RADIO NETWORK EVOLUTION

Novák Csaba,
Ericsson Magyarország
HTE Infokom, Tapolca
2016. okt. 13.

ERICSSON

5G USE CASES

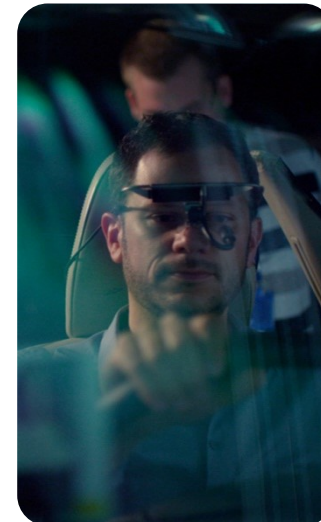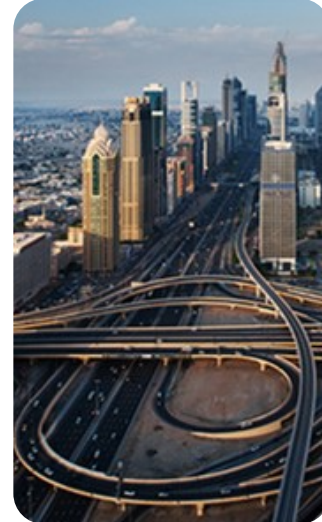| Broadband experience everywhere anytime | Mass market personalized media and gaming | Meters, sensors, "Massive MTC" | Remote controlled machines | Smart Transport Infrastructure and vehicles | Human / machines interaction | And much more… |

3GPP "FEW" 5G USE CASES (TS 22.891)

|		
Ultra-reliable communications	Multiple RAT connectivity and RAT selection	High Accuracy Enhanced Positioning (ePositioning)
Network Slicing	Higher User Mobility	Broadcasting Support
Lifeline communications / natural disaster	Connectivity Everywhere	Ad-Hoc Broadcasting
Migration of Services from earlier generations	Temporary Service for Other Operators Users in Emergency Case	Green Radio
Mobile broadband for indoor scenario	Improvement of network capabilities for vehicular case	Massive IoT's M2M and device identification
Mobile broadband for hotspots scenario	Connected vehicles	Light weight device communication
On-demand Networking	Mobility on demand	Fronthaul/Backhaul Network Sharing
Flexible application traffic routing	Context Awareness to support network elasticity	Device Theft Preventions / Stolen Device Recovery
Flexibility and scalability	In-network and device caching	Diversified Connectivity
MBB services with seamless wide-area coverage	Routing path optimization when server changes	User Multi-Connectivity across operators
Virtual presence	ICN Based Content Retrieval	Moving ambulance and bio-connectivity
Connectivity for drones	Wireless Briefcase	MBB Direct Air to Ground Communications (DA2GC)
Industrial Control	Devices with variable data	Wearable Device Charging
Tactile Internet	Domestic Home Monitoring	Telemedicine Support
Localized real-time control	Low mobility devices	Network Slicing – Roaming
Coexistence with legacy systems	Materials and inventory management and location tracking	eMBMS using a Dedicated Radio Carrier
Extreme real-time communications and the tactile internet	Cloud Robotics	Wireless Local Loop
Remote Control	Industrial Factory Automation	5G Connectivity Using Satellites
Light weight device configuration	Industrial Process Automation	Delivery Assurance for High Latency Tolerant Services
Wide area sensor monitoring and event driven alarms	SMARTER Service Continuity	Priority, QoS and Policy Control
IoT Device Initialization	Provision of essential services for very low-ARPU areas	Vehicular Internet & Infotainment
Subscription security credentials update	Network capability exposure	Local UAV Collaboration
Access from less trusted networks	Low-delay speech and video coding	Best Connection per Traffic Type
Bio-connectivity	NW enhancements to support scalability and automation	Multi Access network integration
Wearable Device Communication	Wireless Self-Backhauling	

3GPP REQUIREMENTS (38.913)

Performance Measure	Requirement
Peak data rate	DL: [20 Gbps] UL: [10 Gbps]
Peak spectral efficiency	DL: [30 bps/Hz] UL: [15 bps/Hz]
Bandwidth	TBD
Control plane latency	[10 ms]
UP latency URLLC, one-way	[0,5 ms]
UP latency eMBB, one way	[4ms]
Latency for infrequent small packets	10s/UL at MCL ~164db
Mobility interruption time (intra-syst.)	[0 ms]
Mobility	Up to 500 km/h
Inter-system mobility	TBD
Reliability	[$1-10^{-5}$] in [1ms] & TP:[300Mbps]
Coverage	MCL [164dB] for [160bps]

| Performance Measure	Requirement
Ue Battery life	>10y 200B/day UL, (15y wished)
UE energy efficiency	Qualitative
Cell/Transmission Point/TRP spectral efficiency	TBD
Area traffic capacity	Report value, no requirement
TRP spectral efficiency	[3x IMT-A requirement]
User experienced data rate	5% usr.sp.eff. X BW
User sp. eff. at 5% percentile	[3x cell edge IMT-A requirement]
Connection density	[1,000,000 devices/Km2]
NW energy efficiency	Qualitative & Quantitative KPI

