5G - THE MULTI ANTENNA ADVANTAGE

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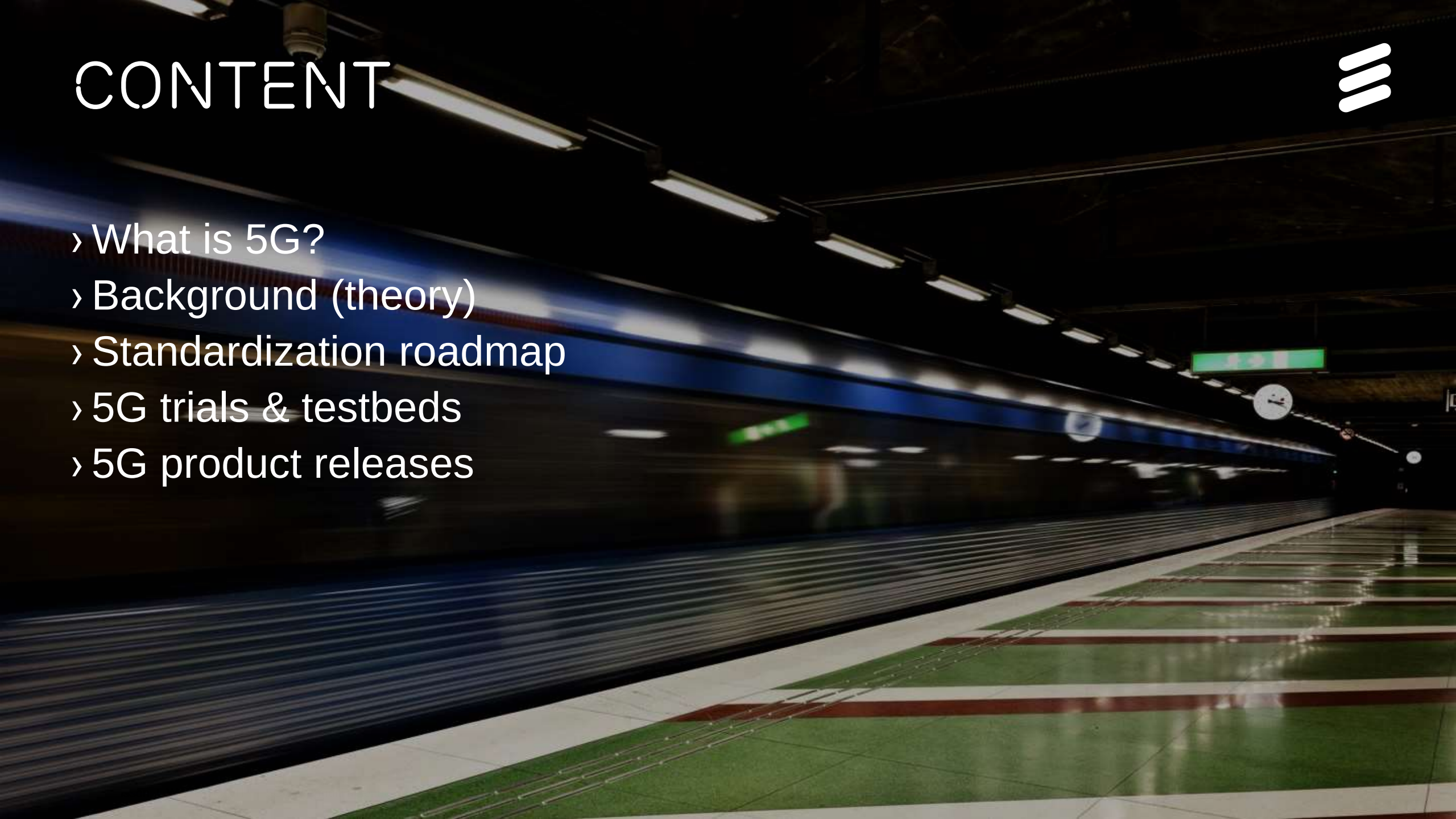
Systems & Technology

CONTENT



- What is 5G?
- Background (theory)
- Standardization roadmap
- 5G trials & testbeds
- 5G product releases

5G
WHAT AND WHY?

