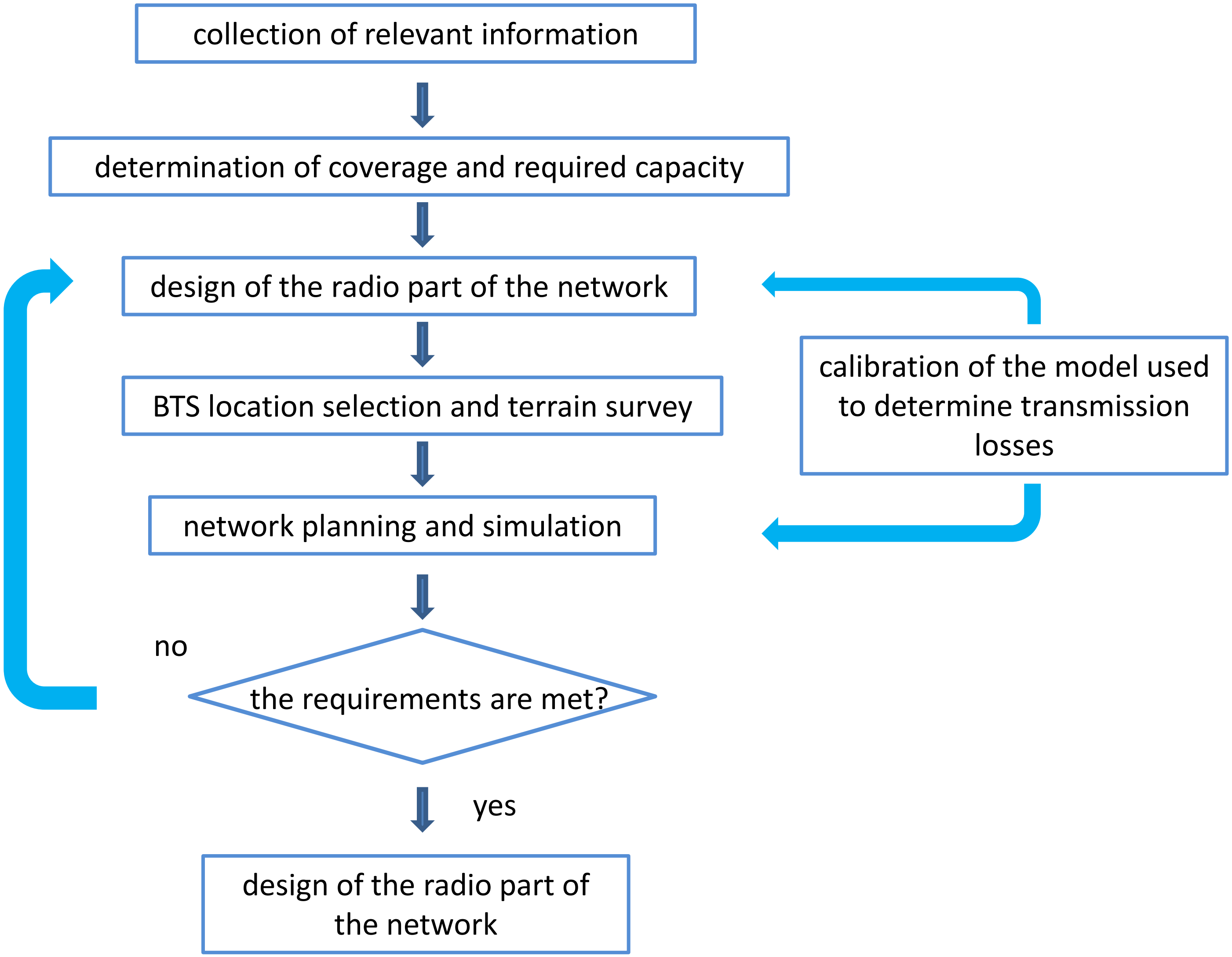
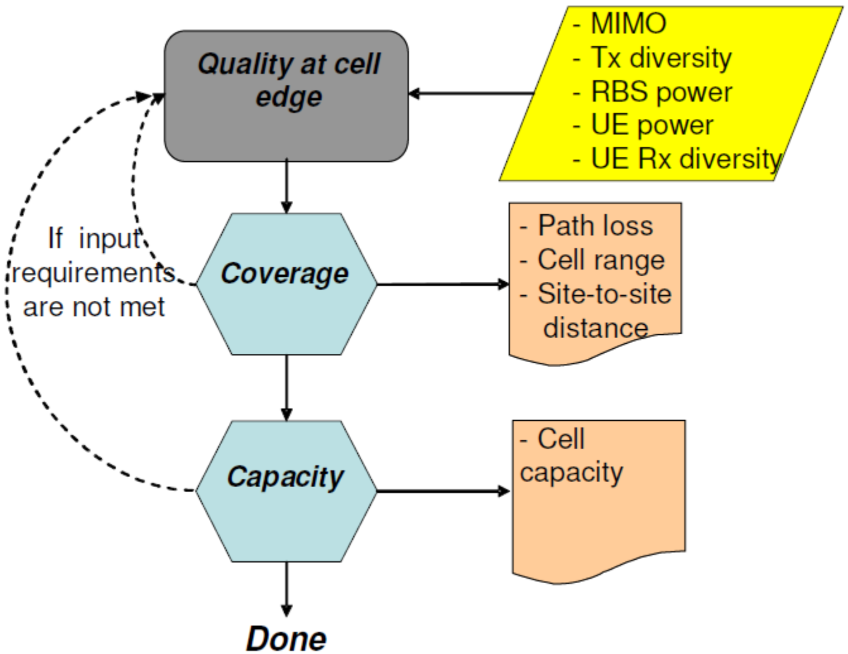
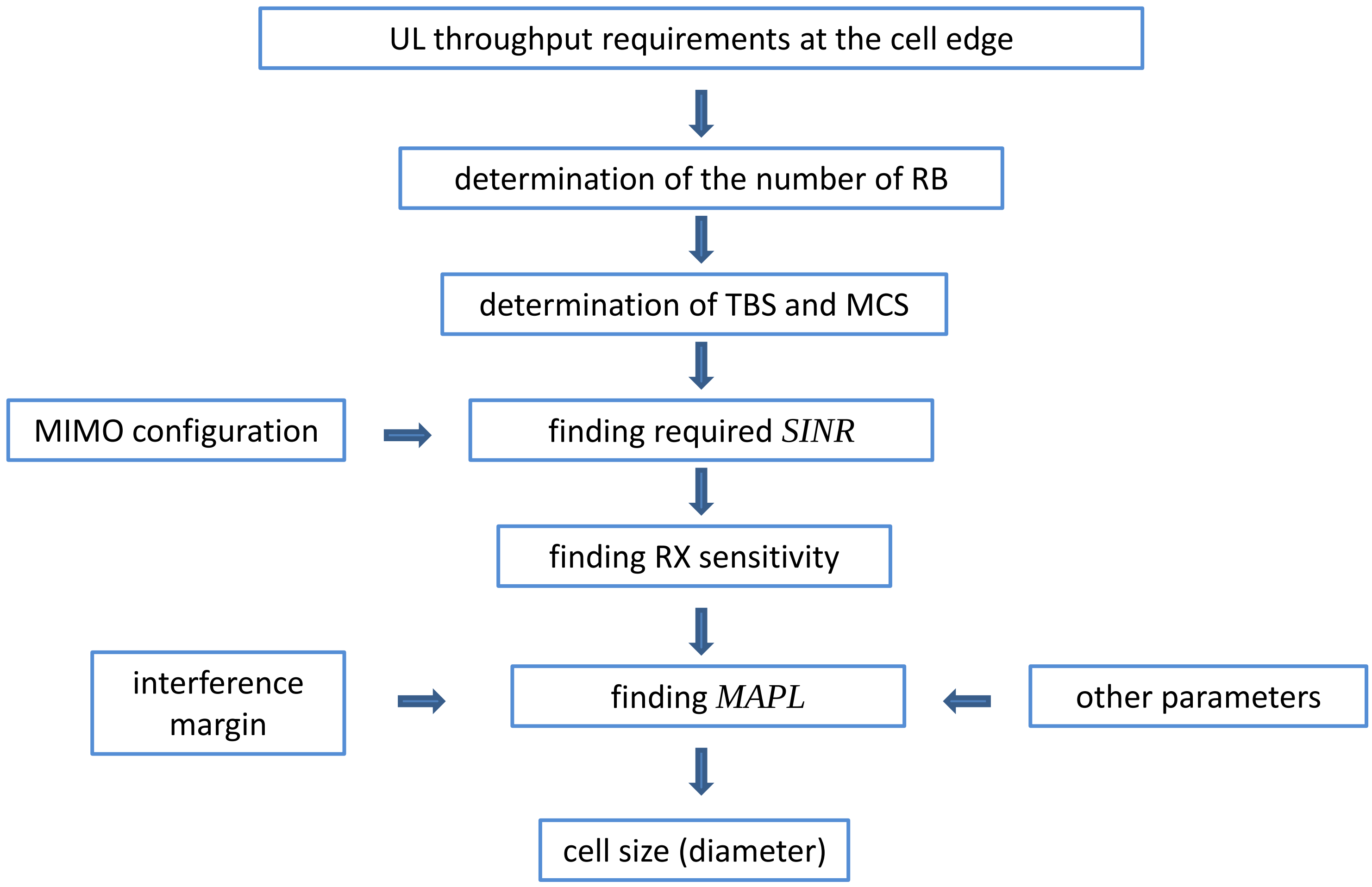