NR – KEY TECHNOLOGY FEATURES

Extension to higher frequencies and wider band widths

4G

5G

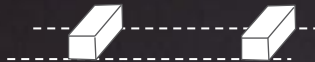1 GHz   3 GHz   10 GHz   30 GHz   100 GHz
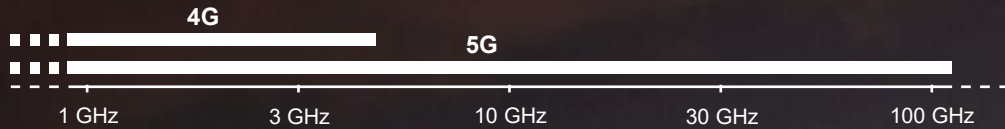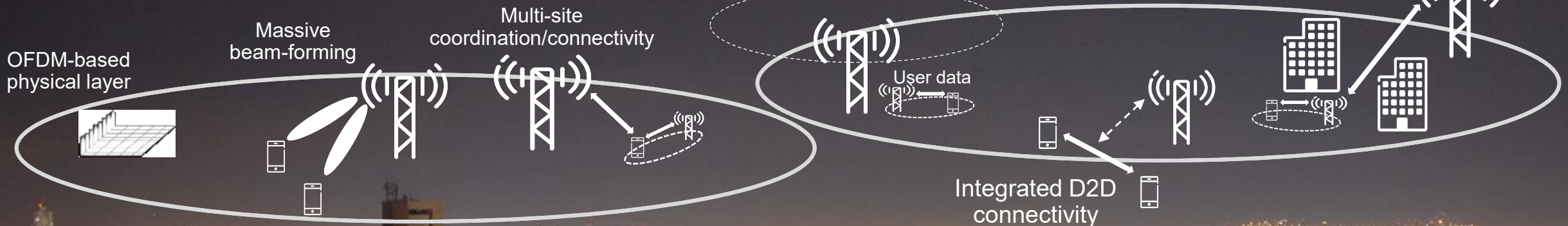
Flexible and scalable Layer 1 design
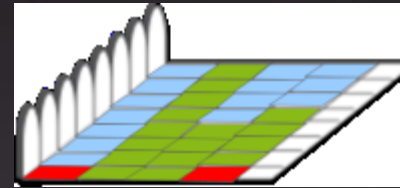
- OFDM with flexible numerology
- Multiplexing of wideband and narrowband devices on the same radio resource
- Filtering and shaping by digital processing
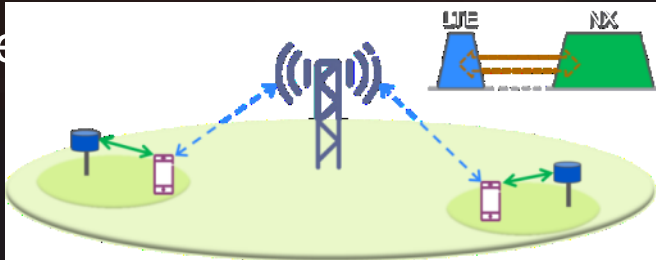- Support for various spectrum allocation schemes

Ultra-lean design

Minimize network transmissions
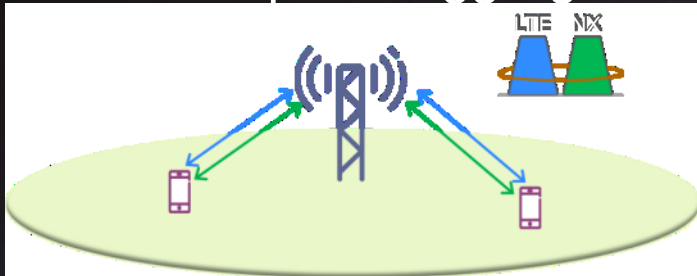not directly related to UD delivery

Separate
system-access functionality

System control

Access/backhaul
integration

Multi-site
coordination/connectivity

Massive
beam-forming

User data

OFDM-based
physical layer

Integrated D2D
connectivity

5G TECHNOLOGIES AND SPECTRUM
LTE AS PART OF 5G OVERALL RADIO SOLUTION

Dual-conne

User-plane aggregation

5G technology components

LTE deployment compatible

Applicable to all bands

Massive MIMO

M2M enhancements

D2D

Self-backhaul

Latency reductions

Ultra lean design

Very high BW

Primarily for (not limited to) "new" bands (from <1 GHz to >100 GHz)

Timing decided by operator

Non LTE-deployment compatible

LTE deployments ~2020

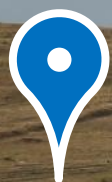1 GHz   3 GHz   10 GHz   30 GHz   100 GHz

