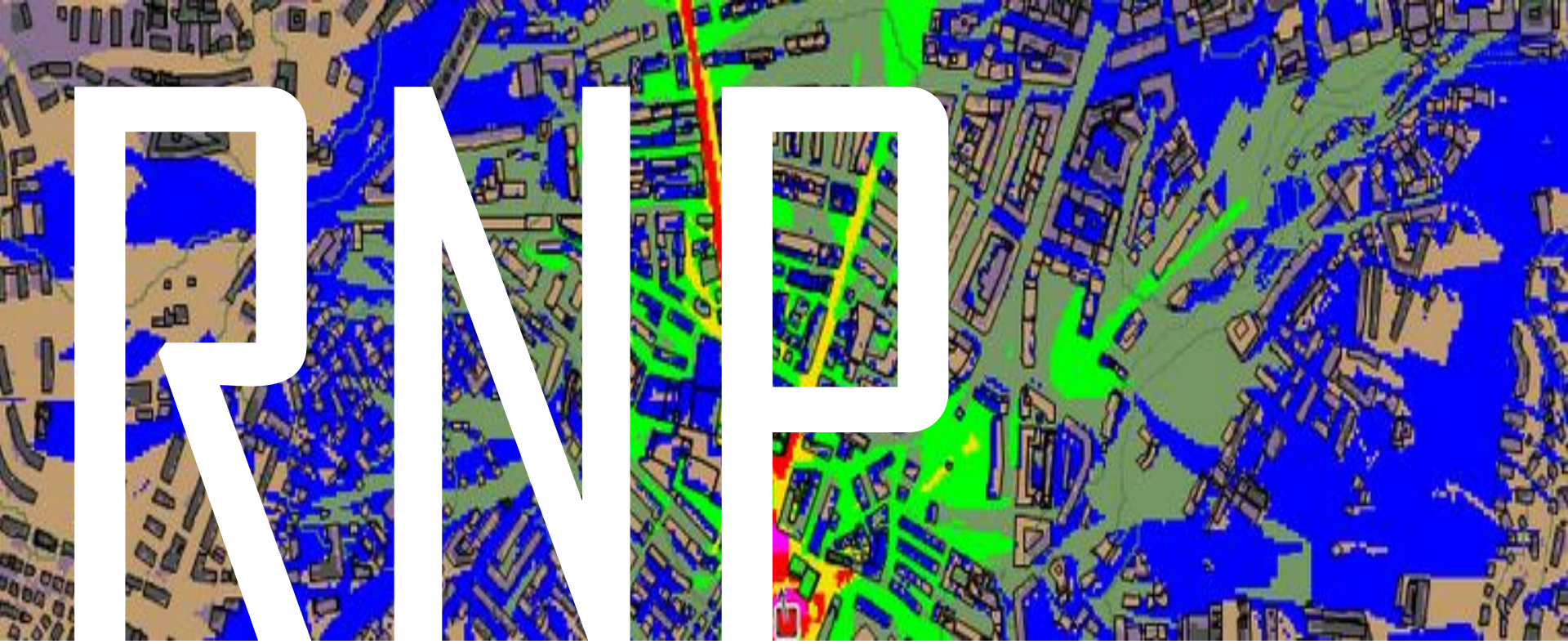


Radio Network Planning

Toha Ardi Nugraha

Syllabus

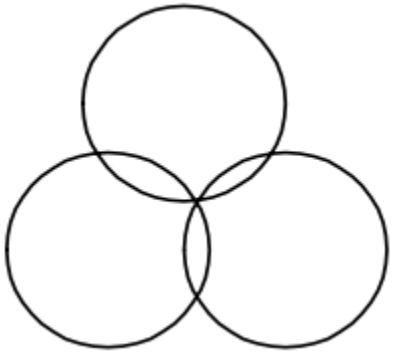
- Mobile Communication Technology
- 3G RNP Overview
- RNP Concept
  - Step Radio Network Planning
  - GSM, 3G, and LTE Planning Differences
- Radio Network Dimensioning
  - Link Budget Calculation
- Simulation
- Analysis

Mobile Communication Technology

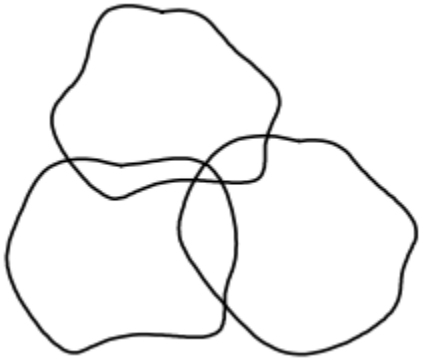
- Mobile Cellular Concept
- Mobile Cellular Evolution
- System Architecture
- 3G WCDMA Concept
- Radio Aspect/Physical Layer

Mobile Cellular Concept

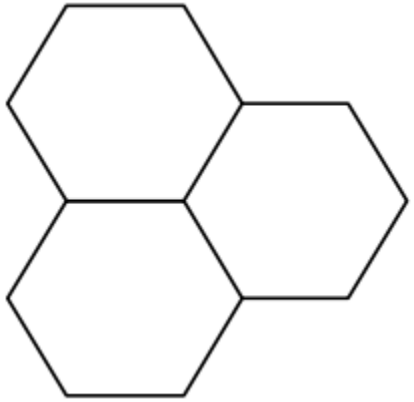
Cell Ideal

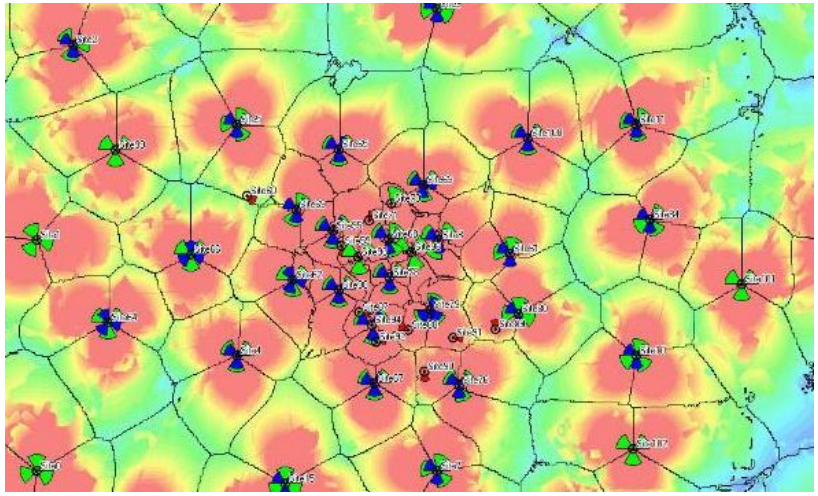


Cell Real



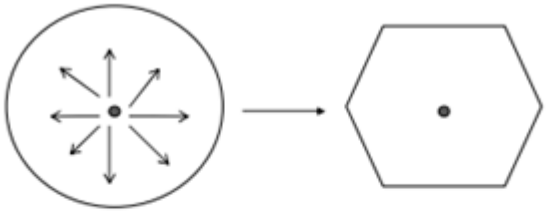
Cell Model



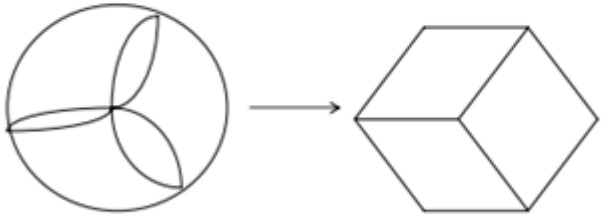


Cell Configuration

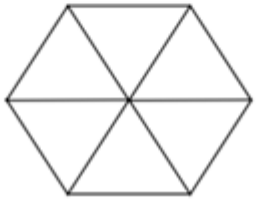
1) Omnidirectional



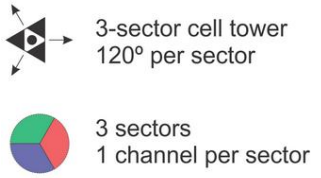
2) Sectoring 120°

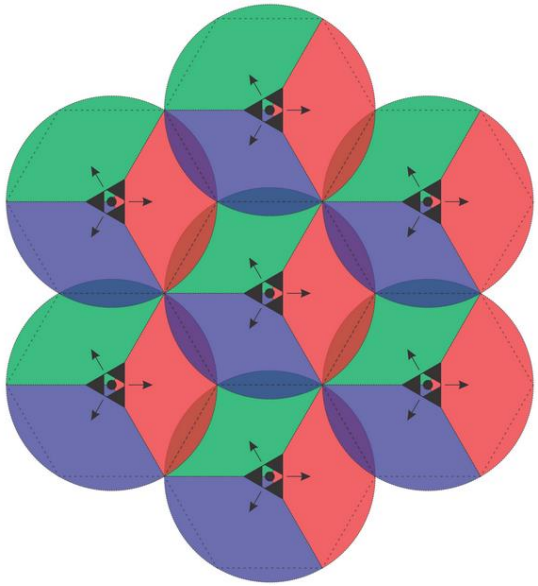


3) Sectoring 60°

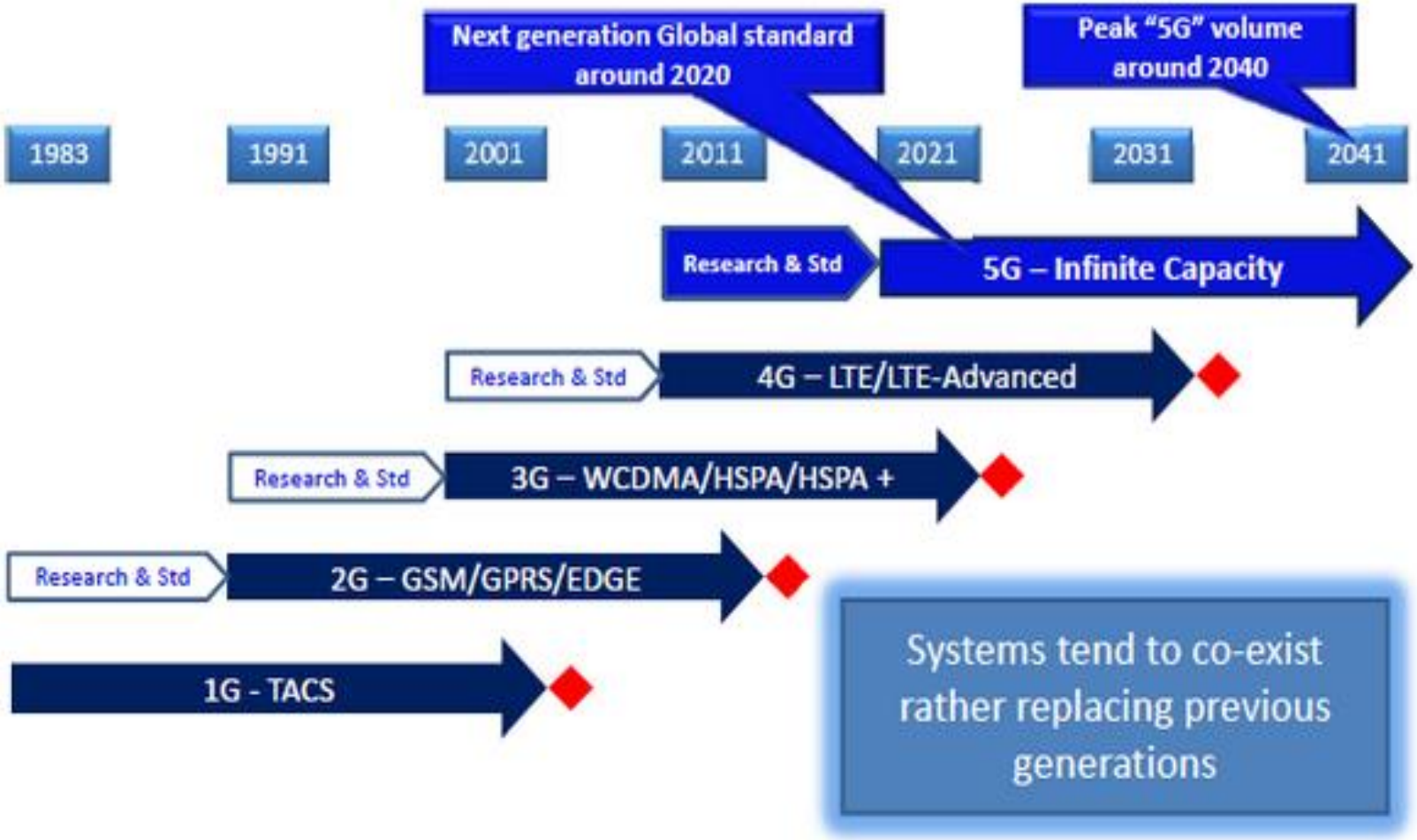


Example :