the radio part design procedure

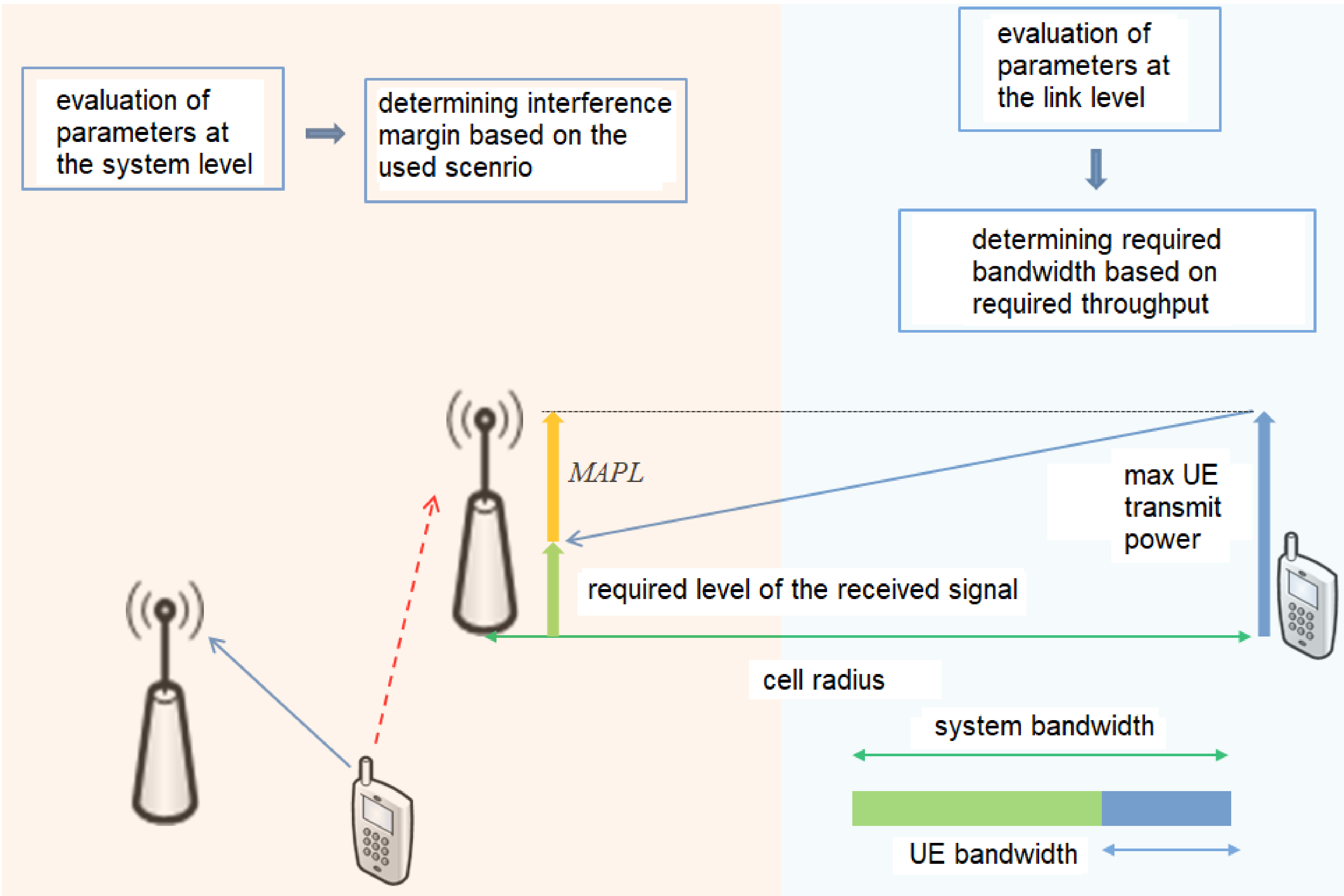


radio dimensioning methodology in LTE

Source: R. Ekstrand: LTE Radio dimensioning



LTE FDD UL LB design process



LTE FDD UL LB methodology

inputs to determine coverage :

- the size of the area to be covered
- selected cell edge service types
- signal penetration inside (buildings, cars, ...)

necessary network information:

- network specific information
- LTE frequency used
- maximum available bandwidth

→ link budget / RF planning →

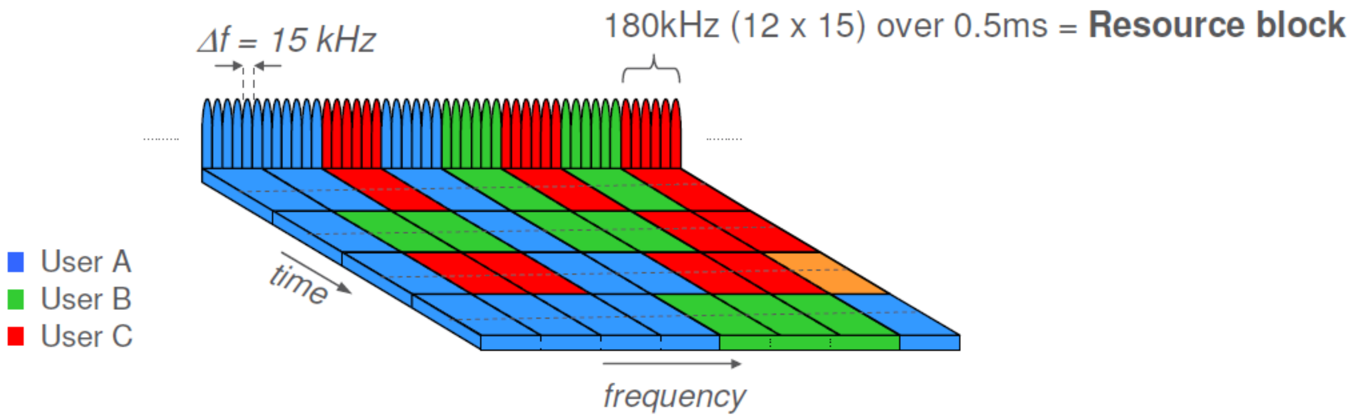
outputs of the coverage analysis :

- cell size
- possibility of use existing BTS
- required number of BTS

LB requirements	outputs
UL throughput requirements at the cell edge	cell size in the UL direction DL throughput at the cell edge
DL throughput requirements at the cell edge	cell size in the DL direction UL throughput at the cell edge
DL and UL throughput requirements at the cell edge	cell size in the UL direction cell size in the DL direction reducing link span and cell size
fixed cell radius requirements	UL throughput at the cell edge DL throughput at the cell edge