OPERATOR
WAYPOINTS
ON THE ROAD TO 5G

5G

PERFORMANCE EVOLUTION
Massive MIMO // Cloud RAN // Gigabit speeds

NETWORK DENSIFICATION
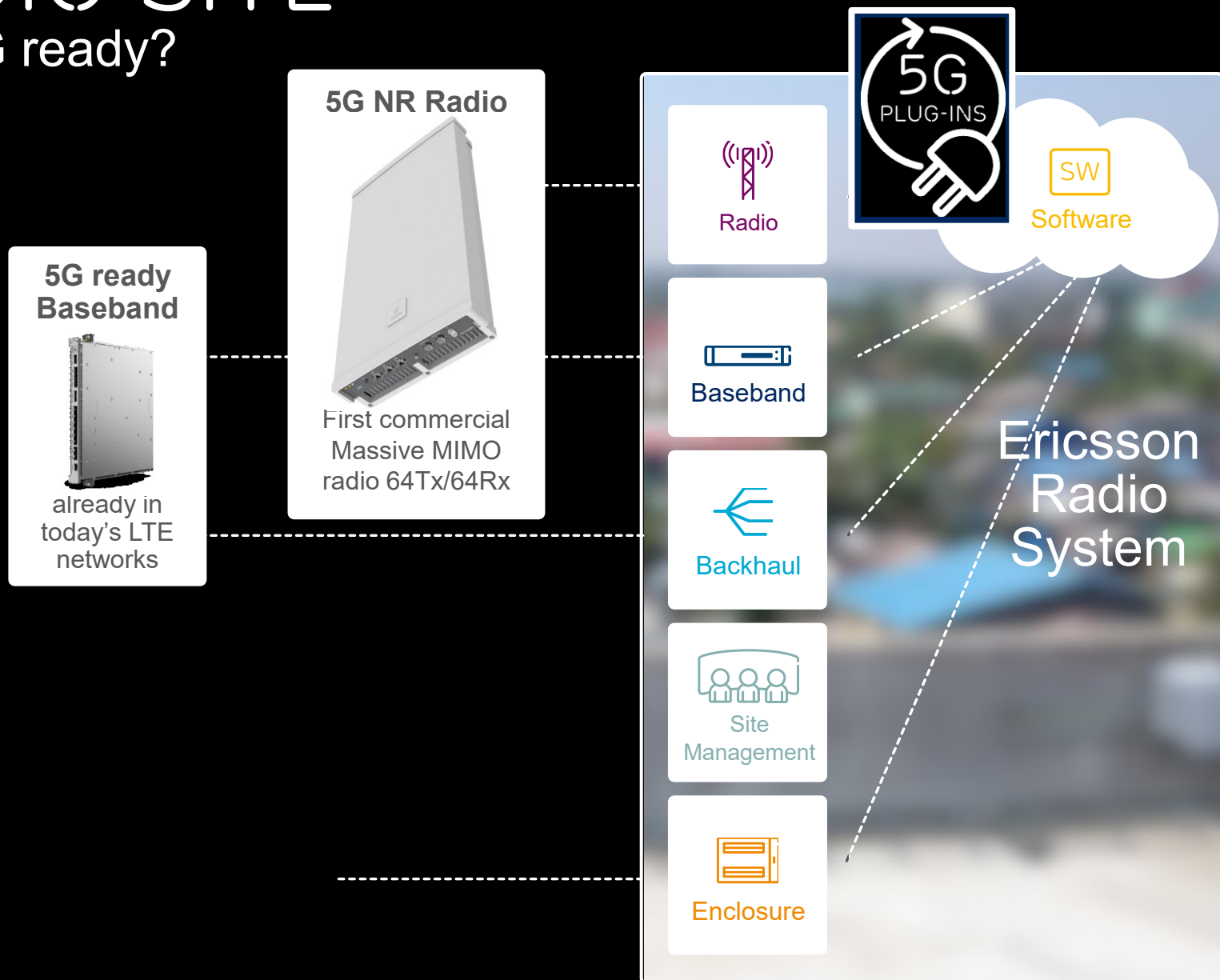Add macro // Add micro // Minimize footprint

SPECTRUM OPTIMIZATION
Analyze // Optimize // Add unlicensed bands

THE RADIO SITE
What makes it 5G ready?

5G NR Radio

5G ready Baseband

already in today's LTE networks

First commercial Massive MIMO radio 64Tx/64Rx

5G PLUG-INS

Radio

Baseband

Backhaul

Site Management

Enclosure

SW
Software

Ericsson Radio System

ON THE ROAD TO 5G

2016	2017	2018	2019	2020

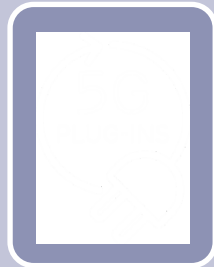| 3GPP Rel-14	Rel-15	Rel-16	Rel-17

Early deployments | 5G new Carrier Type, NR

Low latency

RAN Virtualization

Massive MIMO

Massive IoT

LTE Advanced

MASSIVE MIMO

## Single-user MIMO

› One user per time-frequency resource
› User specific BF provide array gain
› SINR increases as #antenna ports increases
› Benefits regardless of load

Multi-user MIMO

› Multiple users on the same resource
› User specific BF to spatially separate users
› Requires sufficiently high load to show benefits
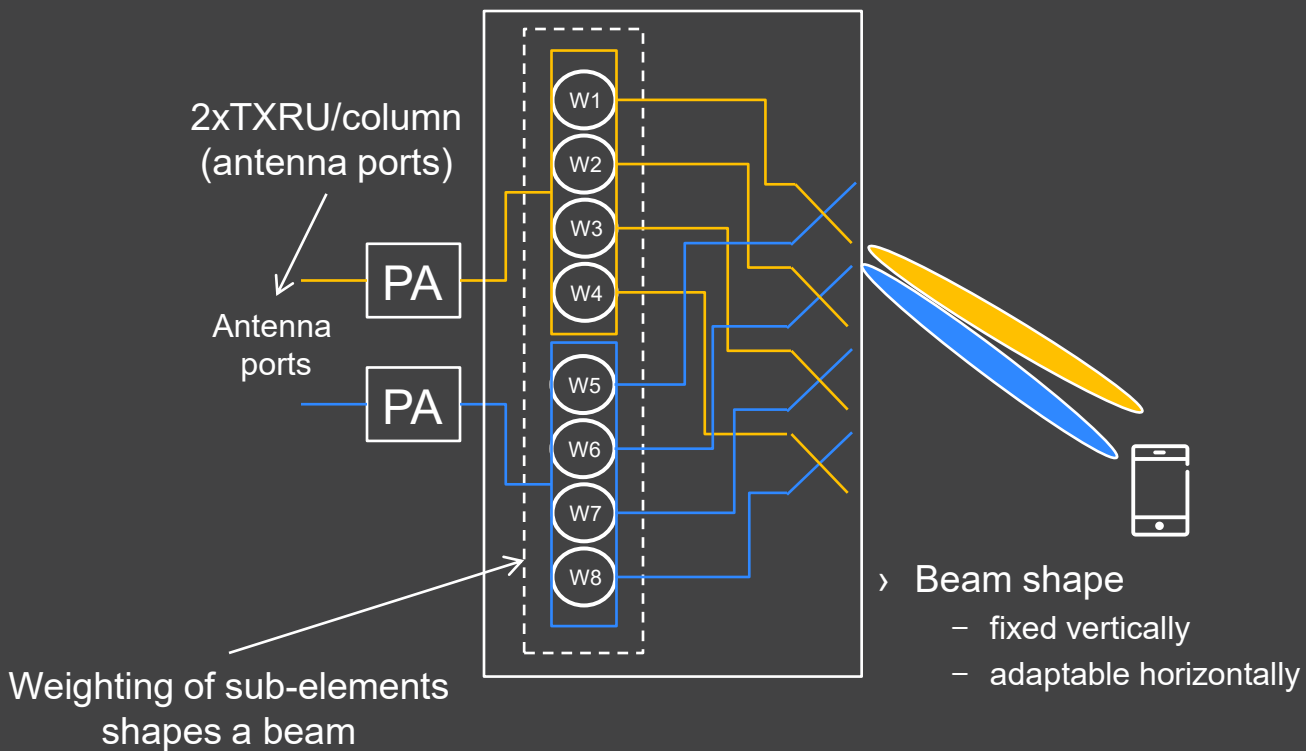› Dynamic switching to SU-MIMO crucial