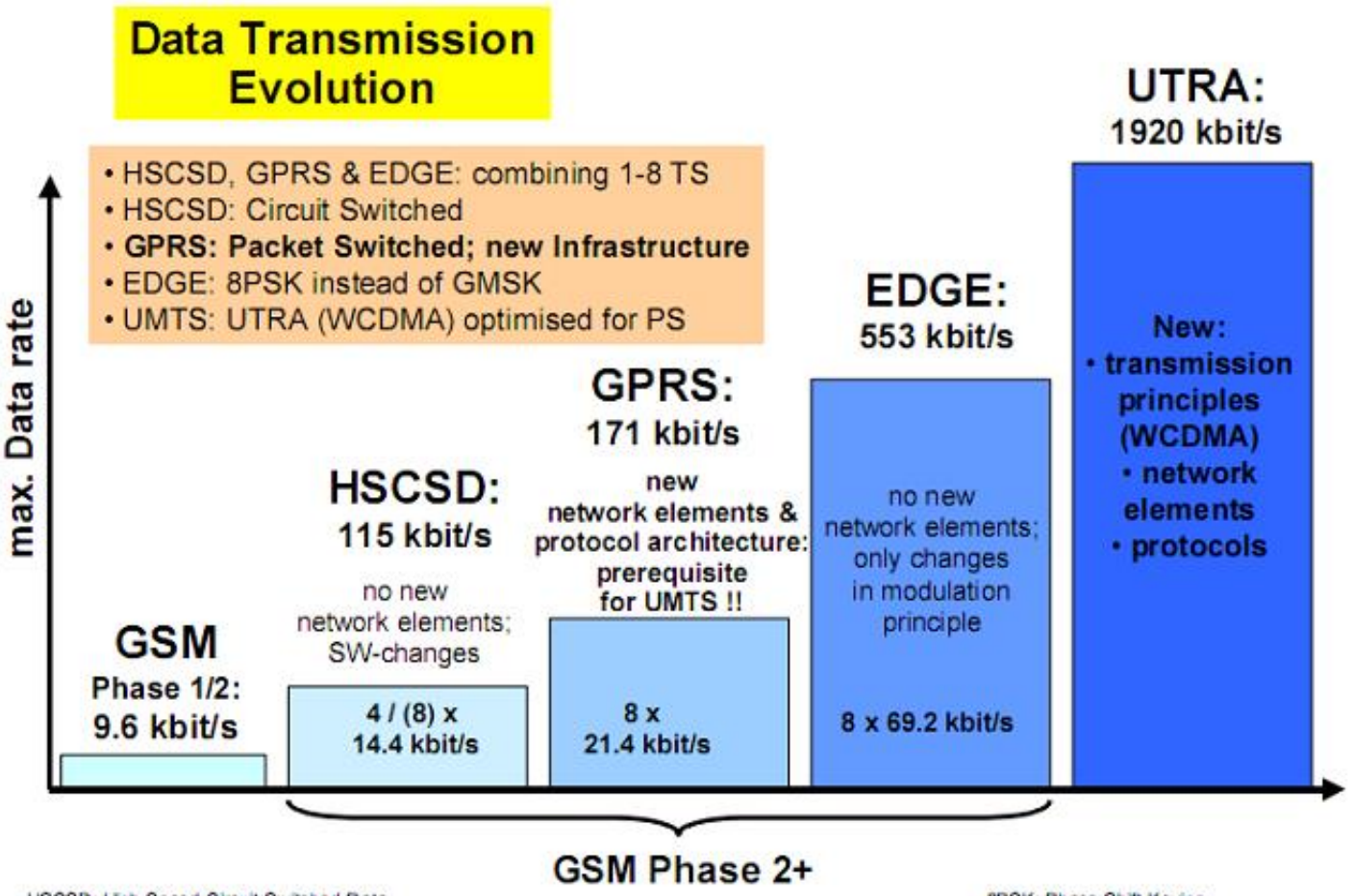




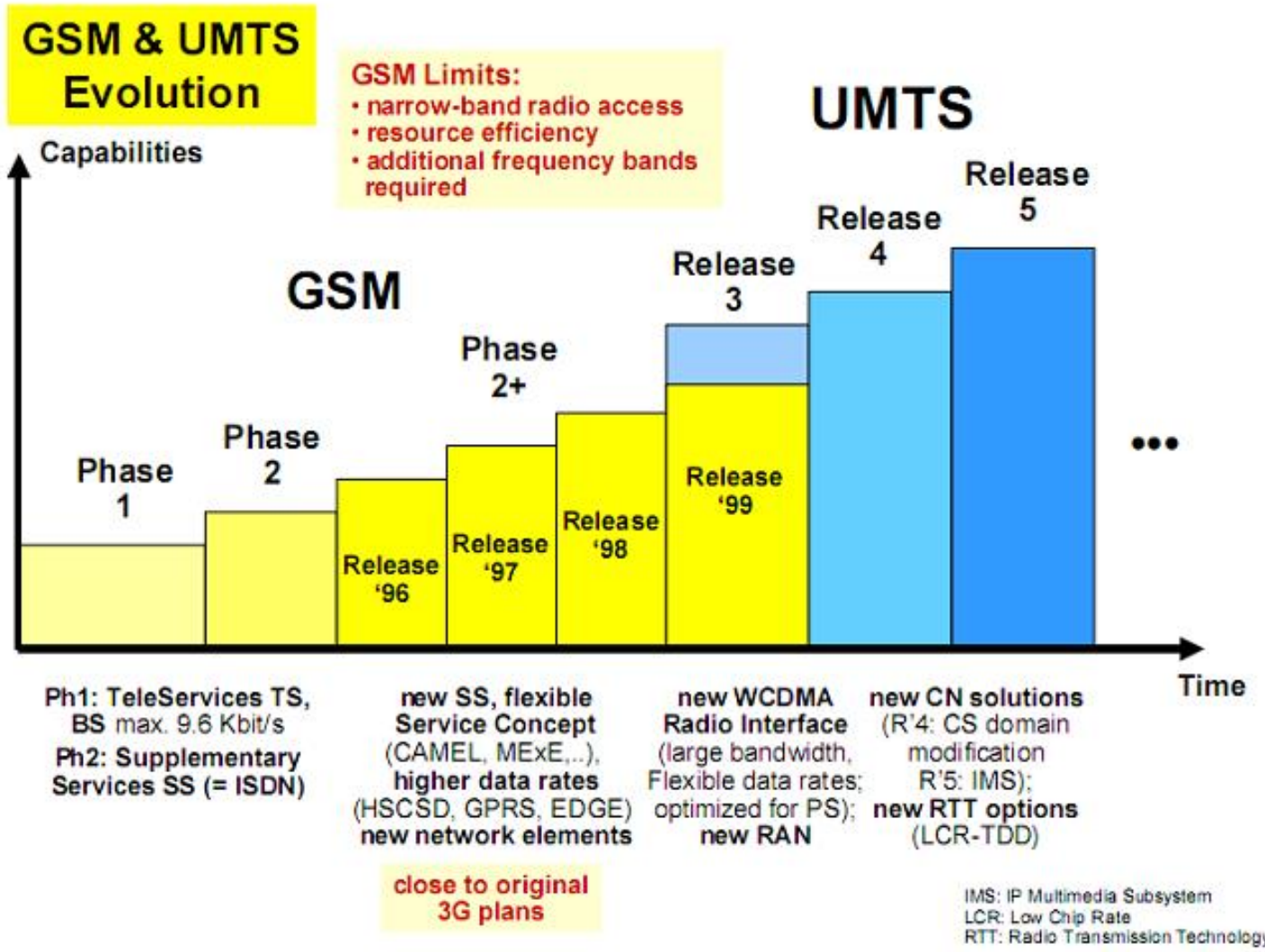
Mobile Cellular Evolution



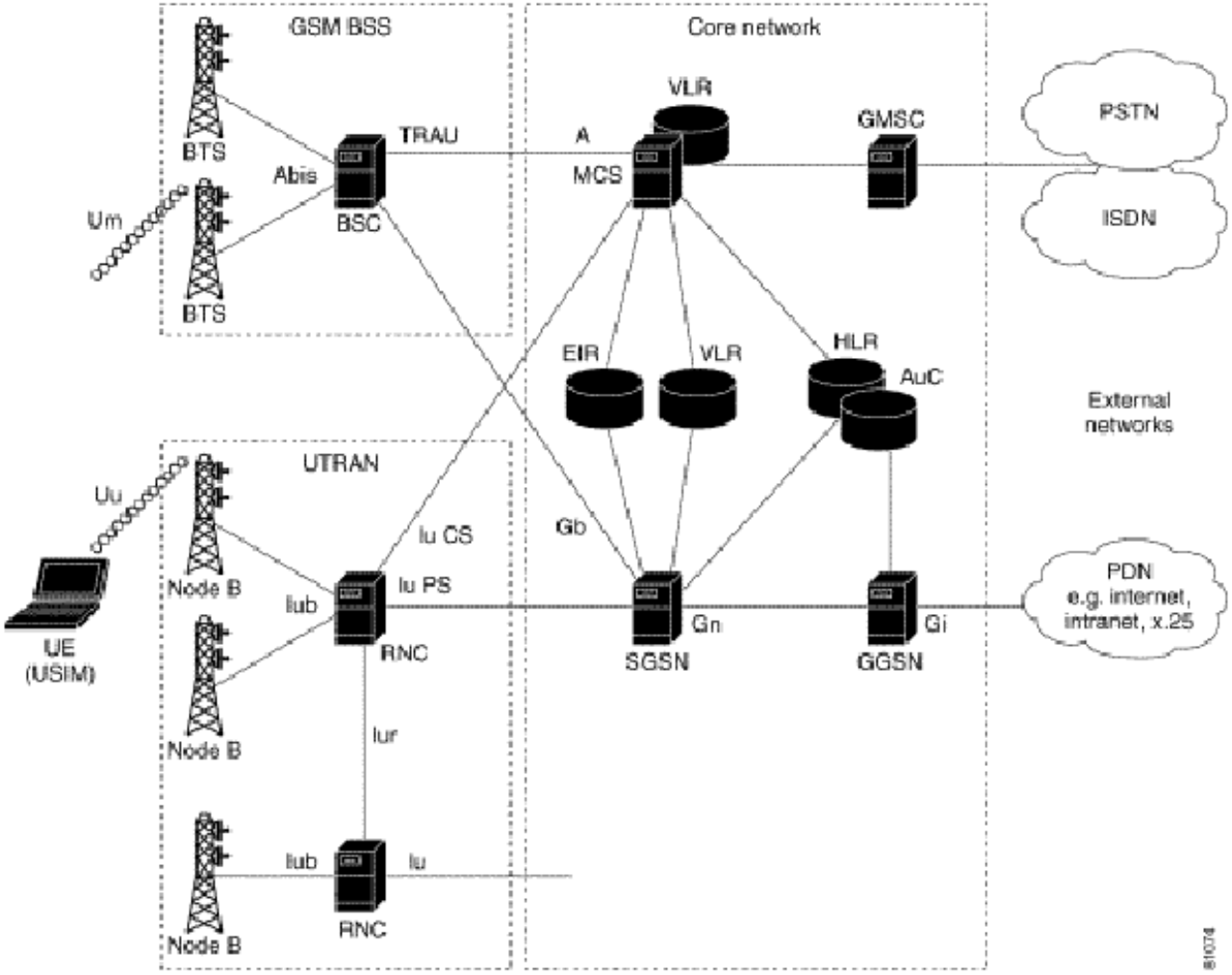
Data Transmission Evolution



GSM & UMTS Evolution



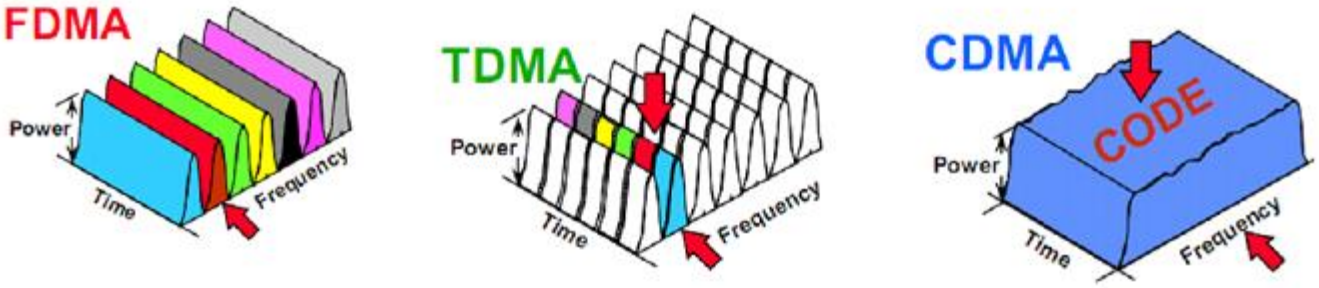
GSM and 3G Architectures



3G WCDMA - Wideband CDMA

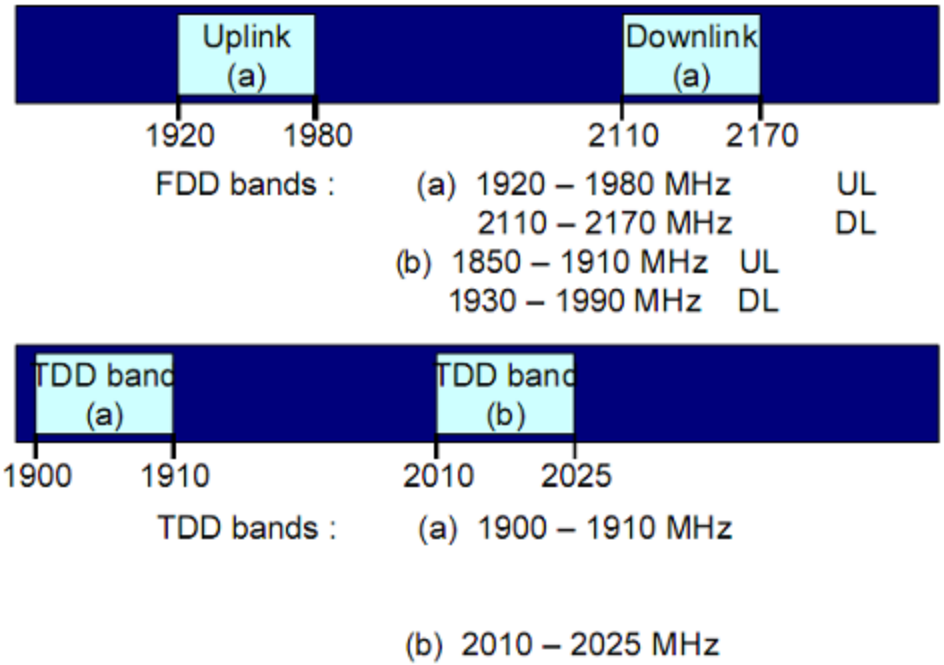
Radio access technology for one of the UMTS access modes (UTRA FDD) using 5 MHz duplex channels.

