WIRELESS COMMUNICATION. SYSTEM

Modul 11 Coverage Planning

Faculty of Electrical Engineering
Bandung – 2015

Introduction Cellular Planning

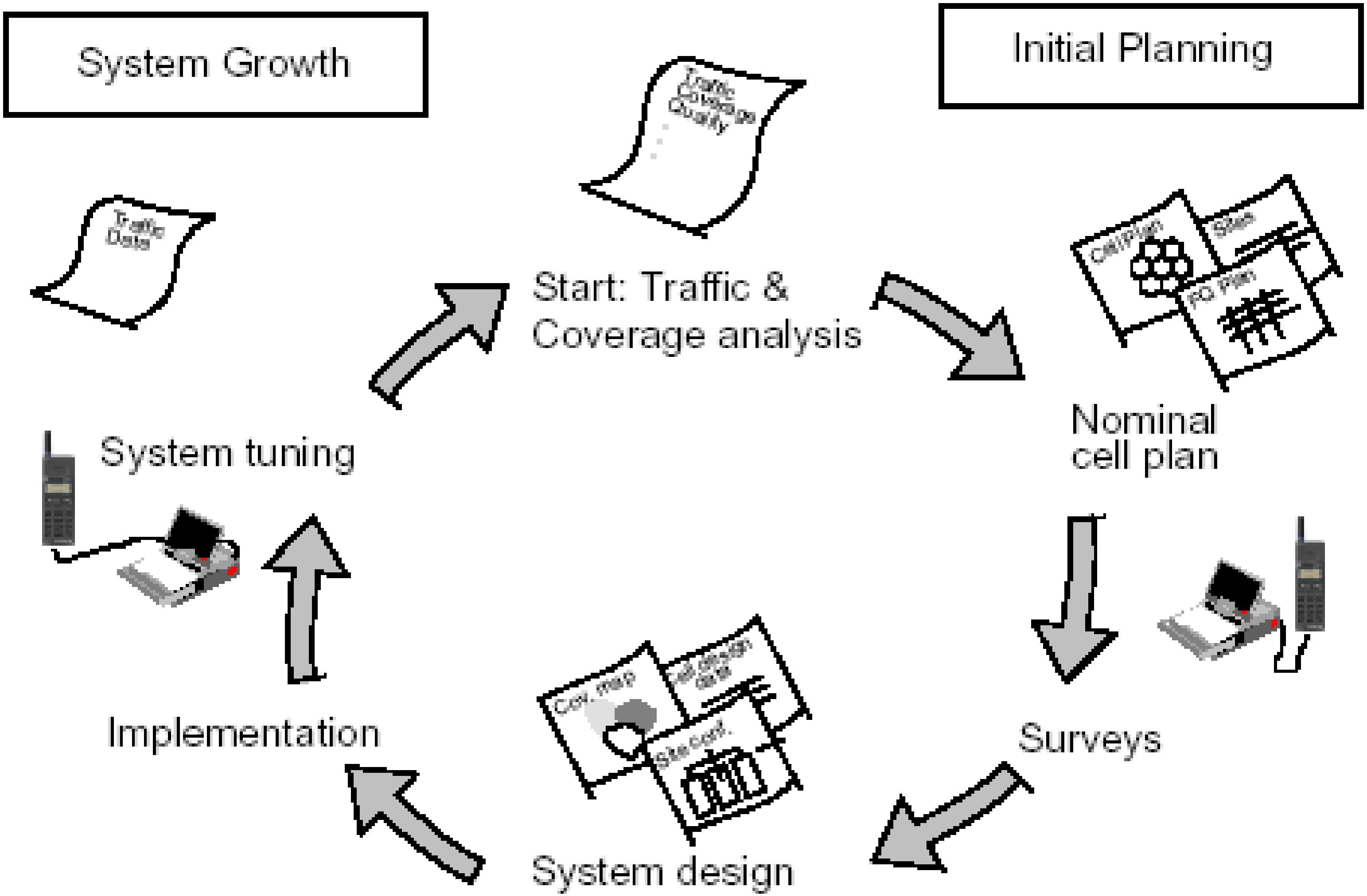
Implementation of a telecommunications network in an area besides dealing with the regulation of telecommunications, will also deal with market situations should be studied carefully to anticipate the various possibilities. Below are three major tasks to be done a market analyst

1. **Prediction of gross income (income coarse).**
   Various measures can be undertaken to examine the gross income, including the study population, average income, the types of growing businesses, etc.

2. **Introduction to competitors**
   It is important to note that there is competition situation, to ensure there is opportunity. In this case can be seen the coverage of its competitors, the system performance, and also the number of subscribers to compare the number of potential customers unserved.

3. **Geographical coverage decisions**
   The question is: where the geographic area covered by the system you need and what types of services that are suitable for the area? That question must be answered to then be forwarded to the Technical

Cellular System Planning Cycle



What is the real role of an engineer?

After receiving a report from economic analysts who examined the economic feasibility, the task of an engineer to create a reliable network in terms of capacity, quality and costs as efficiently as possible

1. Starting sketch plan in the area of service, the aim is to produce a range of services in service areas with the least possible number of cells, perhaps for the allocation of capacity for a given BW, as well as good quality as possible.

2. Determining the number of RF channels needed to serve the traffic during rush hour predictions until several years into the future.

3. Studies of interference problems.
Cochannel interference, adjacent channel interference, and also the possibility of intermodulasi of each cell. Furthermore, finding ways to overcome this.

4. Studies on the blocking probability in each cell, and seek measures to minimize it

5. Planning technology to absorb new customers.
Increase the number of new customers will depend on the communication cost, system performance, as well as business trends. The technique should consider upgrading the system, capacity development techniques for BW is limited to service mobile communication systems.

Tujuan Perencanaan Jaringan

- Tujuan Coverage / Peliputan :
  - Wilayah Peliputan
  - Penetrasi Peliputan
- Tujuan Capacity / Trafik :
  - Jumlah pelanggan
  - Trafik per pelanggan
  - GOS yang diinginkan
- Tujuan Cost / Business dan Logistik :
  - Anggaran Modal
  - Penjadwalan Instalasi dan Penggelaran
  - Laba / Cost pengoperasian Jaringan

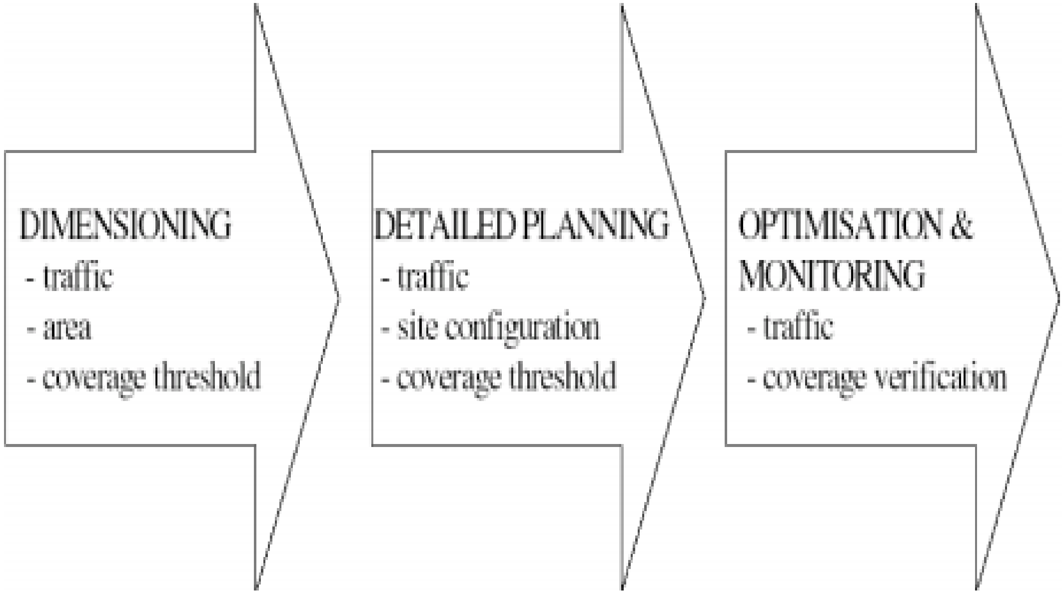
Tahapan Perencanaan Jaringan

A) Tahap Pra-perencanaan
- Dimensioning
- Perencanaan konfigurasi
- Perencanaan kapasitas

B) Tahap perencanaan
- Perencanaan detail
- Perencanaan konfigurasi
- Perencanaan Coverage
- Perencanaan Kapasitas
- Perencanaan Frekuensi
- Verifikasi parameter perencanaan

C) Tahap Post-perencanaan
- Optimisasi
- Monitoring (key performance indicator)

Parameter global dalam perencanaan jaringan
- Trafik
- Threshold coverage
- Ketinggian antena