highly focused beam
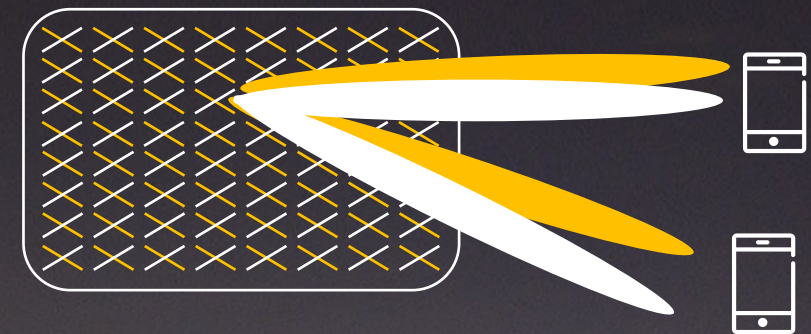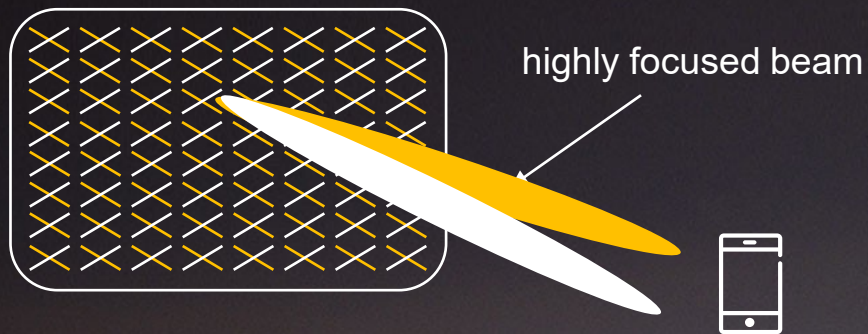
Massive MIMO highly interesting even without MU-MIMO (Channel knowledge ("CSI") is the key!)

5G RAN Evolution | Public | © Ericsson Hungary 2016 | 2016-10-19 | Page 10

HOW TO DO MASSIVE MIMO
CLASSICAL VS. FLEXIBLE ACTIVE ANTENNAS

Classical Antenna

2xTXRU/column
(antenna ports)

Antenna
ports

PA

PA

W1
W2
W3
W4

W5
W6
W7
W8

Weighting of sub-elements
shapes a beam

› Beam shape
  – fixed vertically
  – adaptable horizontally

Flexible Active Antenna

1 x TXRU (small PA & RX) / sub-element

Antenna ports

W1 — PA
W2 — PA
W3 — PA
W4 — PA

W5 — PA
W6 — PA
W7 — PA
W8 — PA

BB can access each
sub-element

› Adaptable & flexible weighting
  – Also vertically
  – Possible inside the antenna as well
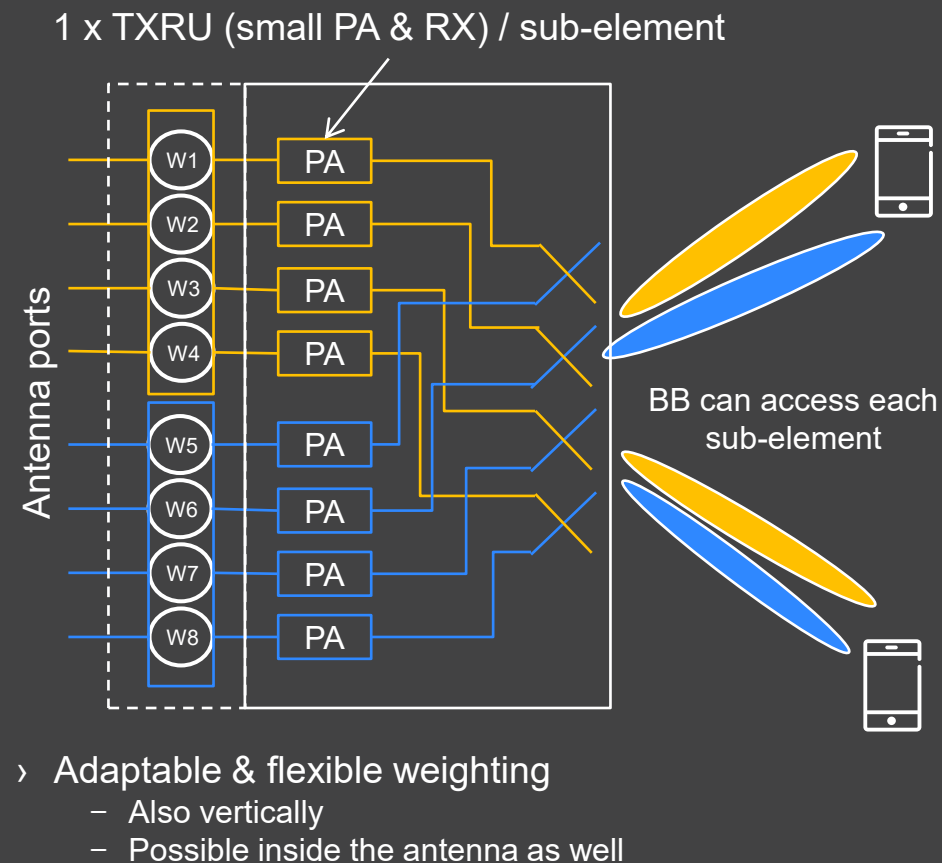
Increased opportunities to adapt the weights!

