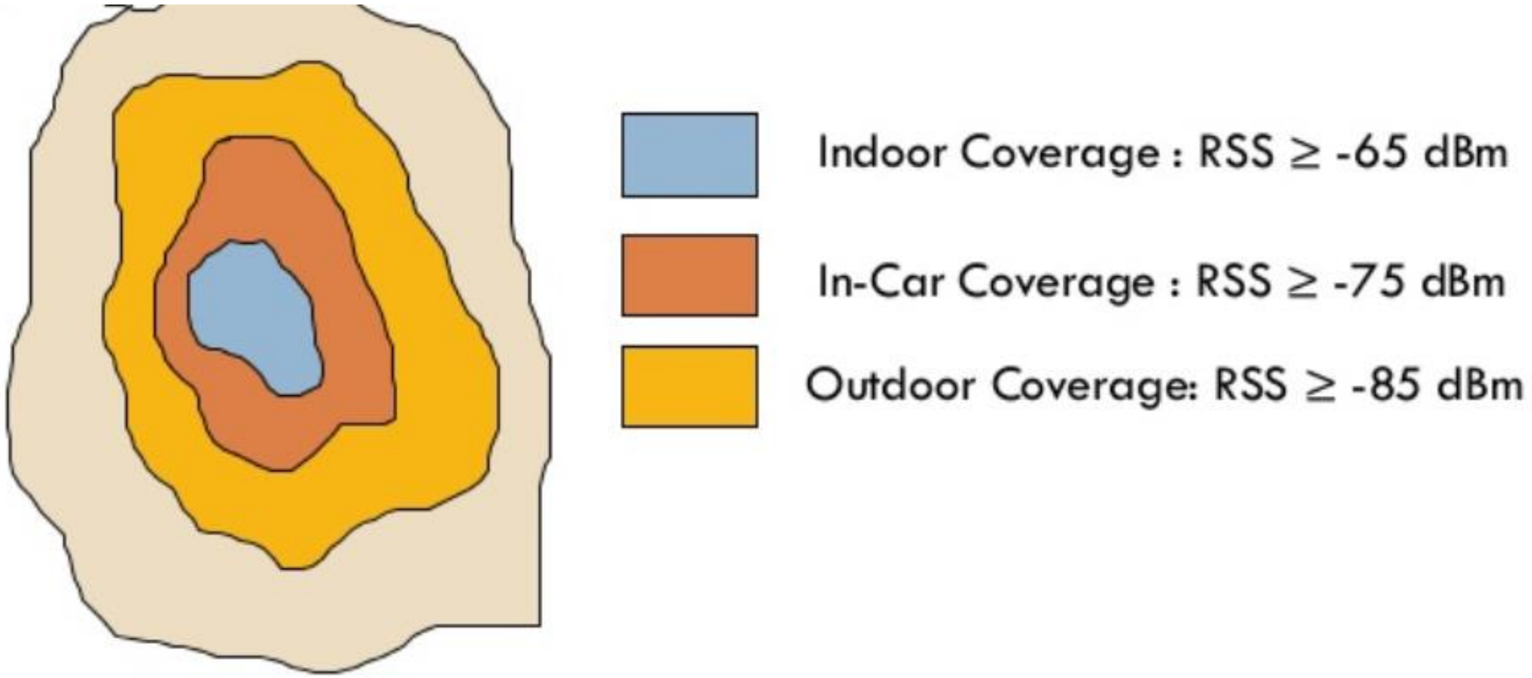
Composite Probability of Service & Fade Margin



Standard Deviation	Cumulative Probability
-3.09	0.1%
-2.32	1%
-1.65	5%
-1.28	10%
-0.84	20%
-0.52	30%
0	50%
0.52	70%
0.675	75%
0.84	80%
1.28	90%
1.65	95%
2.35	99%
3.09	99.9%
3.72	99.99%
4.27	99.999%

