Internet everywhere:

Technology, regulatory and network-sharing solutions for the rural

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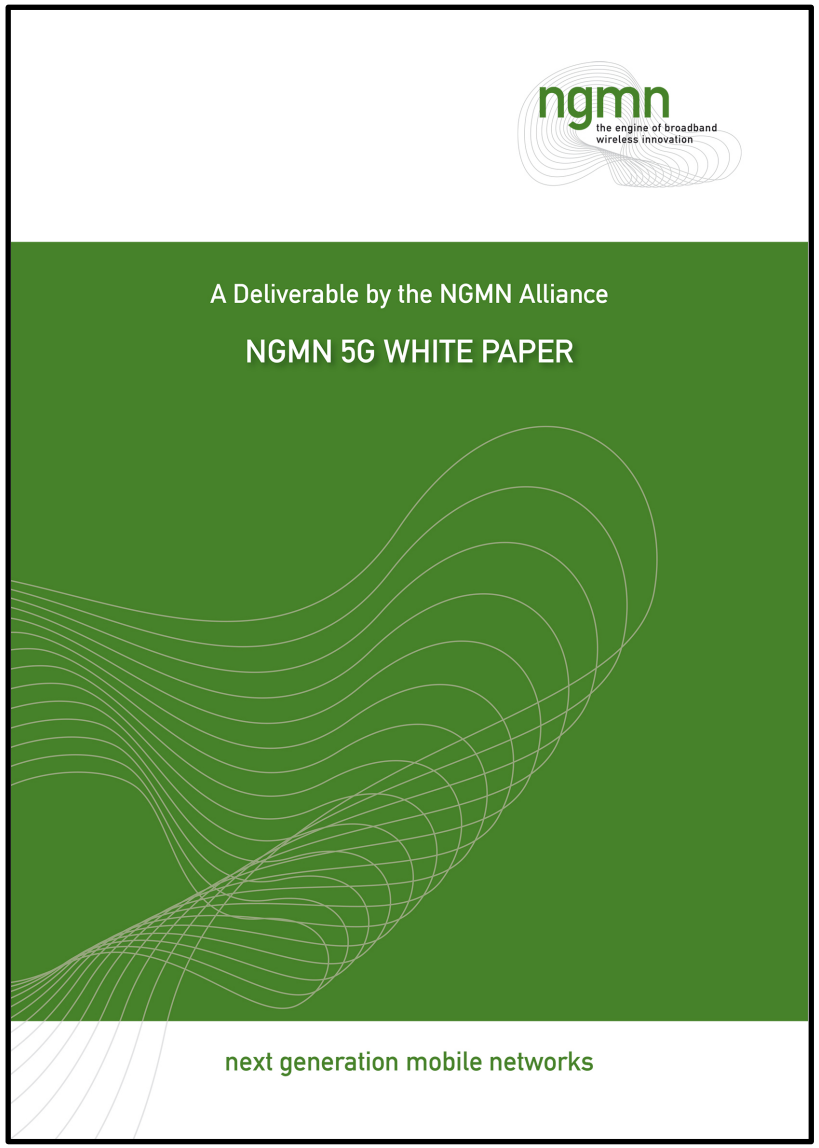
Rural radio communications

- limited access to roads/infrastructure
- limited access till electricity
- limited access to a backhaul
- few people (per unit area)
- abundance of radio spectrum

- compare: the low-ARPU regime

March 2015: “50 Mbps everywhere”



Does *5G* deliver?