3GPP 3D-CHANNEL MODELING
PERFORMANCE

3GPP 3D UMi	3GPP 3D UMa
- UE height: 1.5-22.5m	- UE height: 1.5-22.5m
- eNodeB height: 10m	- eNodeB height: 25m
- ISD 200m	- ISD 500m
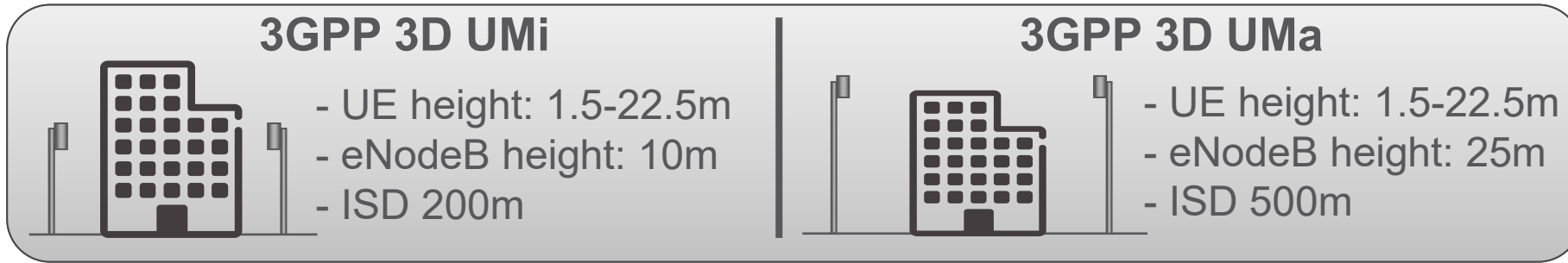
Propagation paths from BS
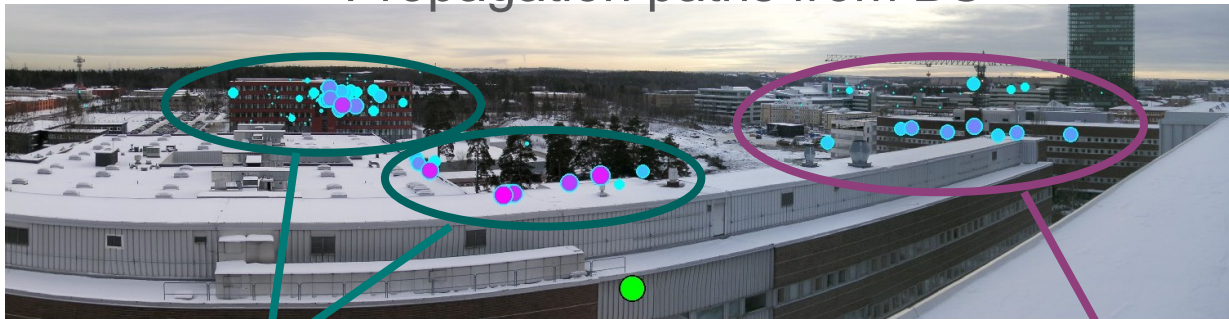
Above rooftop

UE (behind building)