CONNECTED DEVICES

IN 2021

28 BILLION

Source: Ericsson Mobility Report, June 2016

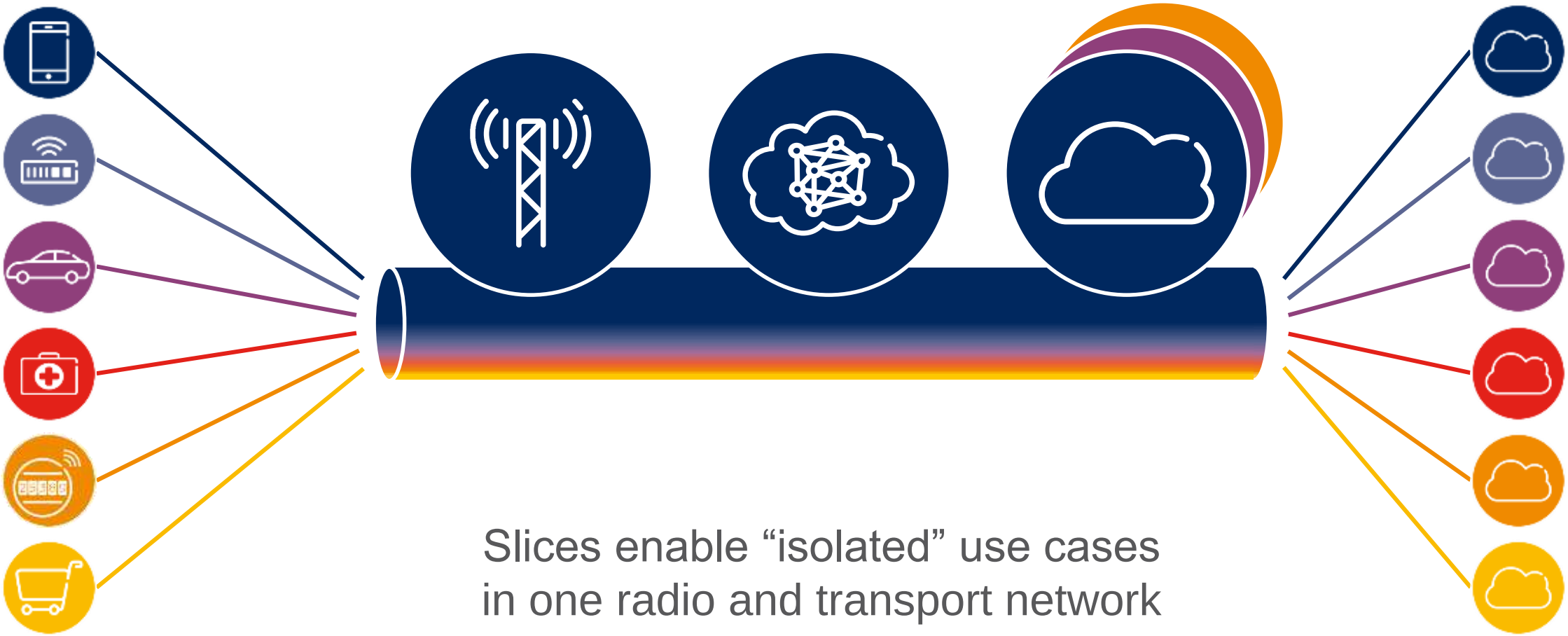
