Quality Of Service and MObility driven cognitive radio Systems

Mapping cognitive radio system scenarios into the TVWS context

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Overview

- Background
- Scenarios for cognitive radio systems
- Range expectations in TVWS
- Capacity estimates in TVWS
- Conclusions and work in progress

Background

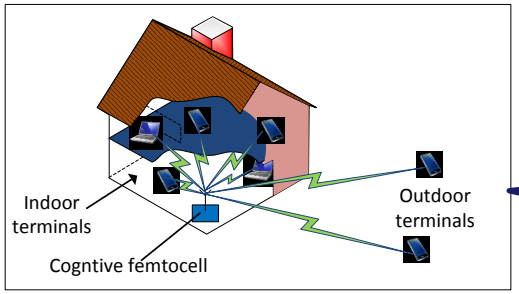
- The QoSMOS project is researching the techniques for providing QoS and mobility using opportunistic access
- The QoSMOS project has defined viable scenarios for the deployment of cognitive radio systems
- These scenarios need to be evaluated and tested for business viability and technical feasibility in relevant frequency bands and under regulatory constraints

- The UHF TV band (470-790MHz) is the first candidate band to be opened for such access
- FCC (US) and Ofcom (UK) have defined emission limits for secondary transmitters in the ”TV White Space” (TVWS)

Scenarios for Cognitive Radio Systems

The QoSMOS scenarios

- Possible use cases and benefits

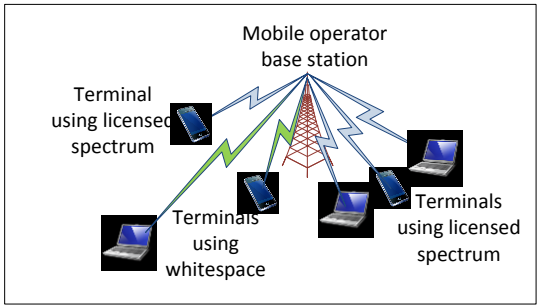


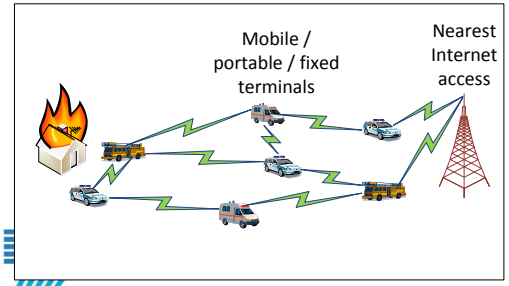
Cognitive femtocell or Wi-Fi like use of WS:

Better interference control
Better user experience

Cellular coverage and/or capacity extension in WS:

Increased operational bandwidths
The use of low frequencies increases range
Better user experience





Cognitive ad hoc networks:

Capacity increase to serve peak demands
The use of low frequency bands is beneficial emergency scenarios

Regulatory constraints in TVWS

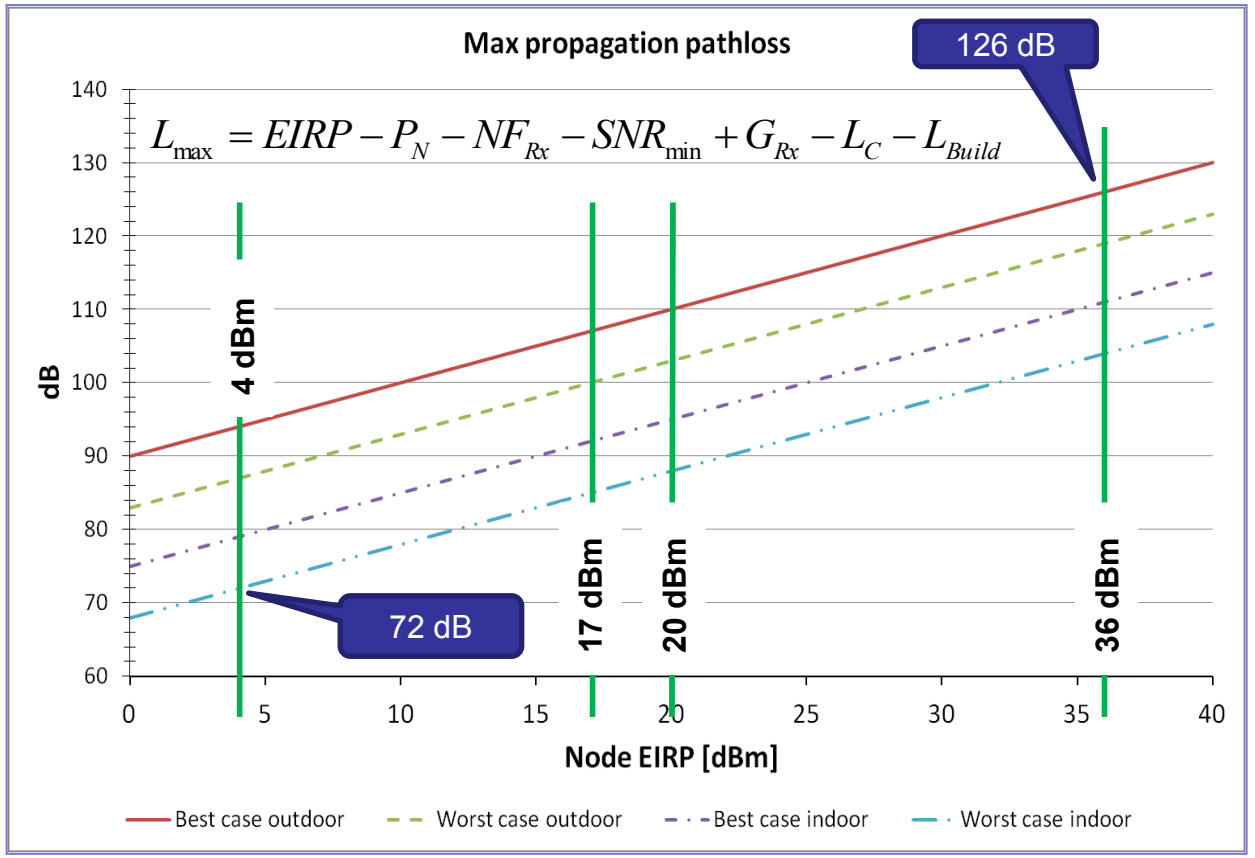
- Primary system:
  - DVB-T – digital terrestrial TV
    - 8 MHz channel width (Europe)
    - Tx power up to several kW
  - Also used for PMSE – program making and special events: wireless microphone systems and audio links
    - Narrow channels: 200 – 600 kHz
    - Tx power 0-17 dBm (handheld); 47 dBm for audio p2p links