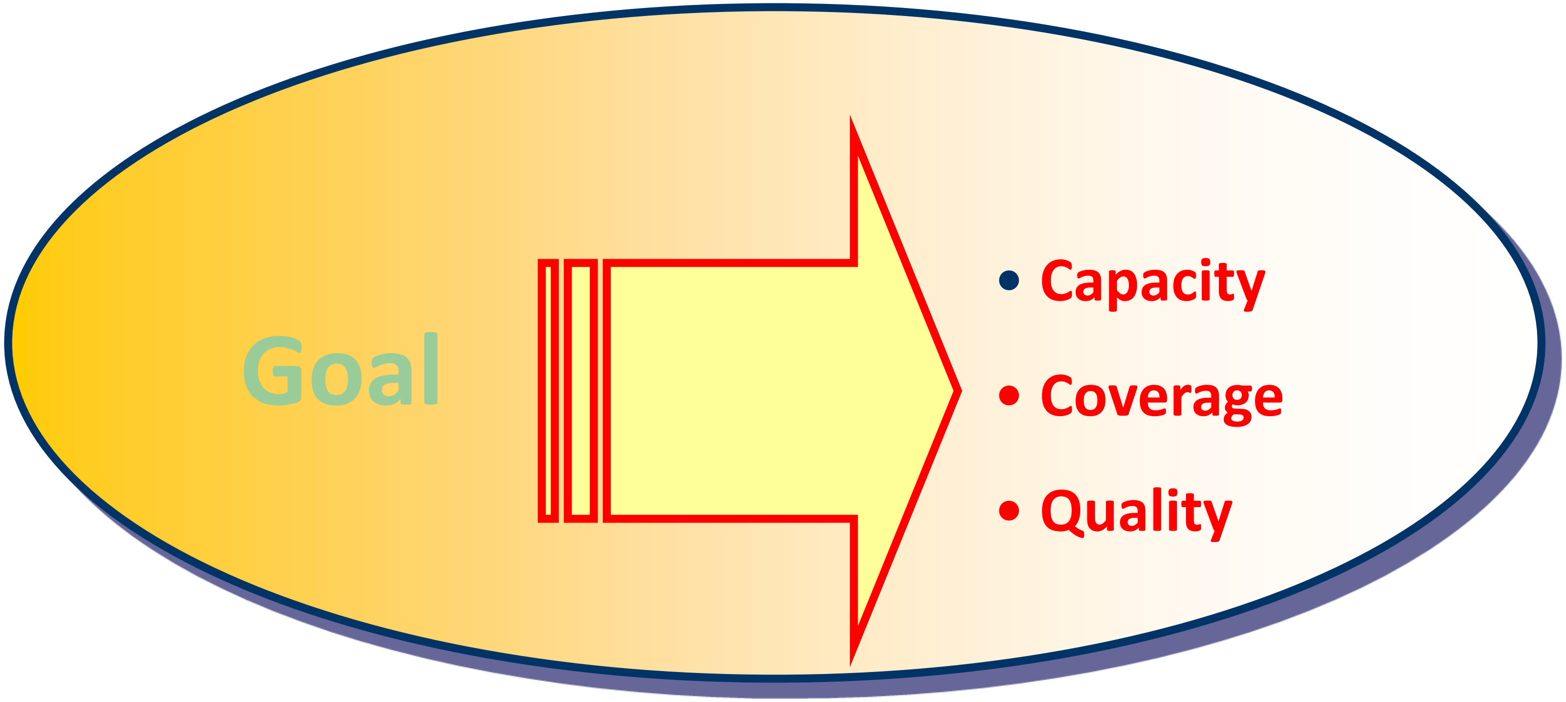


Objectives of the Planning

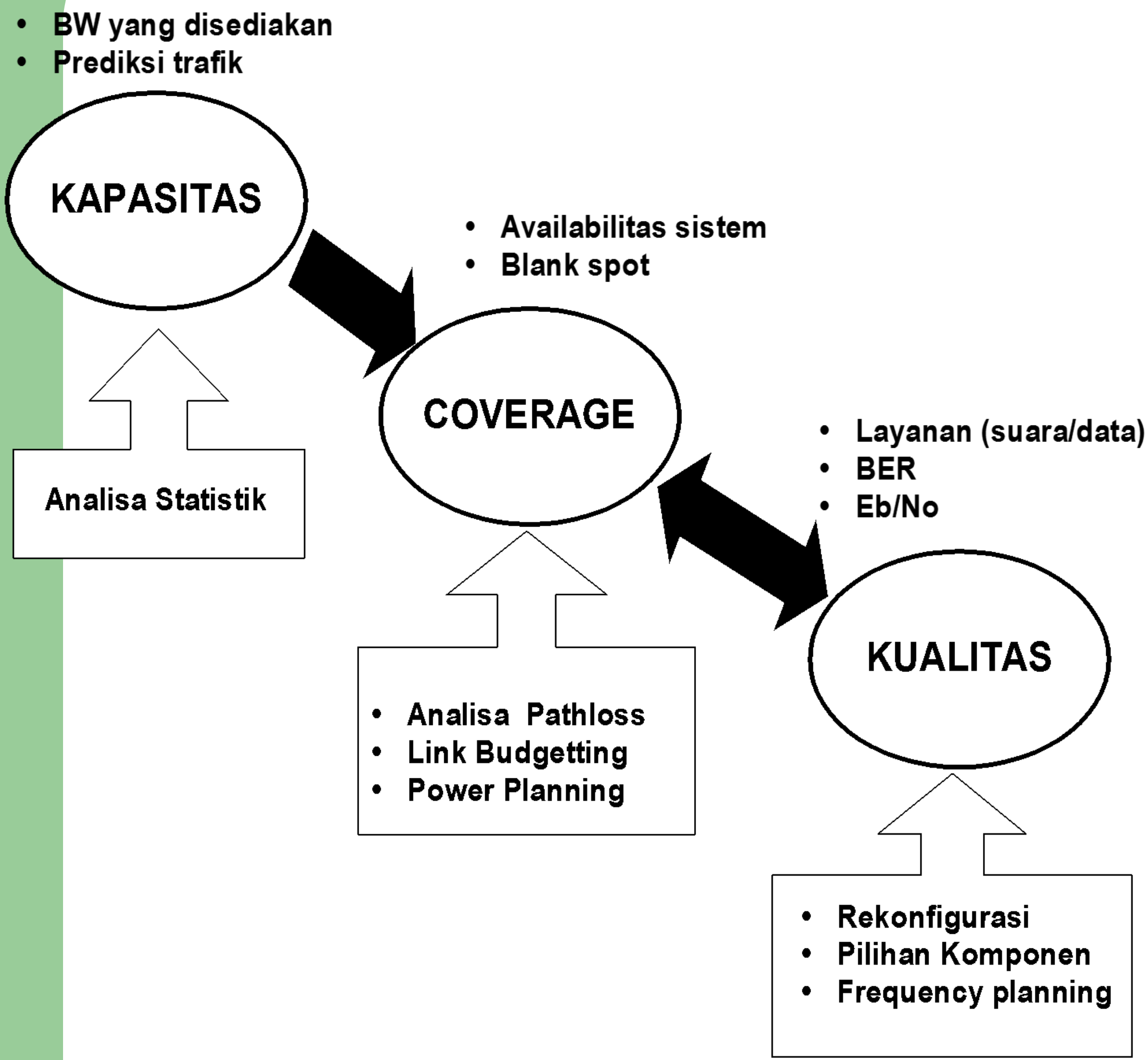
- Traffic Forecasting:
  - To measure the demand on targeted marked so as to allow an appropriate growth of the Network.
- Coverage:
  - To obtain the ability of the network ensure the availability of the service in the entire service area.
- Capacity:
  - To support the subscriber traffic with sufficiently low blocking and delay.
- Quality:
  - Linking the capacity and the coverage and still provide the required QoS.
- Costs:
  - To enable an economical network implementation when the service is established and a controlled network expansion during the life cycle of the network.

Cellular Network Planning Objectives...

It is quite difficult to achieve the expected performance in mobile communication environment is very complex. Because it is expected that an engineer has a wide knowledge to perform the optimization of the system which will involve various compromise solutions from a variety of conditions that would trade off faced. Various methods of optimizing the mobile cellular communication network is provided in a later section.

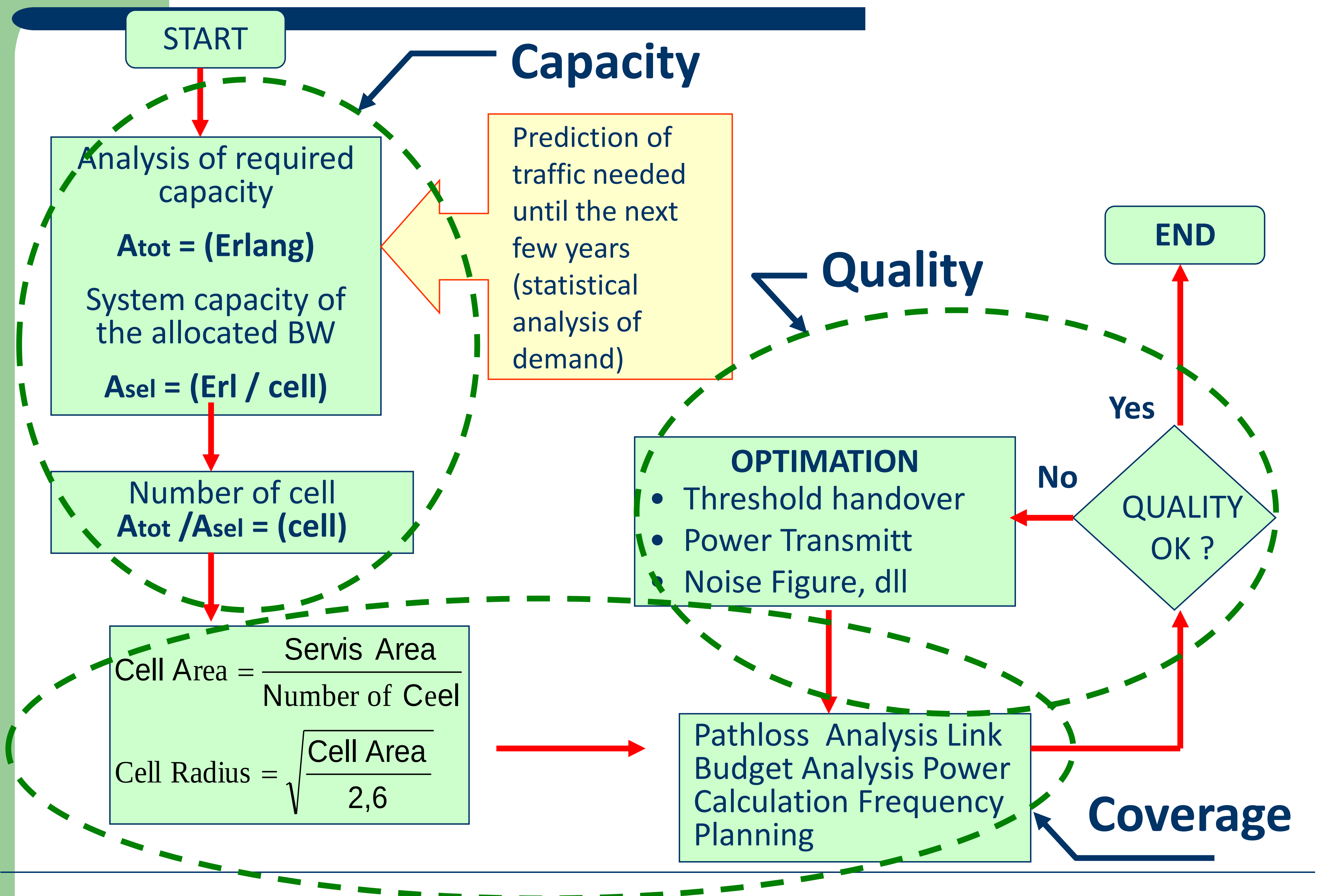


The purpose of the Planning

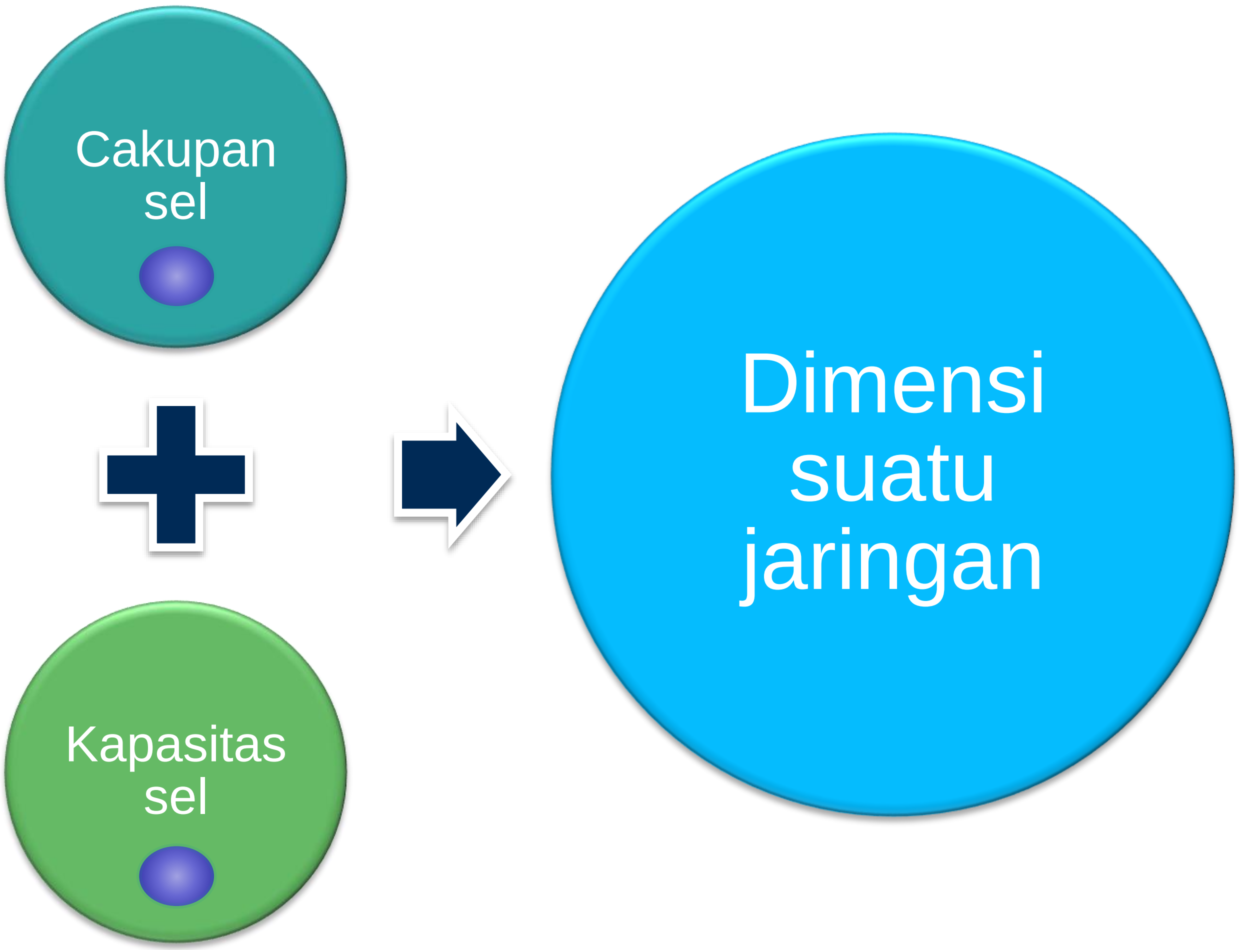


Network planning starts from the bandwidth allocation provided by the government to a mobile operator.
Bandwidth allocation is used by operators to provide communications services with the quality of communication as well as possible and for as many users.