- Frame length is of 10 msec, Chip rate is 3.84 Mcps
- All users share the same frequency and time domain
- Users separated by the codes



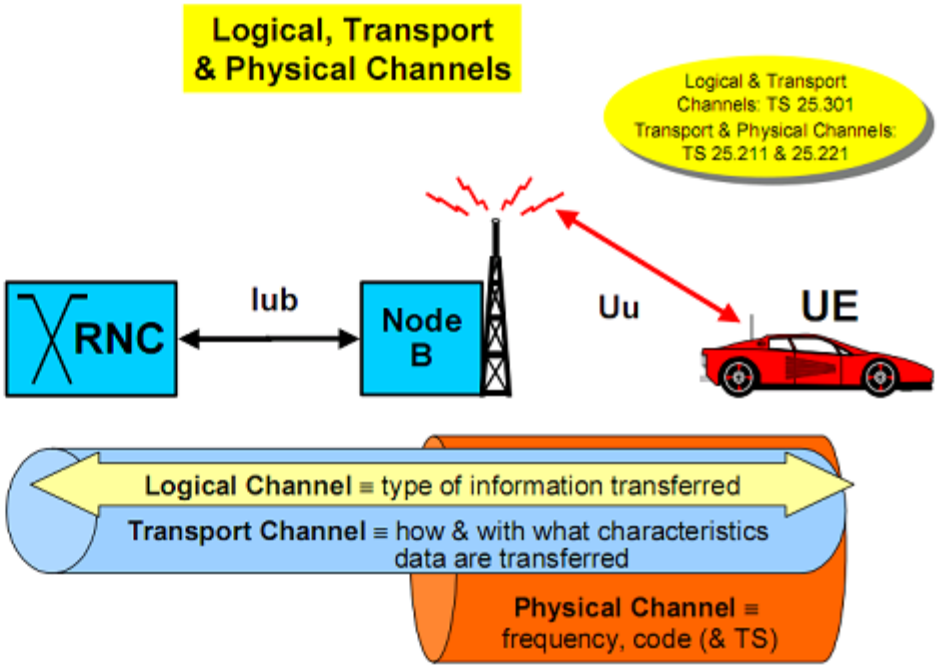
UMTS Radio Frequency Ranges

- FDD (Frequency Division Duplex)
- TDD (Time Division Duplex)



Channelization in UMTS

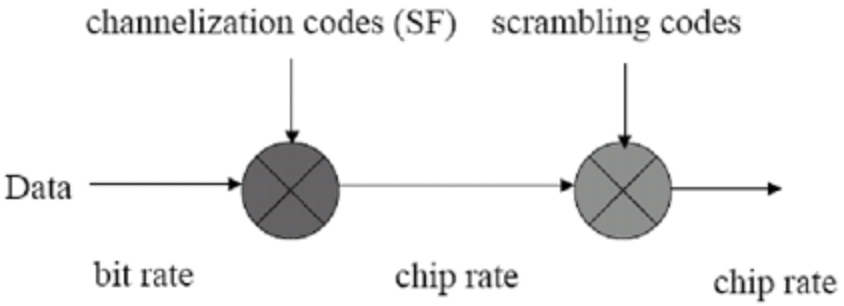
- Logical Channel between RLC and MAC
  - Specific for information types
  - What type of data to be transferred
- Transport channel between MAC and PHY
  - Specific for "how to transfer information?" (quality guarantee)
  - How and with which type of characteristic the data is transferred by the Physical Layer
- Physical Channel
  - Exact Physical characteristics of the radio channel

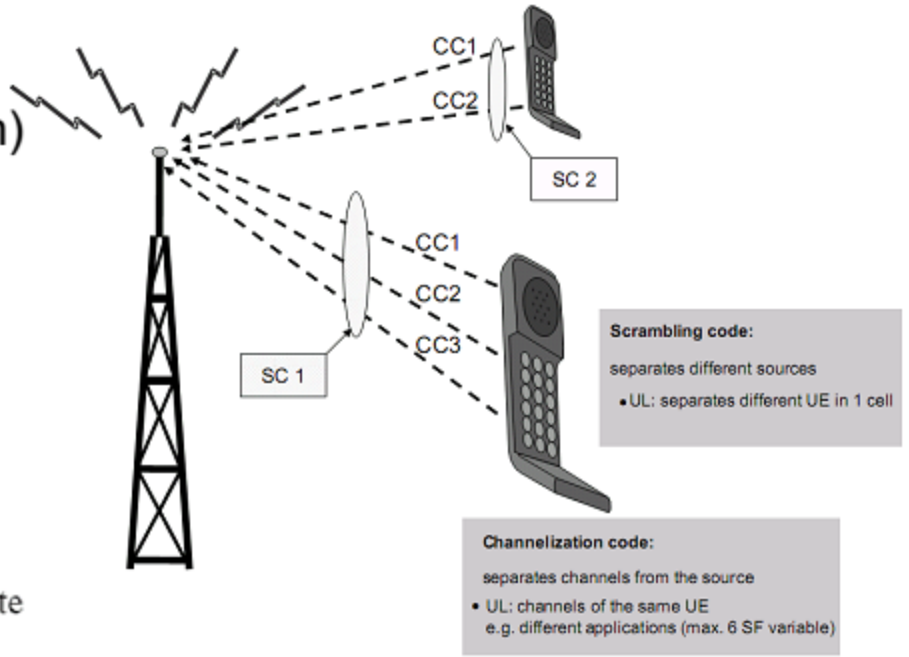


WCDMA Channel (Cont.'s)

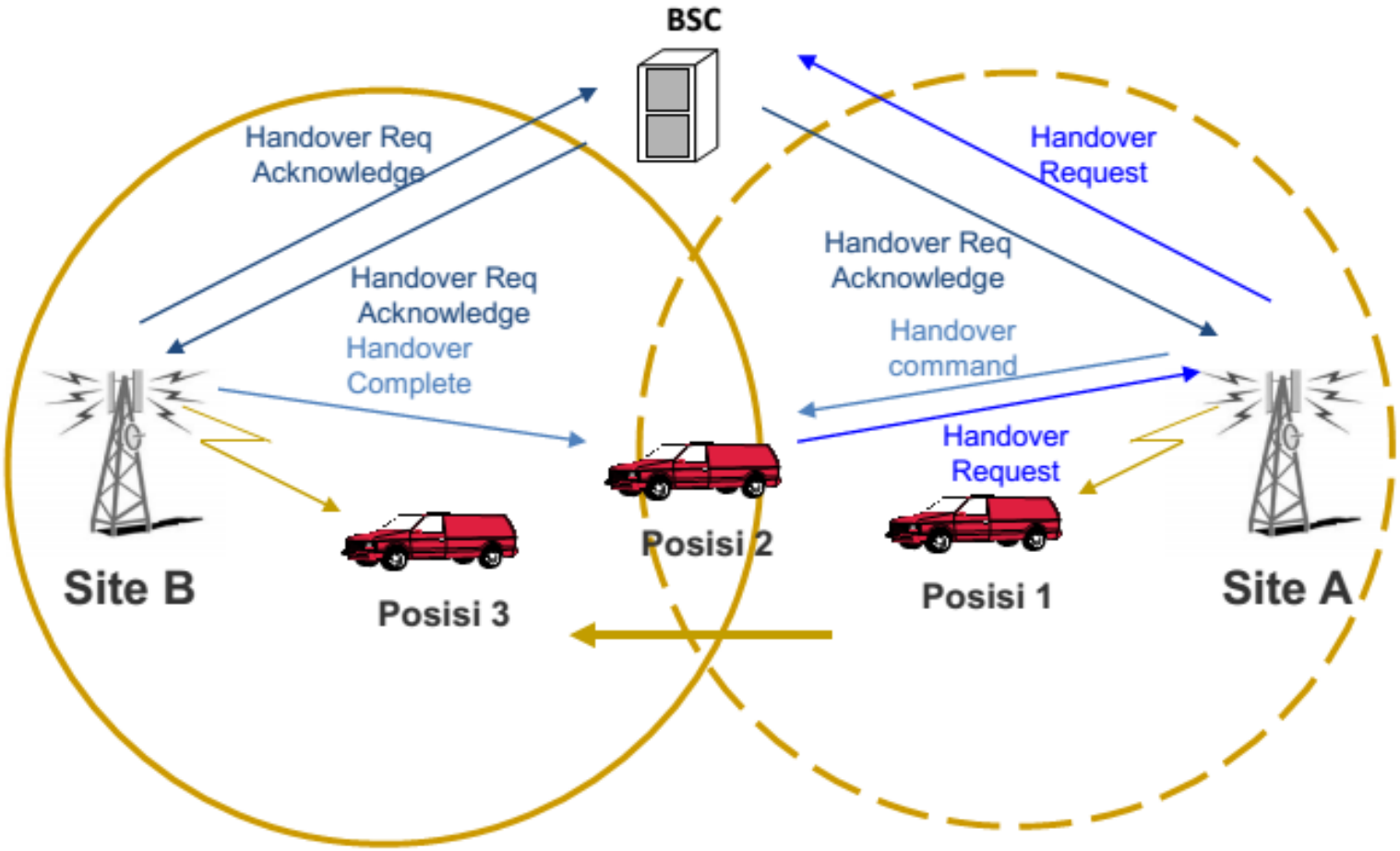
- Spreading means increasing the signal bandwidth
- Spreading includes two operations
  - Channelization (increases signal bandwidth)
    - Orthogonal Spreading
  - Scrambling

  (does not affect the signal bandwidth)
    - Use pseudo-noise codes





Handover Concept



Radio Network Planning

- RNP Overview
- Objective
- GSM and 3G Planning Differences
- Radio Network Dimensioning
- Power Link Budget

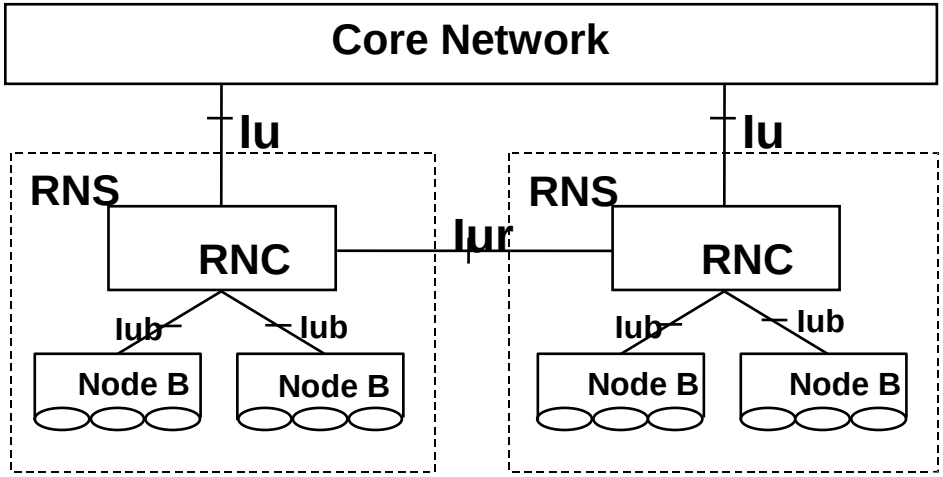
Radio Network Planning Overview

Radio Network Planning?

According to deployment and evolution requirements, as well as cost-effectiveness consideration, generate the amount of **Network Elements (NE), NE configuration, and Transmission design** between different NE.

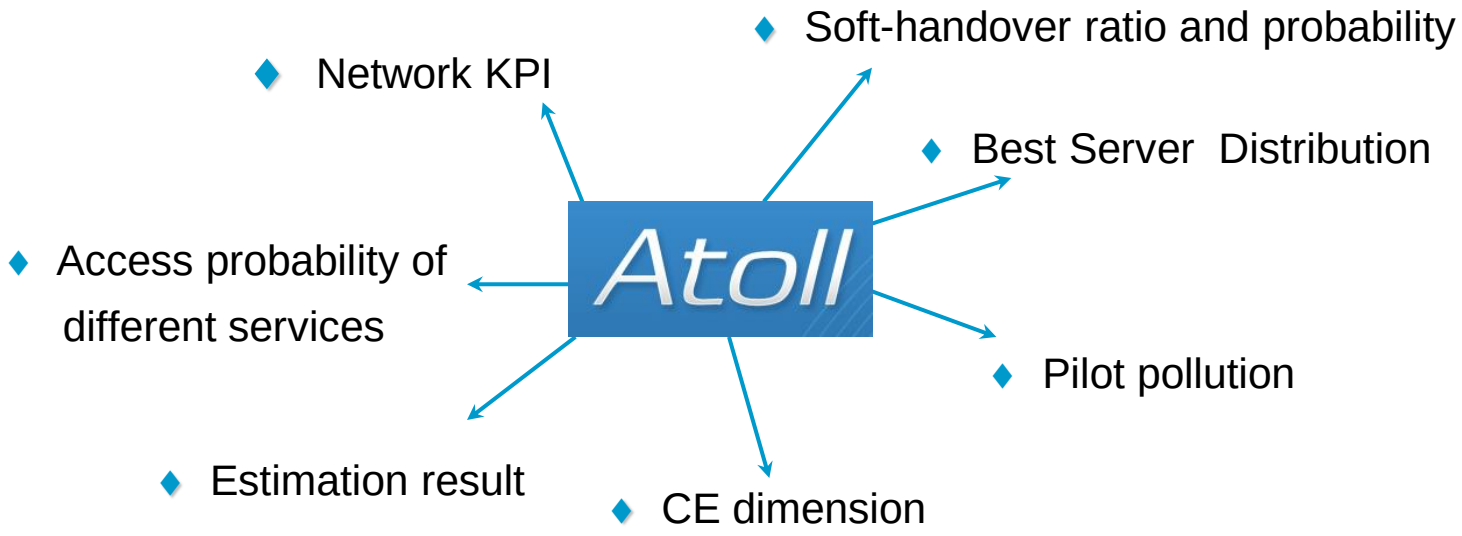
Network Planning Scope：

- **Core network**：focus on CN element dimension and configuration.
- **Radio network**：focus on RAN element dimension and configuration
- **Transmission network**：focus on link dimension and configuration between network elements.