Parameter	FCC	OFCOM
Power for FD in adjacent band	Not allowed	Not applicable
Power for FD in non-adjacent band with geo-location capability	**30dBm (1W)** (36dBm EIRP with 6dB gain antenna)	Not applicable
Power for PPD in adjacent band	**16dBm (40mW)** (Gain antenna not allowed)	4dBm
Power for PPD in non-adjacent band with geo-location capability	**20dBm (100mW)** (Gain antenna not allowed)	17dBm
Power for PPD in non-adjacent band without geo-location capability	**17dBm (50mW)**	

FD: Fixed Device; PPD: Personal Portable device

Link budgets

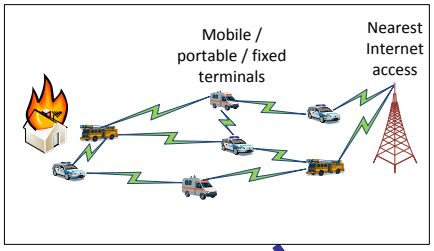
Main assumptions	
Rx noise power	-105 dBm @ 8 MHz
Rx noise figure	6 dB
Required SNR	8 dB
Rx antenna gain	Best case: 0 dBi Worst case: -7 dBi *
Cable and connector loss	1 dB
Building penetration loss	15 dB



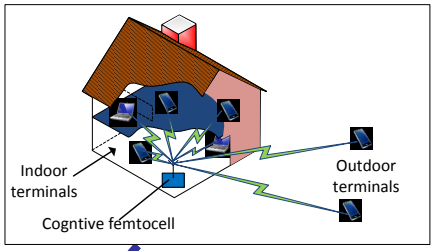
*) ETSI TR 102 377: *DVB-H Implementation Guidelines*, 2005

Propagation scenarios

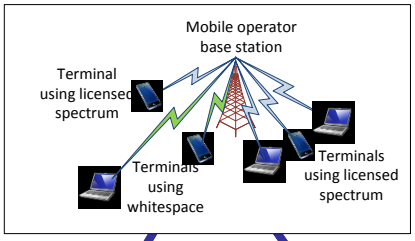
Cognitive ad hoc network



Cognitive femtocell



Cellular extension in WS



Indoor short range for PPD

Mobile cellular

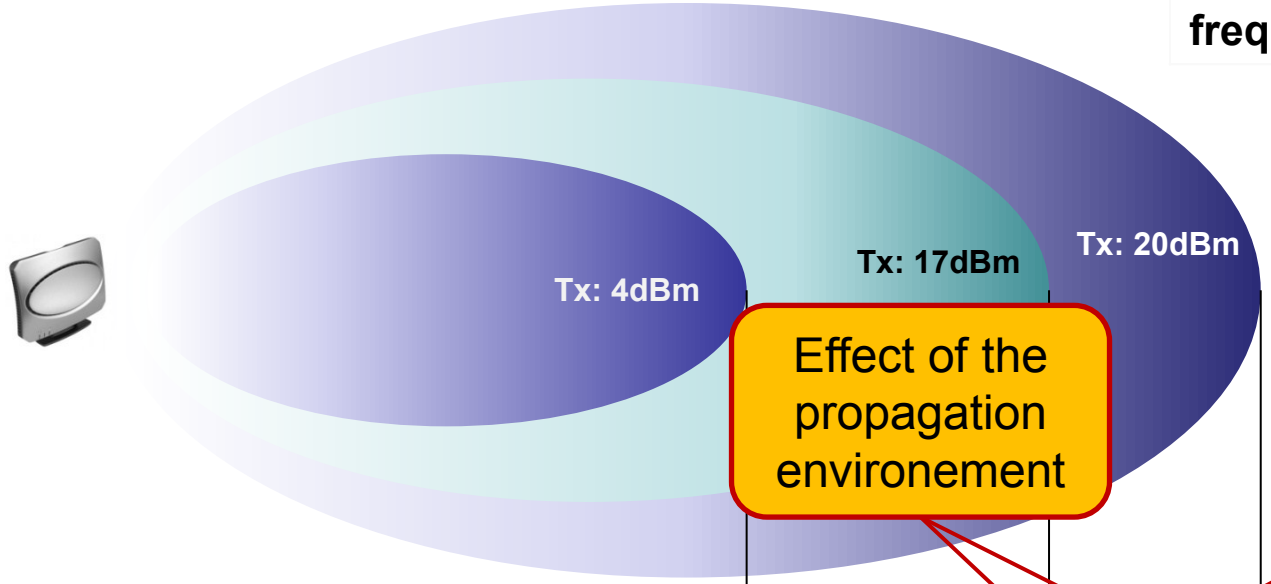
Fixed long range access

Range	1 – 100 m	0.1 – 10 km	1 – 10 km
Prop Model	Saleh-Valenzuela (1987)	Okumura-Hata (1980) 3GPP TR36.814	Okumura-Hata