at&t · Bell · BT · 中国移动通信 CHINA MOBILE 移 动 信 息 专 家

T · kpn · kt · NTT docomo

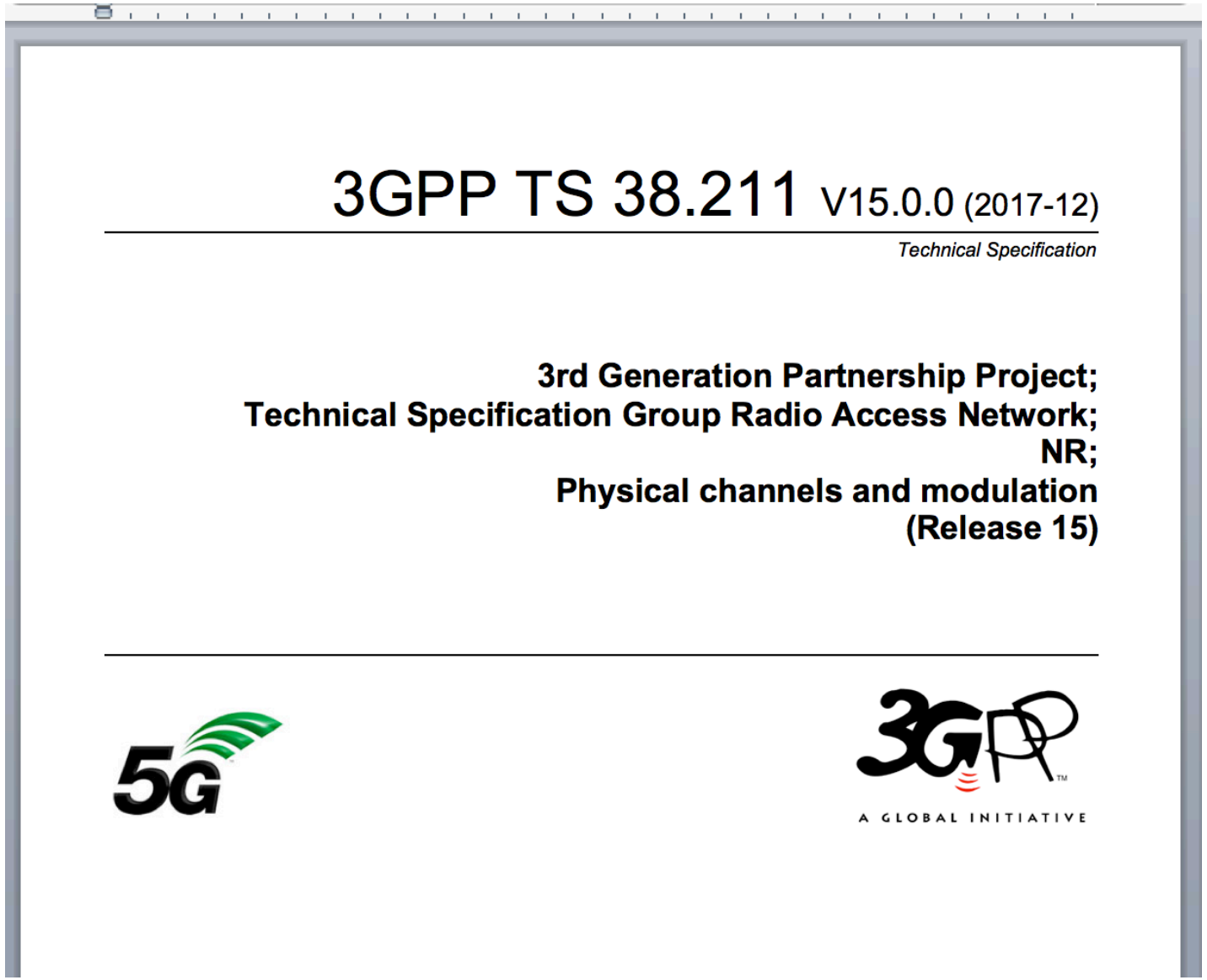
orange · Singtel · SK telecom · TELE2

TELECOM ITALIA · Telefónica · TELEKOM AUSTRIA GROUP · TeliaSonera

Telstra · TELUS the future is friendly · TURKCELL · VimpelCom

vodafone

3GPP's 5G NR – an *urban* standard



3GPP TS 38.211 V15.0.0 (2017-12)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
NR;
Physical channels and modulation
(Release 15)

5G

3GPP

A GLOBAL INITIATIVE

today,
areal coverage is not among
marketed features by operators

potential revenue
rural: $ 262 /square mile /year *
urban: $248,000 /square mile /year *

based on residential end-users

* A.-M. Kovacs, "Regulation in Financial Translation: Will the Incentive Auction Increase Mobile-Broadband Competition in Rural America?", May 2014

Increasing values in rurality

- economic values
  - forestry
  - mining
  - power
  - tourism
  - transport/logistics
  - maritime sector
- societal values
  - public services
  - democracy
  - attractive regions
  - migration / urbanization
  - safety / security

connectivity targets

European commission - goals:

by 2020:
50% EU citizens have access to at least 100 Mbit/s
100% EU citizens have access to at least 30 Mbit/s

Swedish government –Broadband Strategy, Dec. 2016:

by 2025
98% access to at least 1 Gbit/s
99.9% access to at least 100 Mbit/s
100% access to at least 30 Mbit/s

2% = 90000 households
0.1% = 4500 households

and: mobile coverage “wherever people reside and move”

digital oasis

- cluster of residences/working places

- remote
- peripheral to the ”urban” Internet

- locally:
  - high-quality local network
  - high-quality local infrastructure

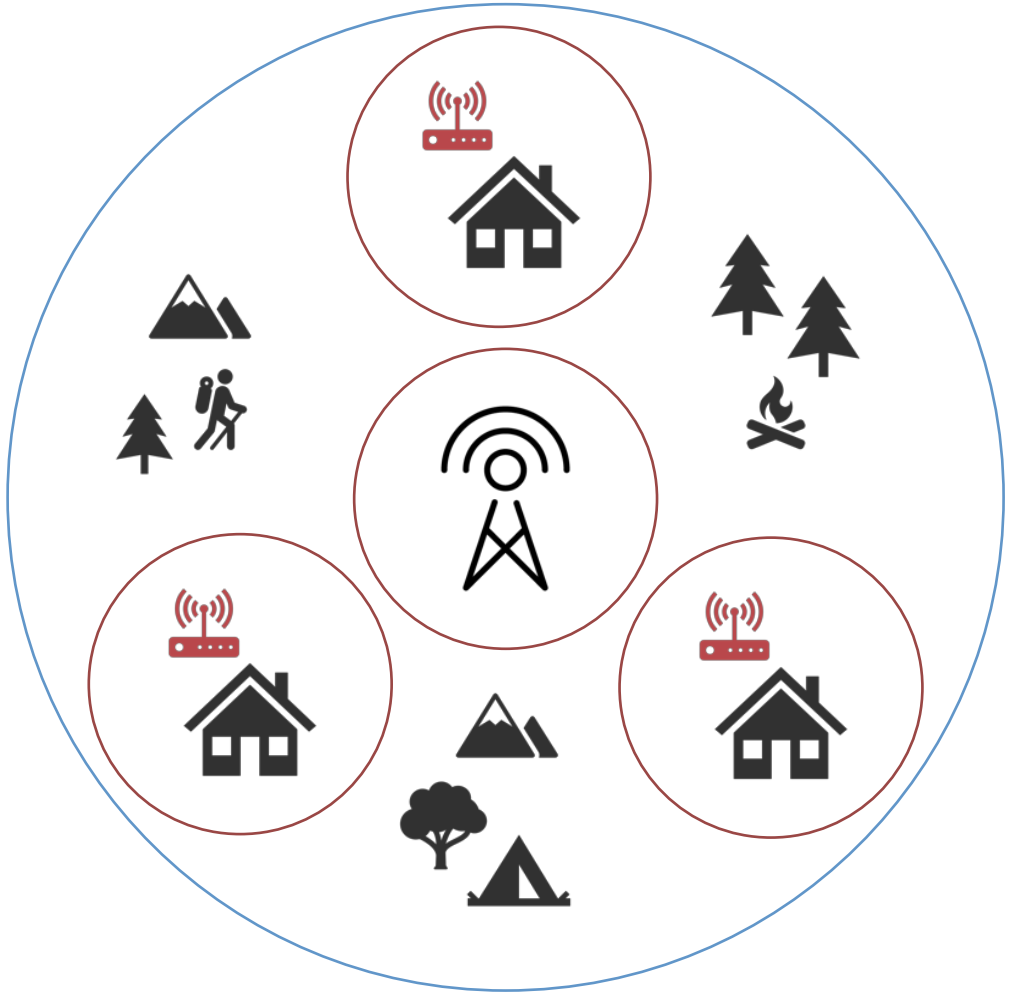
- surroundings
  - poor backhaul
  - poor infrastructure

Can/will 6G address this scenario?