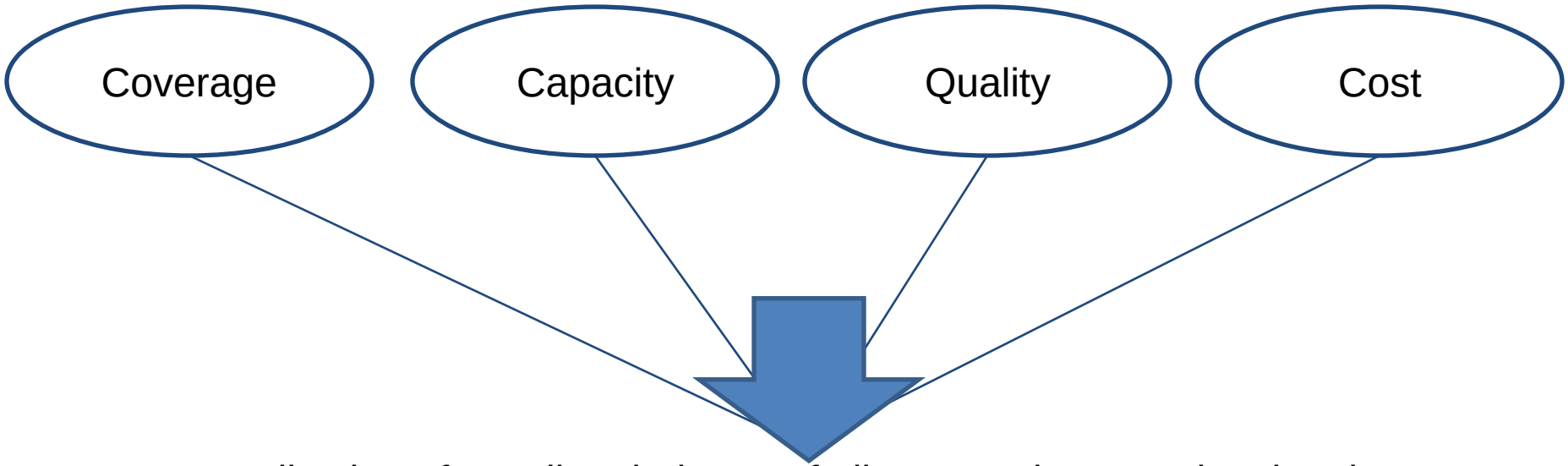
Radio Network Planning Solution

- 3G Radio network planning (NodeB/RNC)
- 3G Transmission network planning (Iu/Iur/Iub)
- 3G Core network planning (CS/PS domain)
- 3G RNP tools development



Objectives of Network Planning

The RF Design of wireless system revolves four main principles. These principles are **Coverage, Capacity, Quality and Cost**. And further, adapt to the future network development and expansion.



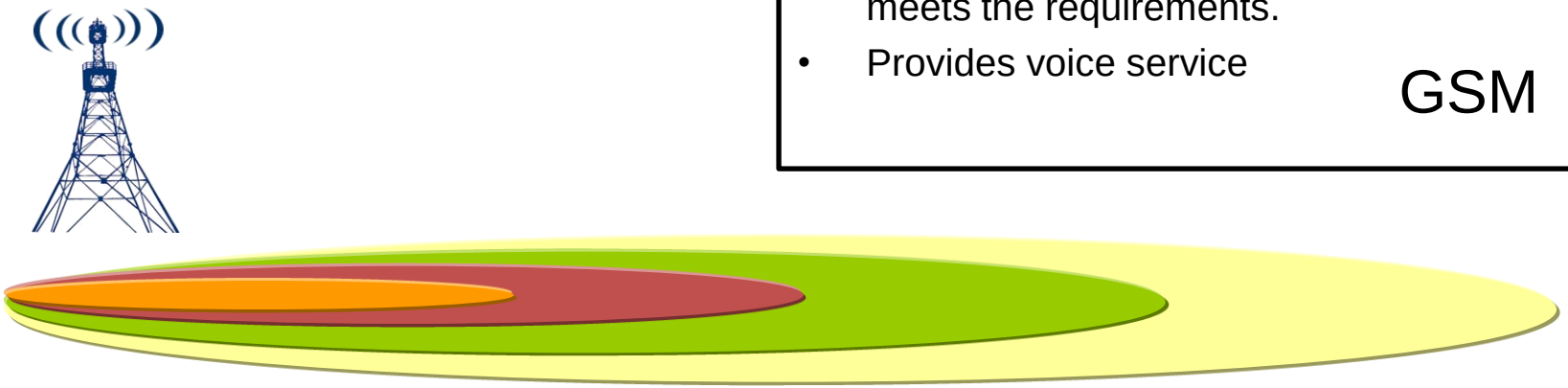
GSM and 3G Planning Differences

- Realize 1×1 **frequency reuse**
- The capacity per WCDMA cell is “soft” for it is related to environment and neighbor cell interference.
- Supports multiple services with different speed rate and QoS, and each service has different coverage range.

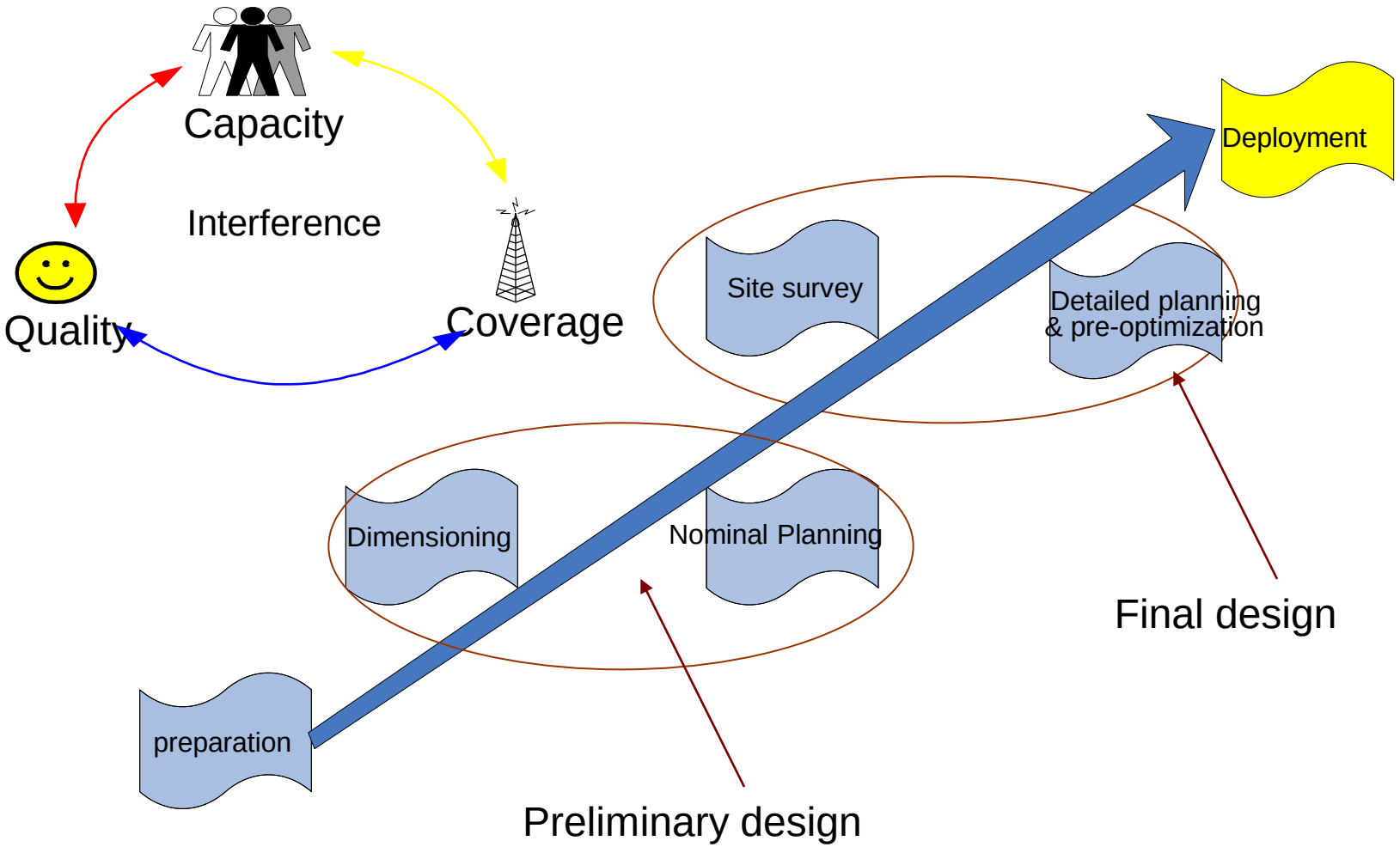
3G

- Adopts cellular network structure and frequency planning to guarantee **intra/inter-frequency interference**
- Users supported can be calculated from carriers and timeslots if the interference meets the requirements.
- Provides voice service

GSM



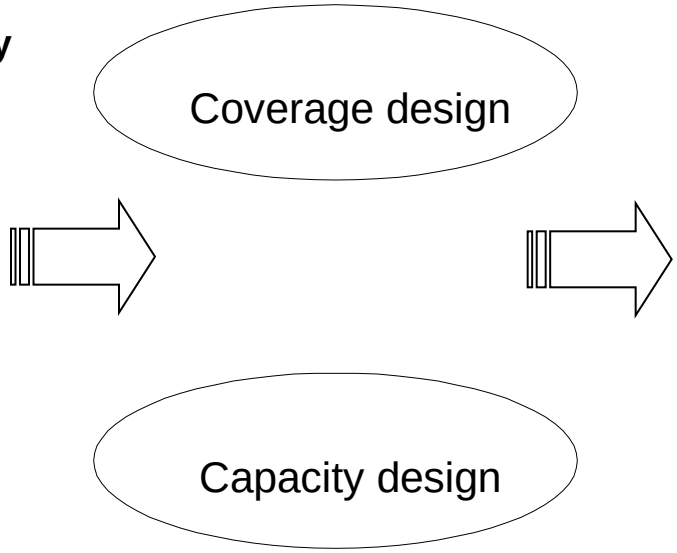
3G RNP Procedure Overview



Radio Network Dimensioning

Input

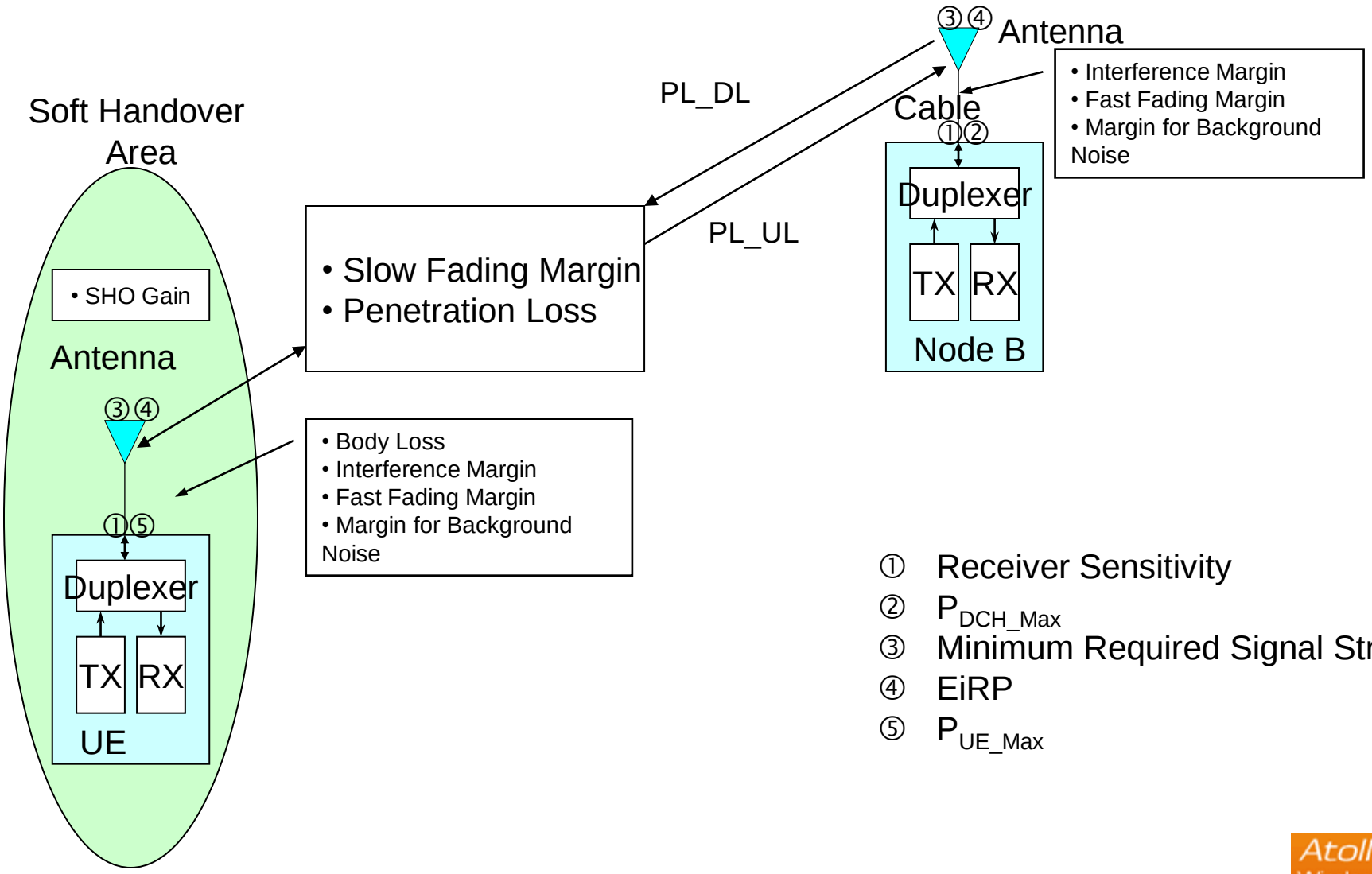
- Coverage related
  - **Coverage area**
  - **Coverage probability**
- Capacity related
  - **Traffic model**
  - **Service model**
  - **User density**
- Quality related
  - **QoS requirements**
  - **GoS requirements**
  - **Demodulation threshold**