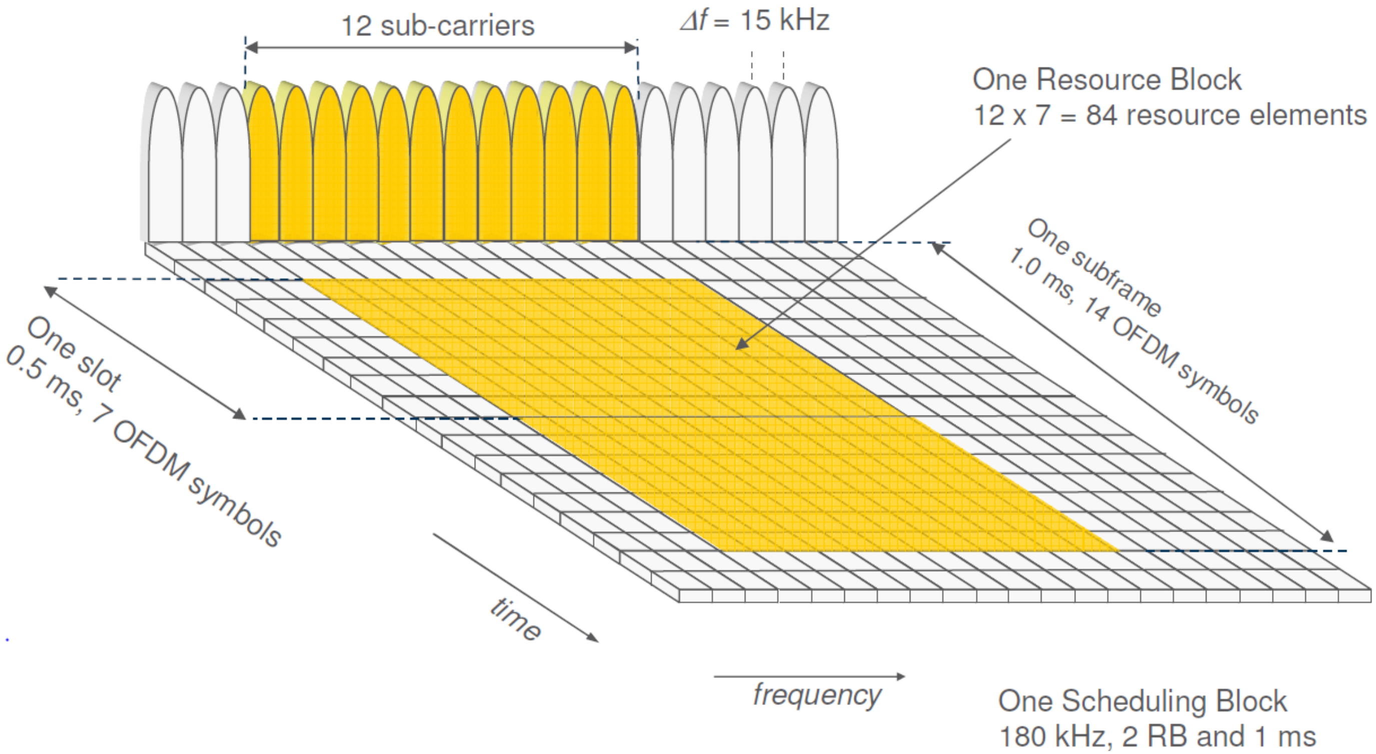
LB requirements

$$C = W \log_2\left(1 + \frac{S}{N}\right) [b/s]$$



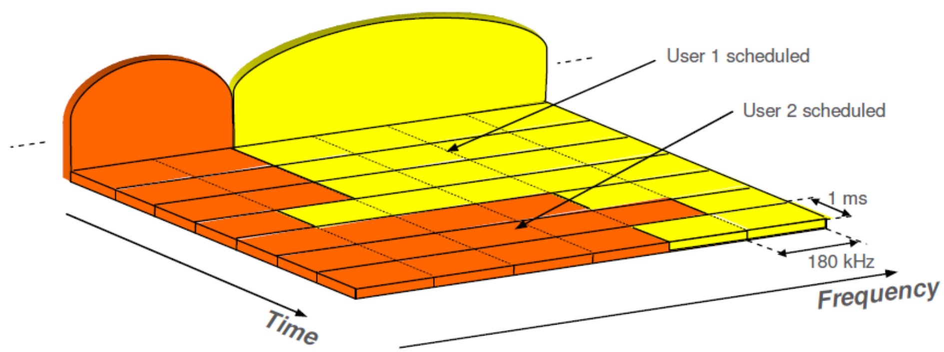
basic source units in LTE

Source: R. Ekstrand: LTE Radio dimensioning



basic source units in LTE

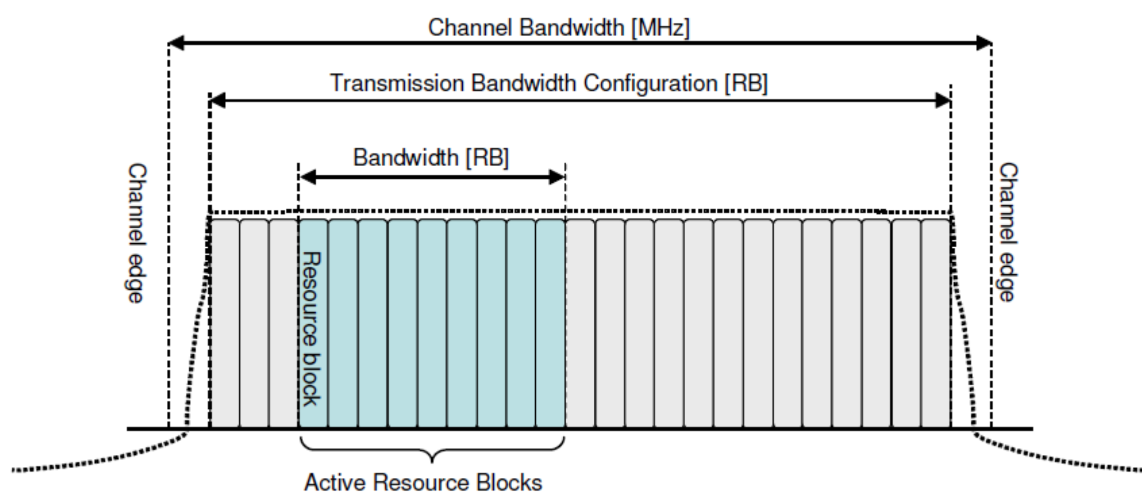
Source: R. Ekstrand: LTE Radio dimensioning



In the UL direction, the RBs must follow each other

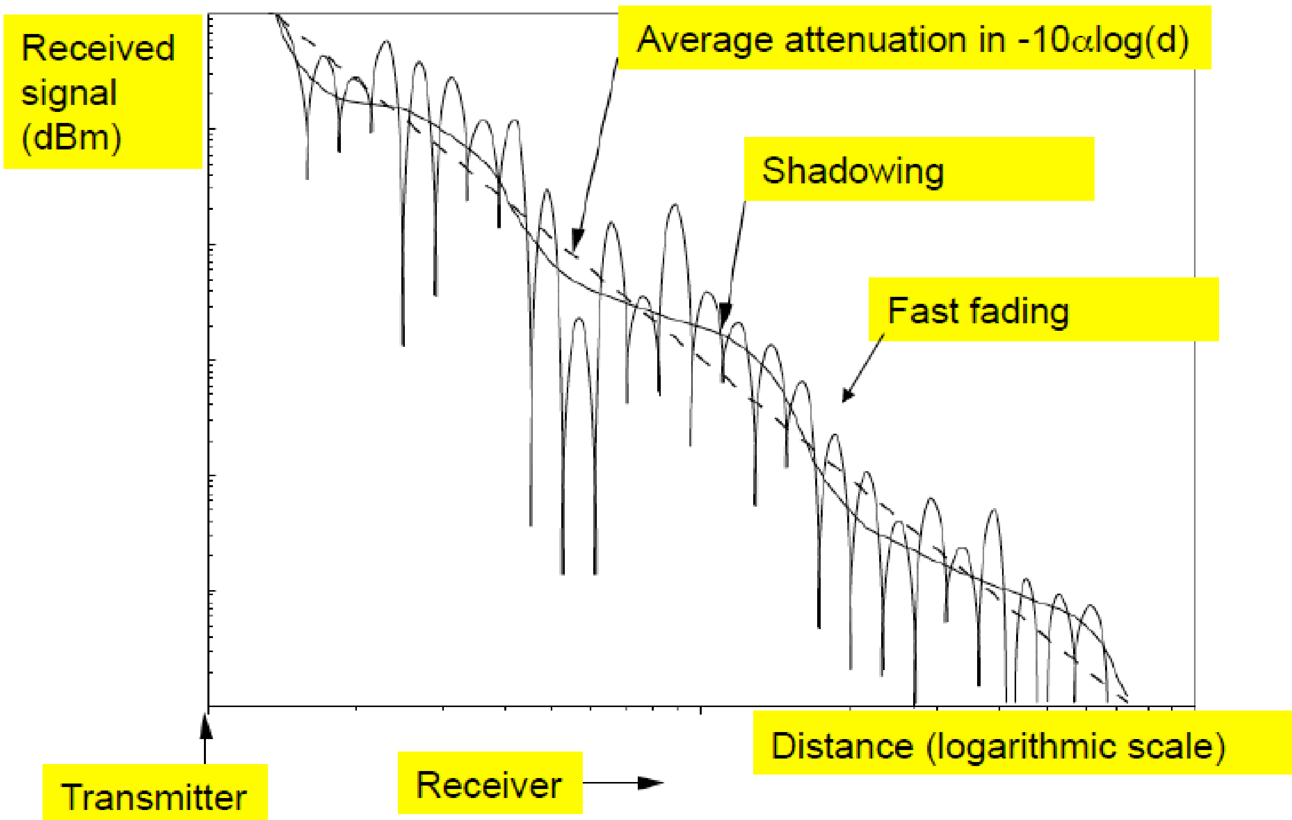
Channel Bandwidth $BW_{Channel}$ [MHz]	1.4	3	5	10	15	20
Number of Resource Blocks (n_{RB})	6	15	25	50	75	100

possible channel bandwidths



channel bandwidth definition

Source: R. Ekstrand: LTE Radio dimensioning

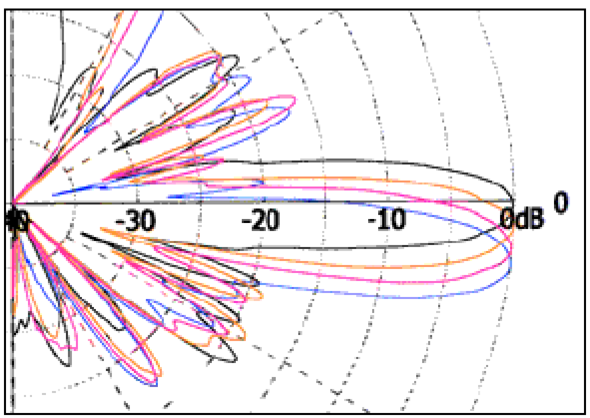


propagation model

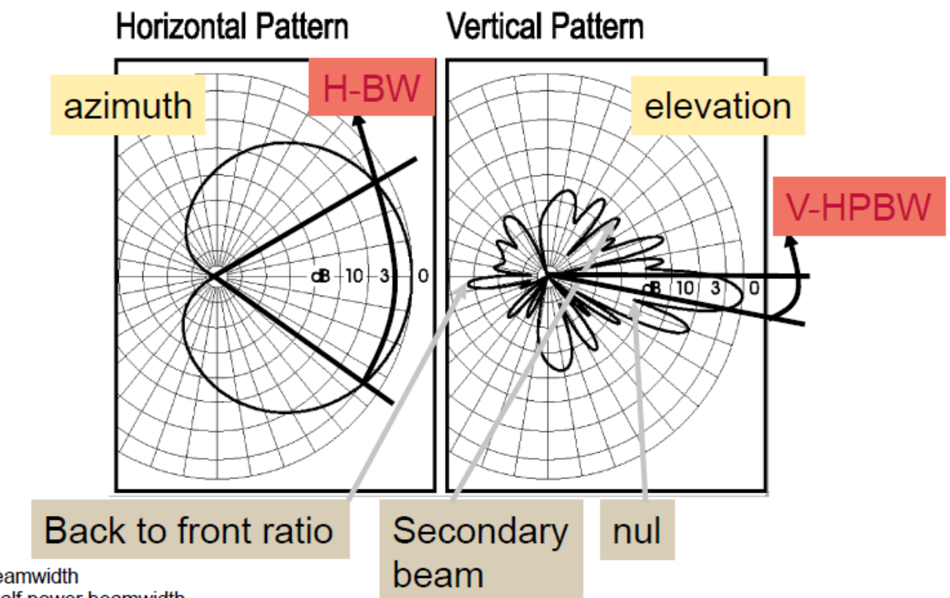
Source: M. Coupechoux: Institut Mines-Télécom

Main characteristics of antennas:

- frequency band
- horizontal width of the radiated beam [°] (typically for -3dB 65°)
- vertical width of the radiated beam [°] (typically for -3dB 7°)
- gain [dBi]
- polarization (V: suburban, rural areas, cross: dense urban, urban, suburban areas)
- physical dimensions (usually <2m)
- electrical or mechanical tilt of the radiation beam[°]



Antenna pattern



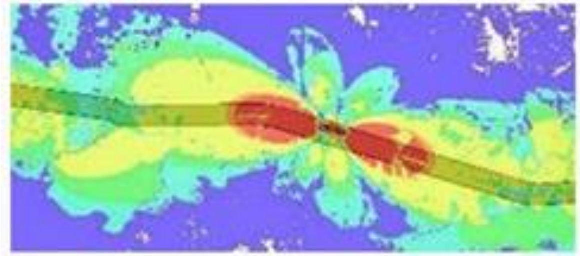
HBW: Horizontal beamwidth
V-HPBW: Vertical half power beamwidth

characteristics of antennas

Source: M. Coupechoux: Institut Mines-Télécom

Spectrum	Omni	Tri-sectorized
Low bands (700 — 900 MHz)	12 dBi	16 dBi
Intermediate bands (1.3 – 2.3 GHz)	13 dBi	18 dBi
Higher bands (2.5 – 2.6 GHz)	14 dBi	19 dBi

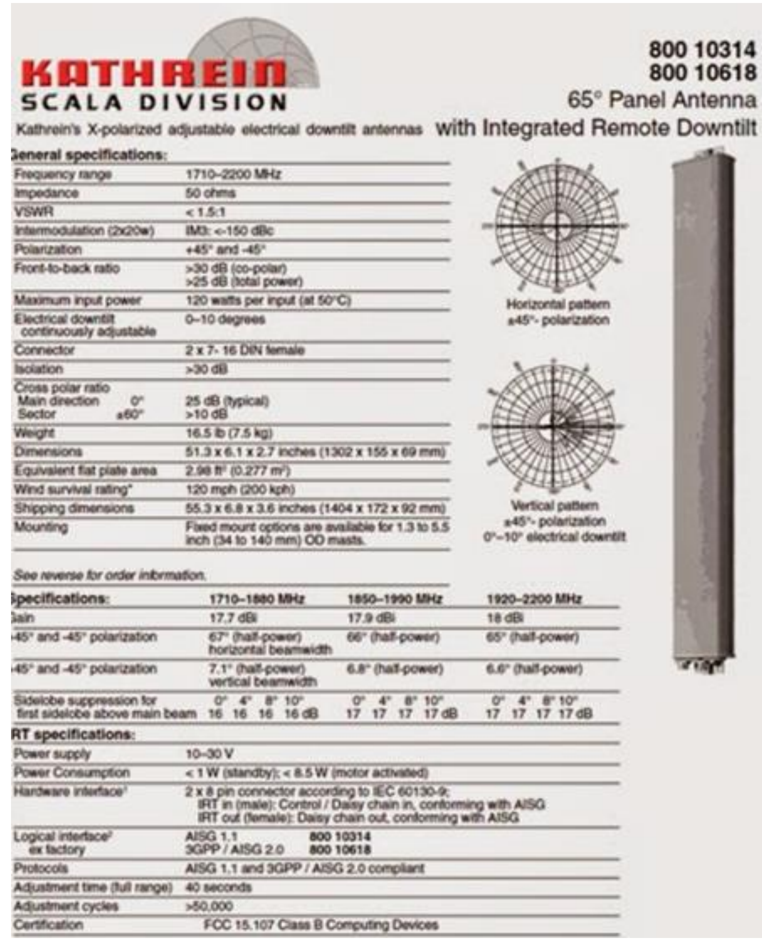
typical antenna gains



special case of road coverage, or railways

G = 21 dBi

beam width 33°



KATHREIN SCALA DIVISION

800 10314
800 10618

65° Panel Antenna with Integrated Remote Downtilt

Kathrein's X-polarized adjustable electrical downtilt antennas

General specifications:

Frequency range	1710–2200 MHz
Impedance	50 ohms
VSWR	< 1.5:1
Intermodulation (2x20w)	IM3: <-150 dBc
Polarization	+45° and -45°
Front-to-back ratio	>30 dB (co-polar) >25 dB (total power)
Maximum input power	120 watts per input (at 50°C)
Electrical downtilt continuously adjustable	0–10 degrees
Connector	2 x 7- 16 DIN female
Isolation	>30 dB
Cross polar ratio Main direction 0° Sector ±60°	25 dB (typical) >10 dB
Weight	16.5 lb (7.5 kg)
Dimensions	51.3 x 6.1 x 2.7 inches (1302 x 155 x 69 mm)
Equivalent flat plate area	2.98 ft² (0.277 m²)
Wind survival rating*	120 mph (200 kph)
Shipping dimensions	55.3 x 6.8 x 3.6 inches (1404 x 172 x 92 mm)
Mounting	Fixed mount options are available for 1.3 to 5.5 inch (34 to 140 mm) OD masts.

Horizontal pattern ±45°- polarization

Vertical pattern ±45°- polarization 0°–10° electrical downtilt

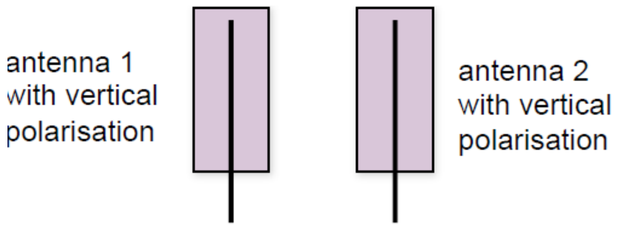
See reverse for order information.

Specifications:	1710–1880 MHz	1850–1990 MHz	1920–2200 MHz
Gain	17.7 dBi	17.9 dBi	18 dBi
+45° and -45° polarization	67° (half-power) horizontal beamwidth	66° (half-power)	65° (half-power)
+45° and -45° polarization	7.1° (half-power) vertical beamwidth	6.8° (half-power)	6.6° (half-power)
Sidelobe suppression for first sidelobe above main beam	0° 4° 8° 10° 16 16 16 16 dB	0° 4° 8° 10° 17 17 17 17 dB	0° 4° 8° 10° 17 17 17 17 dB

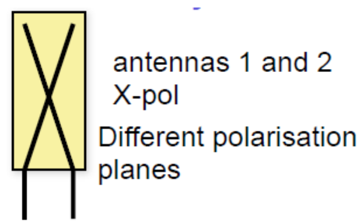
RT specifications:

Power supply	10–30 V
Power Consumption	< 1 W (standby); < 8.5 W (motor activated)
Hardware interface¹	2 x 8 pin connector according to IEC 60130-9; IRT in (male): Control / Daisy chain in, conforming with AISG IRT out (female): Daisy chain out, conforming with AISG
Logical interface² ex factory	AISG 1.1 **800 10314** 3GPP / AISG 2.0 **800 10618**
Protocols	AISG 1.1 and 3GPP / AISG 2.0 compliant
Adjustment time (full range)	40 seconds
Adjustment cycles	>50,000
Certification	FCC 15.107 Class B Computing Devices

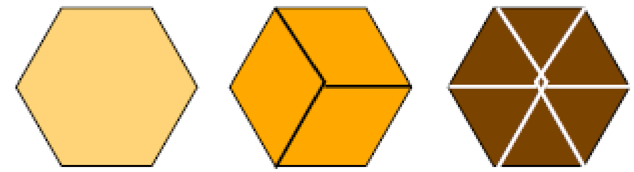
Source: M. Coupechoux: Institut Mines-Télécom