Around buildings

Roof-edge diffracted specular reflection

Direct path (2D) + roof-edge diffraction

"Around building" double diffraction

"Around building" single diffraction

Specular reflection

Roof-edge diffracted specular reflection
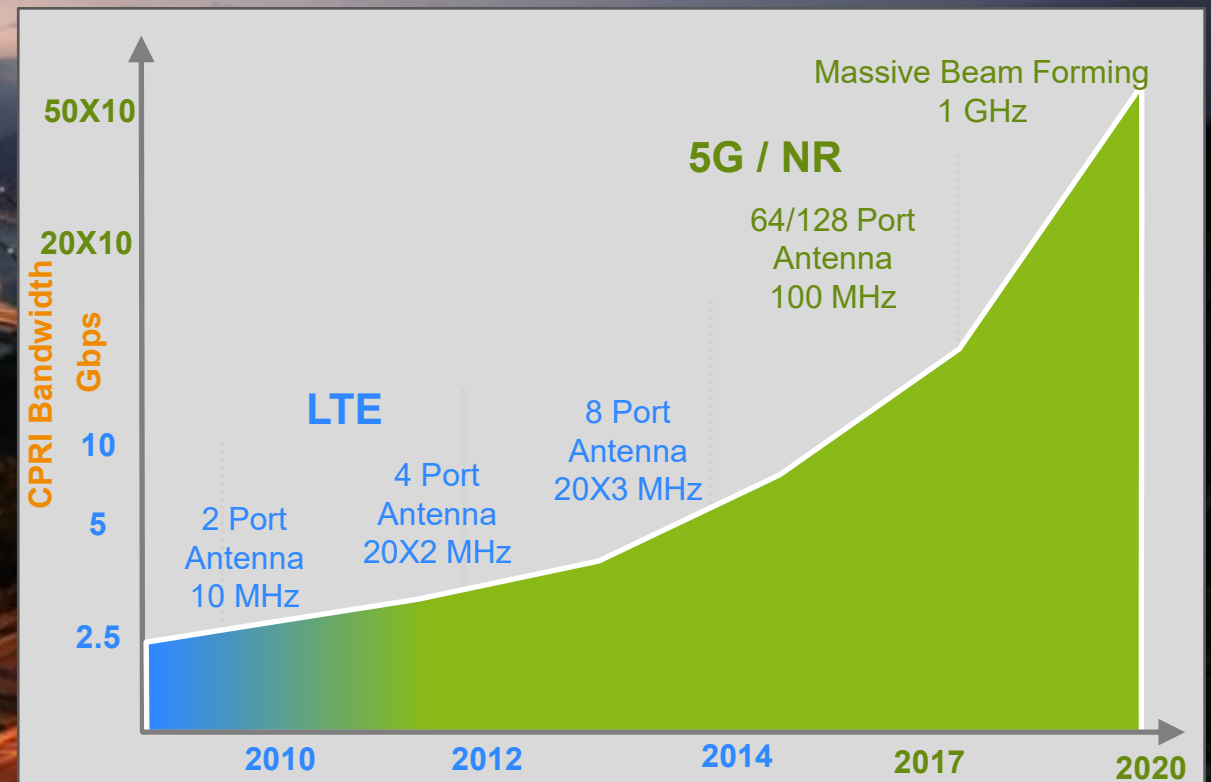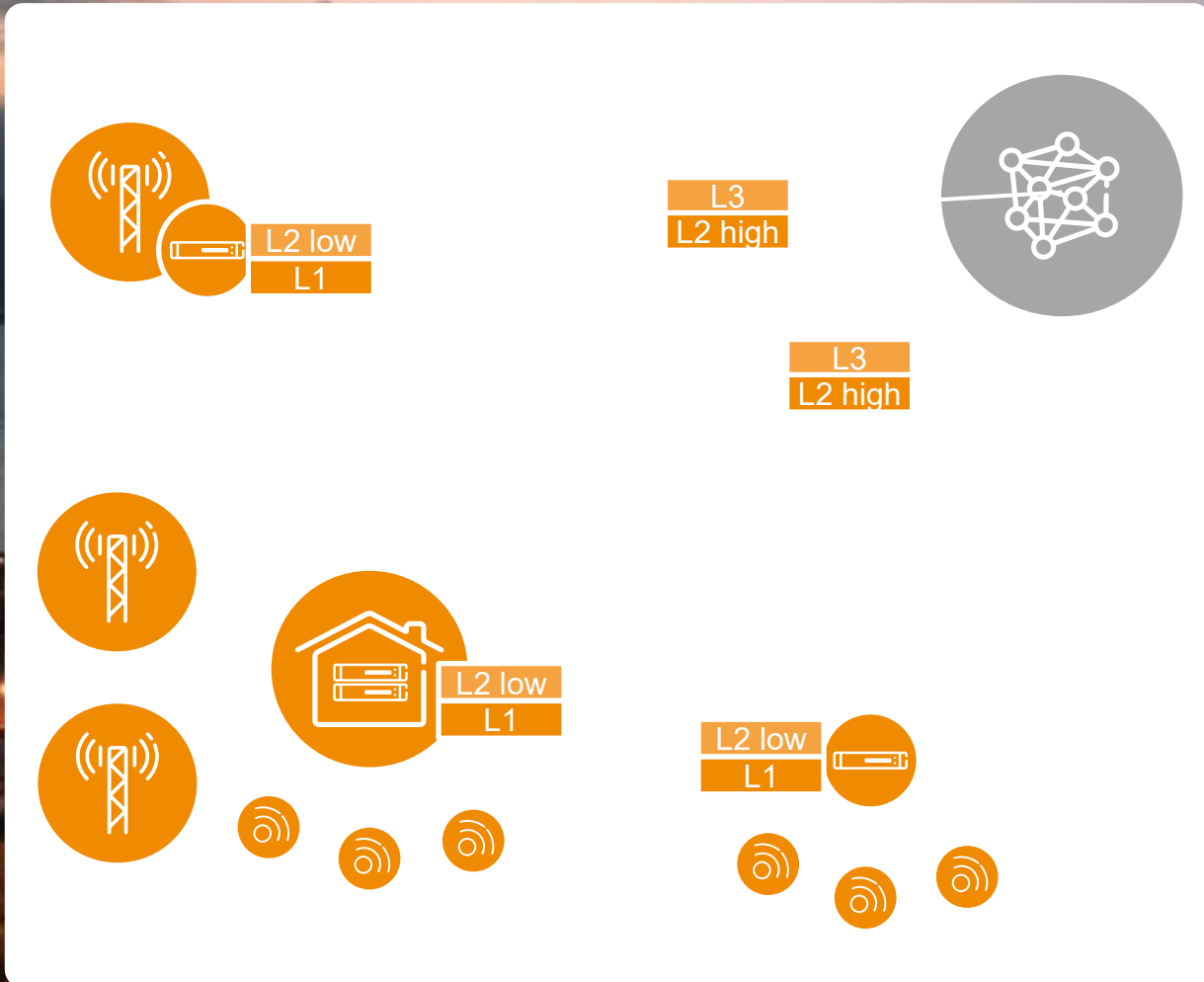
To (behind building)