Output

- System dimensioning
  - **Number of sites**
- System configuration
  - **Sector structure**
  - **Number of carriers**
- Cost on network construction
  - **Site cost**
  - **Equipment cost**

Power Link Budget



① Receiver Sensitivity
② P_{DCH_Max}
③ Minimum Required Signal Strength
④ EiRP
⑤ P_{UE_Max}

Example Calculation

Coverage

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

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:

Propagation Model

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

Area

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

Voice

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

Example Calculation

Capacity

$$M = \eta \left[1 + \frac{Rc \; x \; Gs}{\frac{Eb}{No} \; x \; Ri \; x \; Vi \; (1+f)} \right]$$

- Eb/No = 8.5 dB
- Chip Rate, Rc = 3,84 Mcps
- Bit Rate, Ri = 12.2 kbps (*voice*)
- Activity factor, Vi= 0.4
- Gs (*Antenna Sector Gain*) = 1
- f (*other-cell relative interference factor*) = 0,6
- η (*load factor*) = 0,5

	BER	Eb/No (dB)
Voice Conversation	10^{-4}	8.5
Data	10^{-6}	10.6
Video Telephony	10^{-7}	11.4

$$M = 0{,}5\,[1 + 69.46]$$

$$M = 35.23 \approx 35$$

Blocking Probability 2%

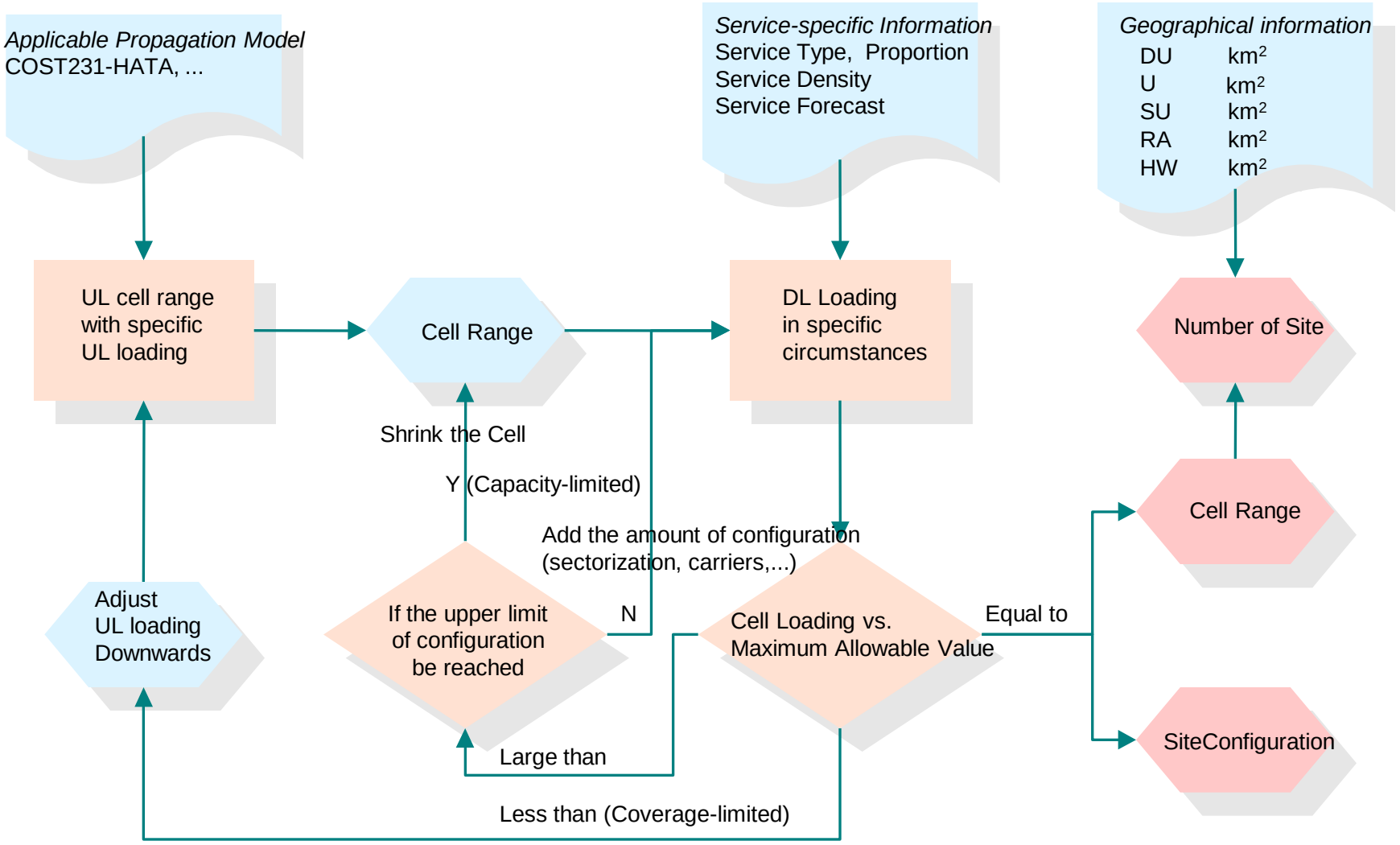
Erlang Table

A (35; 2%) = 26.435 Erlang

$$\sum user = \frac{A_{carried\ trafik}}{A_{subs}}$$

$$= \frac{26.435}{0.025} = 1057.4 \approx 1058\ user$$

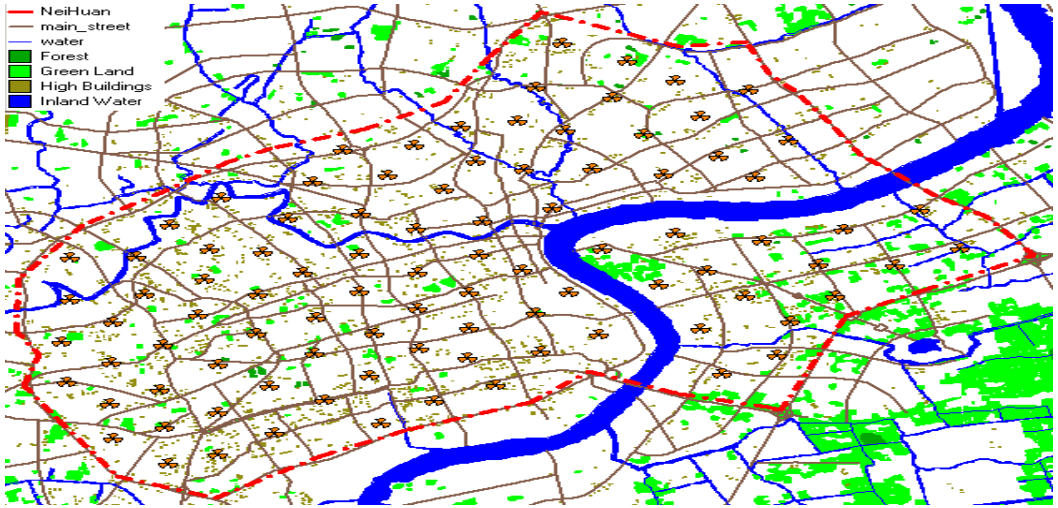
Network Dimension flow chart



Nominal Planning

Based on the result of network dimension, preliminary design present Information of theoretical sites including following :

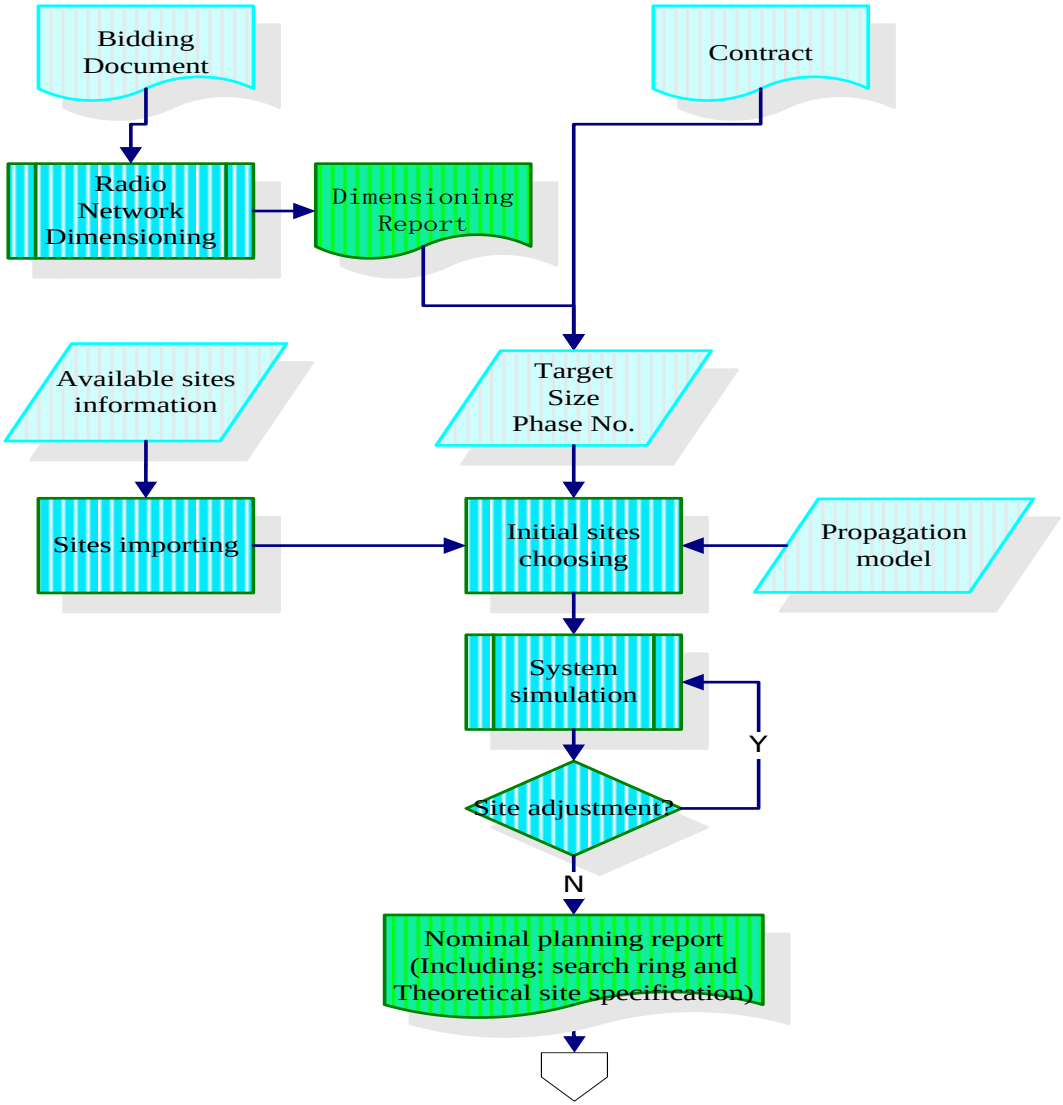
- Site coordinates.
- Engineering parameters such as Antenna height, azimuths and tilts.
- Radio parameters such as scrambling code ,transmit power of different channels , etc.



Software Simulation

- Simulation Flow Chart
- Simulation Output
- Step by Step
- Verification by System Simulation