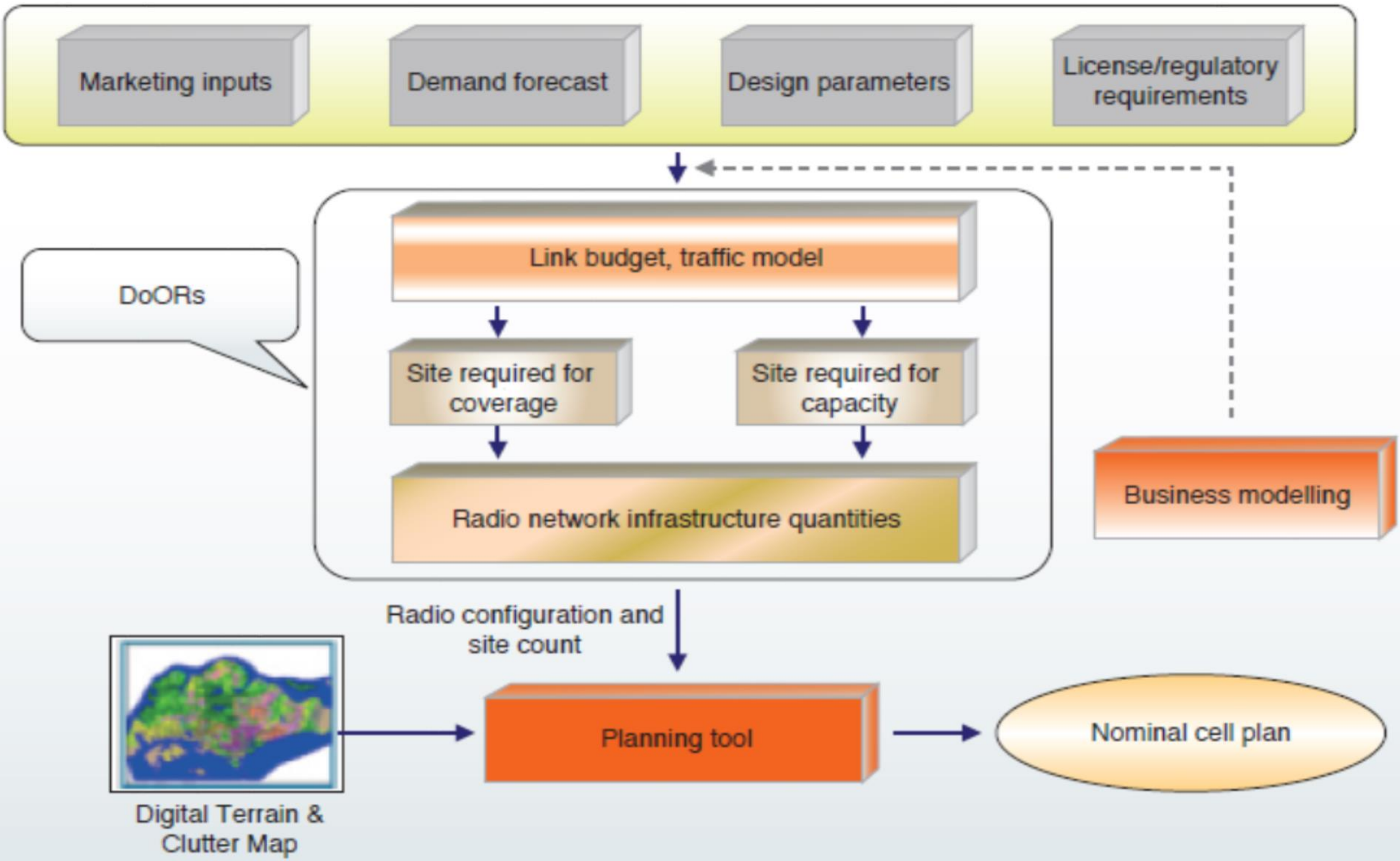
Cell Planning Flowchart



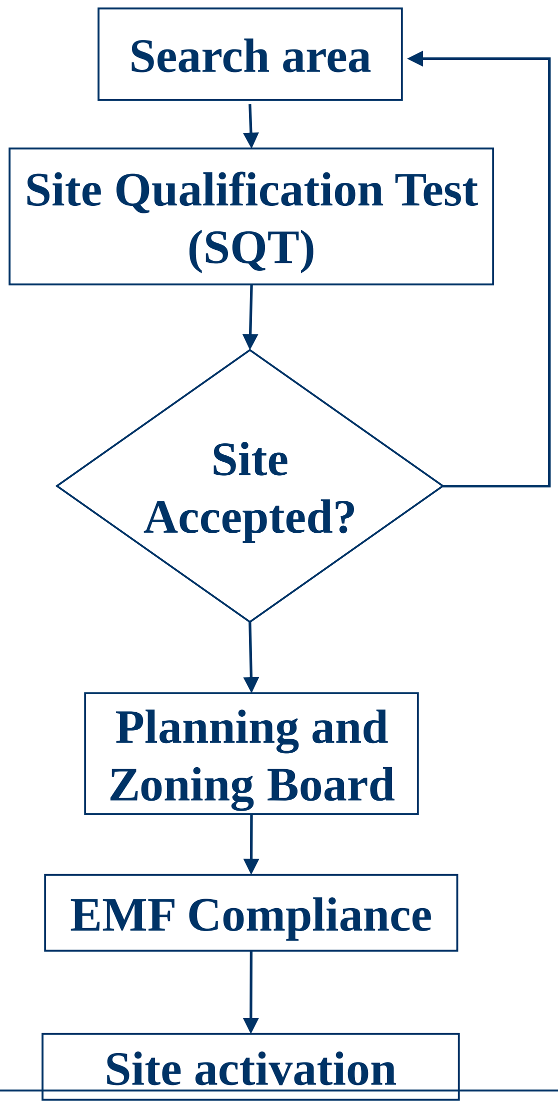
Pendimensian Jaringan dalam Analisis Techno-Economics



Network Dimensioning & Planning Tool



Cell Site Design (1)



Cell Site Design (2)

- **Search Area:**

  - searching area to place cell site/BTS that meet the specifications
  - plot the propagation path, including clearance
  - mapping the area for planning & documentation

- **SQT:**

  - to assure the area is a viable candidate for a cell site by measurements
  - include a sketch of the location, antenna type, height, ERP, path clearance, and do callibration

- **Site acceptance:**

  - if SQT is positive then the area is accepted to place a cell site
  - if not, then area is rejected
  - both site acceptance and rejection should be documented

Cell Site Design (3)

- **Planning and zoning board:**
  - why the site is needed
  - how the site will improve the network
  - drawing the sketch of site

- **Electromagnetic Force (EMF) Compliance:**
  - EMF identify the source of EM from the site itself and surrounding area
  - to ensure it complies with personal safety and government regulation
  - incorporated the type of Txer, power, frequency range, etc
  - method for calculating EMF, e.g. IEEE C95.1 – 1991 standard

- **Site activation:**
  - when every steps above is OK, the cell site/BTS could be placed and turn on

Implementasi Pendimensian Jaringan: Studi Kasus

STUDI KASUS	
Capacity Demand	Luas daerah yang dicakup

↓

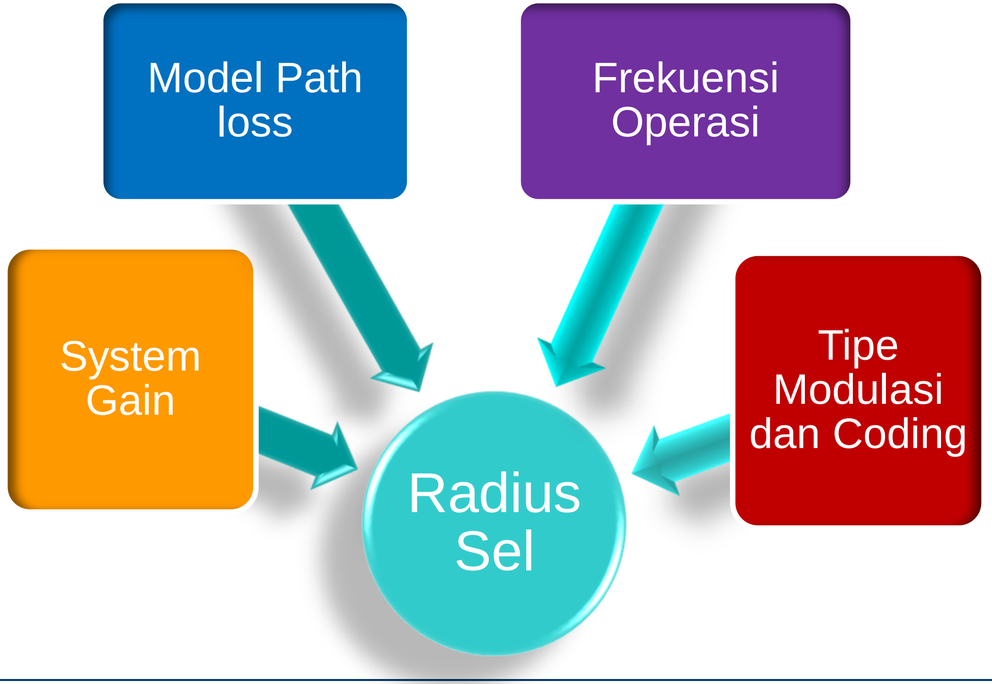
DIMENSI JARINGAN	
Kapasitas Sel	Cakupan Sel

↓

KEBUTUHAN SEL	
Metode Trafik	Metode Cakupan Sel

Cakupan Sel (System Coverage)

- Cakupan sel berperan penting dalam menentukan wilayah-wilayah yang mendapatkan layanan telekomunikasi.
- Link Budget digunakan untuk mengetahui cakupan sel.



Memaksimalkan Coverage dan Capacity

- Memaksimalkan coverage
  - Pilih teknologi akses
  - Gunakan band frekuensi yang rendah
  - Tingkatkan tinggi antena
  - Naikkan daya pancar
  - Kurangi persyaratan kualitas
- Memaksimalkan kapasitas
  - Pilih teknologi akses
  - Perbesar band frekuensi
  - Gunakan re-use frequency
  - Kurangi persyaratan C/I
  - Rendahkan tinggi antena
  - Gunakan fitur software
  - Gunakan antena adaptif

Jumlah Pelanggan

⇓

Jumlah BS berdasarkan Kapasitas

⇓

Jumlah BS berdasarkan Coverage

⇓

Jumlah BS berdasarkan Kapasitas ≠ Jumlah BS berdasarkan Coverage

⇓

Jumlah BS berdasarkan Kapasitas → Maksimalkan Tinggi Antena
Jumlah BS berdasarkan Coverage → Minimalkan Tinggi Antenna

Perencanaan Coverage

Propagasi, Link Budget, dan Coverage

- Propagasi sinyal perlu dipelajari untuk menentukan kebutuhan power dan menentukan coverage.

- Terdapat tiga jenis penentuan redaman propagasi pada sistem selular :
    - Free Space Loss, merupakan redaman akibat penyebaran sinyal ke ruang bebas.
    - Prediksi propagasi sinyal secara teoritis, terdiri dari perambatan sinyal pada bumi datar, perkiraan titik demi titik, dan redaman akibat penghalang.
    - Model empirik, suatu konsep propagasi sinyal hasil pengukuran di lapangan yang dibuat dalam bentuk kurva atau formula.

Link Budget

Komponen-komponen dalam perancangan link budget

- Perhitungan RADIUS secara teoritis dilakukan pada perancangan link budget.
- Gain sistem merupakan budget energi dari sistem berdasarkan profil sistem
- Margin Sistem merupakan nilai loss yang diperkirakan akan dialami oleh sistem ketika dioperasikan.
- Radius sel merupakan keluaran dari proses perhitungan link budget.
- Radius sel DIPREDIKSI dengan menggunakan model propagasi.

Gain Sistem

- **Daya Pancar**
- **Gain Antena**
- **Sensitivitas Penerima**
- **SNR threshold tiap modulasi**

Margin Sistem

- Fading Margin
- Interference Margin
- Loss penetrasi bangunan
- Gain/loss sistem lainnya

Radius Sel

- Model Propagasi
- Frekuensi Operasi
- Tinggi Antena pemancar/penerima
- Jarak Referensi

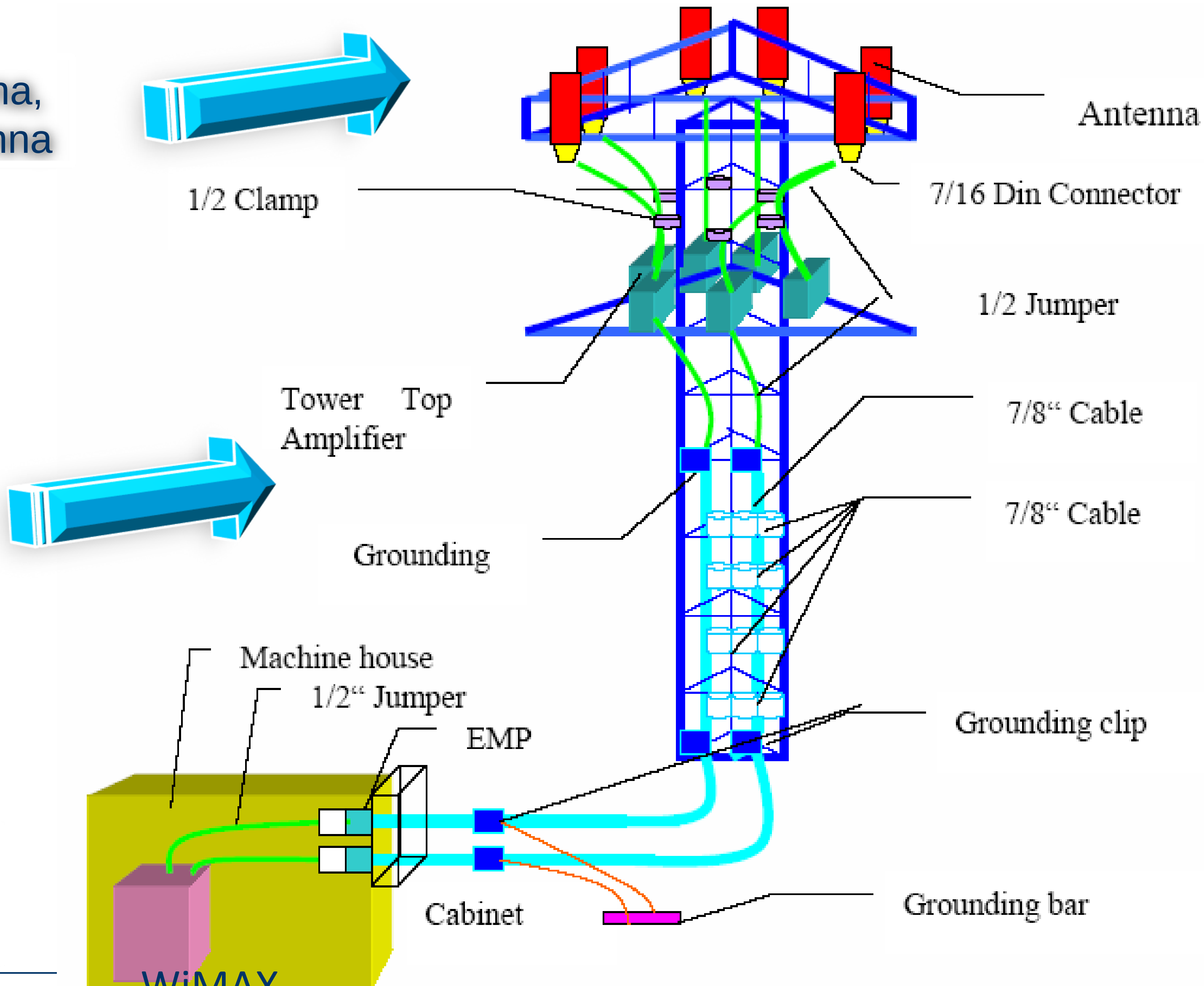
LINK BUDGET

Gain Sistem	Margin Sistem	Radius Sel
Daya Pancar	**Fading Margin**	**Model Propagasi**
Gain Antena	**Interference Margin**	**Frekuensi Operasi**
Sensitivitas Penerima	**Loss penetrasi bangunan**	**Tinggi Antena pemancar/penerima**
SNR threshold tiap modulasi	**Gain/loss sistem lainnya**	**Jarak Referensi**