Range expectations in TVWS

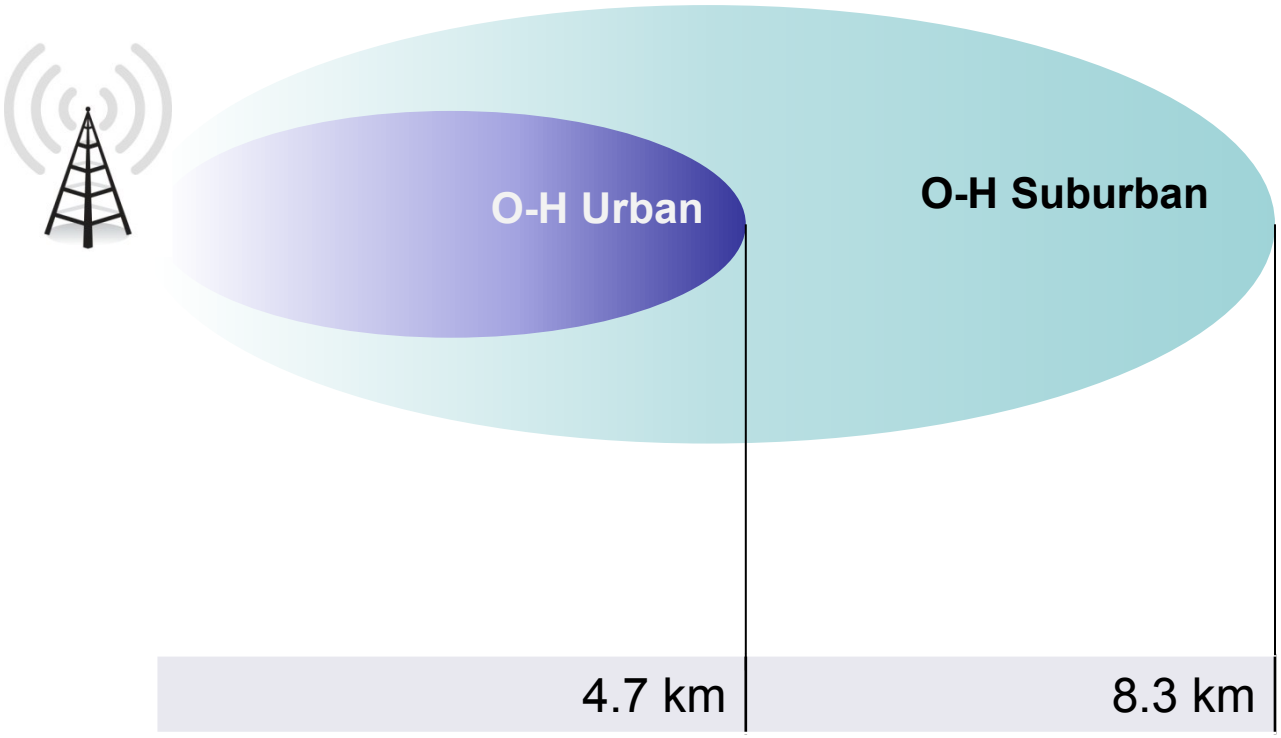
Range for indoor PPD

Carrier frequency: 630 MHz



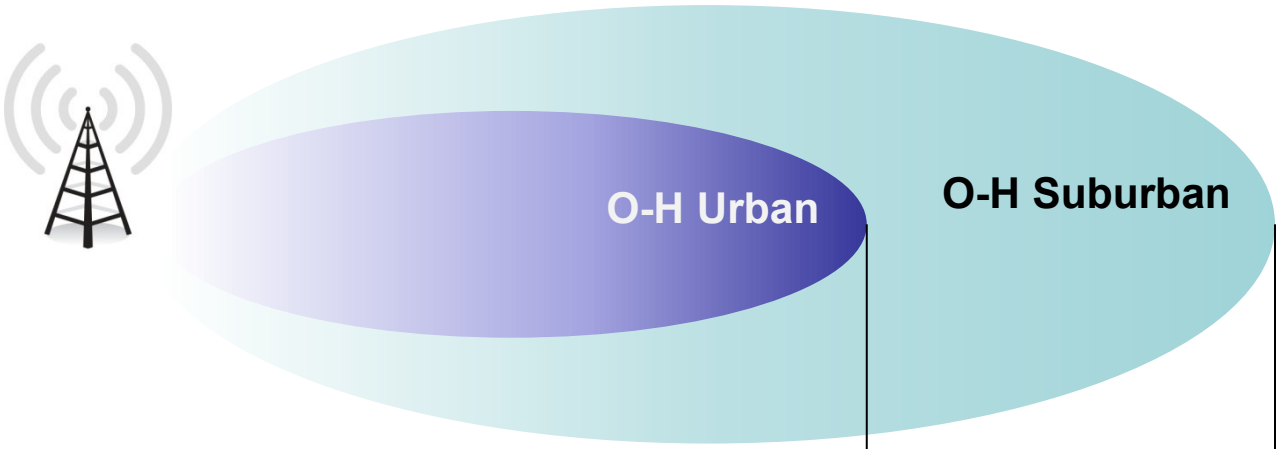
Indoor: α = 3	154 m	416 m	524 m	”Best” case; 0dBi antenna
Indoor: α = 6	12.5 m	20 m	23 m	
Indoor-to-outdoor: α = 3	48 m	132 m	166 m	
Indoor: α = 3	90 m	243 m	306 m	”Worst” case; -7dBi antenna
Indoor: α = 6	9.5 m	15.6 m	17.5 m	

Long range fixed access



Carrier frequency:	630 MHz
CPE height:	4 m
BS height:	15 m
DL Tx EIRP:	36 dBm
CPE antenna gain:	20 dBi