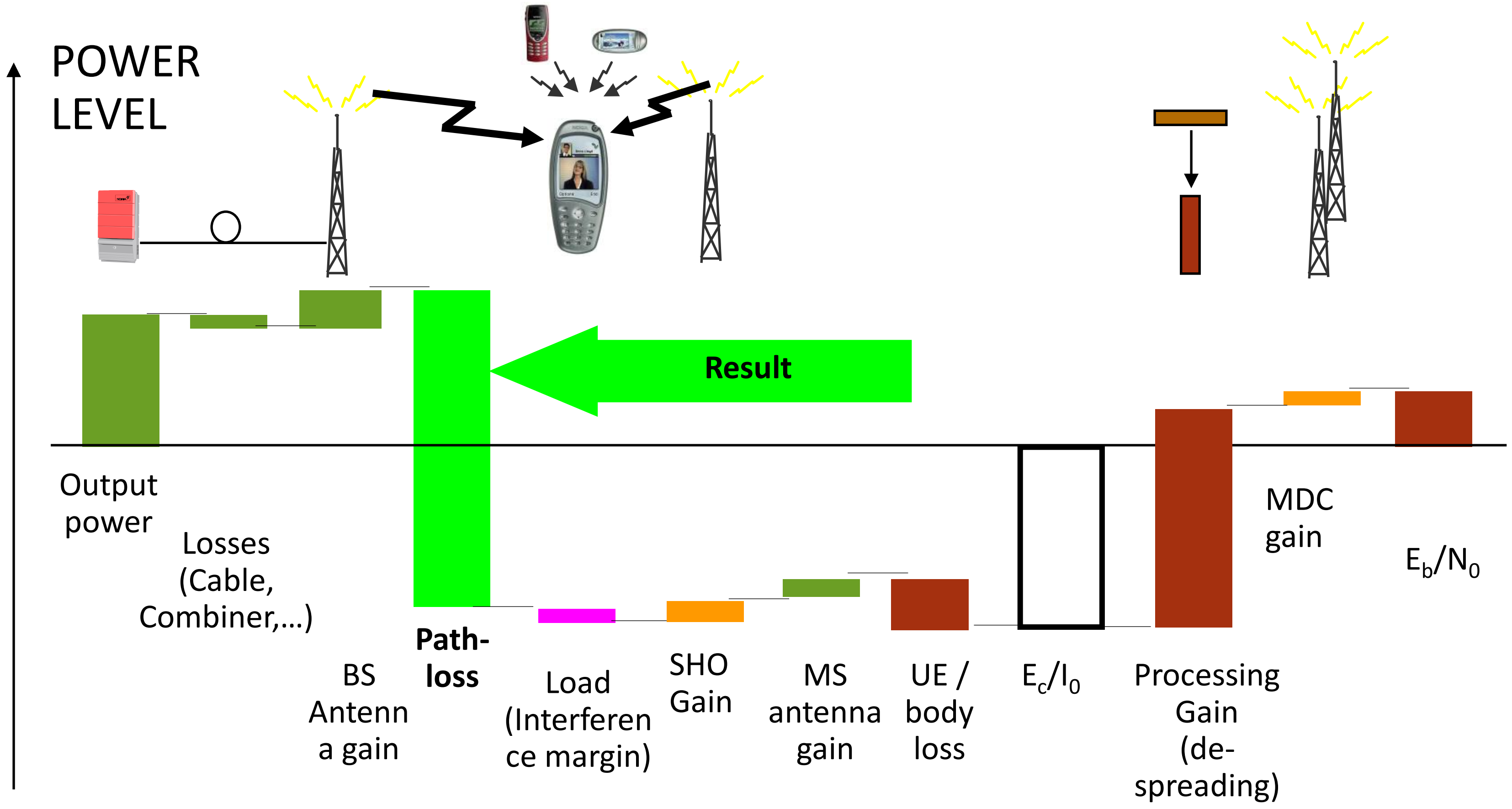
Composite Probability of Service & Fade Margin

- **Example :**
  - Standar deviasi Loss Building Penetration : 9 dB
  - Standar deviasi Outdoor loss : 10 dB
  - Composite : $(9^2 + 10^2)^{1/2} = 13.45$
  - Pada distribusi normal, probabilitas 75% adalah 0.675σ diatas median.
  - Fading margin yang dibutuhkan = 0.675 * 13.45 = 9 dB