Sistem Antena Base Station (BTS)

Gain antenna,
Beam antenna

Feeder Loss



Tx Power
Receiver Sensitivity
Noise Figure, dll

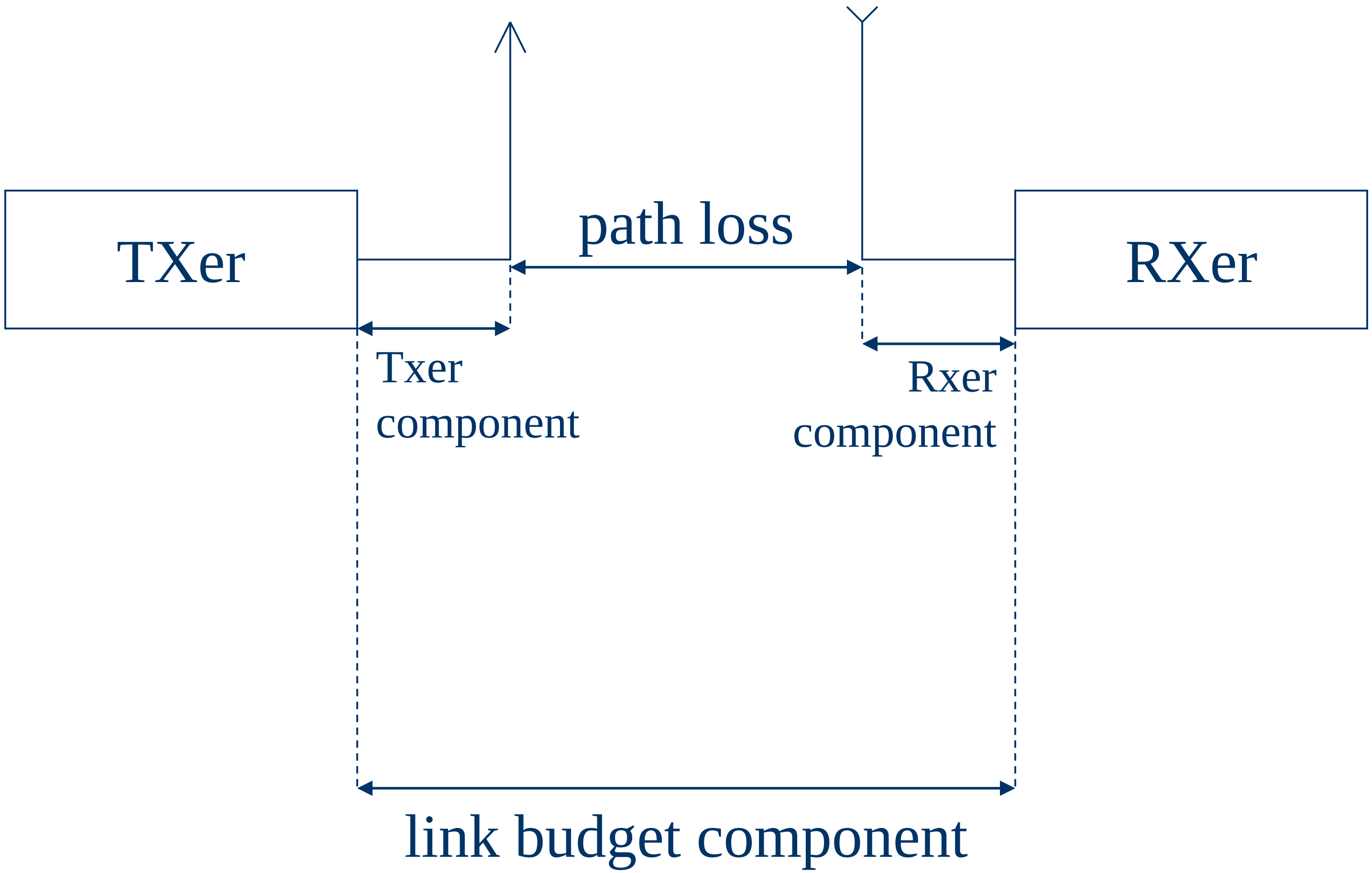
Link Budget

- Perhitungan link budget digunakan untuk memperkirakan maksimum redaman yang diperbolehkan antara perangkat mobile terhadap base station.
- Path loss maksimum memungkinkan kita melakukan perhitungan radius sel suatu BTS untuk suatu lingkungan radio tertentu dan dengan model propagasi tertentu.
- Ukuran sel diperlukan untuk melakukan perhitungan jumlah sel yang dibutukan untuk mengcover suatu area layanan.

Link Budget : Model Propagasi

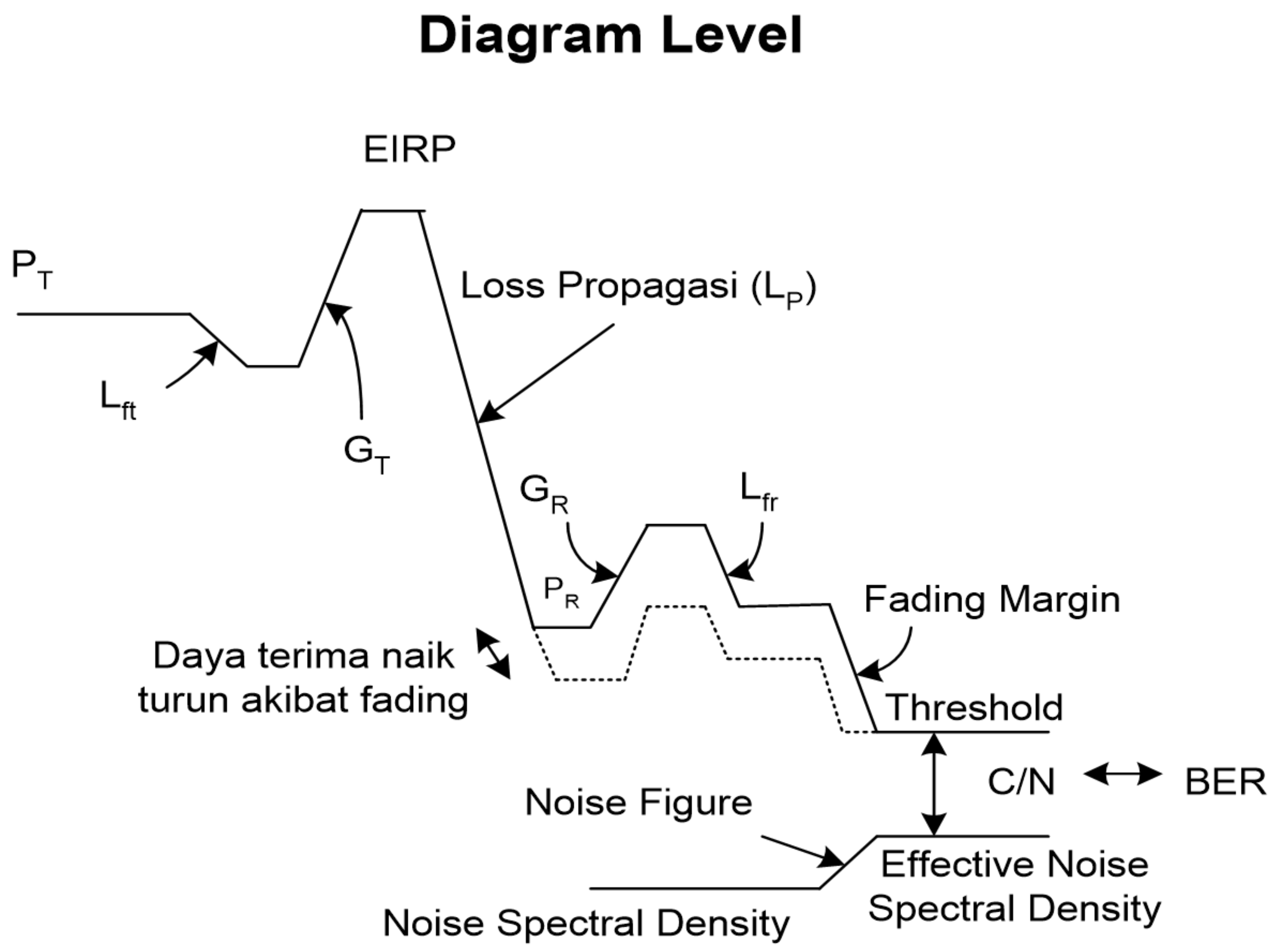
- Suatu model propagasi menggambarkan hubungan redaman jarak rata-rata yang terjadi yang sekaligus dapat digunakan untuk perhitungan jangkauan sel
- Model propagasi bergantung pada :
  - Environment : urban, rural, dense urban, suburban, open, forest, sea...
  - Jarak
  - Frequency
  - Kondisi atmosfer
  - Indoor/outdoor
- Contoh :
  - Free space
  - Walfish–Ikegami
  - Okumura–Hata
  - Longley–Rice
  - Lee

Link Budget



TXer
path loss
RXer
Txer
component
Rxer
component
link budget component

Dasar Pemahaman Link Budget



Parameter yang harus diperhatikan pada Link Budget

1. Ptx = Daya pancar BTS
2. Daya *Threshold* = level tertentu, tergantung dari service yang diberikan, dan QoS yang dicapai
3. FM = Fading Margin, diberikan jika diperlukan (pada siskomsat tidak perlu FM)
4. Lp = Loss Propagasi
5. Prx = Level daya penerima MS
6. Lfr = Rx filter loss (dB)
7. Grx = Gain antena MS
8. Lp = redaman propagasi (dB)
9. Gtx = Gain antena BTS (dB)
10. Lft = Tx filter loss (dB)
11. *Energy to Noise Density Ratio* (Eb/No) = kualitas sinyal di penerima sangat baik

Link Budget – Up Link

- **Frequency range, MHz**

- **Mobile parameters**

  - Tx PA output (max)

  - Cable loss

  - Antenna gain

  -------- (Subsc. ERP max, dB)

- **Environmental margins**

  - Fading margin

  - Environmental attenuation

  - Cell overlap

  -------------------- (dB)

- **Base station parameters**

  - Rx ant. gain Rx jumper loss

  - Rx tower top amp gain (net)

  - Rx cable loss

  - Rx ligthning arrester loss

  - Rx duplexer loss

  - Rx diversity gain

  - Rx coding gain

  - Rx sensitivity

  ------- Up-link budget, dB

Link Budget – Down Link

- **Frequency range, MHz**
- **Base station parameters**

  - Tx PA output power
  - Tx combiner loss
  - Tx duplexer loss
  - Tx ligthning arrester loss
  - Tx cable loss
  - Tx jumper loss
  - Tx tower top amp gain
  - Tx antenna gain

  ------------------------------ (Cell ERP, dB)

- **Environmental margins**
  - Tx diversity gain
  - Fading margin
  - Environmental attenuation
  - Cell overlap

  --------------------------- (dB)

- **Mobile parameters**
  - Antenna gain
  - Rx diversity gain
  - Antenna cable loss
  - Coding gain
  - Rx sensitivity

  ---------- Down-link budget, dB

Link Budget Tipikal

Parameters	Unit	Value
BS TX power into antenna port	dBm	31
Number of TX antennas		2
TX antenna gain, BS (90deg)	dBi	17
EIRP	dBm	51
RX antenna gain, SS (90deg)	dBi	16
Thermal noise/Hz	dBm/Hz	-174
RX noise figure, SS (incl. cable loss)	dB	5
RX noise density/Hz	dBm	-169
Bandwidth (MHz)	MHz	3.5
RX noise floor	dBm	-103.6
Shadowing margin (sigma =8dB)	dB	5
Macro diversity gain	dB	2.0
S/N ratio (zero path loss)	dB	171.2
Modem set-point (NLOS)	dB	6
Path loss margin	dB	160.2

Link Budget Tipikal

Parameters	Unit	Value
Link Distance (Coverage area radius)		km
Erceg A	km	5.0
Erceg B	km	7.7
Erceg C	km	10.5
Cost 231 Hata	km	4.3
Free Space Model	km	694.9
Cost 231 WIM	km	3.4

- Asumsi tipikal penggelaran LTE:
  - BS height 30m
  - Under-the-eve SS installation
  - Active TX STC to reduce the required multipathfading margin
  - 90% coverage and 99% reliability.