a digital oasis – rural hot spot

New ways to share spectrum

New operators: micro-initiatives



energy-autonomous
macro-base stations

New use of existing
TV infrastructure

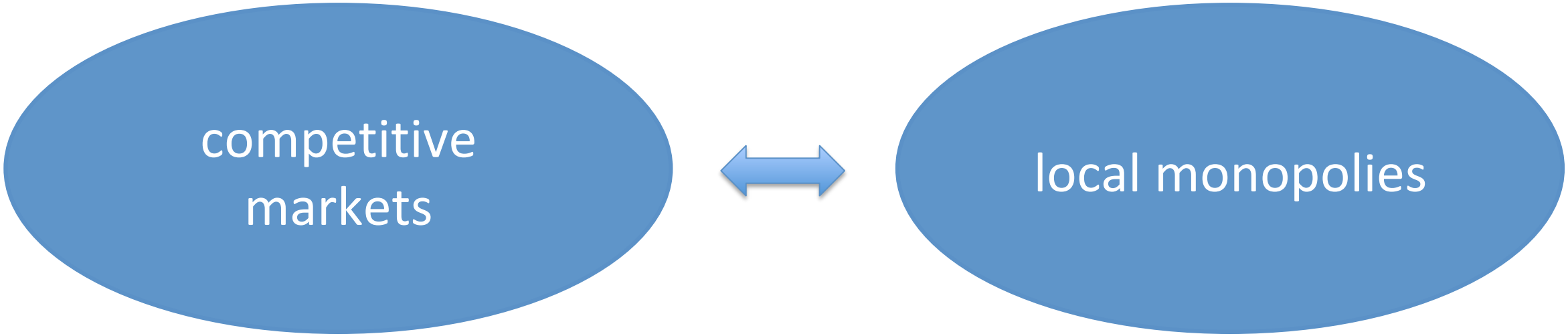
Integration with satellite networks

Caching, edge cloud, computing

new rural operators: local micro-initiatives

the urban

the rural



Current models work well here

Local initiatives deploy local networks

national roaming

flexible spectrum licensing regimes

network sharing

- Agriculture
- Municipalities
- tourism
- industrial sites
- blue-light services
- E-health stations

network/spectrum sharing: MOCN

reduce capex/opex

suitable for rural

roaming: neutral host ?

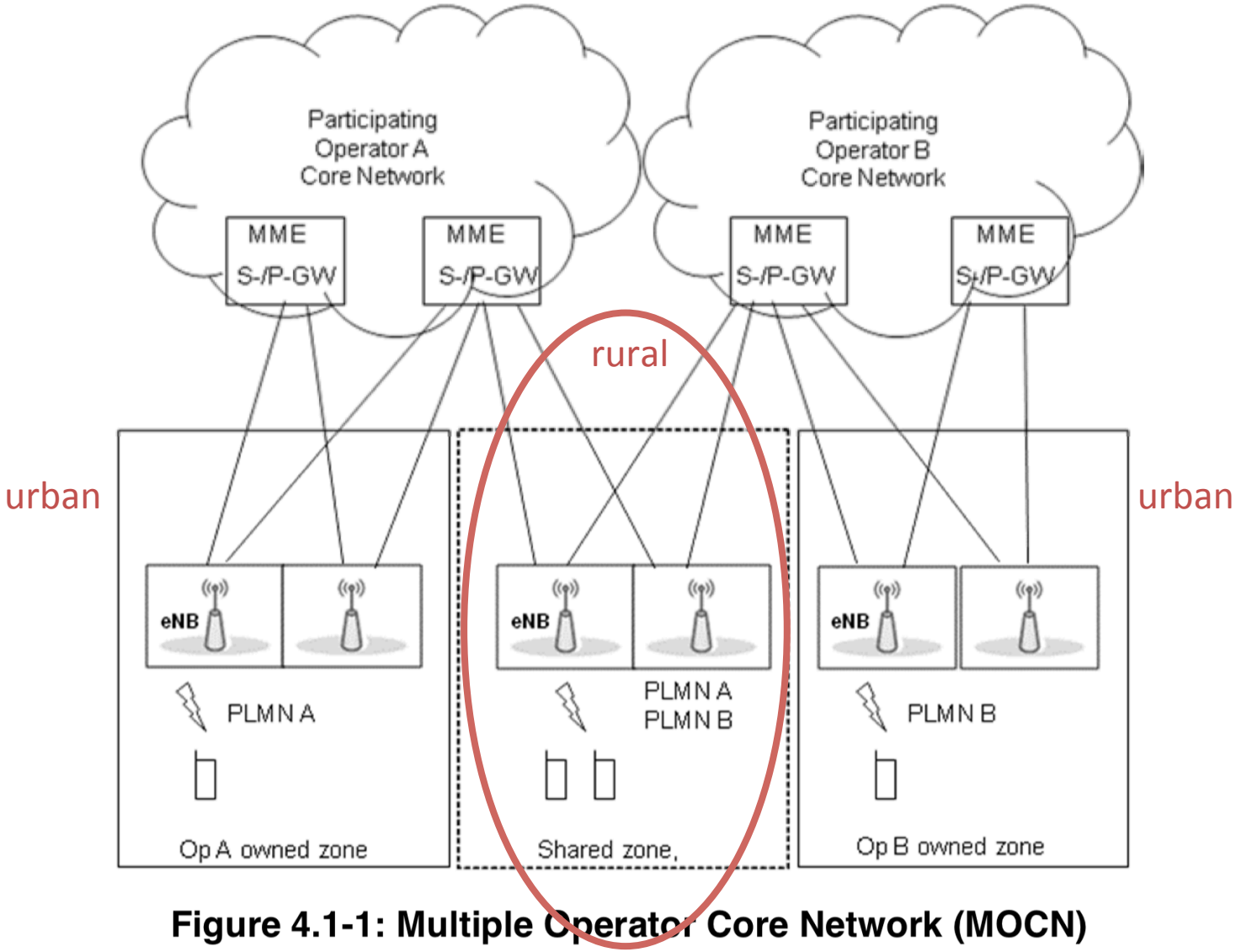
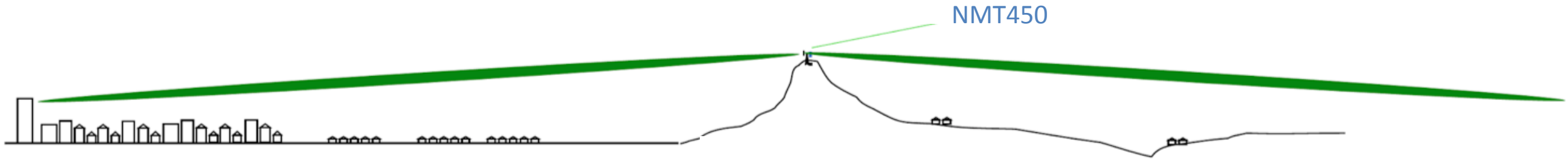


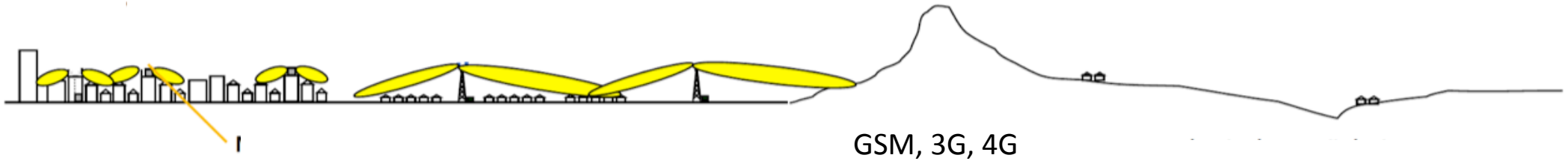
Figure 4.1-1: Multiple Operator Core Network (MOCN)