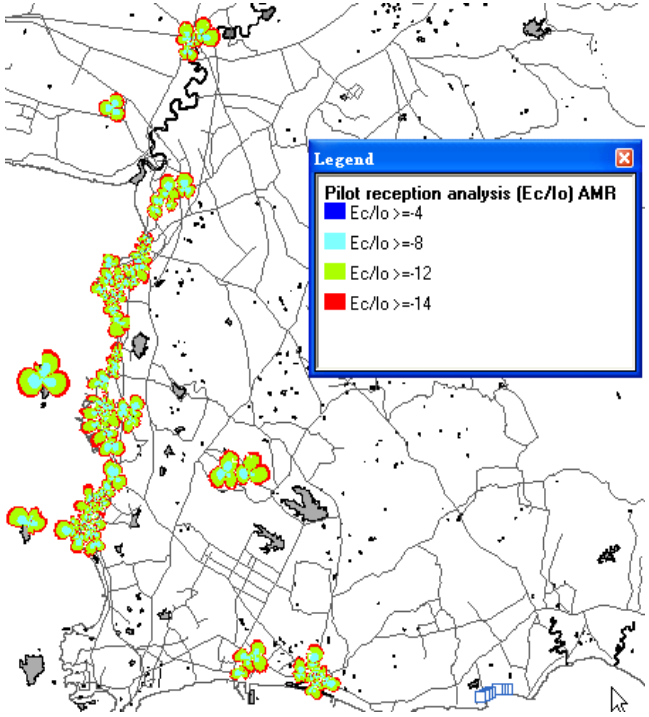
Preliminary design flow chart



Simulation Output

Simulation Parameter

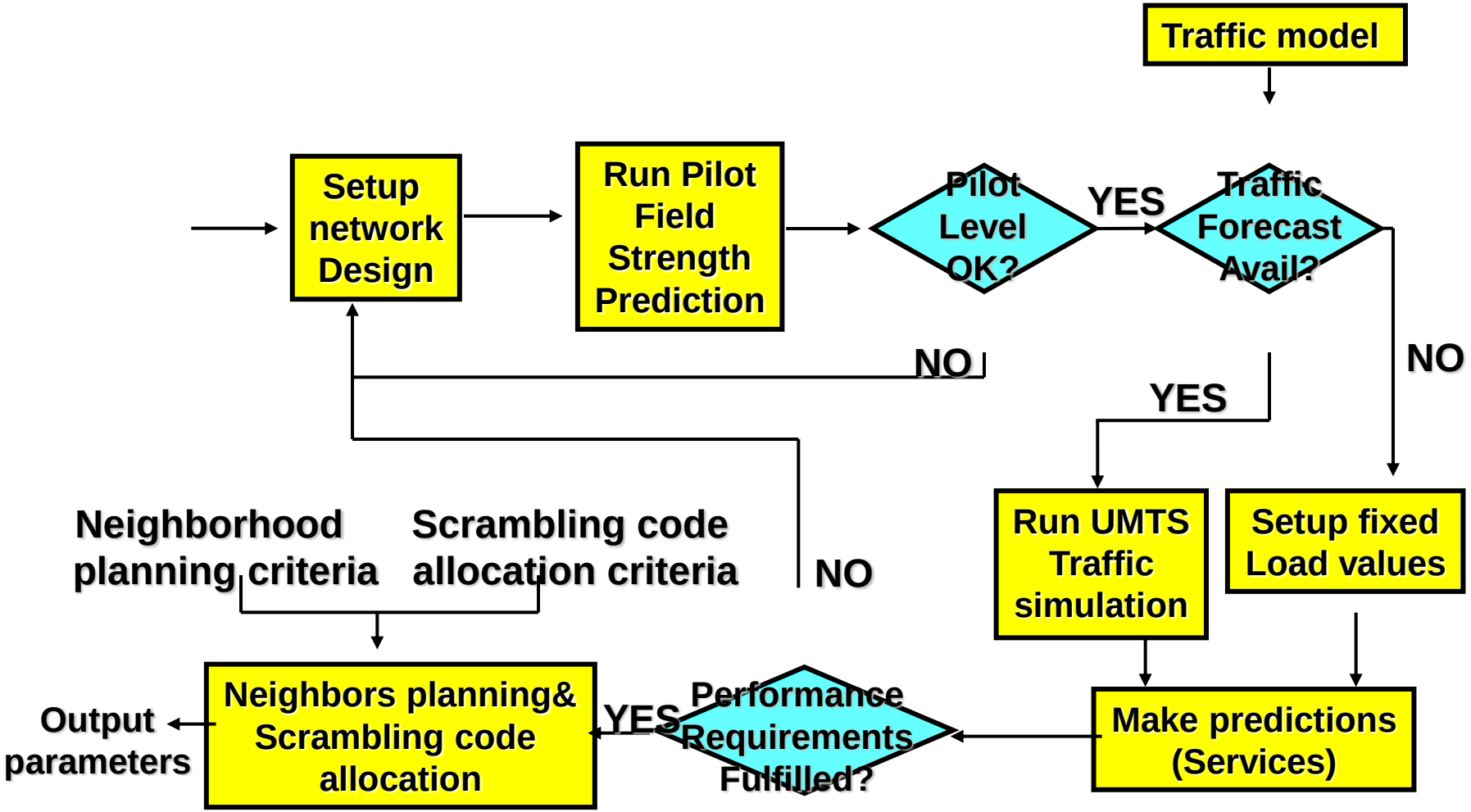
- Pilot coverage (Ec, Ec/Io) in the target areas
- Best server plot
- Coverage probability distribution of each service
- Access failure distribution and statistic of each service
- Continuous coverage areas of each service
- Cell load distribution of downlink and uplink
- Pilot pollution distribution
- Soft handover areas statistic of each service



Task and Excercise

- Find map of Yogyakarta City
- Find number of users in Yogyakarta City
- Plot Cells
  - Based on Calculation of Coverage Cell
  - Based on Capacity Calculation

Simulation flow-chart



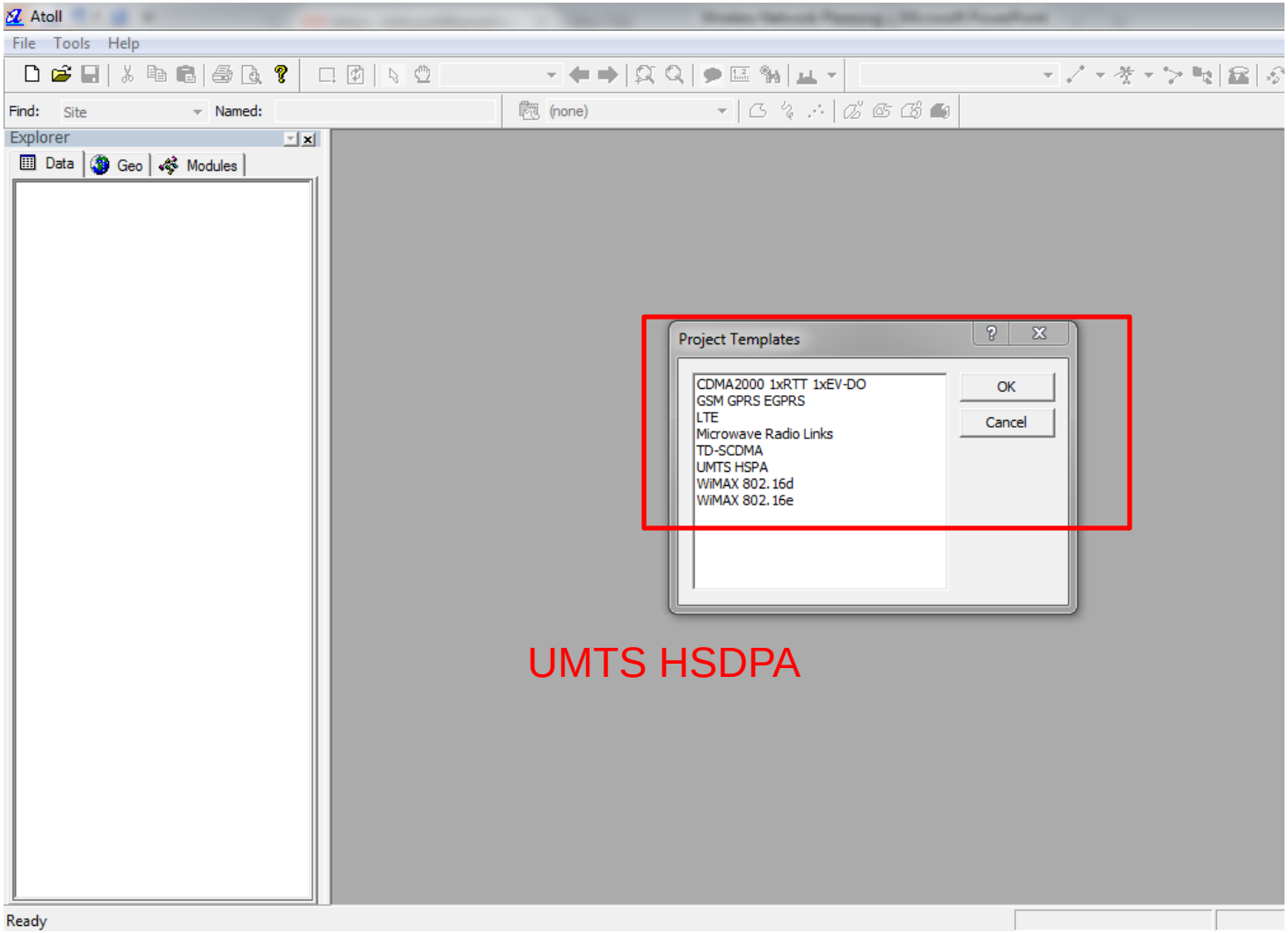
Atoll Simulation Step

1. Preparation
2. Start Project
3. Configure Coordinate
4. Import Digital Maps
5. Set Propagation Model
6. Draw Zone
7. Make Prediction based on Coverage
8. Simulation
9. Make Prediction based on Simulation
10. Check Planning Results

Preparation

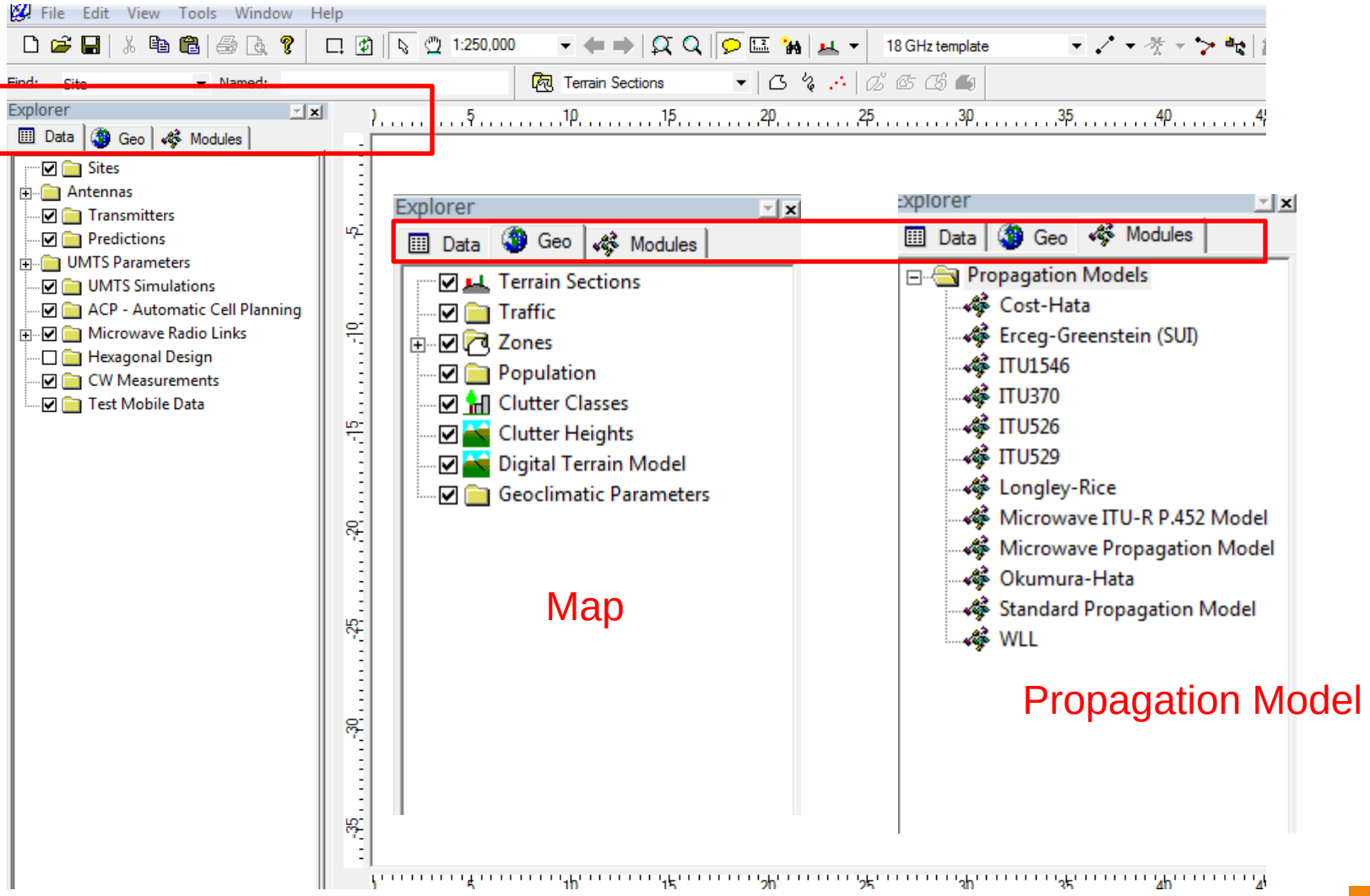
- Data Planning (Import Information)
- Map
  - Vector
  - Clutter
  - Height