WCDMA UMTS Link Budget Parameters

UMTS Link Budget Overview



Input Categories

Hardware related

System related

Capacity related

Application related

Power Budget Calculations

Link budget

Chip rate	3840,00	DL data rate	64,00
UL Data rate	64,00	DL load	85%
UL Load	50%		

NRT 64kbit/s, 3km/h

		Uplink	Downlink
RECEIVING END		**Node B**	**UE**
Thermal Noise Density	*dBm/Hz*	-173,98	-173,98
Receiver Noise Figure	*dB*	3,00	8,00
Receiver Noise Density	*dBm/Hz*	-170,98	-165,98
Noise Power [NoW]	*dBm*	**-105,14**	**-100,14**
Required Eb/No	*dB*	2,00	5,50
Soft handover MDC gain	*dB*	0,00	1,00
Processing gain	*dB*	17,78	17,78
Interference margin (NR)	*dB*	3,01	8,24
Required Ec/Io [q]	*dB*	**-15,78**	**-12,28**
Required Signal Power [S]	*dBm*	**-117,91**	**-105,18**
Cable loss	*dB*	2,00	0,00
Body loss	*dB*	0,00	0,00
Antenna gain RX	*dBi*	18,00	0,00
Soft handover gain	*dB*	2,00	2,00
Power control headroom	*dB*	3,00	0,00
Istropic power	*dBm*	**-132,91**	**-107,18**
TRANSMITTING END		**UE**	**Node B**
Power per connection	*dBm*	21,00	**24,73**
Cable loss	*dB*	0,00	2,00
Body loss	*dB*	0,00	0
Antenna gain TX	*dBi*	0,00	18
Peak EIRP	*dBm*	**21,00**	**40,73**
Isotropic path loss	*dB*	**153,91**	**147,91**
DL peak to average ratio	*dB*		6,00
Isotropic path loss to the cell border			**153,91**

- The calculation is done for each service (bit rate) separately
- The link budget must be balanced (U/L and D/L)

WCDMA Link budget

Link budget

Chip rate	3840.00	DL data rate	64.00	
UL Data rate	64.00	DL load	85%	
UL Load	50%			

NRT 64kbit/s, 3km/h

		Uplink	Downlink
RECEIVING END		**Node B**	**UE**
Thermal Noise Density	dBm/Hz	-173.98	-173.98
Receiver Noise Figure	dB	3.00	8.00
Receiver Noise Density	dBm/Hz	-170.98	-165.98
Noise Power [NoW]	dBm	**-105.14**	**-100.14**
Required Eb/No	dB	2.00	5.50
Soft handover MDC gain	dB	0.00	1.00
Processing gain	dB	17.78	17.78
Interference margin (NR)	dB	3.01	8.24
Required BTS Ec/Io [q]	dB	**-12.77**	**-5.04**
Required Signal Power [S]	dBm	**-117.91**	**-105.18**
Cable loss	dB	2.00	0.00
Body loss	dB	0.00	0.00
Antenna gain RX	dBi	18.00	0.00
Soft handover gain	dB	2.00	2.00
Power control headroom	dB	3.00	0.00
Istropic power	dBm	**-132.91**	**-107.18**
TRANSMITTING END		**UE**	**Node B**
Power per connection	dBm	21.00	**24.73**
Cable loss	dB	0.00	2.00
Body loss	dB	0.00	0
Antenna gain TX	dBi	0.00	18
Peak EIRP	dBm	**21.00**	**40.73**
Isotropic path loss	dB	**153.91**	**147.91**
DL peak to average ratio	dB		6.00
Isotropic path loss to the cell border			**153.91**

Data Rate in UL and DL depends on service, can be asymmetric

Maximum Load needs to be defined for Dimensioning:

- should not exceed 70%
- should be at least 30% to avoid excessive cell breathing
- typically higher in DL than in UL

WCDMA Link budget

Link budget

Chip rate	3840.00	DL data rate	64.00
UL Data rate	64.00	DL load	85%
UL Load	50%		

NRT 64kbit/s, 3km/h

		Uplink	Downlink
RECEIVING END		Node B	UE
Thermal Noise Density	dBm/Hz	-173.98	-173.98
Receiver Noise Figure	dB	3.00	8.00
Receiver Noise Density	dBm/Hz	-170.98	-165.98
Noise Power [NoW]	dBm	**-105.14**	**-100.14**
Required Eb/No	dB	2.00	5.50
Soft handover MDC gain	dB	0.00	1.00
Processing gain	dB	17.78	17.78
Interference margin (NR)	dB	3.01	8.24
Required BTS Ec/Io [q]	dB	**-12.77**	**-5.04**
Required Signal Power [S]	dBm	**-117.91**	**-105.18**
Cable loss	dB	2.00	0.00
Body loss	dB	0.00	0.00
Antenna gain RX	dBi	18.00	0.00
Soft handover gain	dB	2.00	2.00
Power control headroom	dB	3.00	0.00
Istropic power	dBm	**-132.91**	**-107.18**