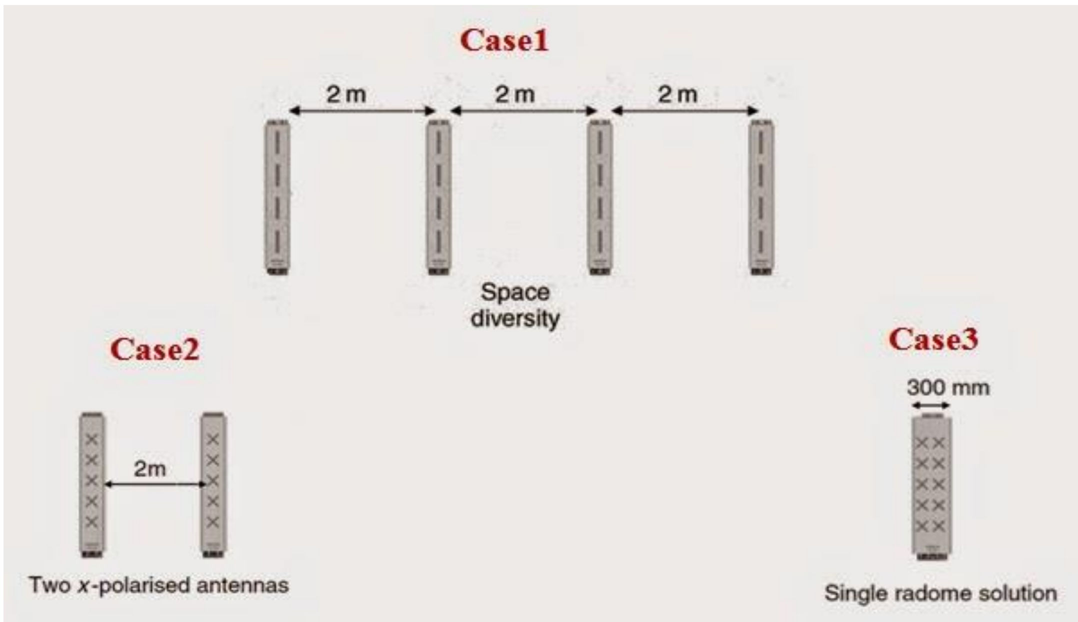
spatial diversity



polarization diversity



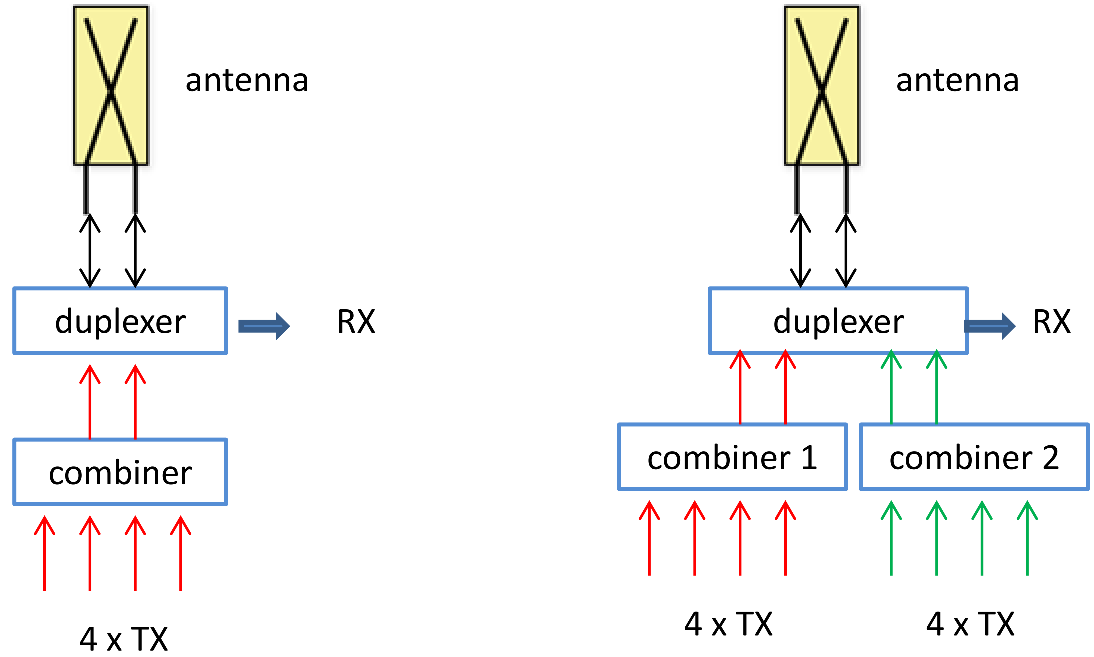
sectorisation



examples of spatial and polarization diversity

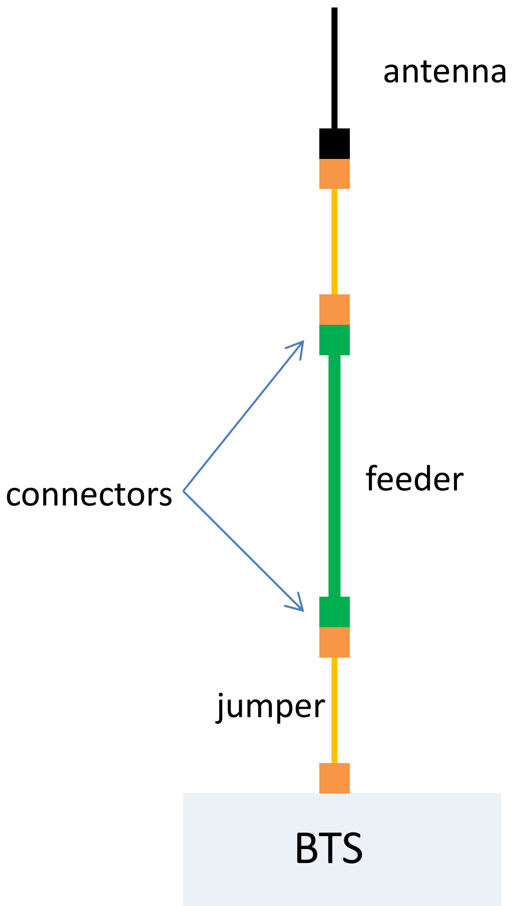
Frequency (MHz)	Attenuation(dB/100m)		
	1/2in	7/8in	1-5/8in
600	5.533	2.846	1.689
700	6.009	3.093	1.840
800	6.456	3.325	1.982
824	6.56	3.379	2.016
894	6.855	3.533	2.110
960	7.124	3.673	2.197
1000	7.284	3.756	2.249
1250	8.226	4.247	2.554
1500	9.093	4.7	2.838
1700	9.744	5.04	3.053
1800	10.058	5.205	3.157
2000	10.666	5.523	3.359
2100	10.961	5.678	3.457
2200	11.251	5.83	3.554
2300	11.535	5.979	3.649
2500	12.09	6.27	3.836
2700	12.627	6.553	4.017

feeder loss



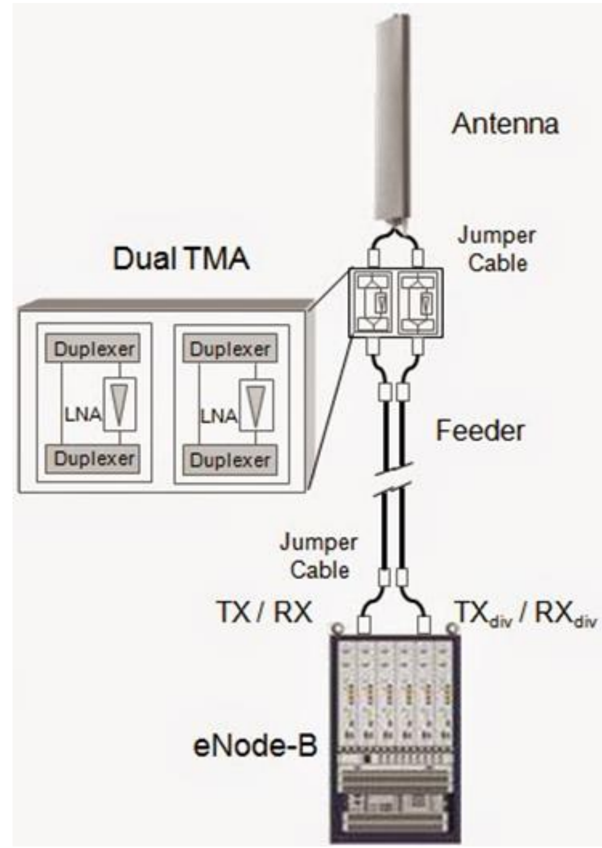
using of duplexers and combiners

Source: R. Ekstrand: LTE Radio dimensioning



TX/RX
PA
Duplexers
Controlers
BBU (Base Band Units)