3GPP: TS 32.130 (SA5)
Network Sharing −
Concepts and requirements

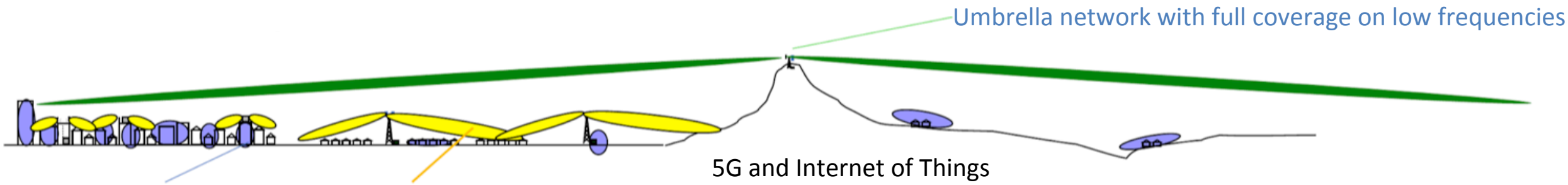

New use of existing
TV infrastructure



1st generation mobile networks, in Sweden NMT450
Low frequencies, outdoor coverage everywhere



GSM, 3G, 4G
Higher frequencies, no full coverage
Focus on cities, roads, and railways



- Indoor
- Companies and real-estate owners

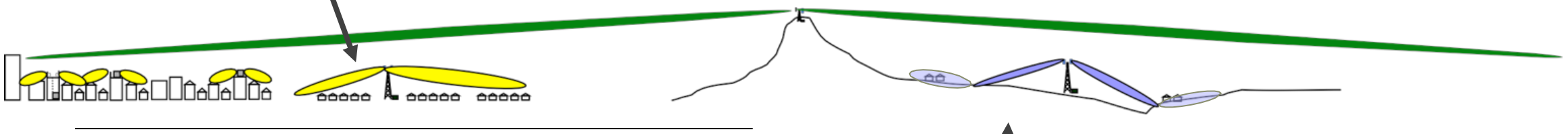
5G and Internet of Things
Guaranteed indoor coverage
All types of devices can access the network

RURAL 5G

National operators

Rural umbrella network for:

- Mobile coverge everywhere
- Backhaul for hotspot
- Society-driven? Blue-light network?