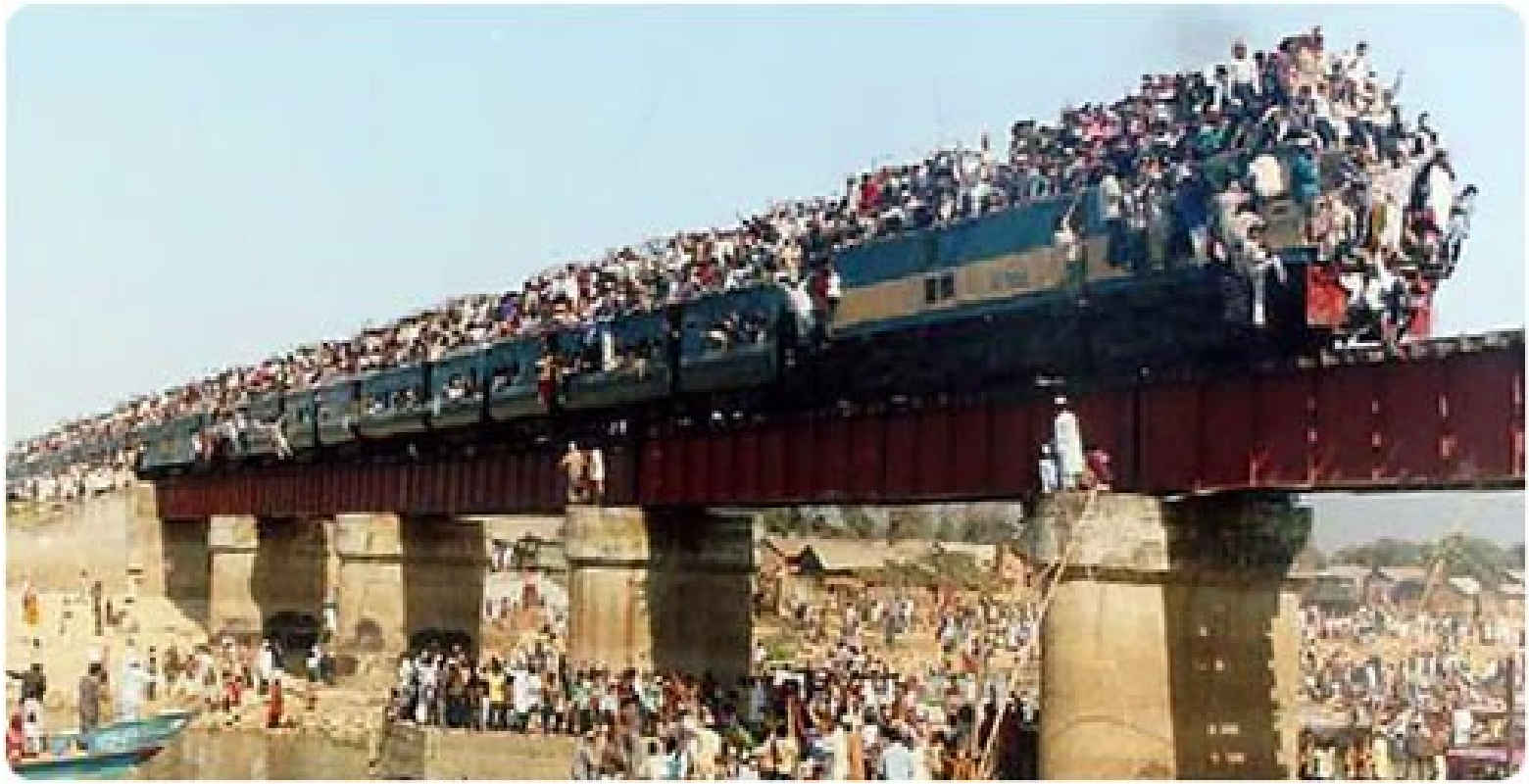
Mobile cellular extension



Carrier frequency:	630 MHz
MS/UE height:	1.5 m
BS height:	15 m
DL Tx EIRP:	36 dBm
MS/UE antenna gain:	-7 dBi or 0 dBi

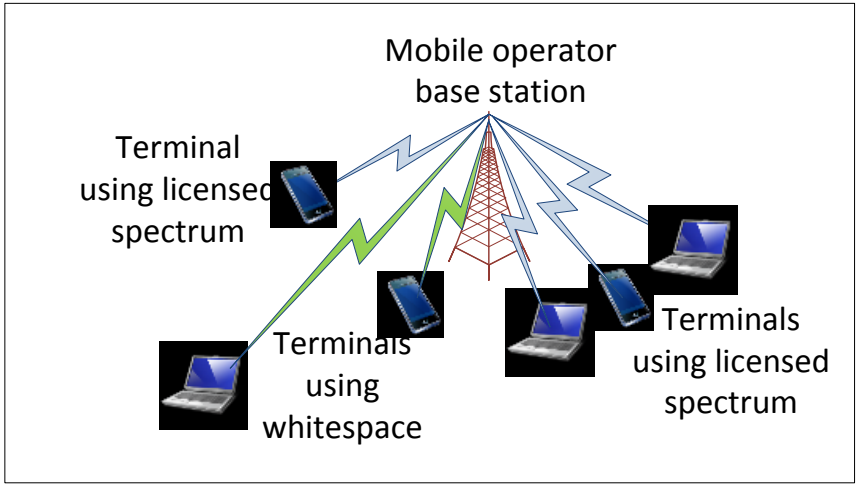
0.97 km	1.7 km	”Best” case: 0dBi antenna
0.63 km	1.1 km	”Worst” case: -7dBi antenna