Start Project



UMTS HSDPA

Interface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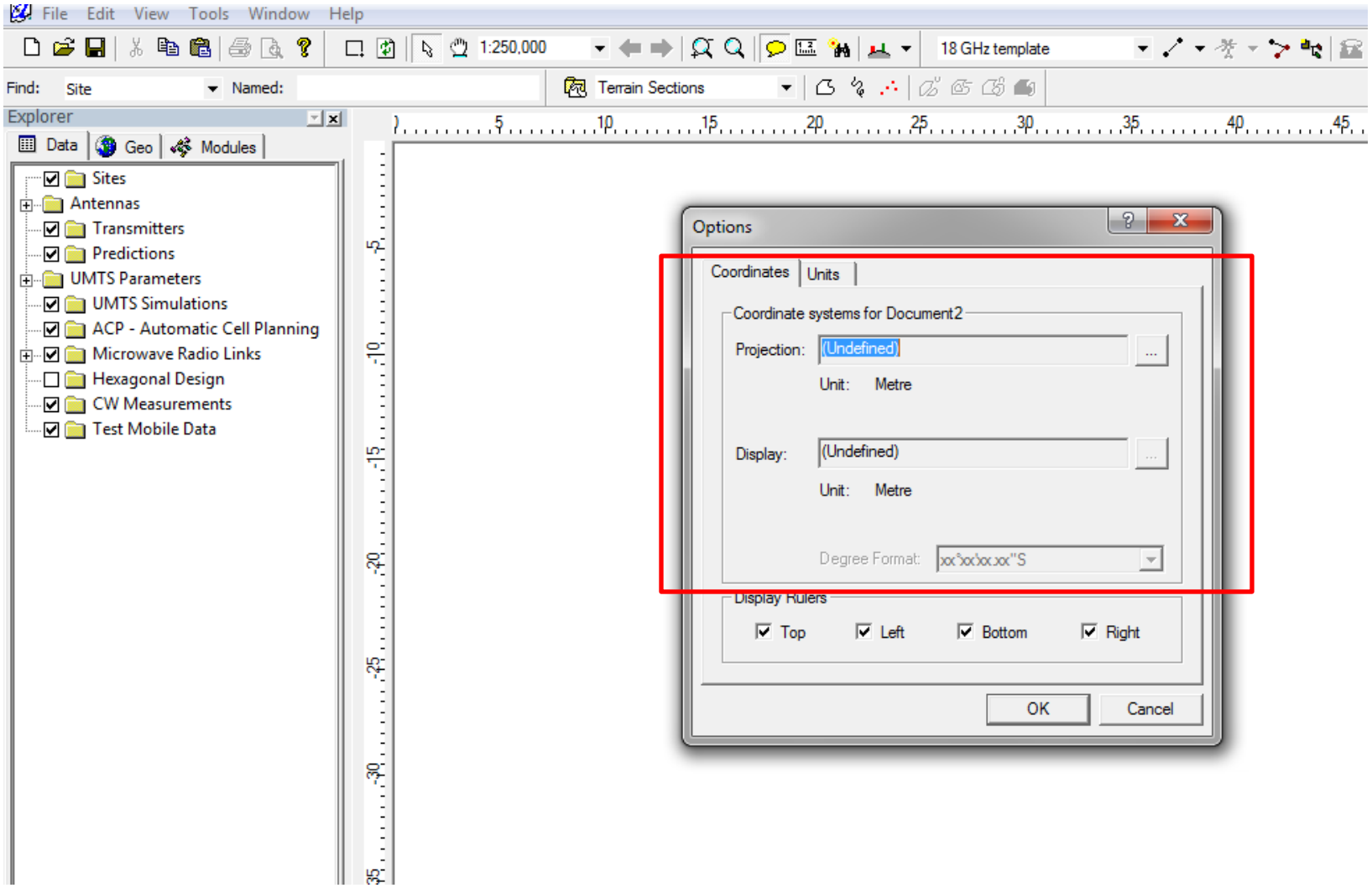
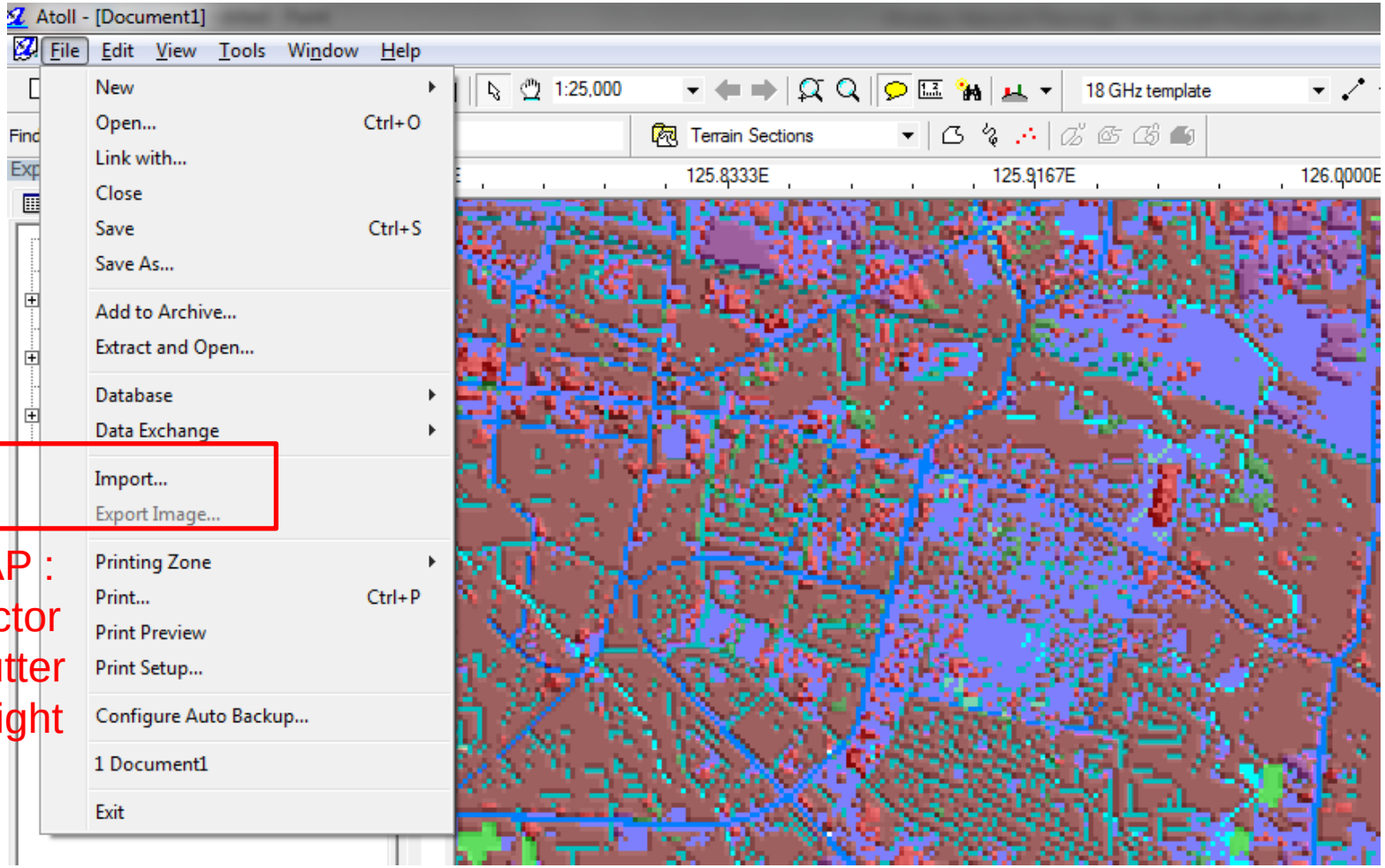
Explorer
Data Geo Modules
Sites
Antennas
Transmitters
Predictions
UMTS Parameters
UMTS Simulations
ACP - Automatic Cell Planning
Microwave Radio Links
Hexagonal Design
CW Measurements
Test Mobile Data
Terrain Sections
Traffic
Zones
Population
Clutter Classes
Clutter Heights
Digital Terrain Model
Geoclimatic Parameters
Map
Propagation Models
Cost-Hata
Erceg-Greenstein (SUI)
ITU1546
ITU370
ITU526
ITU529
Longley-Rice
Microwave ITU-R P.452 Model
Microwave Propagation Model
Okumura-Hata
Standard Propagation Model
WLL
Propagation Model