Contoh Perhitungan Link Budget

- Contoh perhitungan link budget dengan menggunakan Okumura-Hatta . Dimisalkan sistem memiliki data teknis sbb :

	Urban indoor	Suburban indoor	Rural outdoor	Rural outdoor fixed
Base station antenna height (m)	30	50	80	80
Mobile antenna height (m)	1.5	1.5	1.5	5
Mobile antenna gain (dBi)	0	0	0	0
Slow fading standard deviation (dB)	8	8	8	8
Location probability	95%	95%	95%	95%
Correction factor (dB)	0	−5	−15	−15
Indoor loss (dB)	20	15	0	0
Slow fading margin (dB)	8.8	8.8	8.8	8.8

Link Budget arah Uplink

		GSM voice	HSPA	LTE
	Data rate (kbps)	12.2	64	64
	Transmitter – UE			
a	Max tx power (dBm)	33	23	23
b	Tx antenna gain (dBi)	0	0	0
c	Body loss (dB)	3	0	0
d	EIRP (dBm)	30	23	23
	Receiver – BTS/Node B/eNB			
e	Node B noise figure (dB)	–	2	2
f	Thermal noise (dB)	–	-108.2	-118.4
g	Receiver noise (dBm)	–	-106.2	-116.4
h	SINR (dB)	–	-17.3	-7
i	Receiver sensitivity	-114	-123.4	-123.4
j	Interference margin (dB)	0	3	1
k	Cable loss (dB)	0	0	0
l	Rx antenna gain (dBi)	18	18	18
m	Fast fade margin (dB)	0	1.8	0
n	Soft handover gain (dB)	0	2	0
	Maximum path loss	162	161.6	163.4

Link Budget arah Downlink

	Downlink	GSM voice	HSPA	LTE
	Data rate (kbps)	12.2	1024	1024
	Transmitter – Node B			
a	Tx power (dBm)	44.5	46	46
b	Tx antenna gain (dBi)	18	18	18
c	Cable loss (dB)	2	2	2
d	EIRP (dBm)	60.5	62	62
	Receiver – UE			
e	UE noise figure (dB)	–	7	7
f	Thermal noise (dB)	-119.7	-108.2	-104.5
g	Receiver noise fl oor (dBm)	–	-101.2	-97.5
h	SINR (dB)	–	-5.2	-9
i	Receiver sensitivity (dBm)	-104	-106.4	-106.5
j	Interference margin (dB)	0	4	4
k	Control channel overhead (%)	0	20	20
l	Rx antenna gain (dBi)	0	0	0
m	Body loss (dB)	3	0	0
	Maximum path loss	161.5	163.4	163.5

ENGINEERING MODEL
Studi Kasus 3G

What’s New on 3G

- ***Multiservice environment:***
  - Highly sophisticated radio interface.
    - Bit rates from 8 kbit/s to 2 Mbit/s, also variable rate.
  - Cell coverage and service design for multiple services:
    - different bit rate
    - different QoS requirements.
  - Various radio link coding/throughput adaptation schemes.
  - Interference averaging mechanisms:
    - need for maximum isolation between cells.
  - “Best effort” provision of packet data.
  - Intralayer handovers

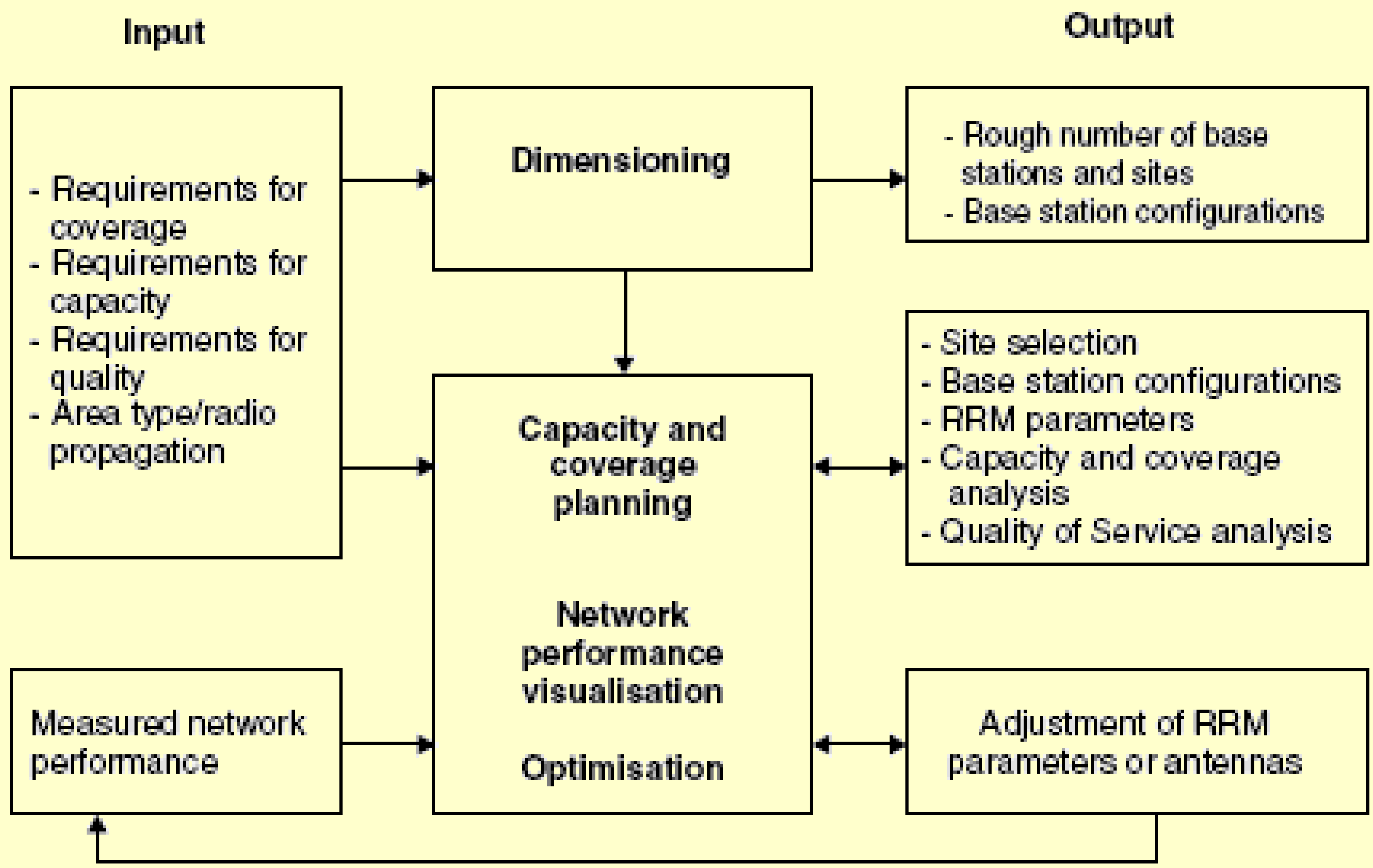
What's New on 3G

- *Air interface:*
  - Capacity and coverage coupled.
  - Fast power control.
  - Planning a soft handover overhead.
  - Cell dominance and isolation
  - Vulnerability to external interference

What's New on 3G

- *2G and 3G:*
  - Co-existence of 2G and 3G sites.
  - Handover between 2G and 3G systems.
  - Service continuity between 2G and 3G.

3G (WCDMA) Radio Network Planning Process



1st. Coverage

- coverage regions;
- area type information:
  - Dense Urban, Urban, sub-urban, or rural
- propagation conditions:
  - Indoor, outdoor

Radio Link Budgets (WCDMA)

- There are some WCDMA-specific parameters in the link budget that are not used in a TDMA-based:
  - **Interference margin**:
    - it is needed due to the traffic loading of the cell. The more loading is allowed, the larger is the interference margin needed in the uplink, and the smaller is the coverage area. Typical values for the interference margin are 1.0–3.0 dB, corresponding to 20–50% Cell loading.
  - **Fast fading margin** (power control headroom):
    - Some headroom is needed in MS TX power for maintaining adequate closed loop fast power control to be able to effectively compensate the fast fading. Typical values for the fast fading margin are 2.0–5.0 dB for slow-moving MS.
  - **Soft handover gain**:
    - Soft handover gives an additional macro diversity gain against fast fading by reducing the required Eb/No relative to a single radio link. The soft handover gain is assumed between 2.0 and 3.0 dB

RLB: Assumptions for MS and BS

MS	Speech terminal	Data terminal
Maximum transmission power	21 dBm	24 dBm
Antenna gain	0 dBi	2 dBi
Body loss	3 dB	0 dB

BS	
Noise figure	5.0 dB
Antenna gain	18 dBi (3-sector base station)
E_b/N_0 requirement	Speech: 5.0 dB 144 kbps real-time data: 1.5 dB 384 kbps non-real-time data: 1.0 dB
Cable loss	2.0 dB

Example of WCDMA RLB for Voice

Link budget of AMR 12.2 kbps voice service (120 km/h, in-car users, Vehicular A type channel, with soft handover)

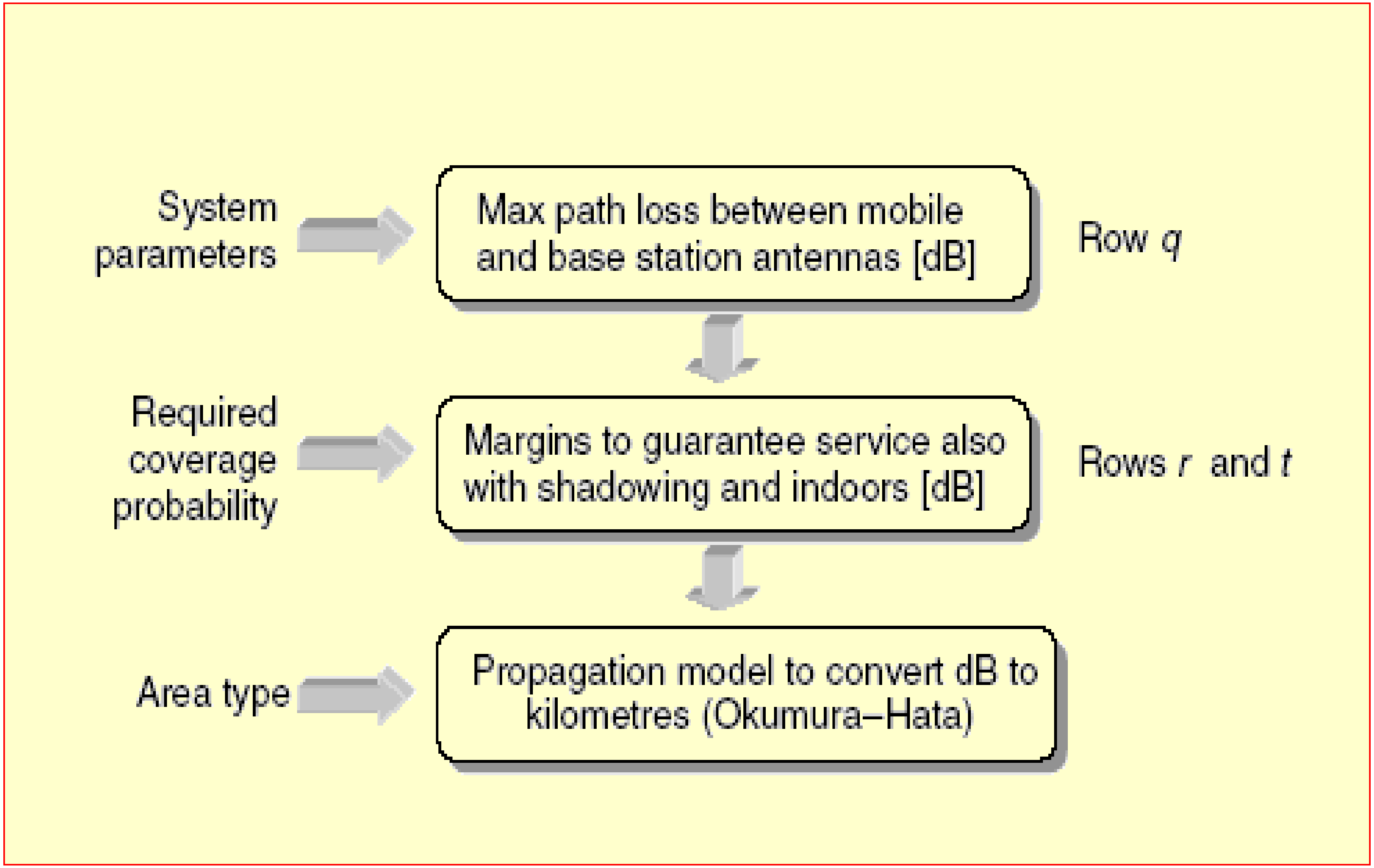
Transmitter (mobile)		
Max. mobile transmission power [W]	0.125	
As above in dBm	21.0	a
Mobile antenna gain [dBi]	0.0	b
Body loss [dB]	3.0	c
Equivalent Isotropic Radiated Power (EIRP) [dBm]	18.0	$d = a + b - c$
Receiver (base station)		
Thermal noise density [dBm/Hz]	−174.0	e
Base station receiver noise figure [dB]	5.0	f
Receiver noise density [dBm/Hz]	−169.0	$g = e + f$
Receiver noise power [dBm]	−103.2	$h = g + 10^{*} \log (3\,840\,000)$
Interference margin [dB]	3.0	i
Total effective noise + interference [dBm]	−100.2	$j = h + i$
Processing gain [dB]	25.0	$k = 10^{*} \log (3840/12.2)$
Required E_b/N_0 [dB]	5.0	l
Receiver sensitivity [dBm]	−120.2	$m = l - k + j$
Base station antenna gain [dBi]	18.0	n
Cable loss in the base station [dB]	2.0	o
Fast fading margin [dB]	0.0	p
Max. path loss [dB]	**154.2**	$q = d - m + n - o - p$
Log-normal fading margin [dB]	7.3	r
Soft handover gain [dB], multicell	3.0	s
In-car loss [dB]	8.0	t
Allowed propagation loss for cell range [dB]	**141.9**	$u = q - r + s - t$