Capacity estimates in TVWS



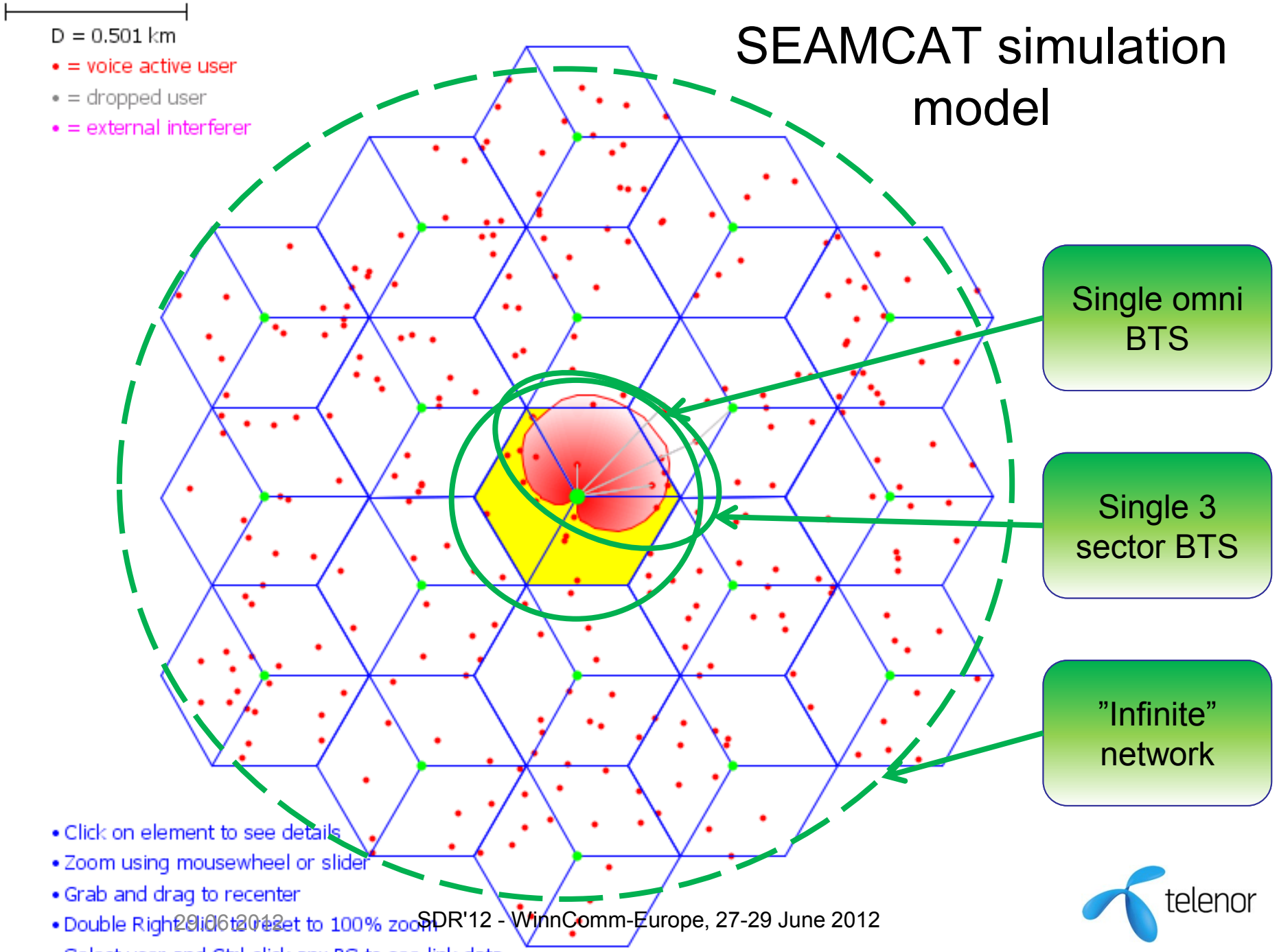
Capacity estimates in TVWS

- Scenario: Mobile cellular extension
- SEAMCAT simulations*



*) *Spectrum Engineering Advanced Monte Carlo Analysis Tools*.
See: www.seamcat.org