TRANSMITTING END		UE	Node B
Power per connection	dBm	21.00	**24.73**
Cable loss	dB	0.00	2.00
Body loss	dB	0.00	0
Antenna gain TX	dBi	0.00	18
Peak EIRP	dBm	**21.00**	**40.73**
Isotropic path loss	dB	**153.91**	**147.91**
DL peak to average ratio	dB		6.00
Isotropic path loss to the cell border			**153.91**

Thermal noise density:

- theoretical Limit for Sensitivity
- depends on Bandwidth and temperature
- *Thermal Noise density* [dBm/Hz] is defined as:

$$Thermal\_Noise\_Density = 10 * Log(kT)$$

Where:
k is Boltzman's constant
T is the temperature in Kelvin

in normal +20 C^0 conditions the thermal noise density is -173.98 dBm/Hz

Receiver Noise Figure:

- Requirement from specifications for BTS and MS performance

WCDMA Link budget

Link budget

Chip rate	3840.00		DL data rate	64.00
UL Data rate	64.00		DL load	85%
UL Load	50%			

NRT 64kbit/s, 3km/h

		Uplink	Downlink
RECEIVING END		**Node B**	**UE**
Thermal Noise Density	dBm/Hz	-173.98	-173.98
Receiver Noise Figure	dB	3.00	8.00
Receiver Noise Density	dBm/Hz	-170.98	-165.98
Noise Power [NoW]	dBm	**-105.14**	**-100.14**
Reguired Eb/No	dB	2.00	5.50
Soft handover MDC gain	dB	0.00	1.00
Processing gain	dB	17.78	17.78
Interference margin (NR)	dB	3.01	8.24
Required BTS Ec/Io [q]	dB	**-12.77**	**-5.04**
Required Signal Power [S]	dBm	**-117.91**	**-105.18**
Cable loss	dB	2.00	0.00
Body loss	dB	0.00	0.00
Antenna gain RX	dBi	18.00	0.00
Soft handover gain	dB	2.00	2.00
Power control headroom	dB	3.00	0.00
Istropic power	dBm	**-132.91**	**-107.18**
TRANSMITTING END		**UE**	**Node B**
Power per connection	dBm	21.00	**24.73**
Cable loss	dB	0.00	2.00
Body loss	dB	0.00	0
Antenna gain TX	dBi	0.00	18
Peak EIRP	dBm	**21.00**	**40.73**
Isotropic path loss	dB	**153.91**	**147.91**
DL peak to average ratio	dB		6.00
Isotropic path loss to the cell border			**153.91**

Receiver Noise Density [dBm/Hz]