Example of WCDMA RLB for Data

Link budget of 144 kbps real-time data service (3 km/h, indoor user covered by outdoor BS, Vehicular A type channel, with soft handover)

Transmitter (mobile)		
Max. mobile transmission power [W]	0.25	
As above in dBm	24.0	a
Mobile antenna gain [dBi]	2.0	b
Body loss [dB]	0.0	c
Equivalent Isotropic Radiated Power (EIRP) [dBm]	26.0	d = a + b − c
Receiver (base station)		
Thermal noise density [dBm/Hz]	−174.0	e
Base station receiver noise figure [dB]	5.0	f
Receiver noise density [dBm/Hz]	−169.0	g = e + f
Receiver noise power [dBm]	−103.2	h = g + 10* log (3 840 000)
Interference margin [dB]	3.0	i
Total effective noise + interference [dBm]	−100.2	j = h + i
Processing gain [dB]	14.3	k = 10* log (3840/144)
Required E_b/N_0 [dB]	1.5	l
Receiver sensitivity [dBm]	−113.0	m = l − k + j
Base station antenna gain [dBi]	18.0	n
Cable loss in the base station [dB]	2.0	o
Fast fading margin [dB]	4.0	p
Max. path loss [dB]	**151.0**	q = d − m + n − o − p
Log-normal fading margin [dB]	4.2	r
Soft handover gain [dB], multicell	2.0	s
Indoor loss [dB]	15.0	t
Allowed propagation loss for cell range [dB]	**133.8**	u = q − r + s − t

Cell range calculation



RLB: Okumura-Hatta Model

(1) L_{HATA} *(urban)* [*dB*] =69.55 + 26.16 x log (*f*) + [44.9 - 6.55 x log (h_b)] x log (d) -13.82 x log (h_b) - *A* (h_m)

(2) L_{HATA} *(suburban)* [*dB*] = L_{HATA} *(urban)* - 2 x [log (*f/28*)]^2 - 5.4

(3) L_{HATA} *(rural)* [*dB*] =L_{HATA} *(urban)* - 4.78 x [log (*f*)]^2 - 18.33 x log (*f*) -40.98

(4) *A* (h_m) [*dB*] = [1.1 x log (*f*) - 0.7] x h_m - [1.56 x log (*f*) - 0.8]

(5) *A* (h_m) [*dB*] = 8.29 x [log (1.54 x h_m)]^2 - 1.1 (for f<= 300 MHz.)

(6) *A* (h_m) [*dB*] = 3.2 x [log (1175 x h_m)]^2 - 4.97 (for f > 300 MHz.)

- The propagation model describes the average signal propagation in an environment, and it converts the maximum allowed propagation loss in dB on the row u to the maximum cell range in kilometres.

Cell Range

- From the RLB above, the cell range R can be calculated. e.g with the *Okumura–Hata* propagation model for an urban macro cell with base station antenna height of 30 m, mobile antenna height of 1.5 m and carrier frequency of 1950 MHz:

$L = 137.4 + 35.2 \log_{10} (R_{km})$ .....Urban

$L = 129.4 + 35.2 \log_{10} (R_{km})$ ...Sub-Urban

Cell Range

- From RLB above, MAPL for 12.2 kbps voice service is 141.9 dB:
  - Urban: R_{cell} = 1.34 km
  - Sub-urban: R_{cell} = 2.27 km
- For 144 kbps data service with MAPL = 133.8 dB:
  - Urban: R_{cell} = 0.79 km
  - Sub-urban: R_{cell} = 1.33 km

PROPAGATION MODEL : COST231-Hata

$$L = 46{,}3 + 33{,}9\log f_c - 13{,}82\log h_T - a(h_R) + (44{,}9 - 6{,}55\log h_T)\log d + C_M$$

- Element:

Frekuency	A	B
150 - 1500 MHz	69.55	26.16
1500 - 2000 MHz	46.3	33.9

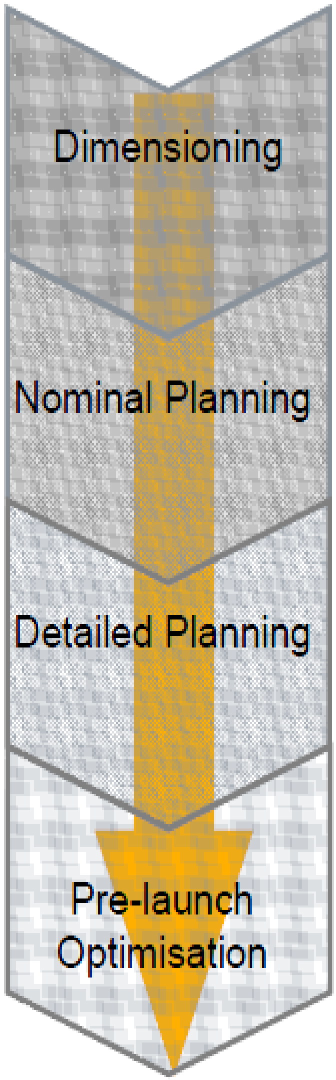
UE Height Correction Factors $a(h_{MS})$

$$a(h_{MS}) = \begin{cases} 3.2[\lg(11.75h_{MS})]^2 - 4.97 & \text{DU, U} \\ [1.1\lg(f) - 0.7]h_{MS} - [1.56\lg(f) - 0.8] & \text{SU} \end{cases}$$

$$CM = \begin{cases} 0\text{ dB} & \text{For Rural and suburban} \\ 3\text{ dB} & \text{For Dense Urban and Urban} \end{cases}$$

Planning Coverage
Studi Kasus LTE

Radio Planning Process Overview



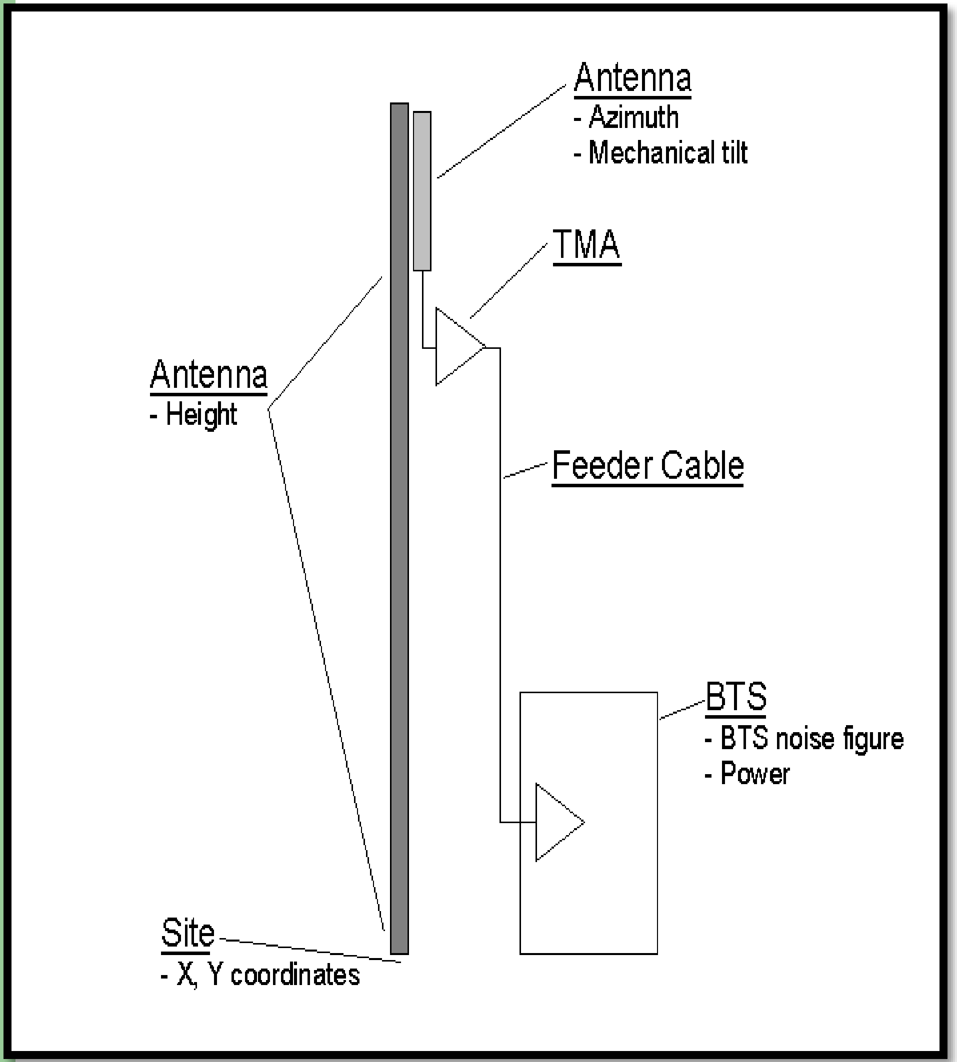
- **Dimensioning** : Spectrum Usage, eNodeB Basic Configuration, RF Features.
- **Nominal Planning** : Propagation model tuning, Nominal Coverage Planning, Capacity Analysis, Site Survey, Site Pre-Validation.
- **Detailed Planning** : Detailed Coverage and Capacity based on planning on planning tools, Site Validation.
- **Pre-launch Optimization** : DT measurements and analysis, ENodeB database parameter checking, Antenna tilt & azimuth tuning based in DT analysis.

LTE Dimensioning Definition

LTE Spectrum Usage

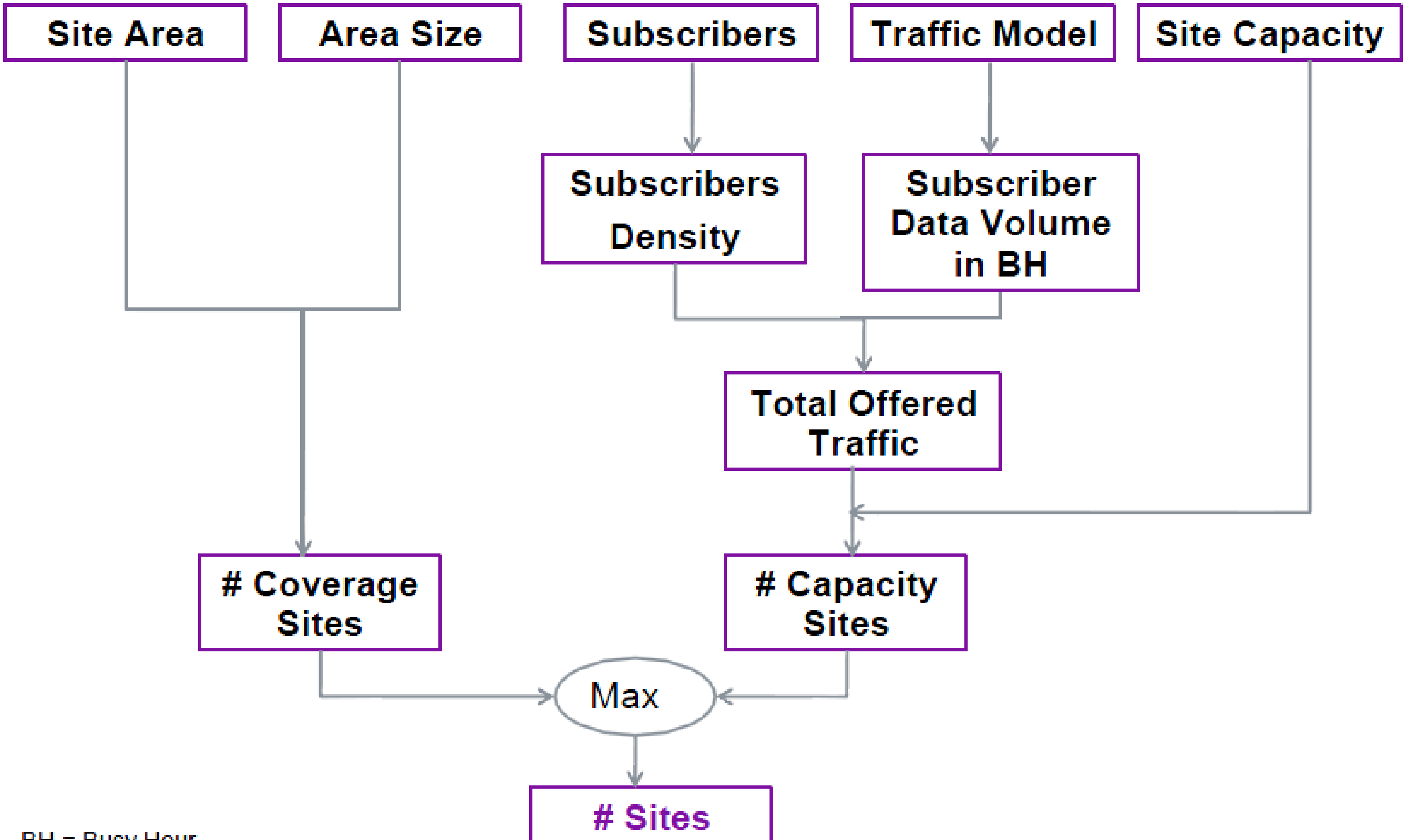
Parameters	Value
LTE Duplex	FDD
Frequency	2100 MHz (BAND 1)
Frequency DL	2110-2170 MHz
Frequency UL	1920-1980 MHz
Bandwidth	10 MHz (50 Resource Block)
Modulasi &Coding Schemes	AMC (QPSK,16QAM,64QAM) & ½ , ¾
Scheduling	Proportional Fair