SEAMCAT simulation model

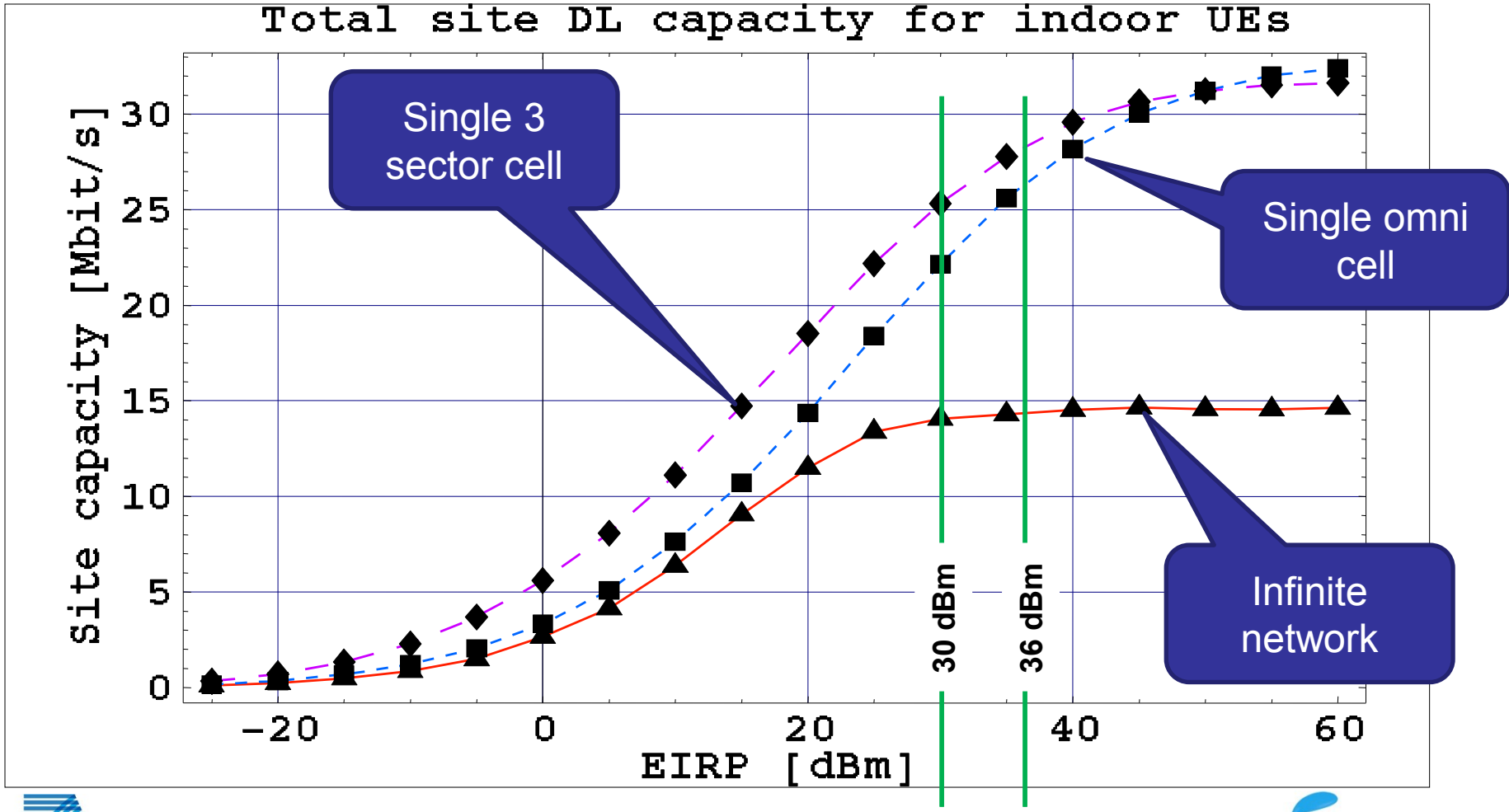


telenor

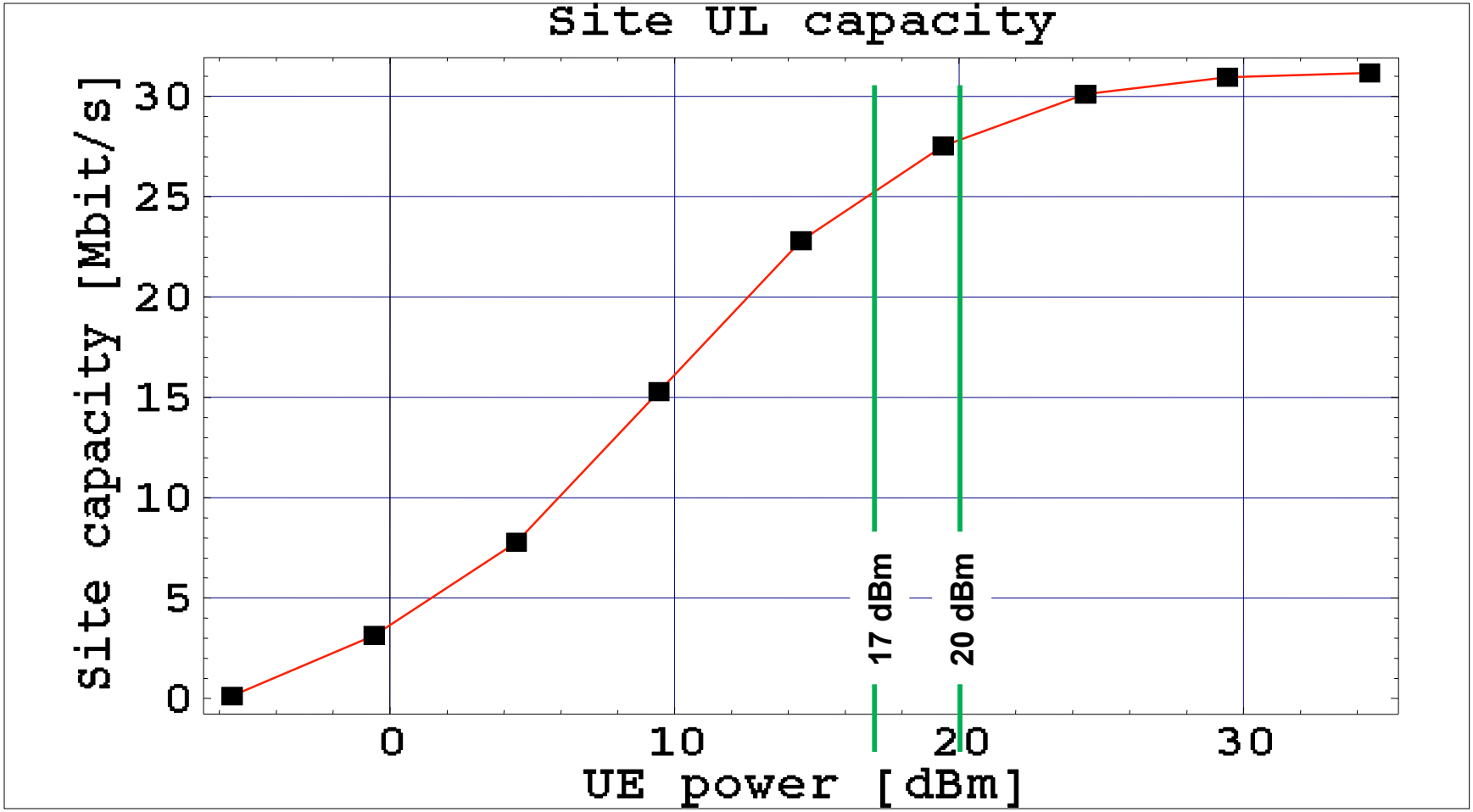
Simulation parameters

Frequency:	630 MHz
Physical layer:	Modified LTE OFDMA multiplex for 8 MHz channel width: 480 SC/40 RBs (∆f=15 kHz; RB=12SCs/180 kHz)
Frequency reuse:	1
Network load:	100 %
LTE UL power control:	Yes
Throughput estimation method:	From SNIR according to 3GPP TR 36.942 Max: 4.4 b/s/Hz (33.5 Mb/s@8 MHz) DL 2 b/s/Hz (15.2 Mb/s@8 MHz) UL
UE distribution:	Random, uniform
BS sector antenna pattern:	According to 3GPP TR 36.942: 6 dBi
Propagation model:	Okumura-Hata w/lognormal fading: σ=10dB
Wall penetration loss:	Mean: 10 dB; Sdev: 5 dB
Rx noise figure:	6 dB
UE antenna gain:	-7 dBi
Cell size:	Equal; inter-site distance: 750 m

DL capacity for indoor use



UL capacity for indoor use



Conclusions

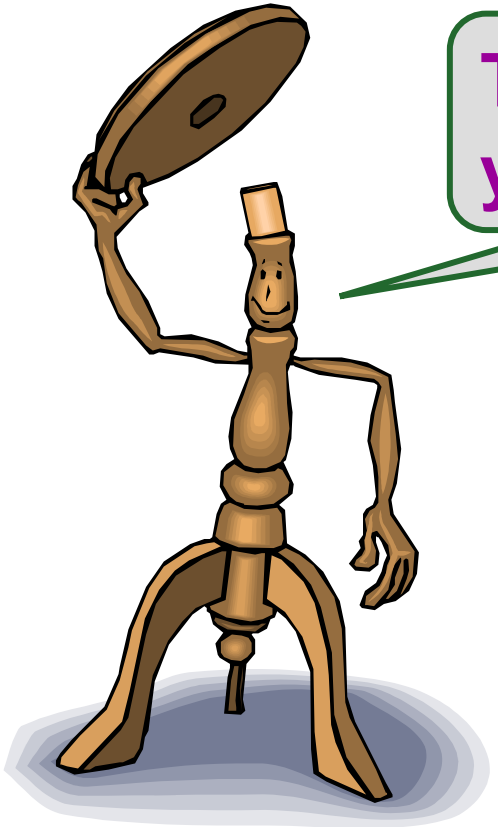
- ***Range estimations in TVWS show that:***
  - Indoor WLAN like scenarios annd rural fixed BB are most realistic in TVWS given FCC's and Ofcom's regulatory limits
  - Mobile cellular extension is possible in dense areas for capacity extension where system offload is required

- ***Capacity estimations for the mobile cellular case show that:***
  - The capacity is limited by EIRP in a single cell (hotspot) case
  - In the multi-cell case, the capacity is limited by the internal co-channel interference from neighbour cells

Work in progress..

- ***A cross-disciplinary approach***
  - Economical and technical feasibility must match

- ***Upcoming QoSMOS deliverables***
  - D1.6 - Economical benefits of a QoSMOS system (Nov 2012)
    - Business case definitions and analysis
  - D2.4 - System architecture consolidation, evaluation and guidelines (Dec 2012)
    - Evaluation of the QoSMOS system and deployment guidelines