KED; inside roof because of "sidestep" method
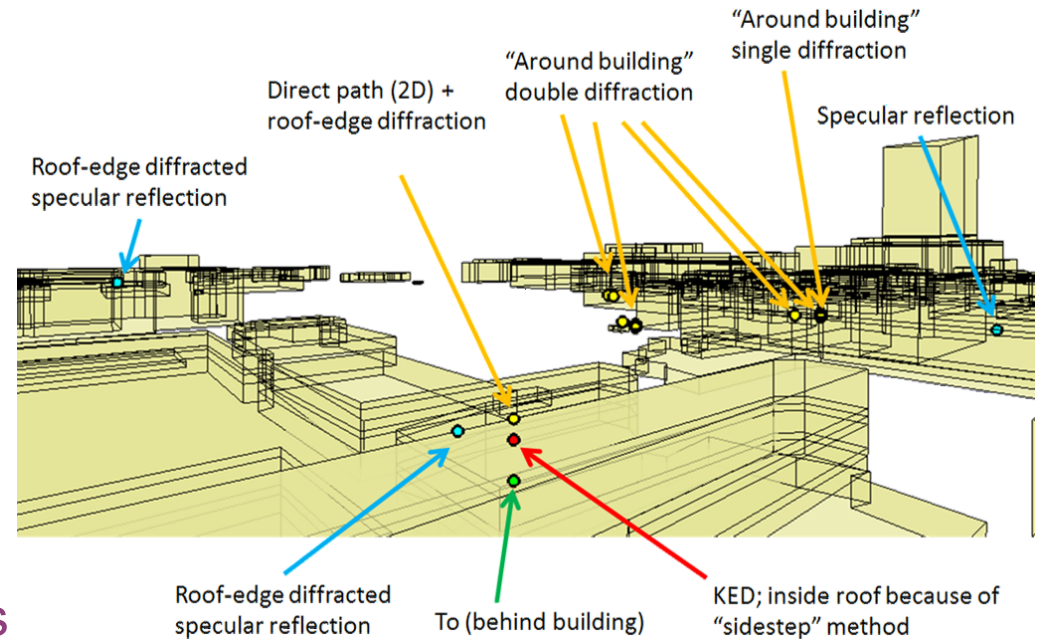
Proper channel modeling is crucial when evaluating Massive MIMO like concepts
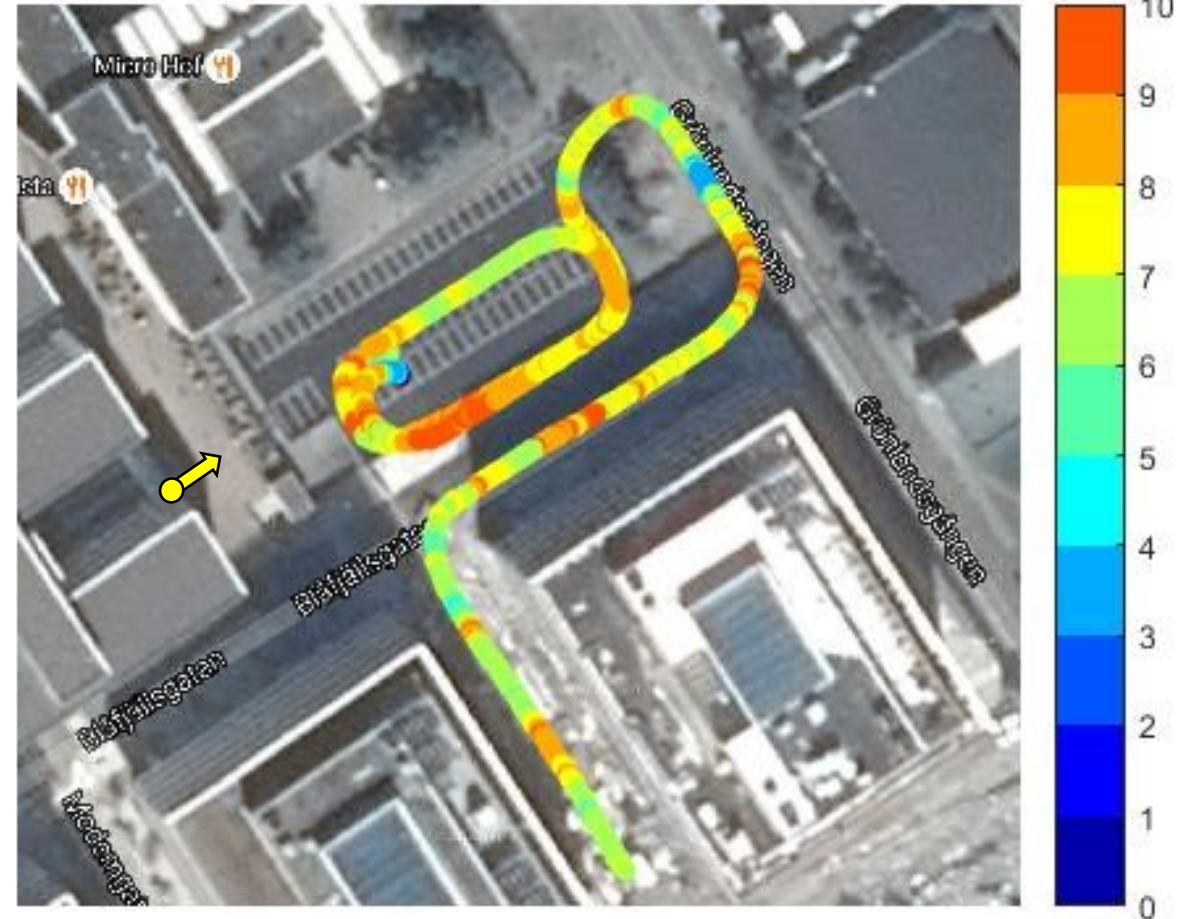
RAN VIRTUALIZATION

STOCKHOLM TRIALS

› Indoor testing in Ericsson Studio
  – Same setup as MWC16
› Outdoor testing with multiple base stations
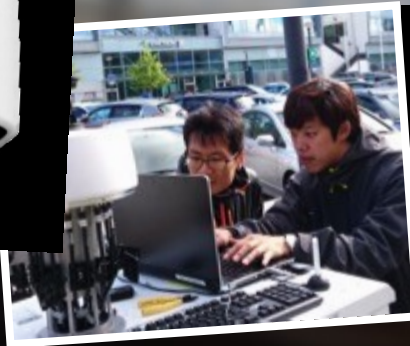› 15 GHz carrier frequency
› 800 MHz BW

Throughput [Gbps]

ERICSSON 5G RADIO TESTBED
Overview

2014/2015

› World wide trials with selected 5G components
› World's first 5+ Gbps
› LTE-NR interworking

"Biggest Contribution to 5G evelopment"

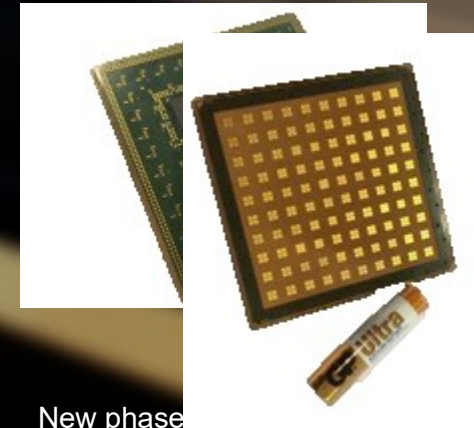### 2017+

› Integration with Cloud RAN and Core Network
› Collaborations with UE partners
› Updated 28 GHz radio with phased array antenna module
› Ready for larger trials