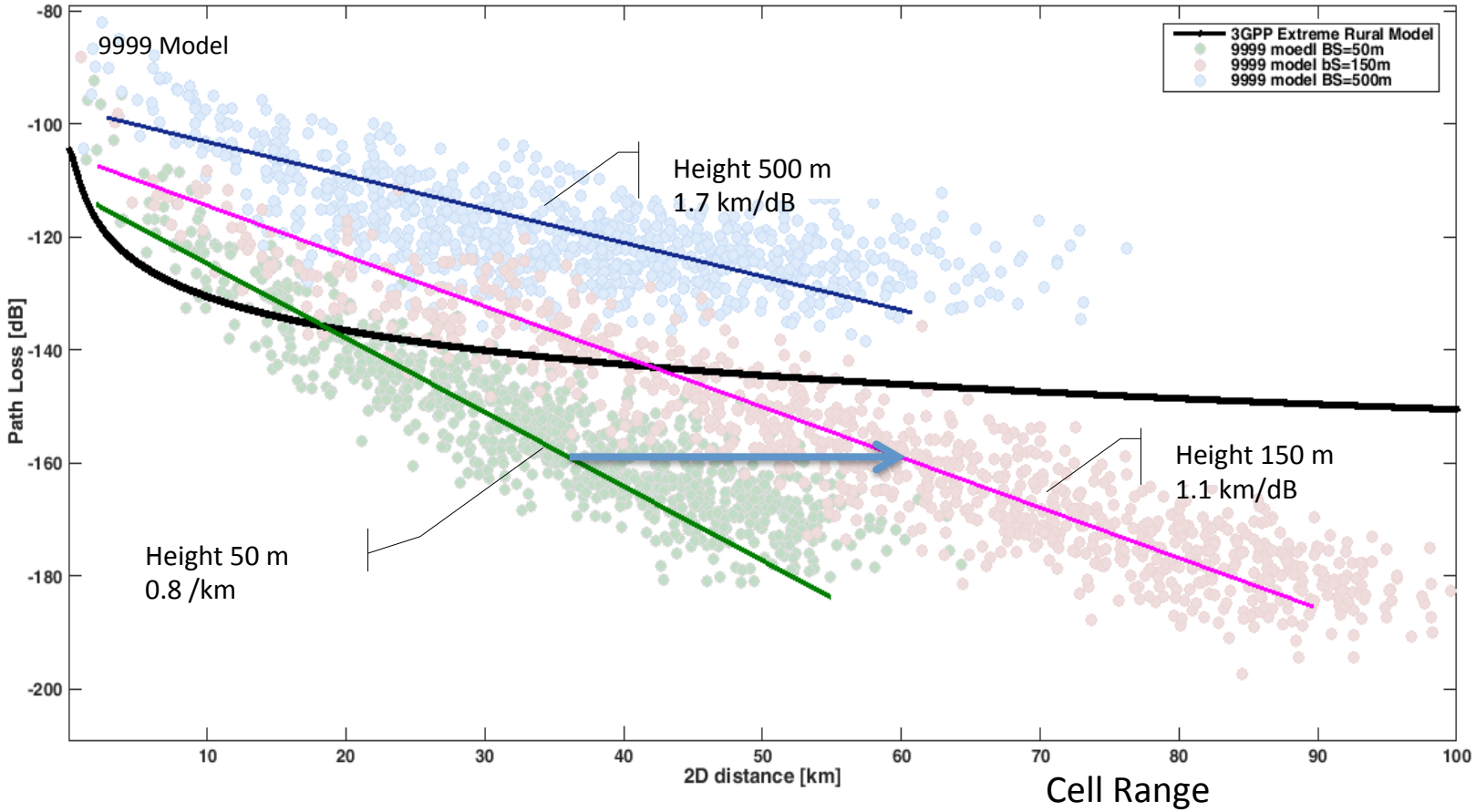


- Combined coverage
- Mobility between networks
- Backhauling

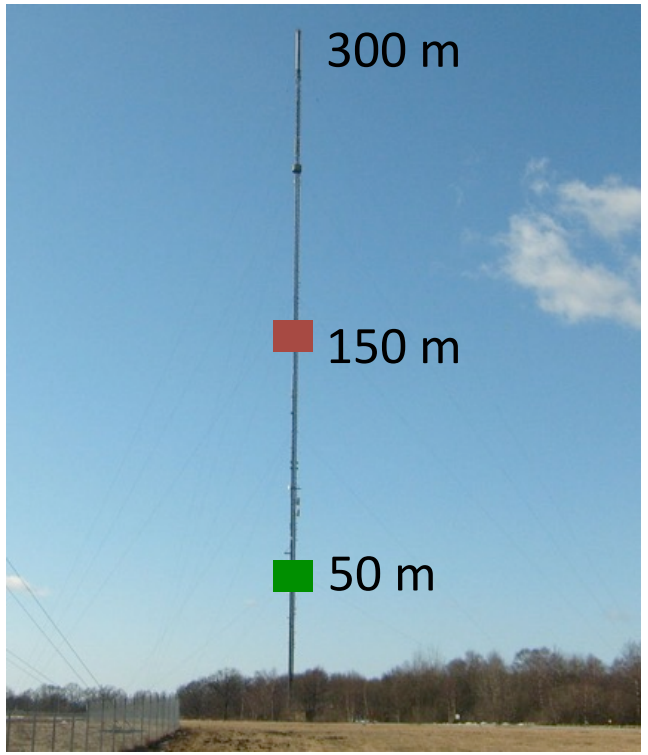
Rural Hotspots:

- Local high-speed networks
- New (local) operators
- Connected through fiber or the rural umbrella network

Base-station Side



Cell Range



On 150m: every additional dB adds a **1.1 km in cell range** and **1.9 km in ISD**

source: Ericsson – used with permission

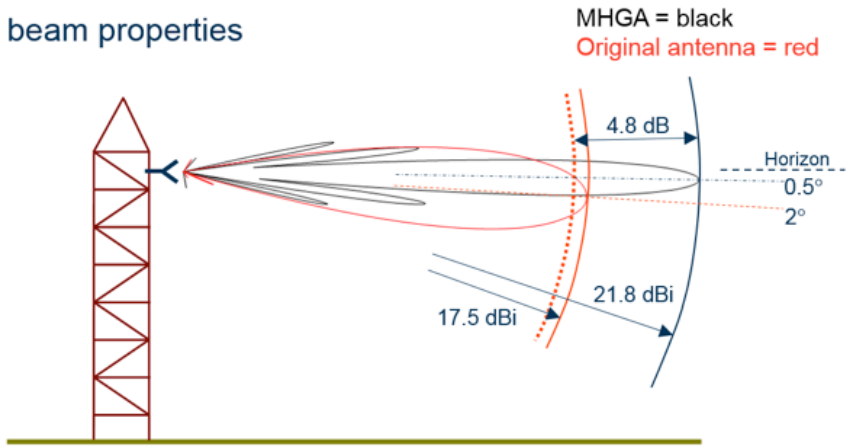
Base-station sectorization and beamforming

TABLE I: ESTIMATED ANTENNA DIMENSIONS FOR DIFFERENT HALF-POWER BEAMWIDTHS (HPBW). DIMENSION ESTIMATES BASED ON ANTMOD [3], GAIN FIGURES AS GIVEN IN [1].

Azim. HPBW (°)	65	65	90	90	45	30	22	14	11	7
Horizontal size (# of columns)	1	1	1	1	2	2	3	5	6	8
Elev. HPBW (°)	8	4	2	1	1	1	1	1	1	1
Vertical size (m)	1	2	4	8	8	8	8	8	8	8
Gain (dBi)	18	21	22	25	28	30	31	33	34.5	36

12 sectors 16 sectors 25 sectors

Modular high-gain antennas



Sectorization/Antenna design: 16 sectors +31 dB [+ 30 km]

source: Radio Innovation AB

Possible upgrade configurations

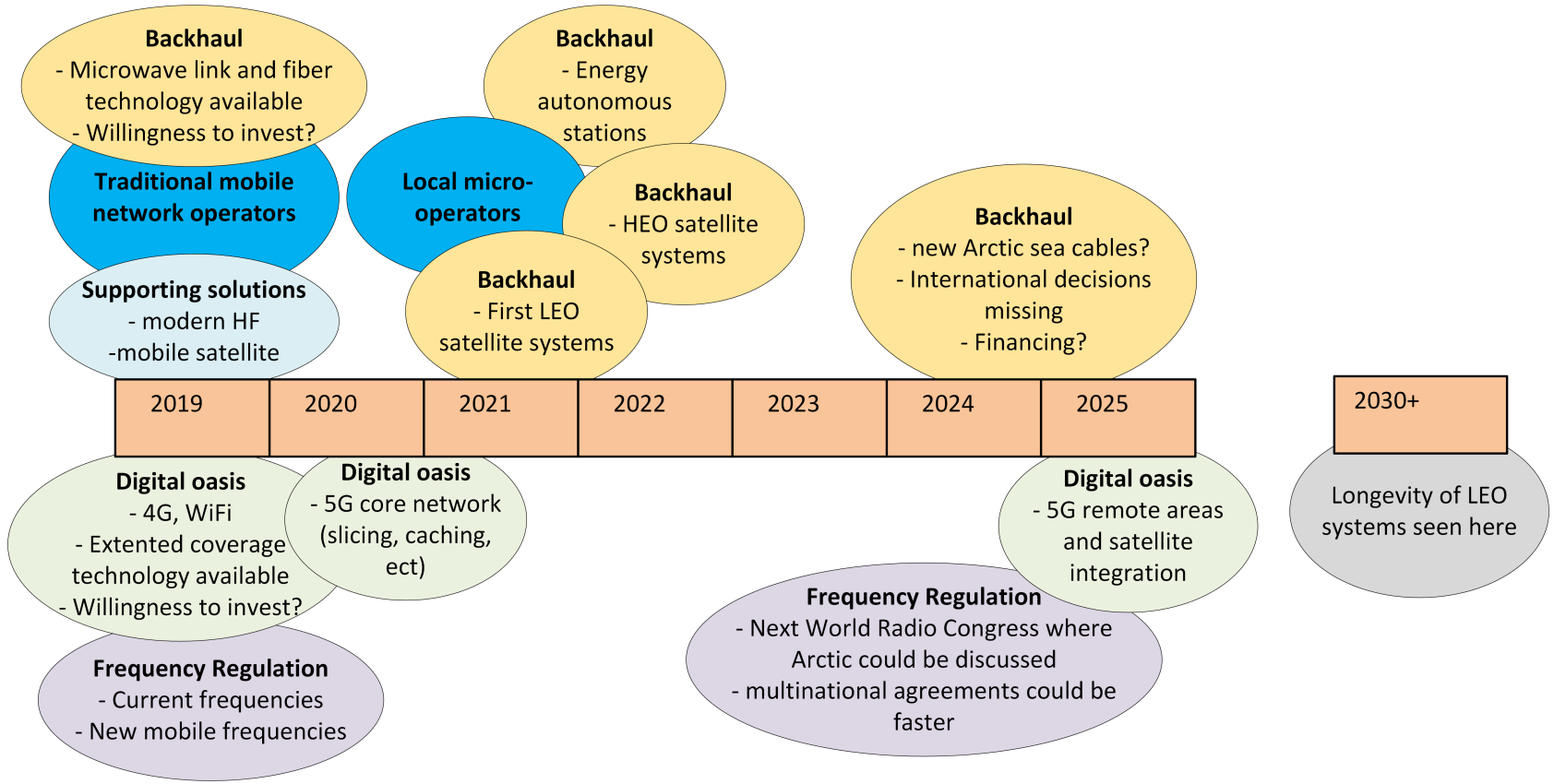
- base station
  - higher tower
  - higher power
  - MIMO, carrier aggregation
  - Higher sectorization
  - LTE-M
- later: mMIMO