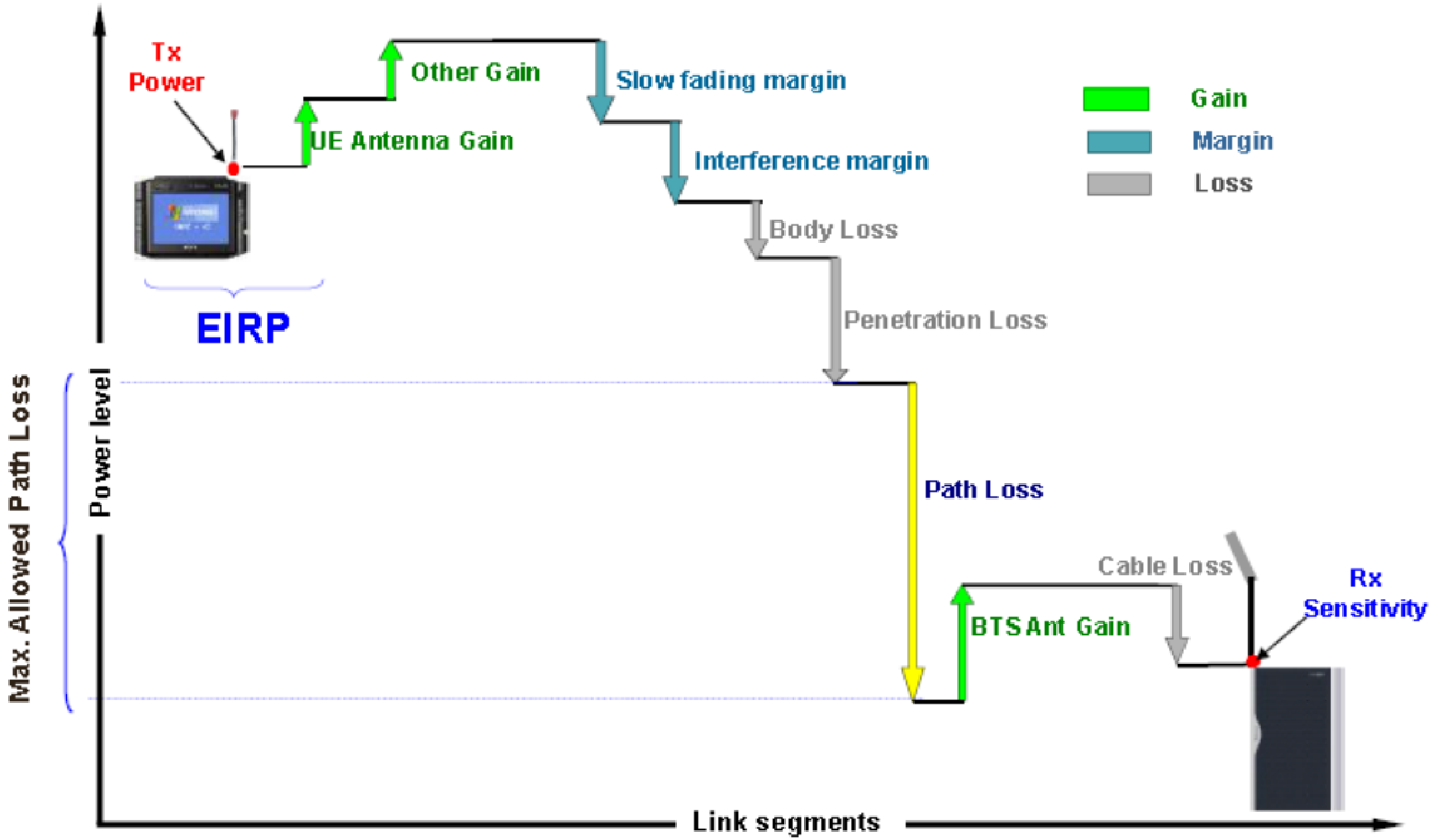
- Receiver noise density is the sum of the thermal noise density and the receiver noise figure.
- Thermal Noise density [dBm/Hz] + Receiver noise figure [dB] = Receiver Noise Density [dBm/Hz]

In order to calculate the *Noise power of the receiver* (minimum base band signal strength at the receiver i.e. the receiver sensitivity for the non loaded network) the receiver noise density has to be scaled to the WCDMA carrier bandwidth.