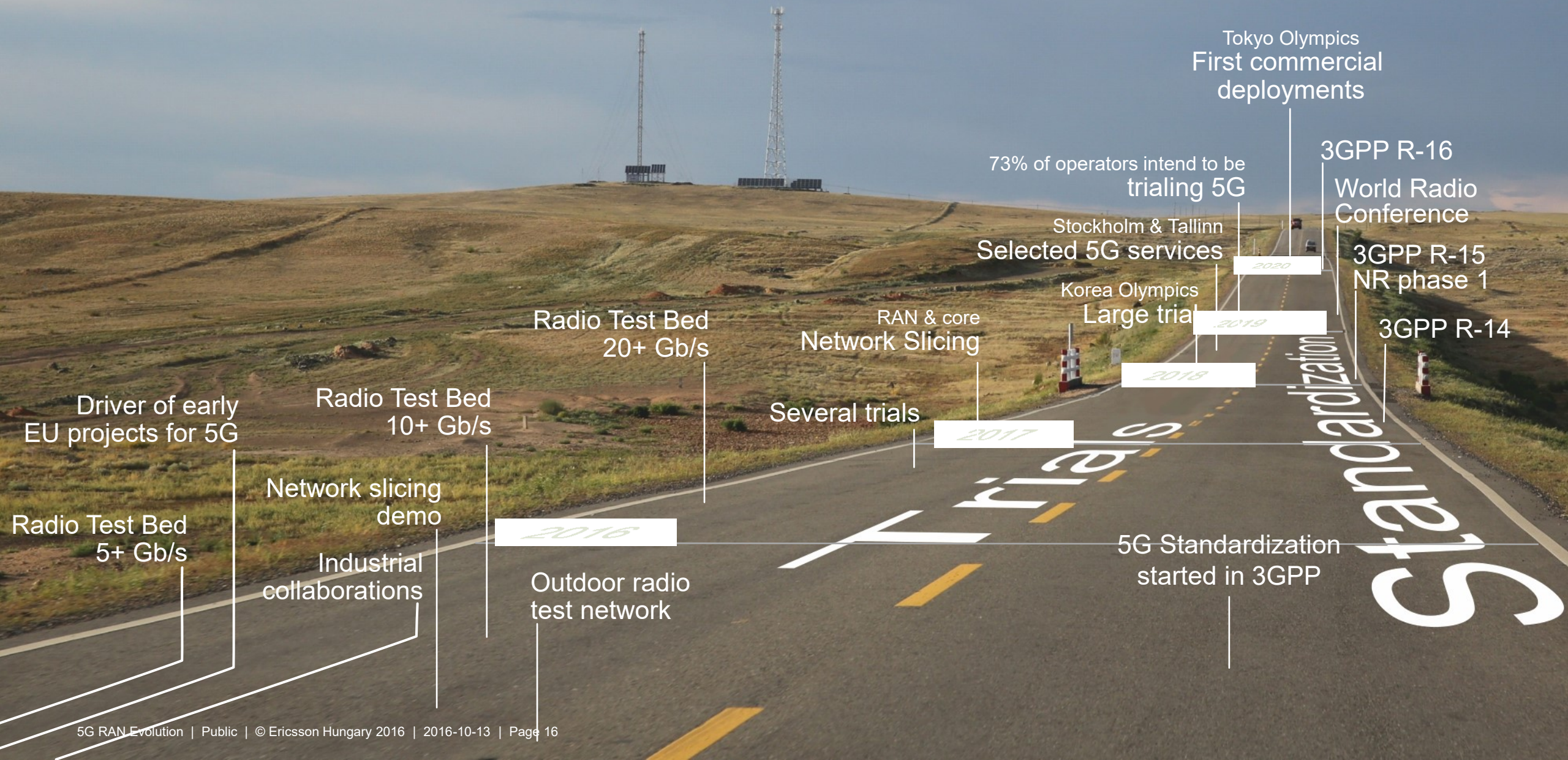New phase[d] [arra]y module. AAA battery for size reference.
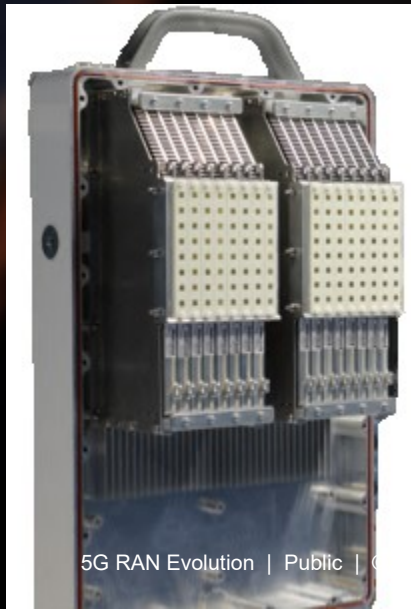
2015/2016

› Full NR concept with advanced beamforming capabilities
› Advanced beamforming radio with 128 antenna elements, 800 MHz IBW
› Up to 15 Gbps per UE
› MU-MIMO with up to 30 Gbps
› Radios at 4, 15 & 28 GHz

5G INDUSTRY HORIZON

Tokyo Olympics
First commercial deployments

73% of operators intend to be trialing 5G

3GPP R-16

Stockholm & Tallinn
Selected 5G services

World Radio Conference

Korea Olympics
Large trial

3GPP R-15
NR phase 1

RAN & core
Network Slicing

3GPP R-14

Radio Test Bed 20+ Gb/s

Several trials

Driver of early EU projects for 5G

Radio Test Bed 10+ Gb/s

2020

2019

2018

2017

Trials

Standardization

Network slicing demo

2016

Radio Test Bed 5+ Gb/s

5G Standardization started in 3GPP

Industrial collaborations

Outdoor radio test network

DEPLOYING 5G