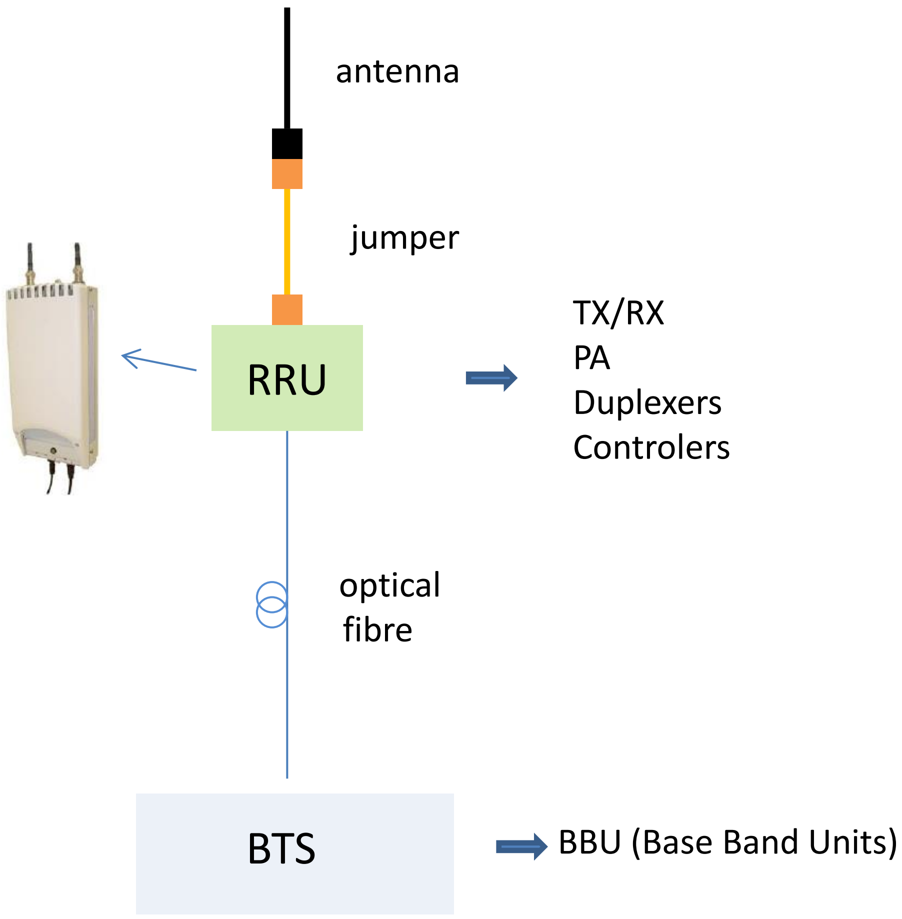
classic antenna and BTS connection



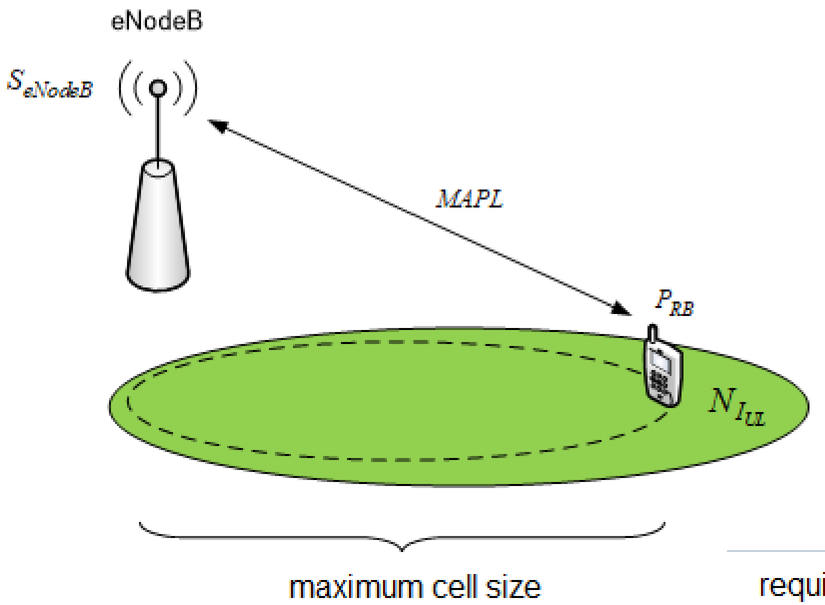
antenna and BTS connection using TMA

Component	Gain	Noise factor
TMA	12dB	2dB
Feeder	-2dB	2dB
Connectors	-0.3dB	0.3dB
BS	-	3dB

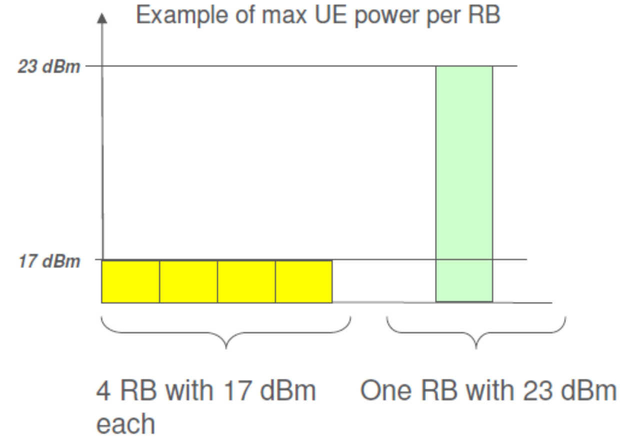
typical values

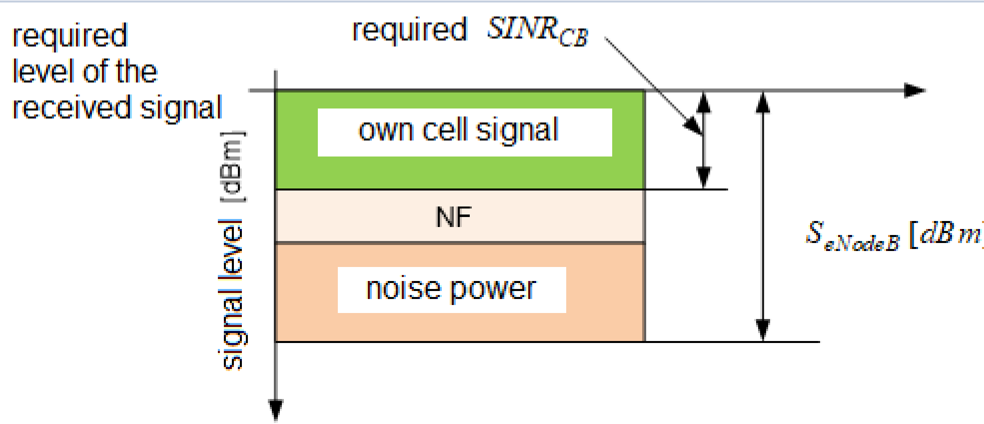


interconnection of BTS and antennas using RRU



UL LB maximum cell size



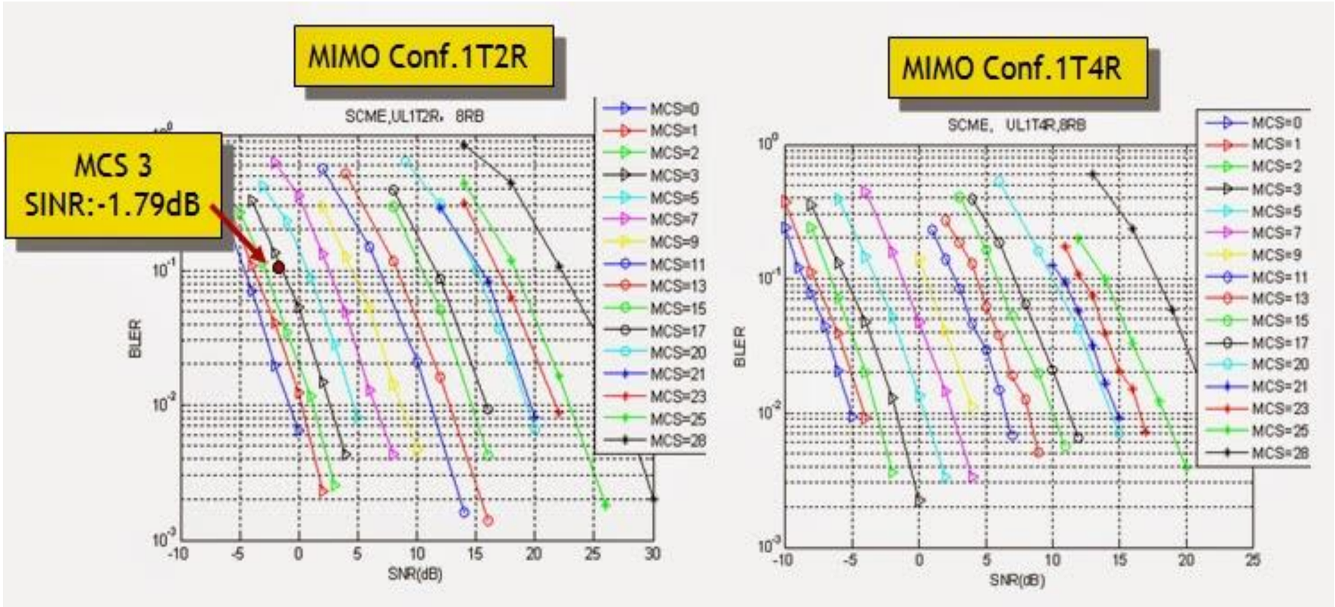


required sensitivity of eNodeB

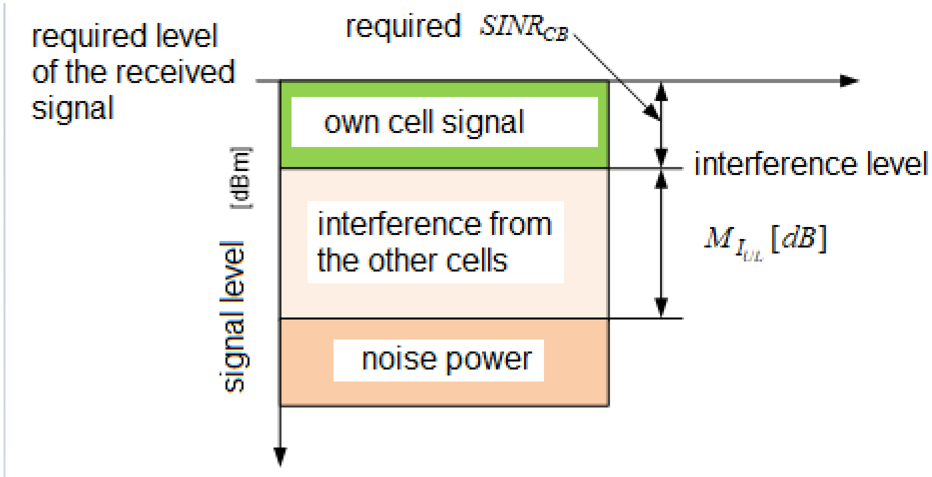
Source: R. Ekstrand: LTE Radio dimensioning

Morph		Dense Urban	Urban	Suburban	Rural	Highway
Cell Edge User Throughput	kbps	512	512	384	128	256
Assign # Resource Blocks	#	10	10	6	3	4
Used Bandwidth	KHz	1800	1800	1080	540	720
eNode-B Noise Figure	dB	3	3	3	3	3
No	dBm/Hz	-174.0	-174.0	-174.0	-174.0	-174.0
SINR Request	dB	-4.0	-3.8	-2.5	-2	-1.8
eNode-B Sensitivity	dBm	-112.4	-112.2	-113.2	-115.7	-114.2