- user equipment
  - higher up (FWA)
  - high power UE
  - local booster relays (FWA)

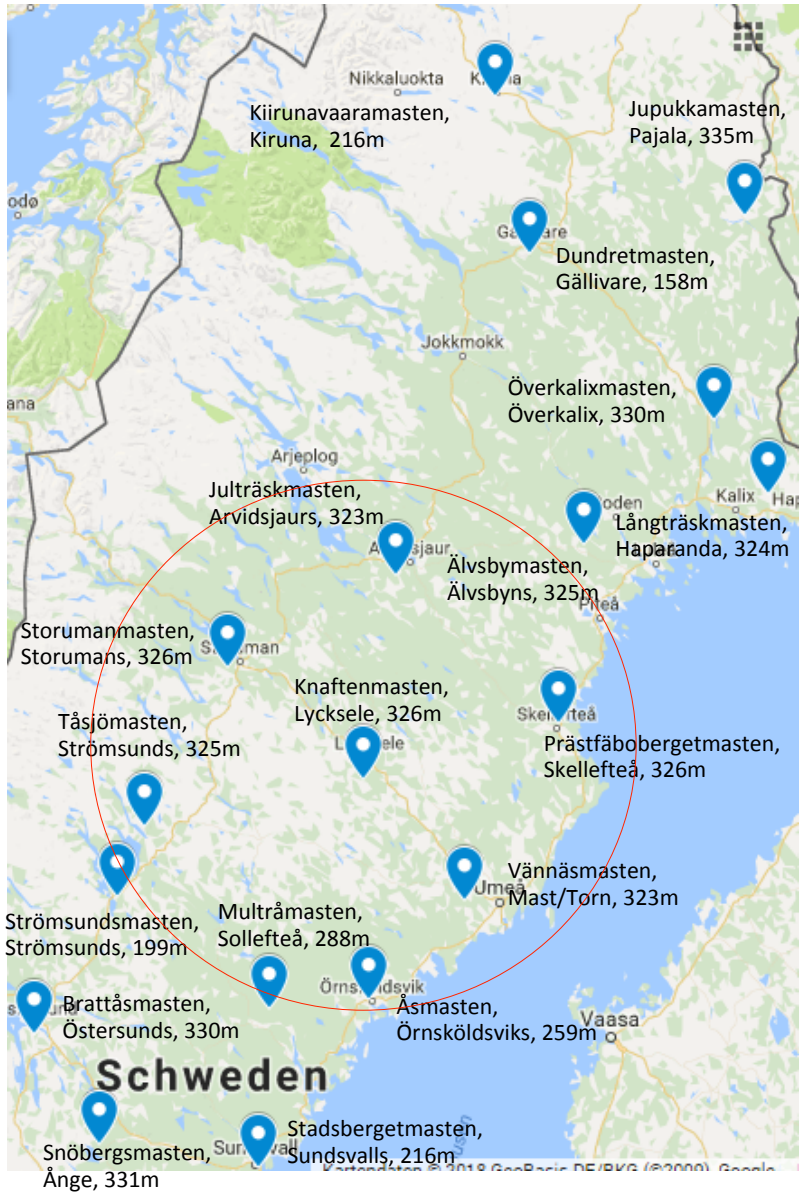
range up to 80 km possible

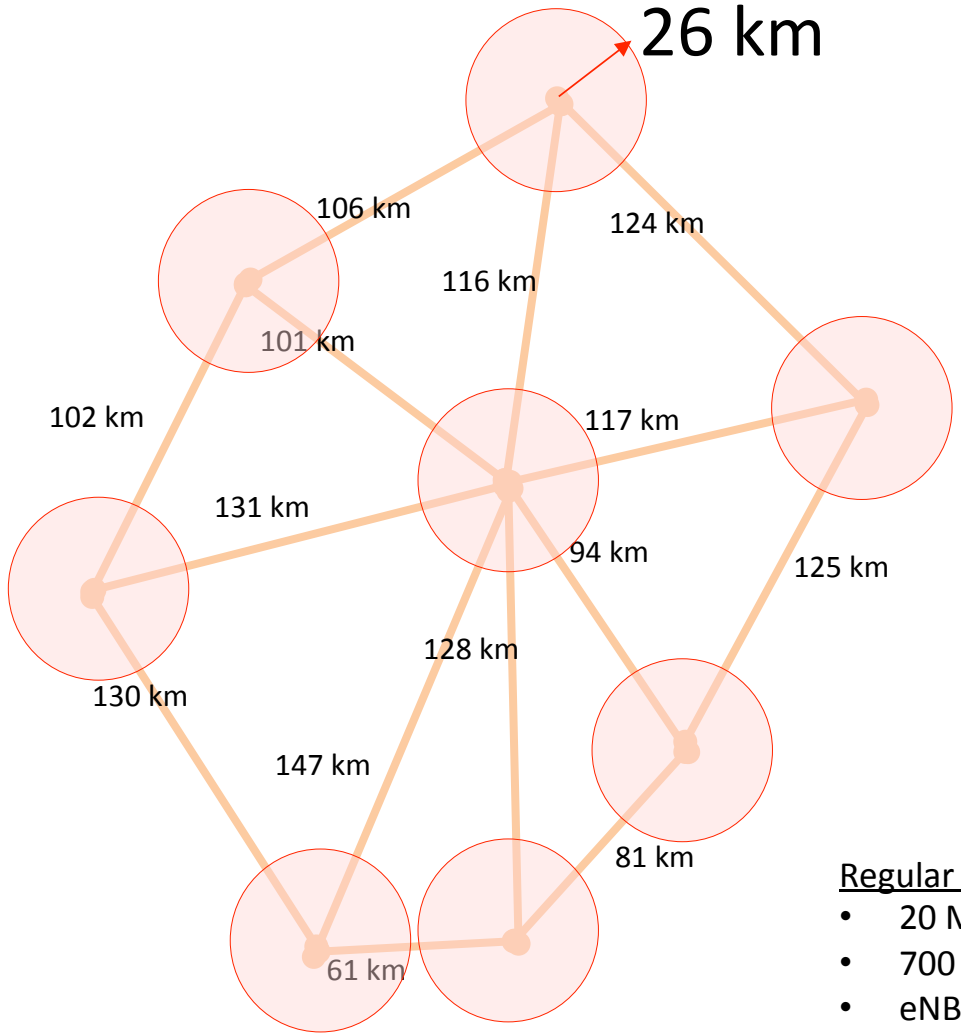
conclusions
emerging new drivers for areal coverage