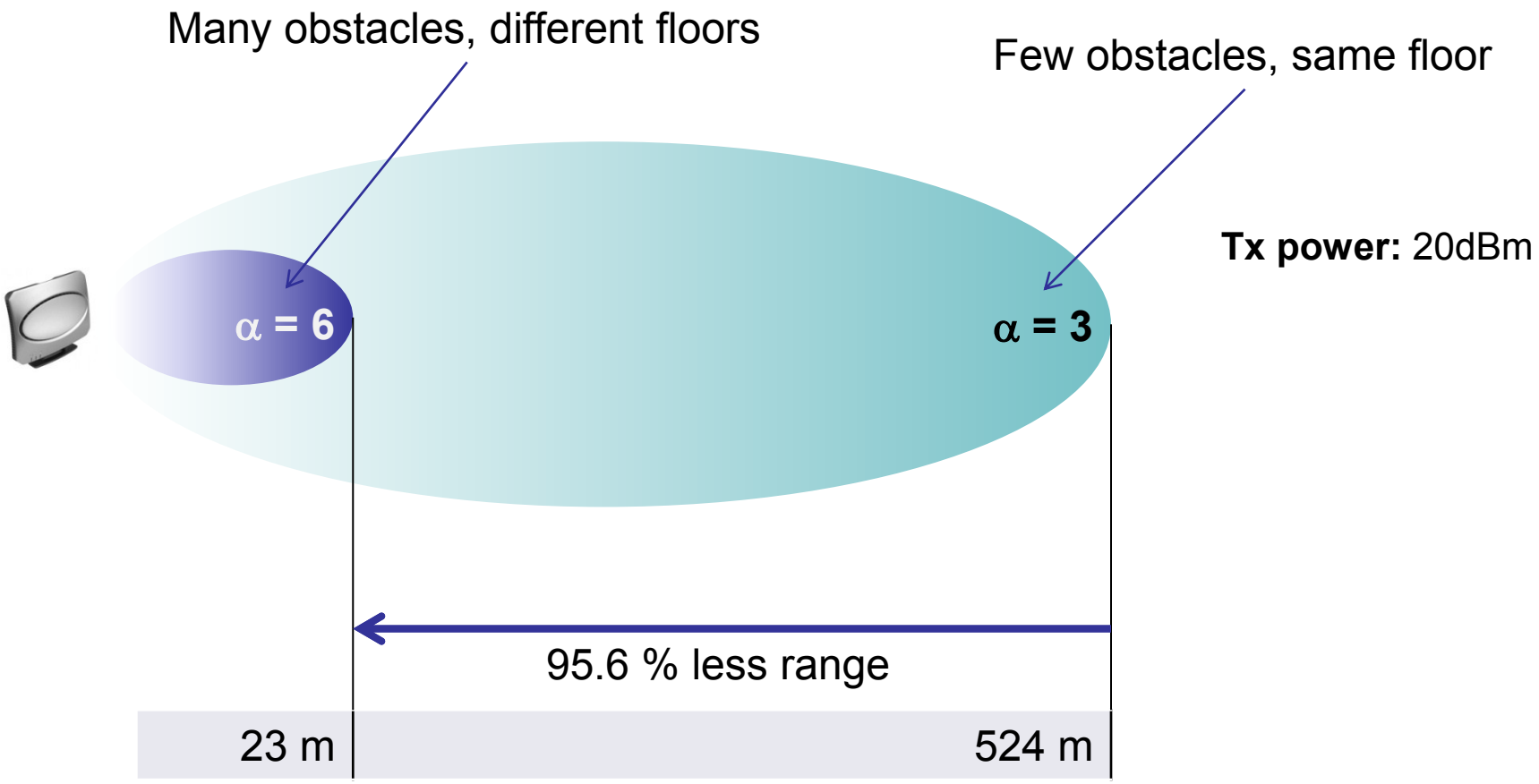


Thank you for your attention!

http://www.ict-qosmos.eu

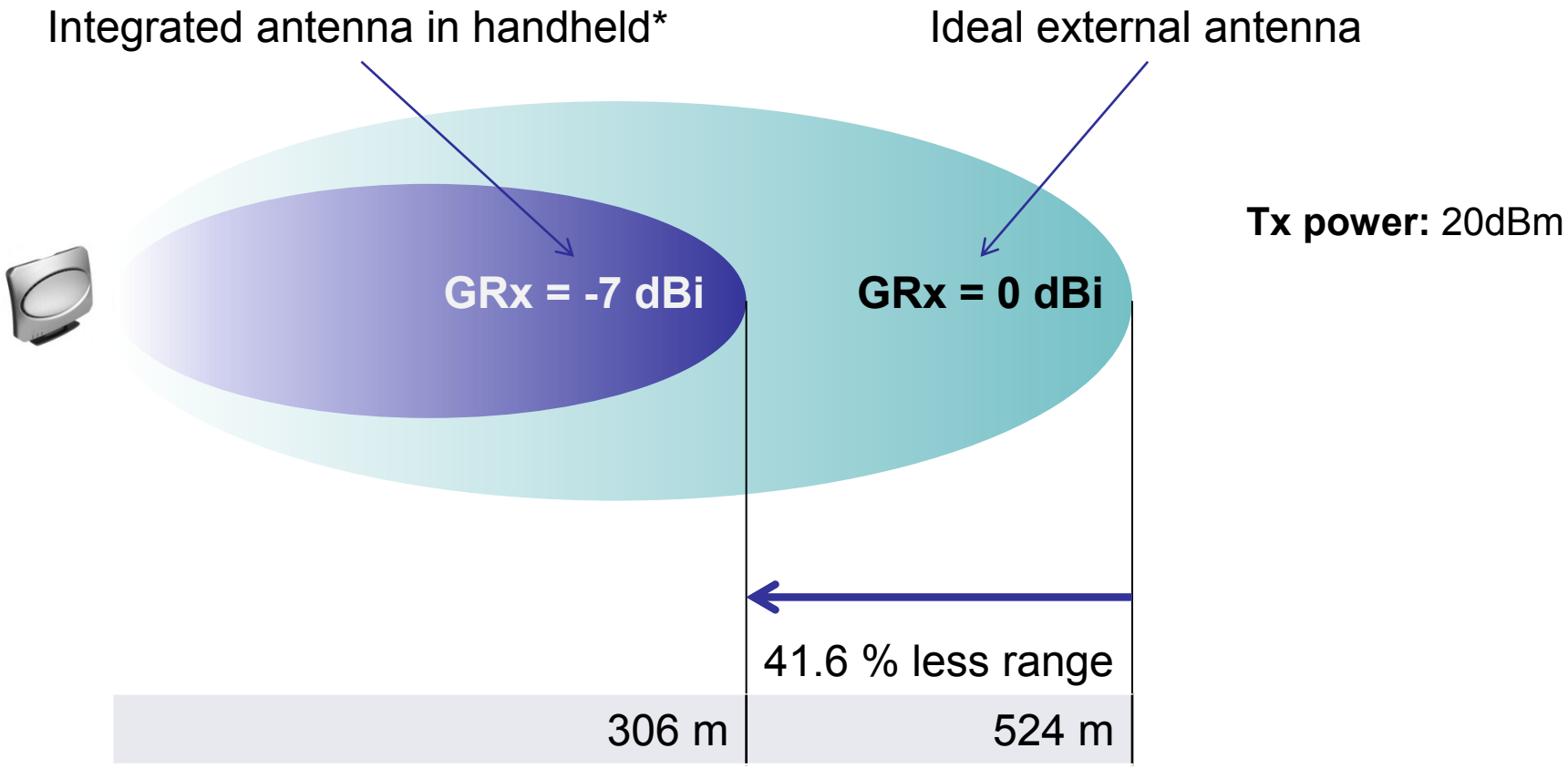
Extra

The effect of the propagation environment



Tx power: 20dBm

The effect of the user terminal antennas



Tx power: 20dBm

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