LTE eNodeB Configuration



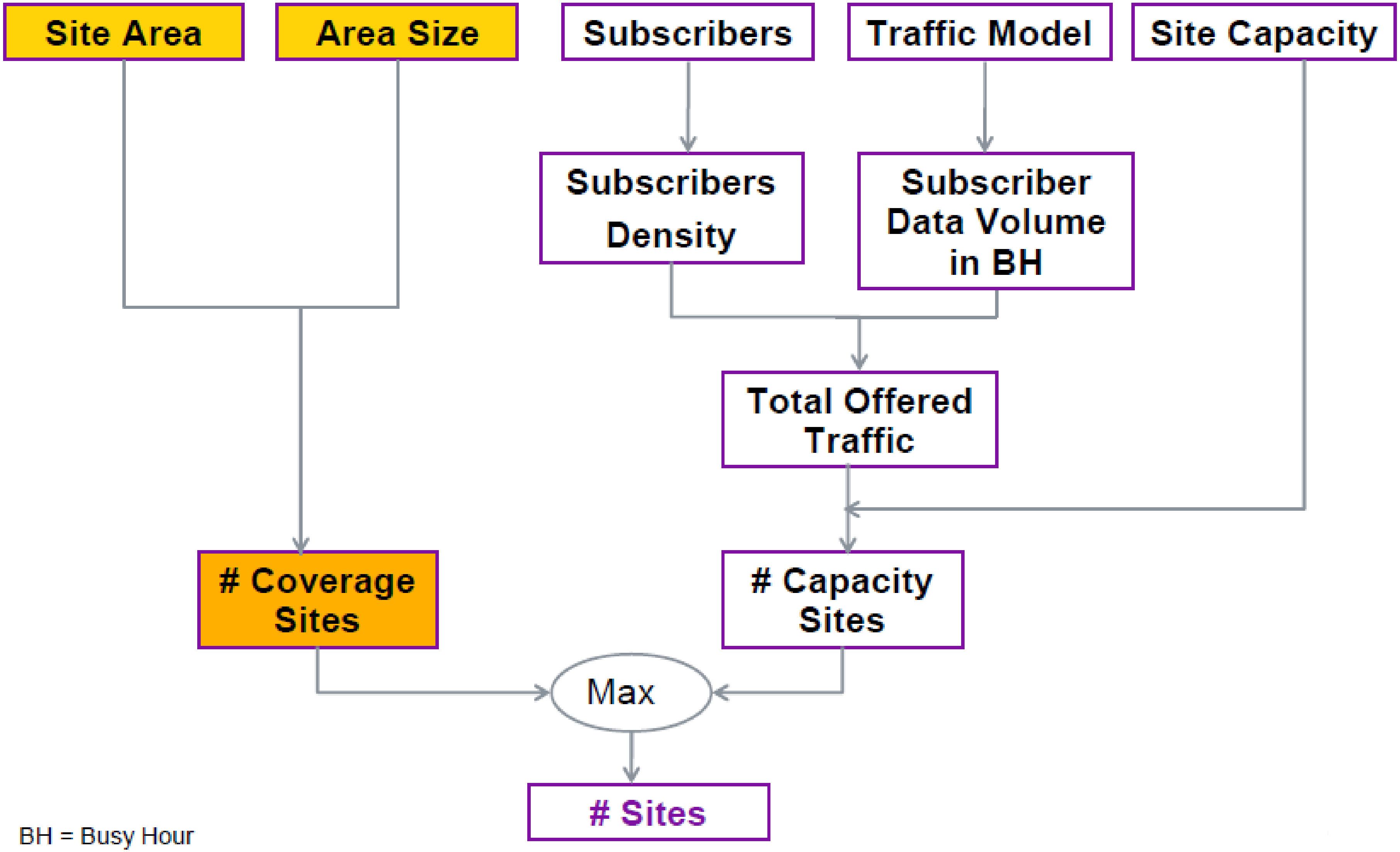
Parameters	Value
PTx (dbm)	46 dbm
Gain Antena Tx	18 dbi
Jumper Cable	0.2 db/m
Feeder Cable	0,4db/km
Rx Sensitivity (dbm)	-100 dbm
Gain Antena Rx	18 dbi
TMA / MHA	13 db
Sector	3

LTE Nominal Planning



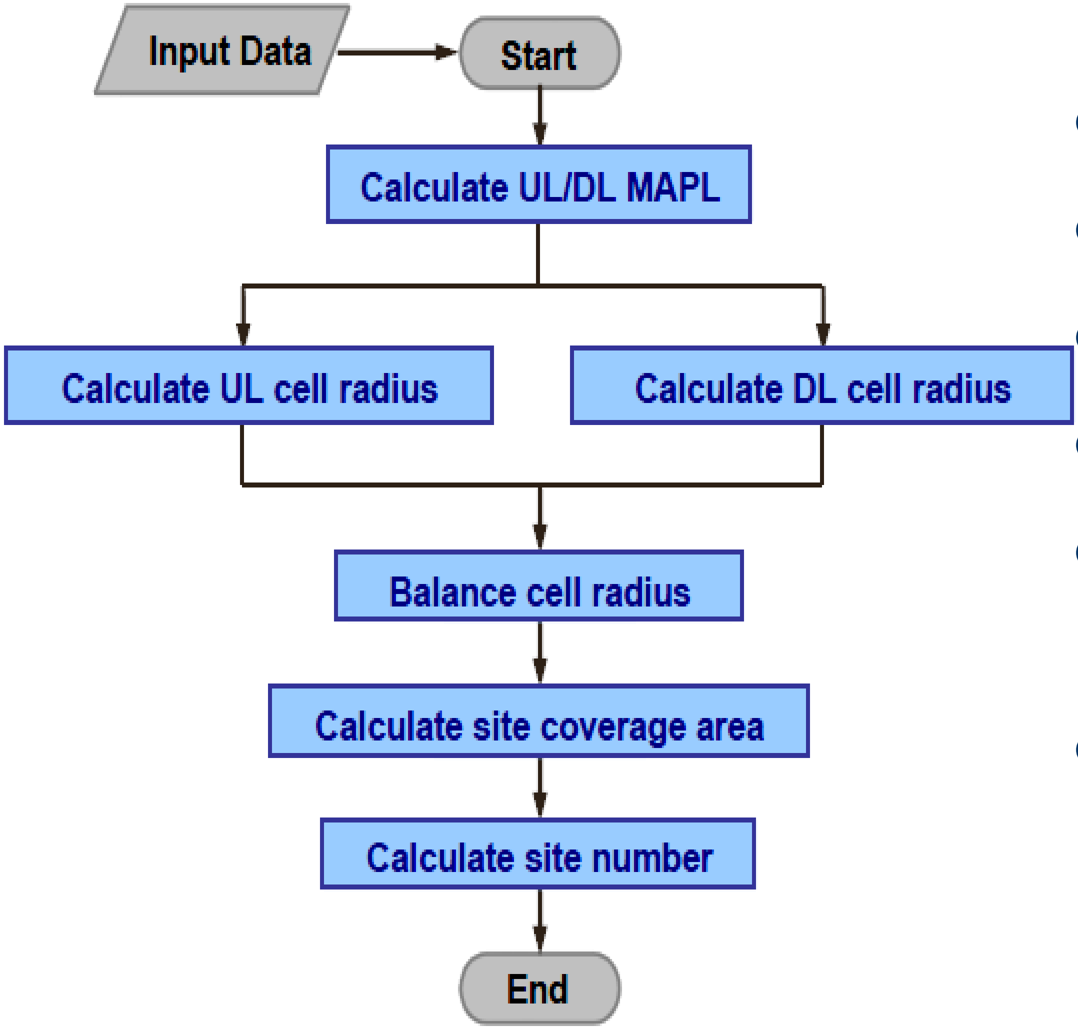
BH = Busy Hour

Nominal Planning By Coverage



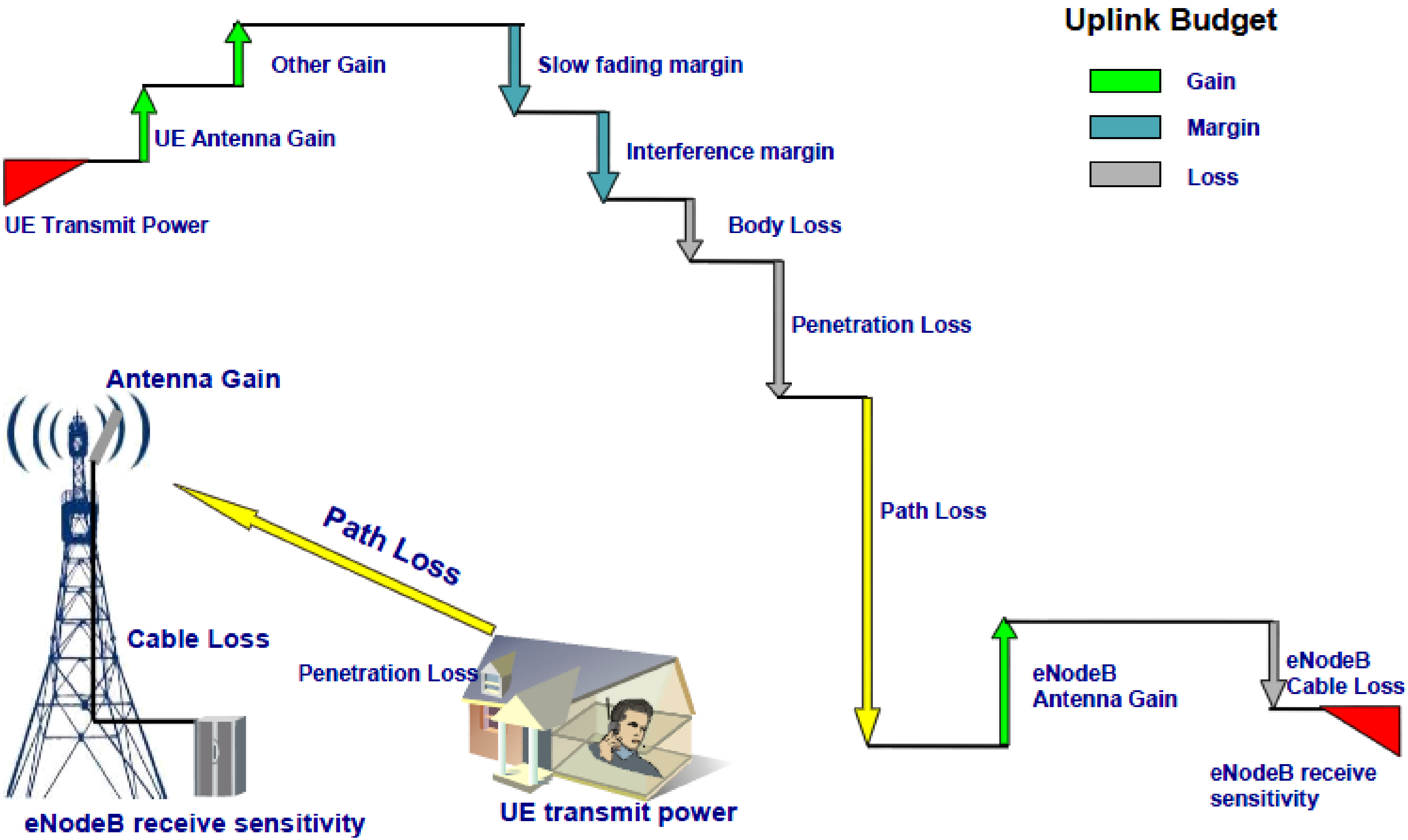
BH = Busy Hour

Nominal Planning By Coverage



- UL Calculate
- UL Radius Cell
- DL Calculate
- DL Radius Cell
- Radius Cell Balance
- Number of Cell