Configure Coordinate

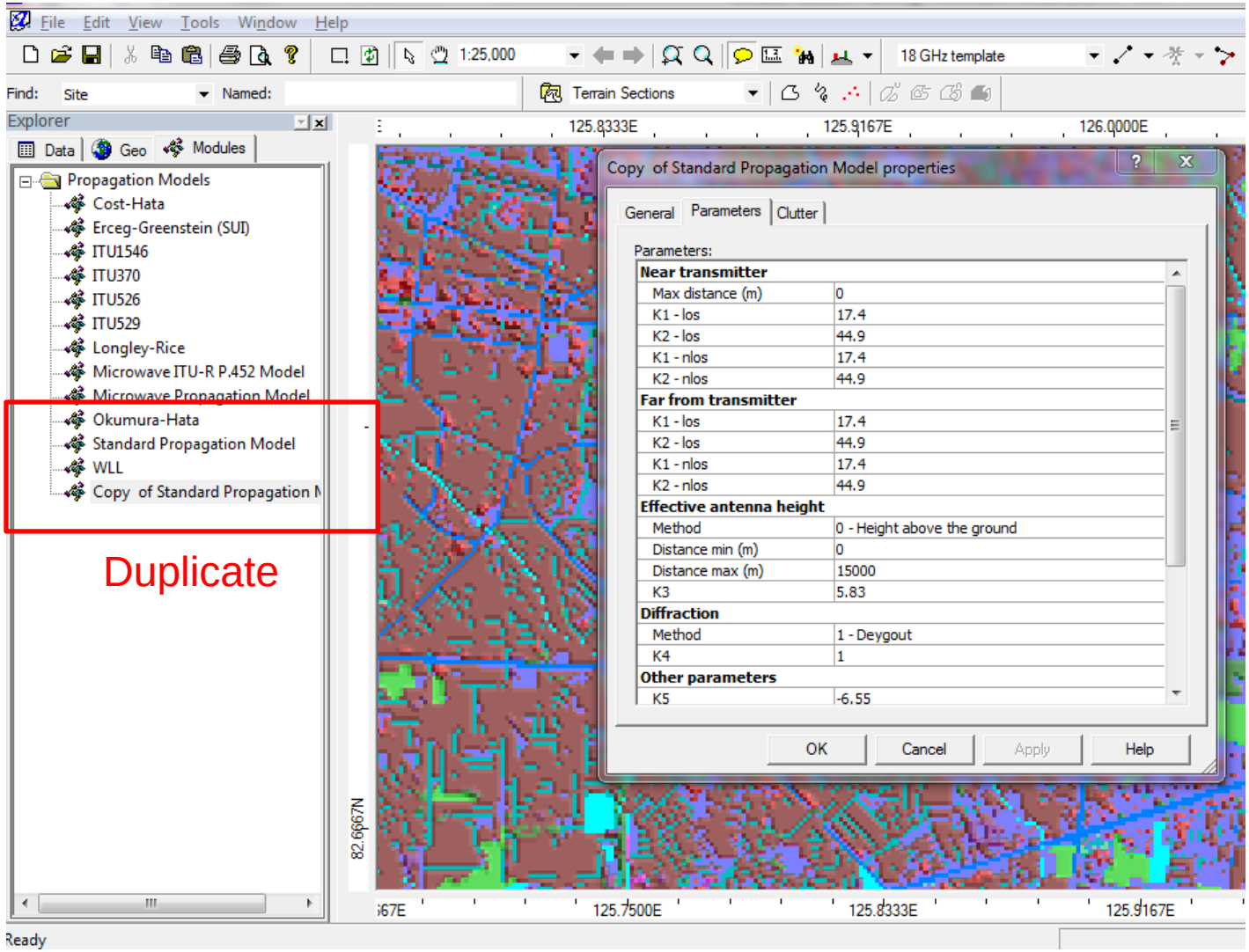


Import Digital Maps

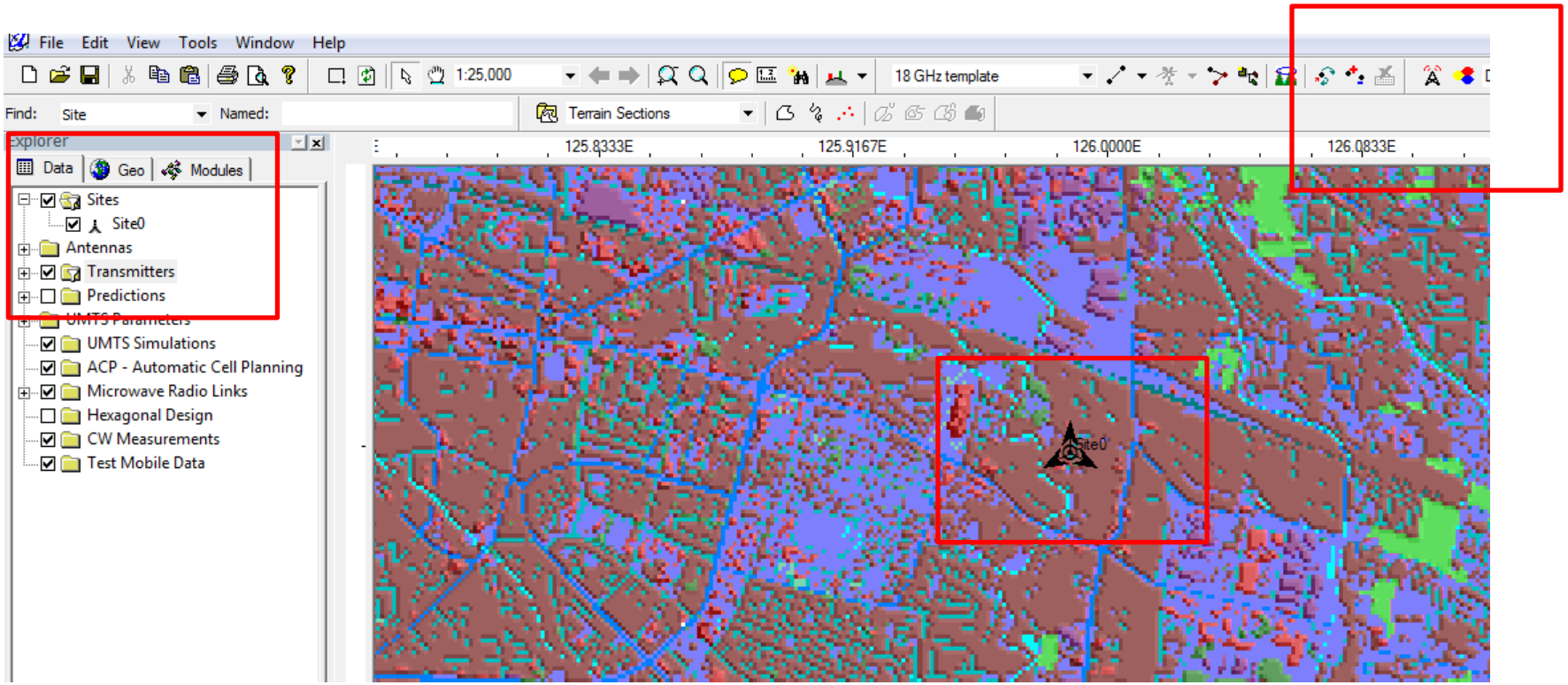


MAP :
Vector
Clutter
Height

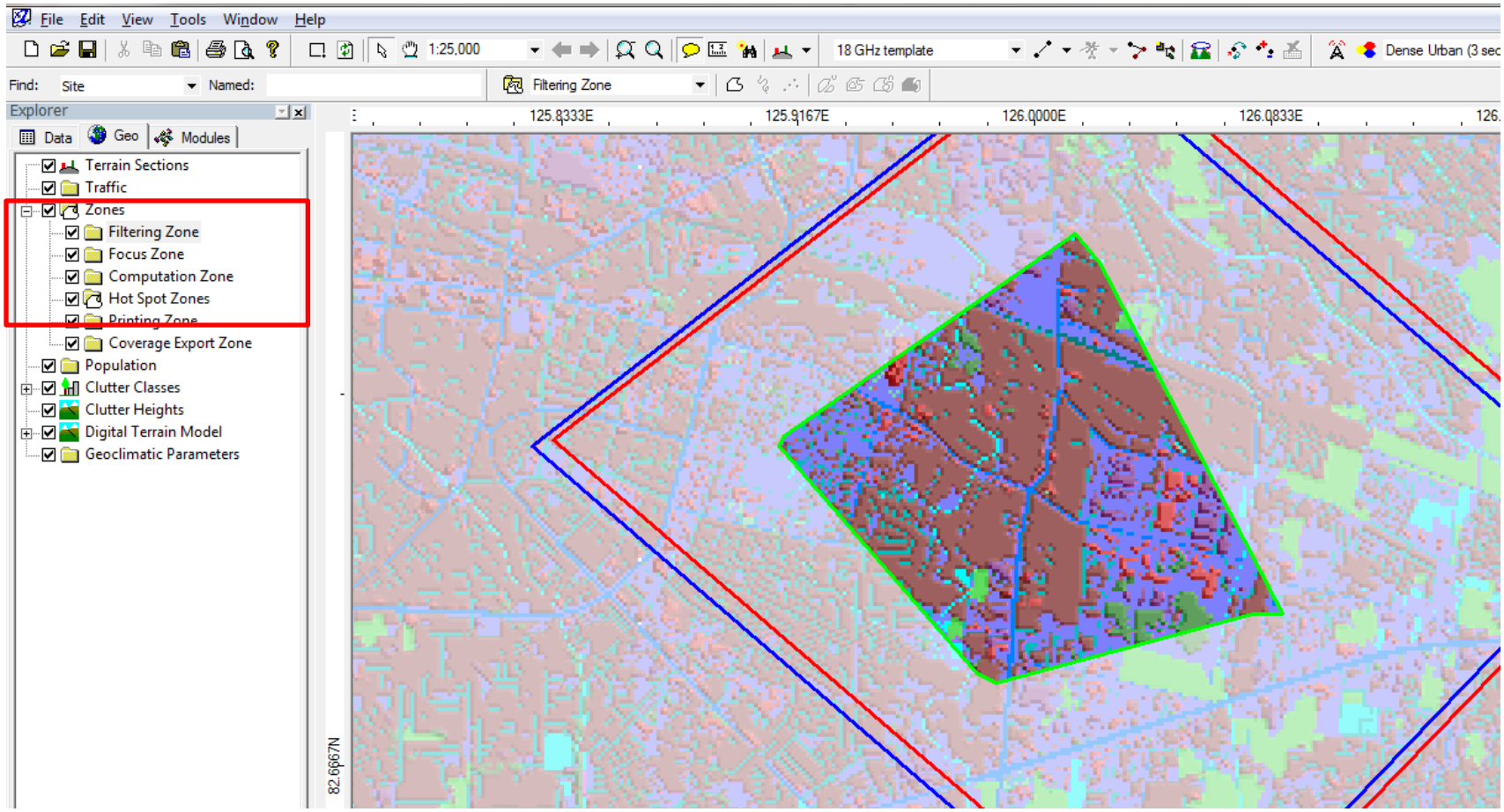
Set Propagation Model



Cell Planning



Draw Zone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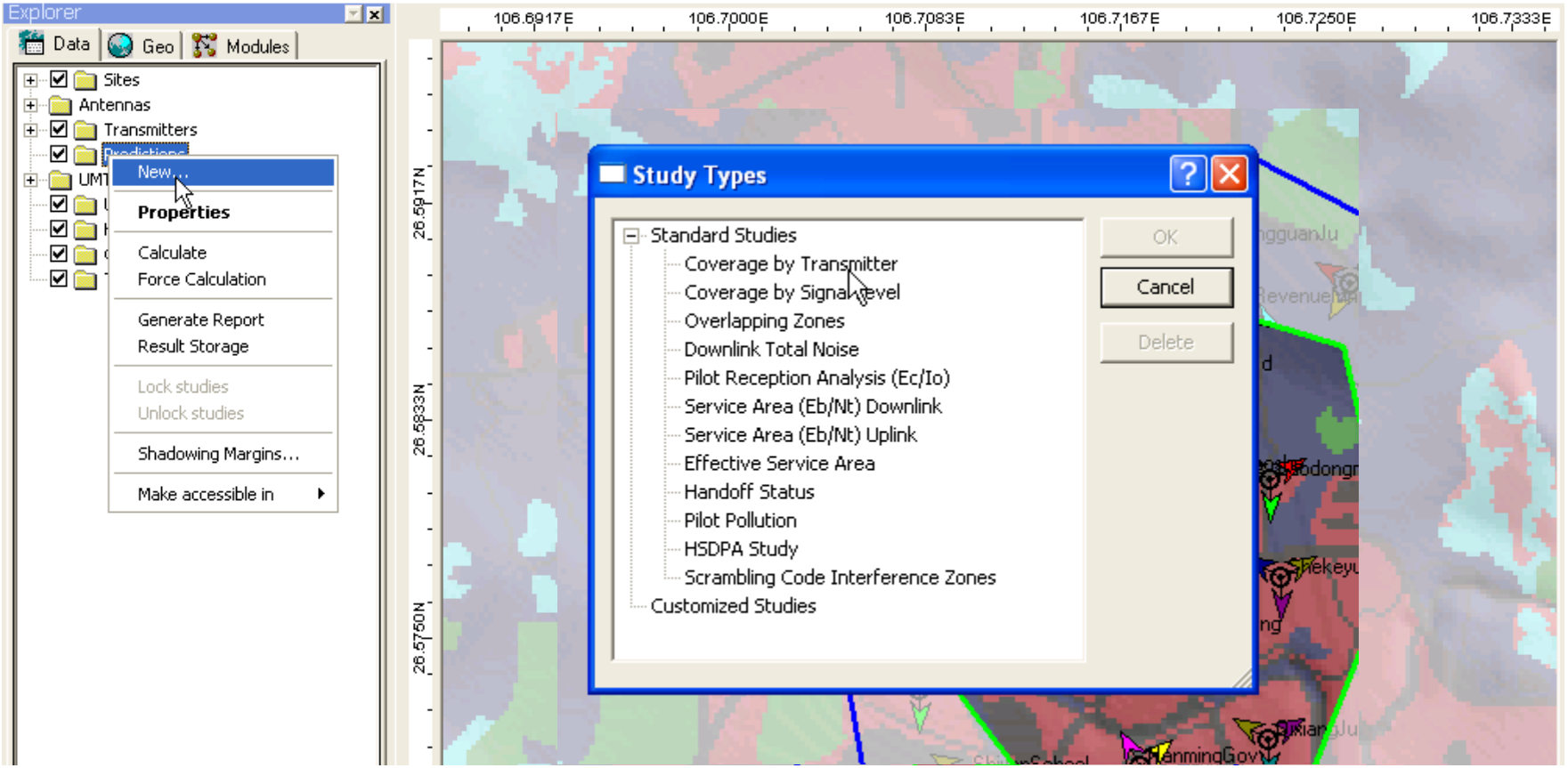
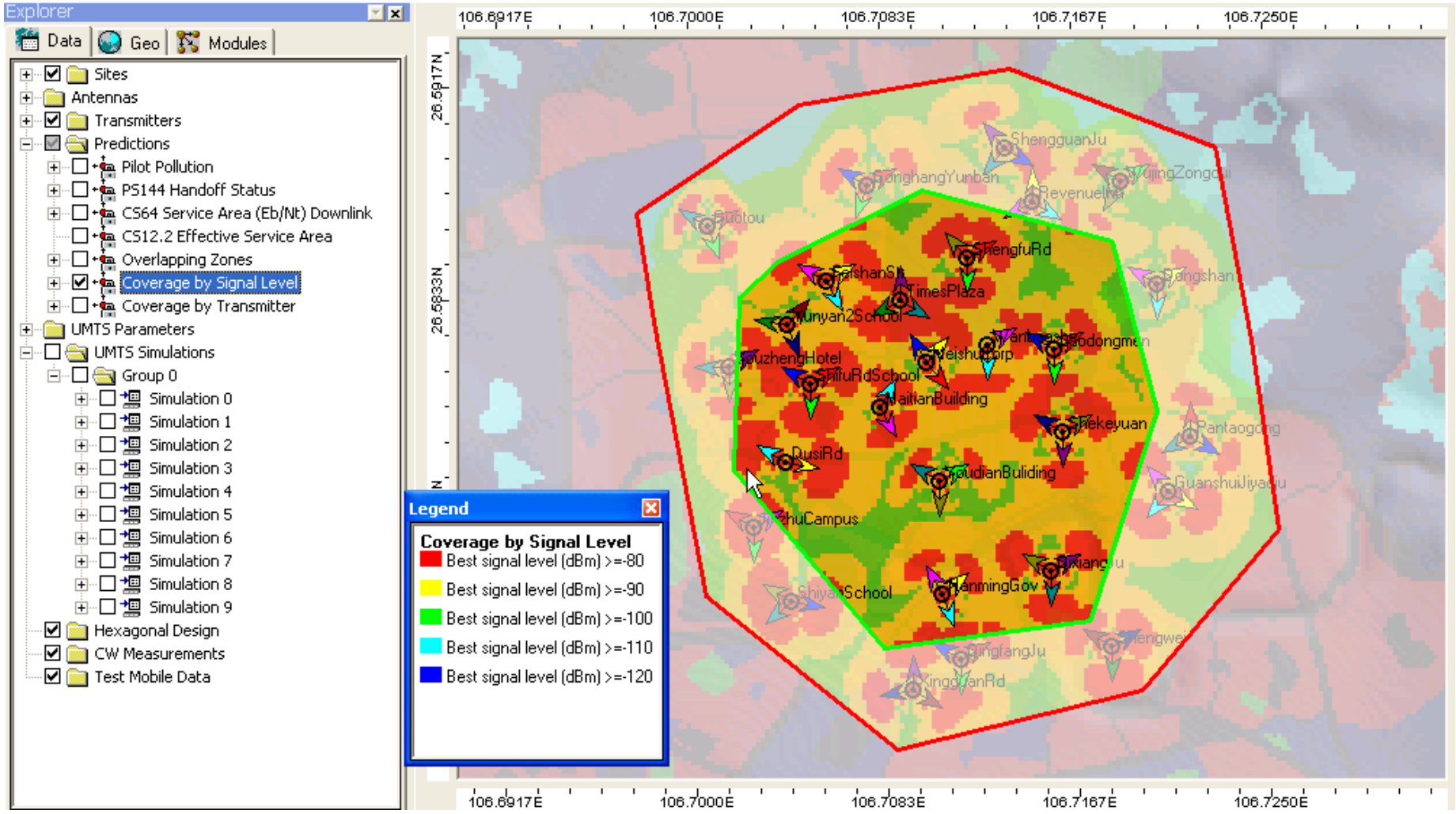
Filtering Zone
Explorer
Data
Geo
Modules
Terrain Sections
Traffic
Zones
Filtering Zone
Focus Zone
Computation Zone
Hot Spot Zones
Printing Zone
Coverage Export Zone
Population
Clutter Classes
Clutter Heights
Digital Terrain Model
Geoclimatic Parameters
125.8333E
125.9167E
126.0000E
126.0833E
82.6667N

Make Prediction based on Coverage

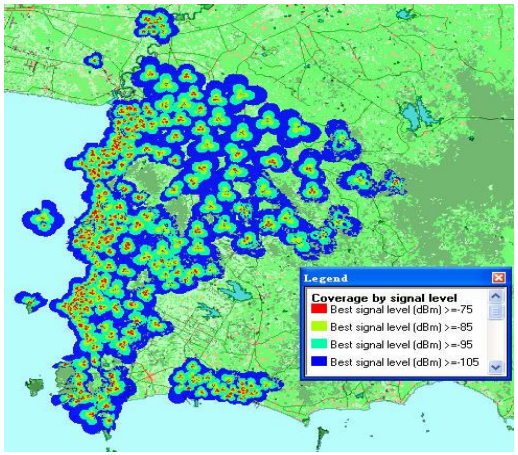


Check Planning Result

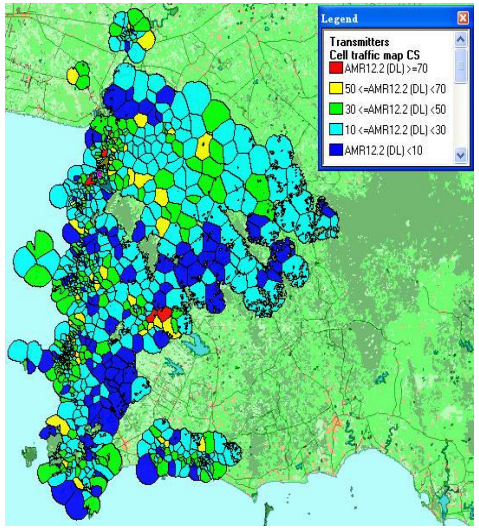


Verification by System Simulation

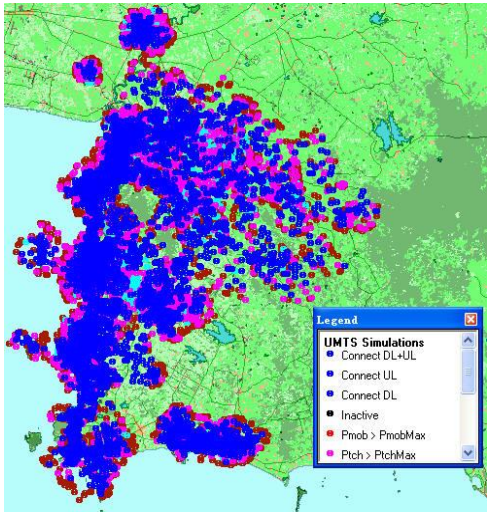
It is an iterative process to verify the final design until all the requirements are fulfilled



Coverage prediction



Traffic distribution



System simulation

Are Requirements Fulfilled?

RNP Planning results

References

- Atoll Manual
- U-Net Planning Tools
- Huawei, WCDMA RNP & RNO Conspectus

Forsk

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감사합니다

Atoll Wireless Network