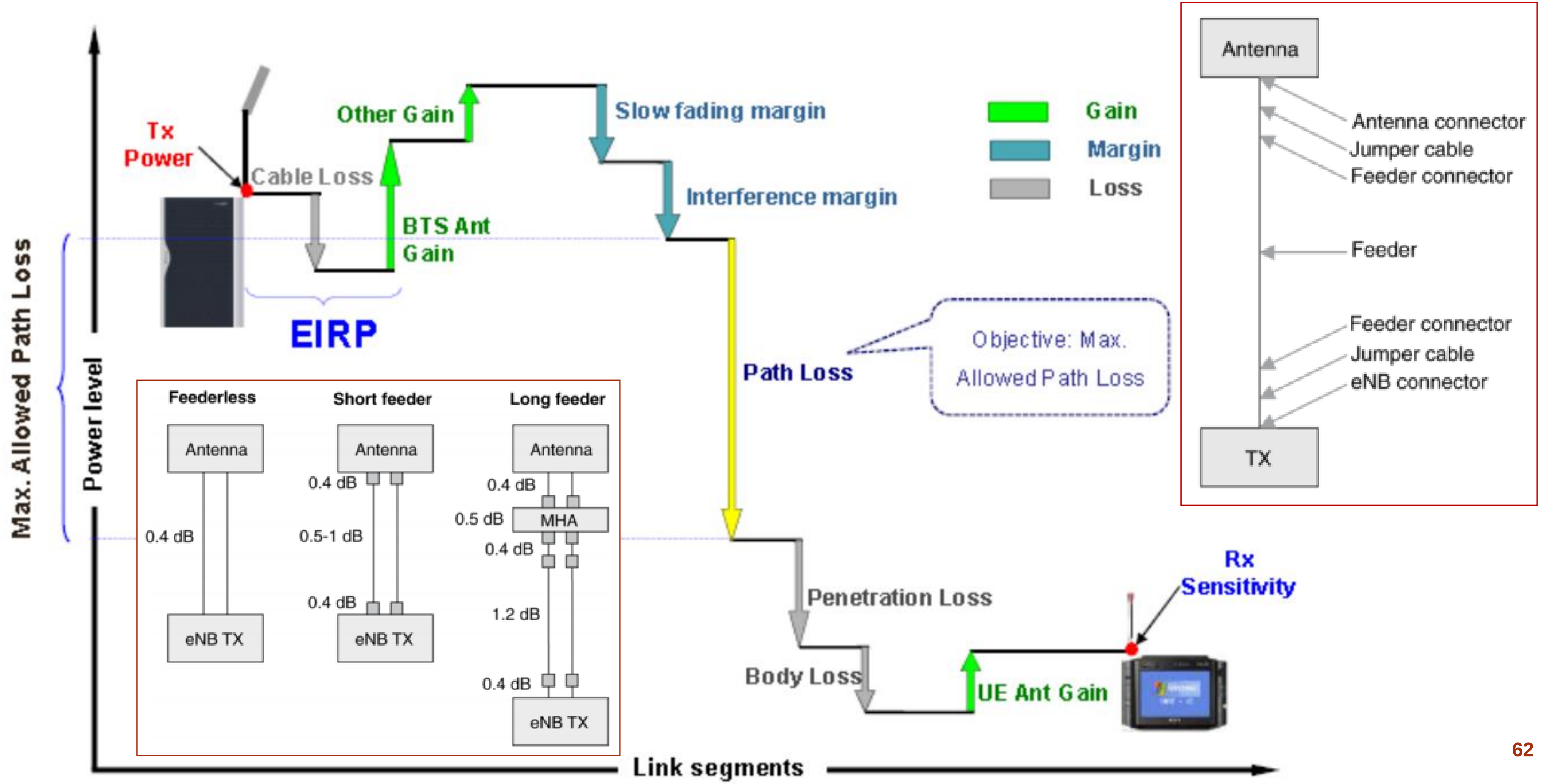
receiver noise power [dBm] =
=Receiver Noise Density [dBm/Hz] + $10\log_{10}(3.84*10^6)$= =-170.98 + 65.84 = -105.14 dBm