- safety and security
  - 911 everywhere
  - blue-light services
- autonomous transports
  - on land (roads)
  - in the air (corridors)
- inclusive societies
  - driven by public sector



Regular LTE - Uplink shown



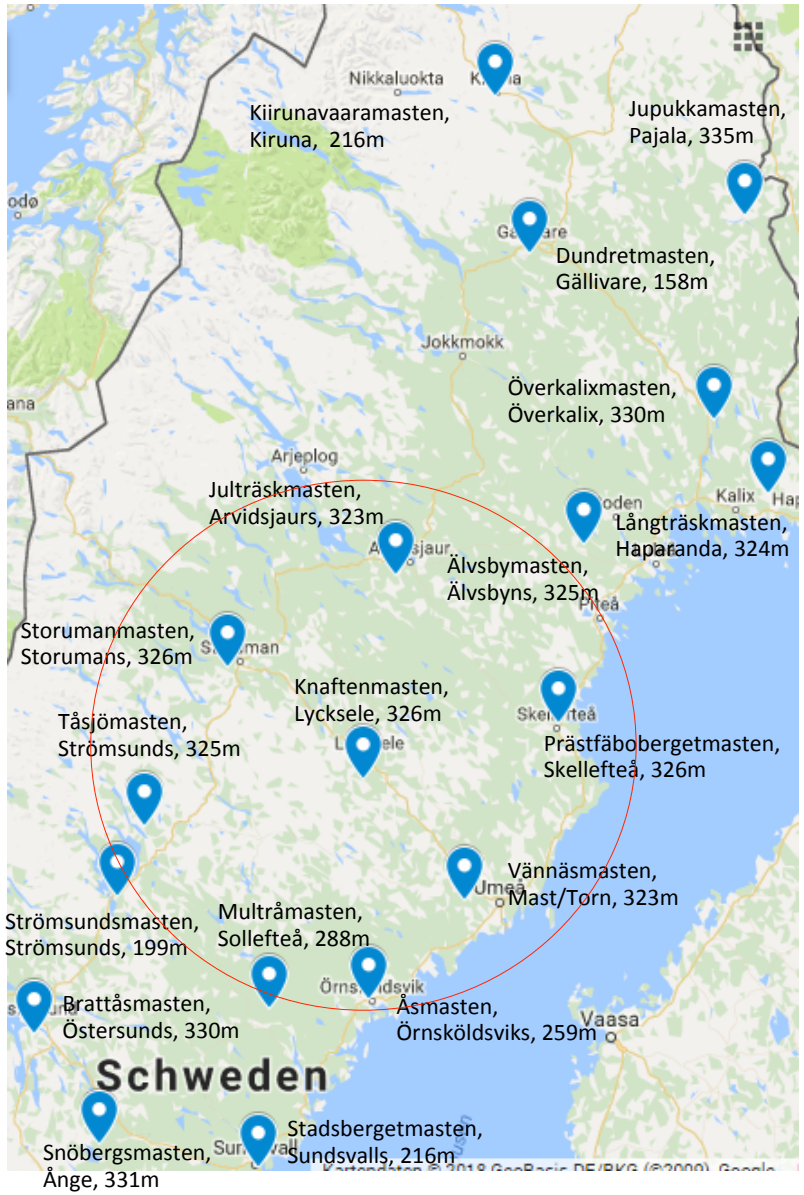


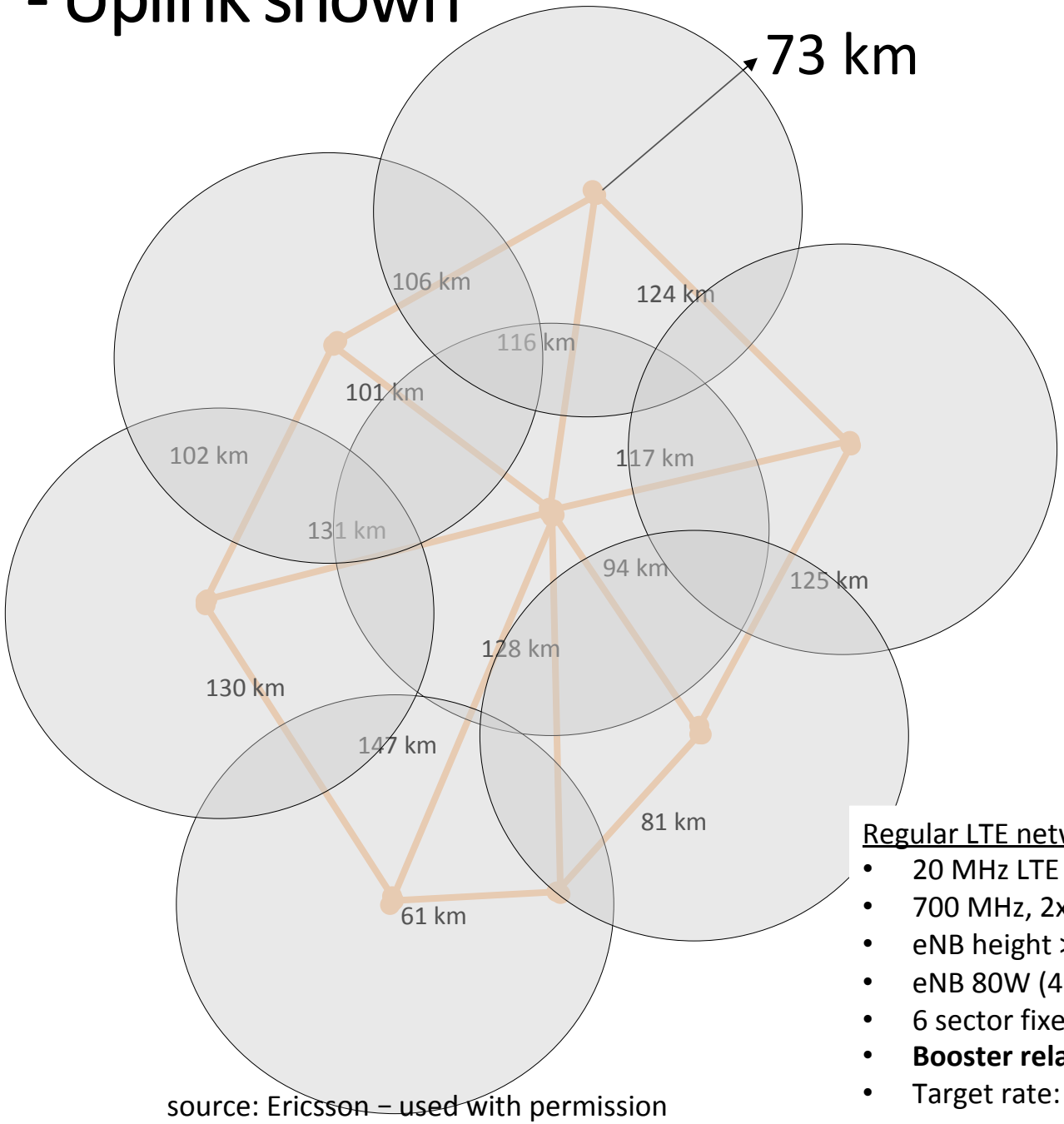
source: Ericsson – used with permission

<u>Regular LTE network and UE</u>

- 20 MHz LTE FDD
- 700 MHz, 2x2 MIMO
- eNB height >150m
- eNB 80W (49 dBm)
- 6 sector antenna (17dBi)
- Class-3 UE (23 dBm)
- Target rate: 10 Mbit/s @ cb

Regular LTE + Super-Booster - Uplink shown





source: Ericsson – used with permission

<u>Regular LTE network + Super-BE</u>