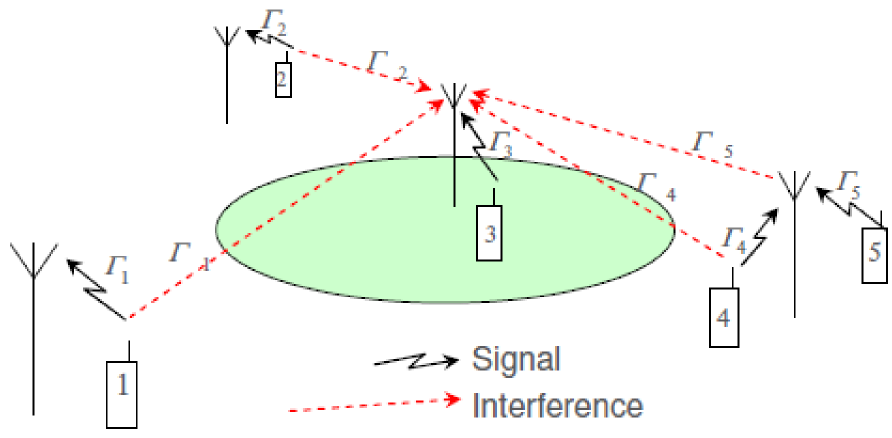
typical eNodeB sensitivity values



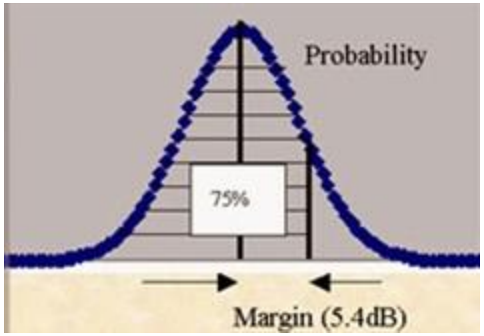
determination of the required SINR value



interference margin



ICI



shadowing margin

Shadowing Standard Deviation	10 dB		8 dB		7 dB		6 dB	
Cell Area Coverage Probability	95%	90%	95%	90%	95%	90%	95%	90%
Cell Edge Coverage Probability	87.7 %	77.7 %	86.2 %	75.1 %	84.9 %	73.3 %	83.9 %	70.9 %
Shadowing Margin	11.7 dB	7.7 dB	8.7 dB	5.4 dB	7.2 dB	4.3 dB	5.9 dB	3.3 dB

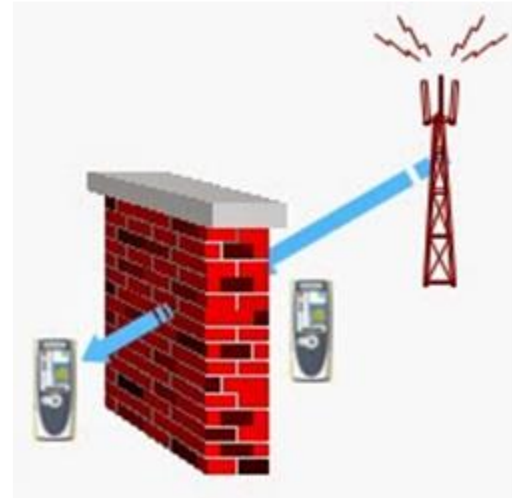
typical values for $M_{LNF}\ [dB]$

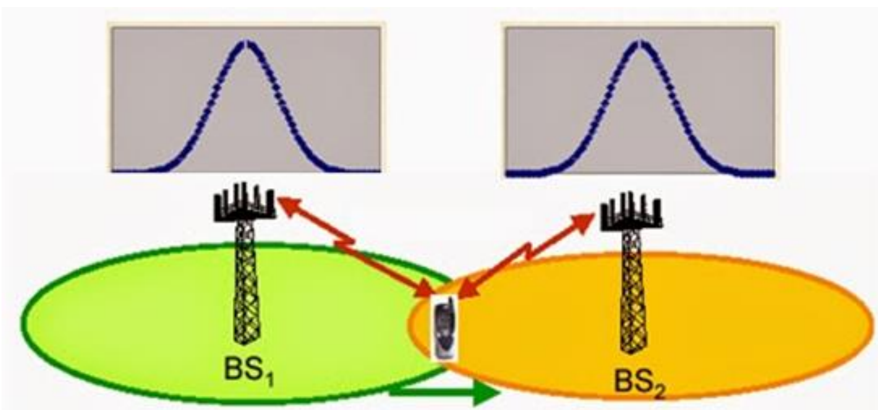
$L_{BL} = 0\ [dB]$

data traffic

$L_{BL} = 3\ [dB]$

voice traffic

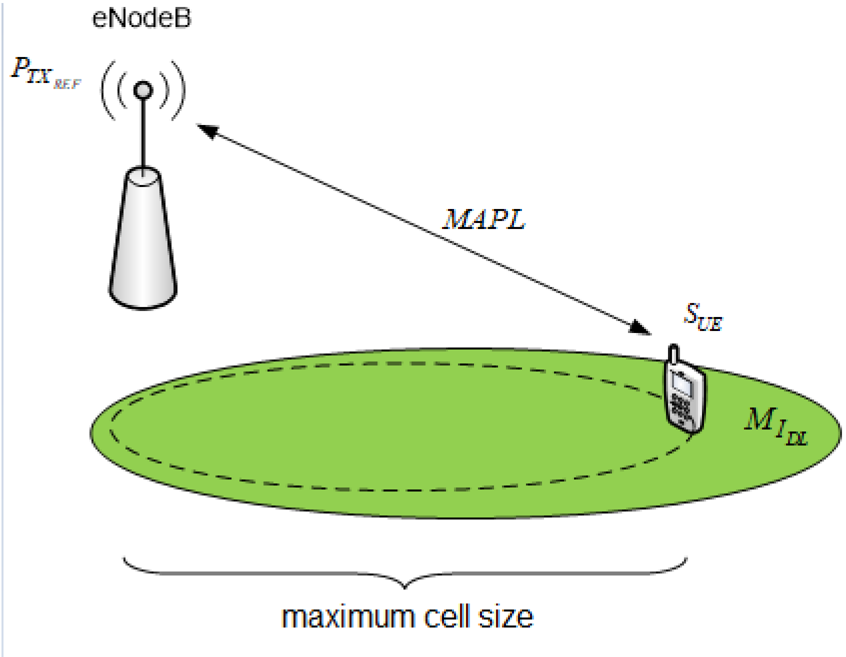




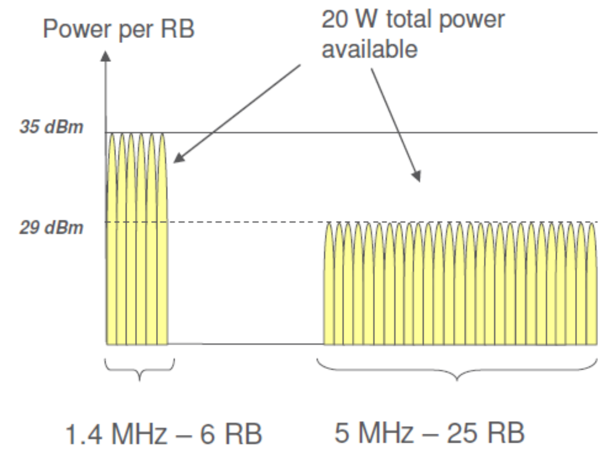
handoff

Environment	Penetration Margin (dB)
Dense Urban – Deep Indoor	20
Urban - Indoor	17
Suburban - Indoor	14
Rural – In car	8