LTE Link Budget Parameters

LTE Link Budget: Uplink



LTE Link Budget: Downlink



Example of LTE Link Budget: Uplink & Downlink

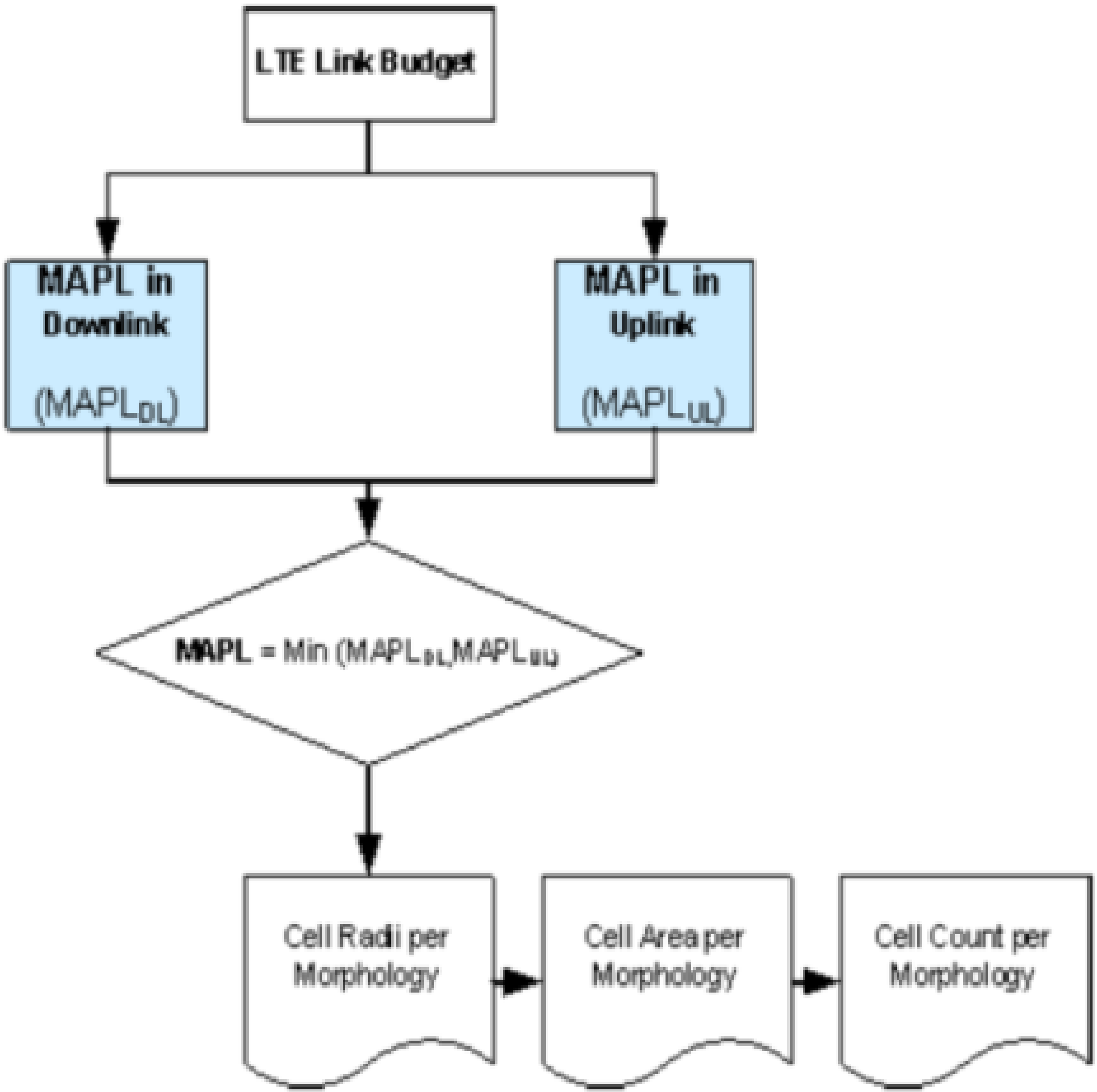
Table 9.2 LTE radio link budget example in the downlink direction.

Transmitter, eNodeB	Unit	Value
Transmitter power	W	40.0
Transmitter power (a)	dBm	46.0
Cable and connector loss (b)	dB	2.0
Antenna gain (c)	dBi	11.0
Radiating power (EIRP) (d)	dBm	55.0
Receiver, terminal	Unit	Value
Temperature (e)	K	290.0
Bandwidth (f)	Hz	10 000 000.0
Thermal noise	dBW	−134.0
Thermal noise (g)	dBm	−104.0
Noise figure (h)	dB	7.0
Receiver Boise floor (i)	dBm	−97.0
SINR (j)	dB	−10.0
Receiver sensibility (k)	dBm	−107.0
Interference margin (l)	dB	3.0
Control channels share (m)	dB	1.0
Antenna gain (n)	dBi	0.0
Body loss (o)	dB	0.0
Minimum received power (p)	dBm	−103.0
Maximum allowed path loss, downlink	dB	158.0
Indoor loss	dB	15.0
Maximum path loss for indoors, DL	dB	**143.0**

Table 9.3 The LTE radio link budget in the uplink direction.

Transmitter, terminal	Unit	Value
Transmitter power	W	0.3
Transmitter power (a)	dBm	24.0
Cable and connector loss (b)	dB	0.0
Antenna gain (c)	dBi	0.0
Radiating power (EIRP) (d)	dBm	24.0
Receiver, eNodeB	Unit	Value
Temperature (e)	K	290.0
Bandwidth (f)	Hz	360 000.0
Thermal noise	dBW	−148.4
Thermal noise (g)	dBm	−118.4
Noise figure (h)	dB	2.0
Receiver noise floor (i)	dBm	−116.4
SINR (j)	dB	−7.0
Receiver sensibility (k)	dBm	−123.4
Interference margin (l)	dB	2.0
Antenna gain (m)	dBi	11.0
Mast head amplifier (n)	dB	2.0
Cable loss (o)	dB	3.0
Minimum received power (p)	dBm	−131.4
Maximum allowed path loss, uplink		155.4
Smaller of the path losses (UL and DL):	dB	**155.4**
Indoor loss	dB	15.0
Maximum path loss in indoors, UL	dB	140.4
Smaller of the path losses in indoors (UL and DL):		**140.4**

Which Link is Limiting? Uplink dan Downlink



End