- 20 MHz LTE
- 700 MHz, 2x2 Div.
- eNB height >150m
- eNB 80W (49 dBm)
- 6 sector fixed-beam (21 dBi)
- **Booster relay (61 dBm)**
- Target rate: 10 Mbit/s @ cb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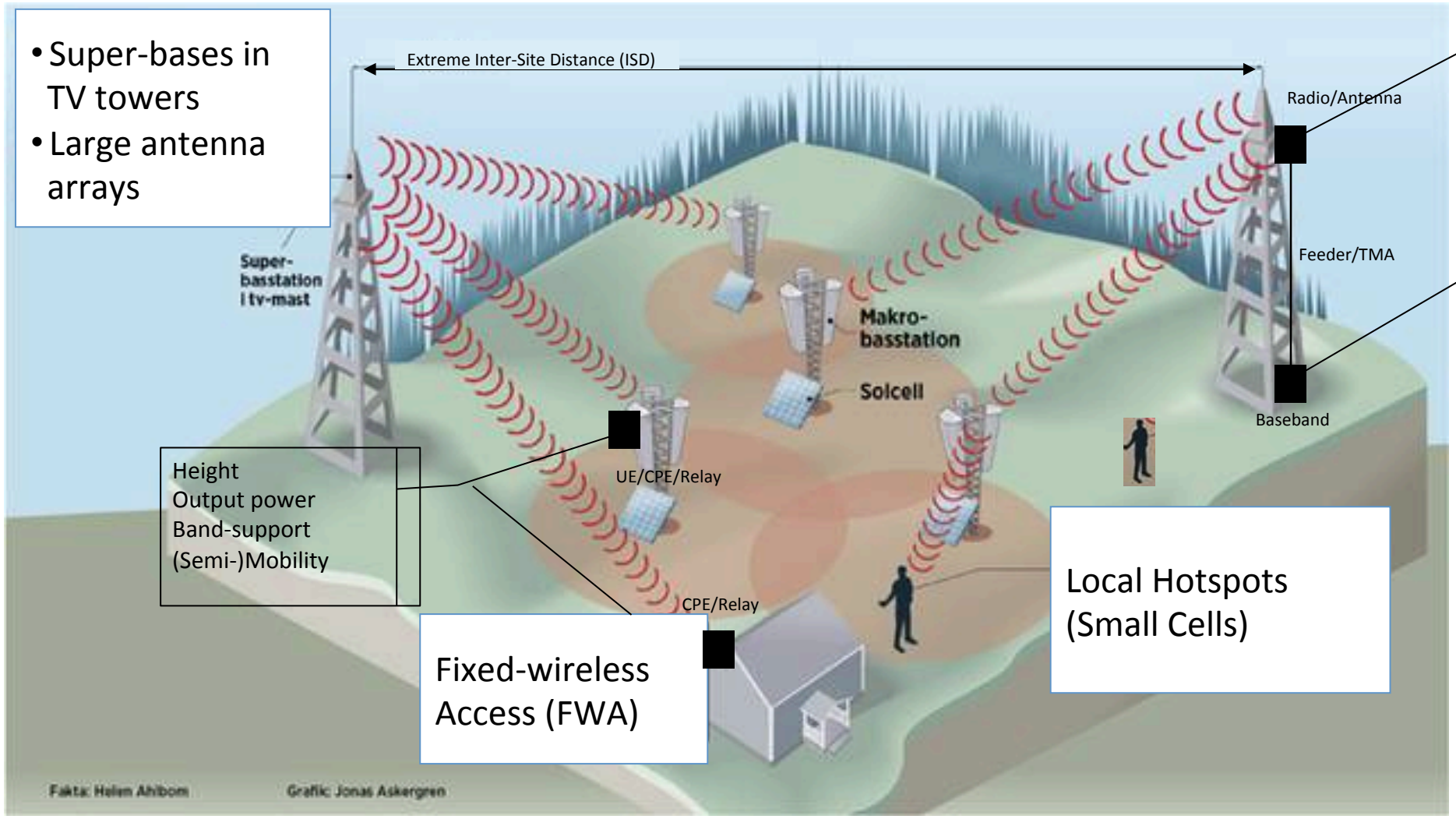
#fullcoverage

Reference Group

HetNet: Umbrella cells + Local Hotspots

- Super-bases in TV towers
- Large antenna arrays



Mast height
eNB Output power
Sectorization
Antenna/Feeder Design

Radio access technology
Spectrum/Band
Protocol parameters
Coverage enhancements

Height
Output power
Band-support
(Semi-)Mobility

Fixed-wireless Access (FWA)

Local Hotspots (Small Cells)