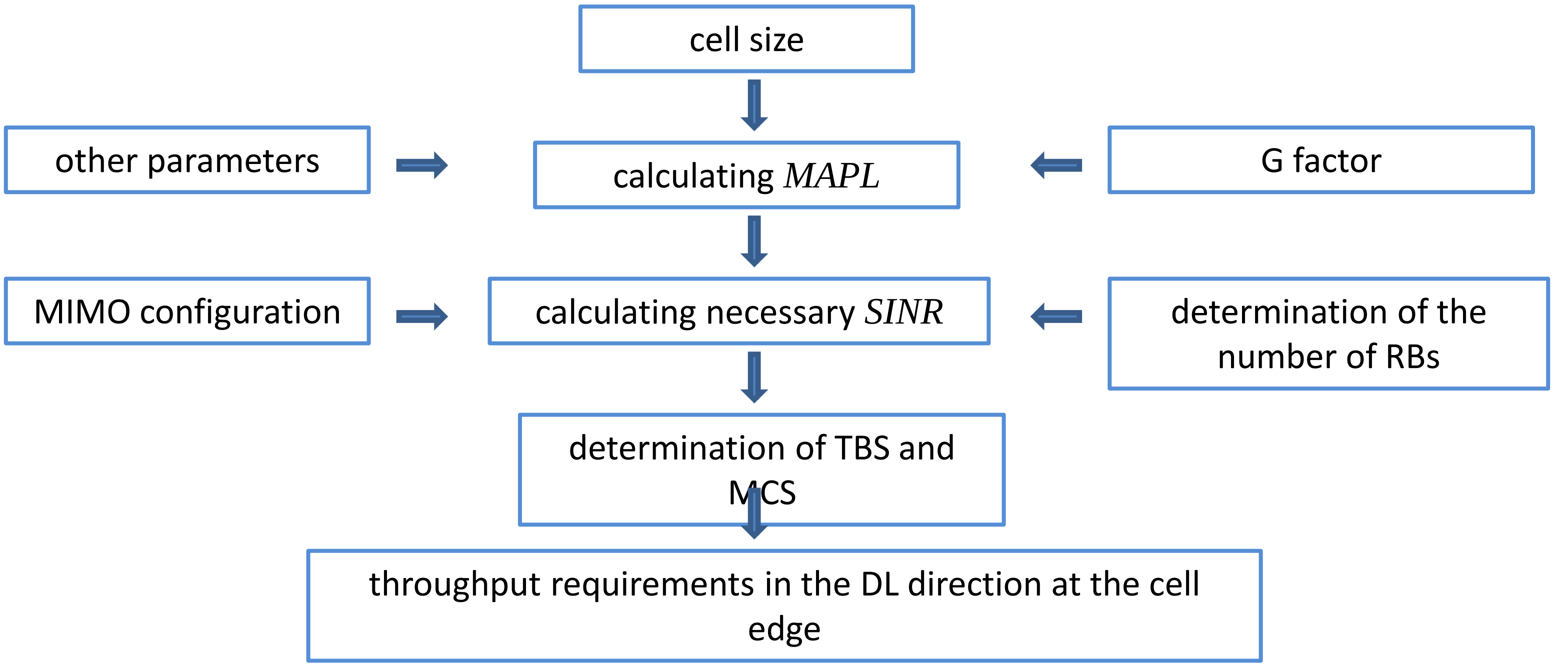
L_{CPL} a L_{BPL} $[dB]$



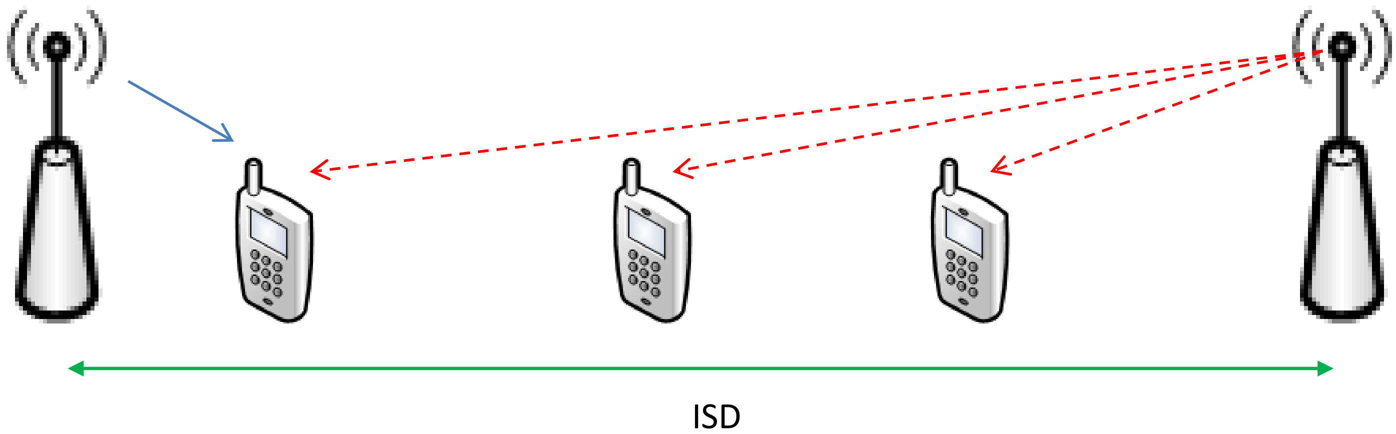
DL LB maximum cell size

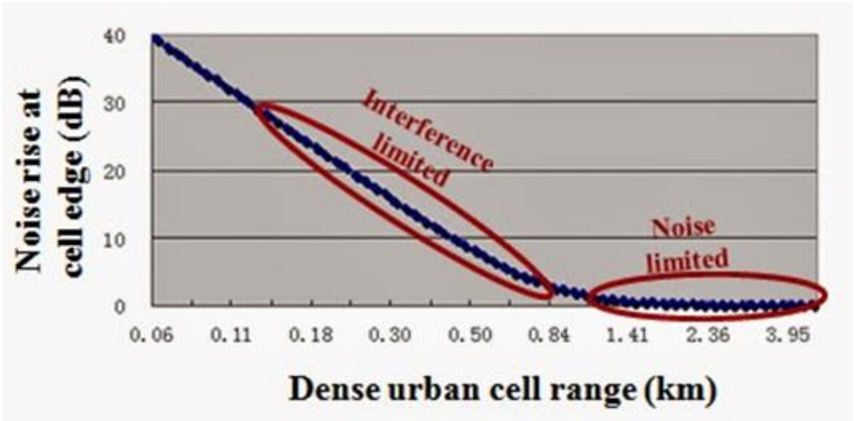


Source: R. Ekstrand: LTE Radio dimensioning

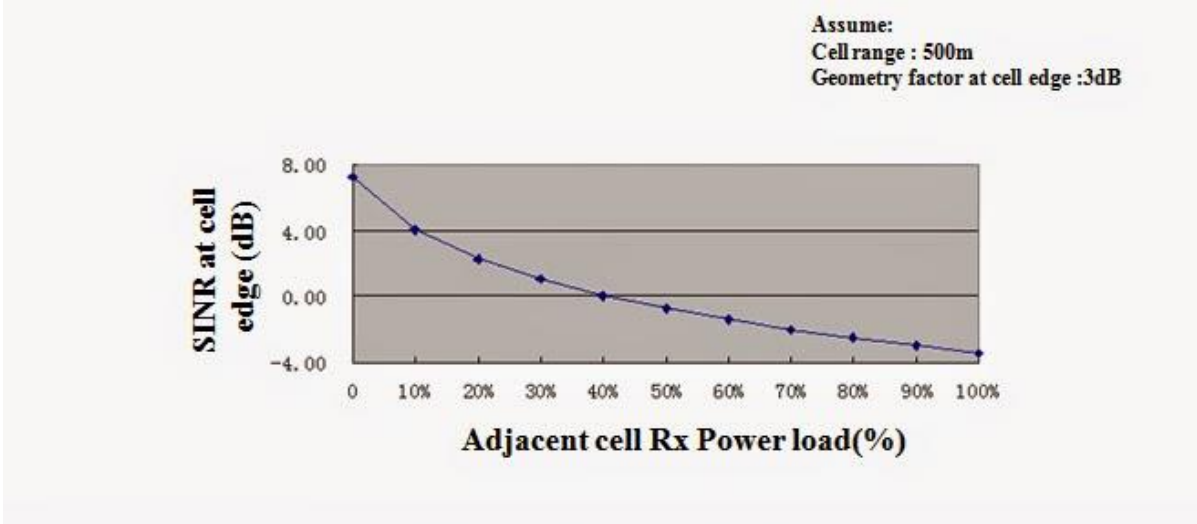


LTE FDD DL LB design process


ISD

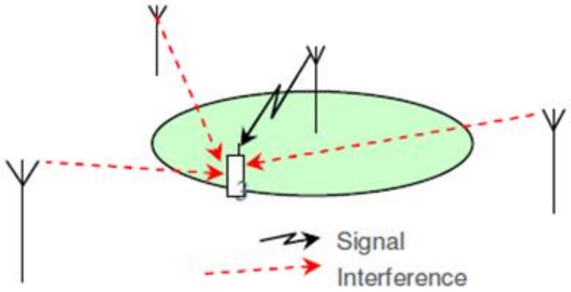

40
30
20
10
0
Noise rise at cell edge (dB)
Interference limited
Noise limited
0.06
0.11
0.18
0.30
0.50
0.84
1.41
2.36
3.95
Dense urban cell range (km)

LTE FDD DL LB

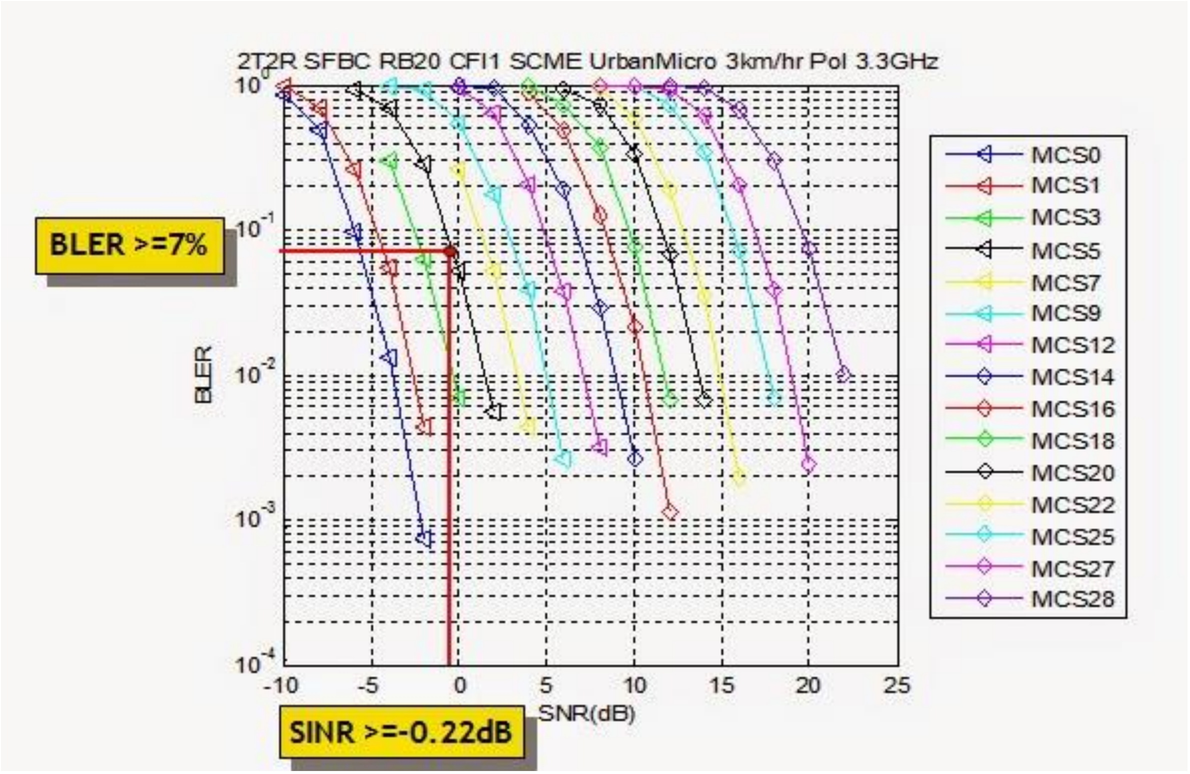


Adjacent cell Rx Powerload(%)	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
SINR @cell edge(dB)	7.24	4.11	2.31	1.04	0.06	-0.74	-1.42	-2.00	-2.52	-2.98	-3.39

$$SINR_{CB_{DL}}\ [dB]$$



G_{DL} [] ICI on the cell edge



BLER depending on SINR

Source: R. Ekstrand: LTE Radio dimensioning