Nominal Planning By Coverage

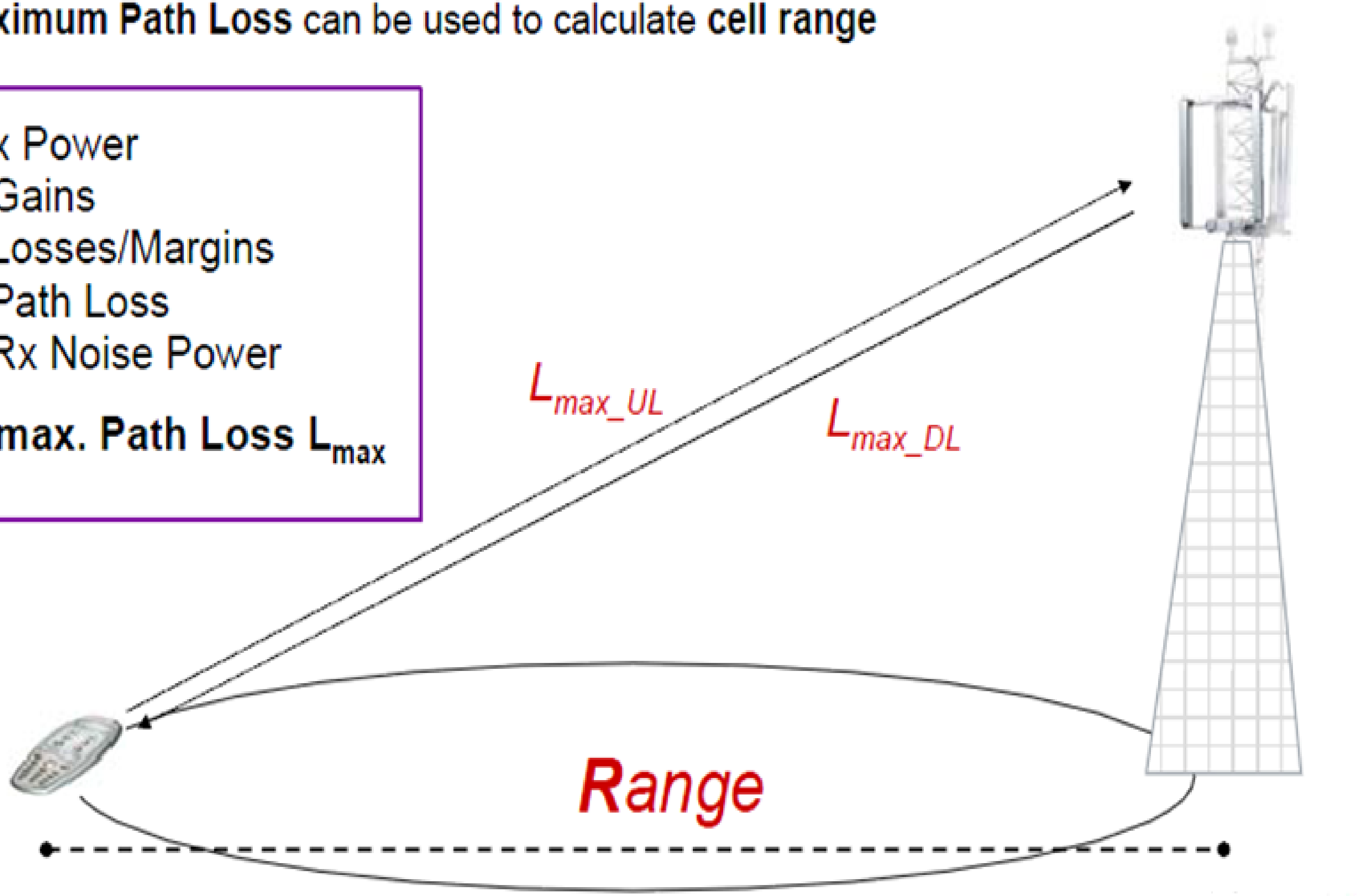


Nominal Planning By Coverage

The **maximum Path Loss** can be used to calculate **cell range**

Tx Power
+ Gains
– Losses/Margins
– Path Loss
≥ Rx Noise Power

⇒ **max. Path Loss L_{max}**



Nominal Planning By Coverage

- PROPAGATION MODEL : COST231-Hata

$$L = 46{,}3 + 33{,}9 \log f_c - 13{,}82 \log h_T - a(h_R) + (44{,}9 - 6{,}55 \log h_T) \log d + C_M$$

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$$CM = \begin{cases} 0\ \text{dB} & \text{For Rural and suburban} \\ 3\ \text{dB} & \text{For Dense Urban and Urban} \end{cases}$$

Nominal Planning By Coverage

- UL Calculate

Uplink Link Budget LTE			
	Unit	Value	Info
Data Rate	Kbps	1024	
Transmitter - UE			
a. Tx Power	dBm	23	a
b. Tx Antenna Gain	dB	0	b
c. Body Loss	dB	0	c
d. EIRP	dBm	**23**	**a+b+c**
Receiver - eNodeB			
e. Noise Figure	dB	2.2	e
f. Thermal Noise	dBm	-107.13	k*T*B
g. SINR	dB	-1.95	g
h. Receiver Sensitivity	dBm	-106.88	e+f+g
i. Interference Margin	dB	1.81	i
j. TMA Gain	dB	2	j
k. Rx antenna gain	dBi	18	k
l. Loss System	dB	0.4	l
MAPL	dB	**147.67**	**d-h-i+j+k-l**

- MAPL = 147.67
- Radius = 0.99 Km

MAPL Calculation (Downlink Link)

Downlink Link Budget LTE			
	Unit	Value	Info
Data Rate	kbps	1000	
Transmitter - eNodeB			
a. Tx Power	dBm	46	a
b. Tx Antenna Gain	dB	18	b
c. Loss System	dB	3	c
d. EIRP	dBm	**61**	**a+b+c**
Receiver - UE			
e. Ue Noise Figure	dB	7	e
f. Thermal Noise	dBm	-102.7	k*T*B
g. SINR	dB	-5	g
h. Receiver Sensitivity	dBm	-100.7	e+f+g
i. Interference Margin	dB	3	i
j. Control Channel Overhead	dB	1	j
k. Rx antenna gain	dBi	0	k
l. Body Loss	dB	0	l
MAPL	dB	**157.7**	**d-h-i-j+k-l**

Propagation Model

- **LTE – 700 MHz**
  - Okumura-Hatta

$$Lp = 69{,}55 + 26{,}16 \log f - 13{,}82 \log hB - CH + [44{,}9 - 6{,}55 \log hB] \log d$$

- **LTE – 2100 MHz**
  - Cost 231-Hatta

$$L_p = 46{,}3 + 33{,}9 (\log f_c) + 13{,}82 \log h_T - a(h_R) + (44{,}9 - 6{,}55 \log h_T) \log d + C_M$$

- **LTE – 2600 MHz**
  - SUI

$$Lp = 109.78 + 47.9 \log (d/100)$$

Pathloss SUI

Lp = 109.78 + 47.9 log (d/100)

$$47.9\log(d/100) = Lp - 109.78$$

$$\log(d/100) = (Lp - 109.78)/47.9$$

$$(d/100) = 10^{(Lp-109.78)/47.9}$$

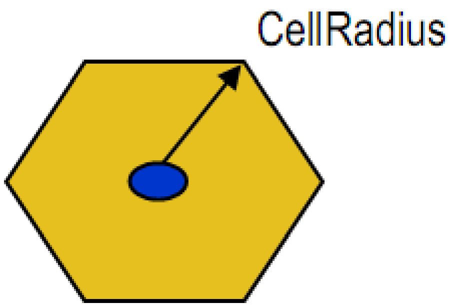
$$d = 100\,x10^{(Lp-109.78)/47.9}$$

$$d = 100\,x10^{(157.7-109.78)/47.9}$$

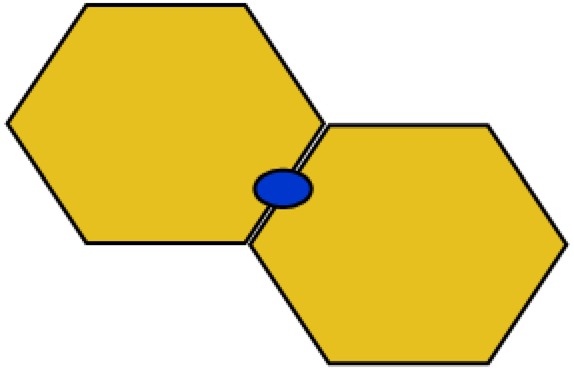
$$d = 100\,x10^{1.00042}$$

$$d = 1000.966$$ meters

Radius Calculation

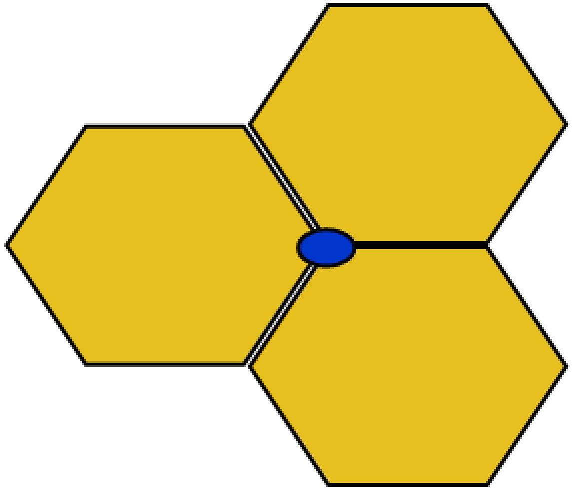


$L = 2{,}6\ d^2$



$L = 1{,}3\ .\ 2{,}6\ .\ d^2$

For 2-sectoral

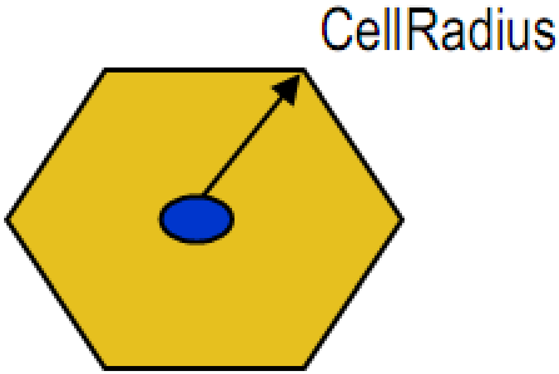


$L = 1{,}95\ .\ 2{,}6\ .\ d^2$

For 3-sectoral

Radius Calculation

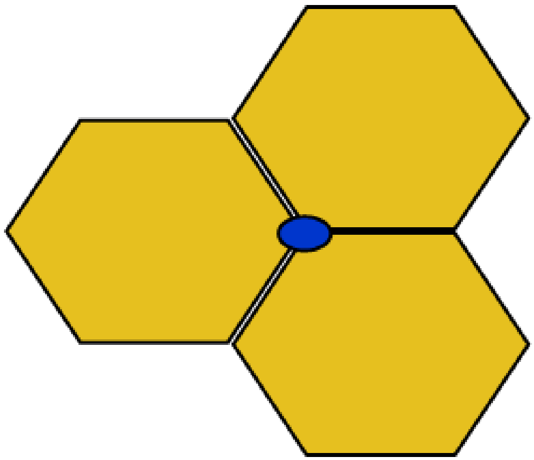
For Omni directional



L = 2,6 d²

$$L = 2.6 \text{ x } (1)^2$$
$$L = 2.6 \ km^2$$

For trisectoral



L = 1,95 . 2,6 . d²

$$L = 1.95 \text{ x } 2.6 \text{ x } (1)^2$$
$$L = 5.07 \ km^2$$

Number of eNodeB

- Urban Area (3 sector)
  - total area 242.928 km^2
  - $N_{eNodeB} = 242.928 / 5.07$
  - $N_{eNodeB} = 48$

Nominal Planning By Coverage

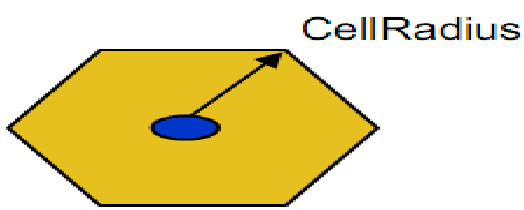
- Balance Site Radius

R = 0.98 km

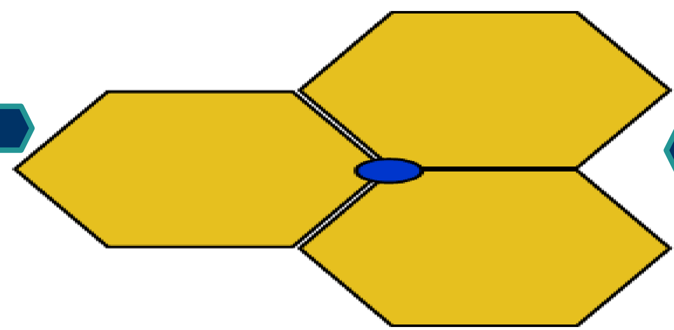
Coverage Site = 4.98 KM^2

Coverage Area = 125 KM^2

- 25 Site

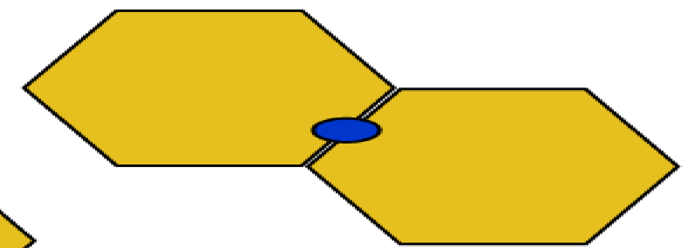


$L = 2{,}6\ d^2$



$L = 1{,}95\ .\ 2.6\ .\ d^2$

For 3-sectoral



$L = 1{,}3.\ 2.6\ .\ d^2$

For 2-sectoral