12 BILLION

PHONES, PC/LAPTOPS/TABLETS

16 BILLION

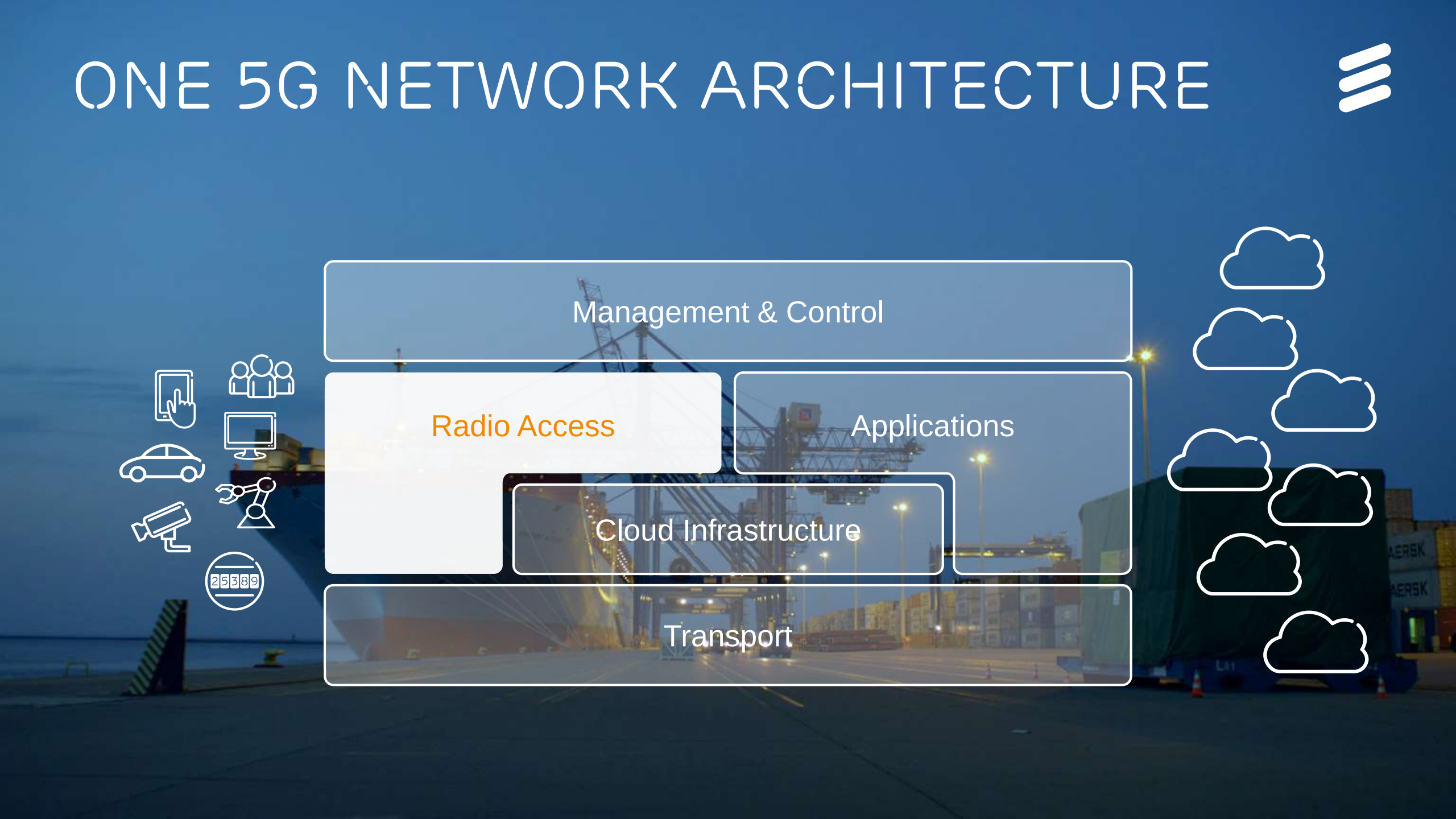
IoT DEVICES

5G RAN – ONE NETWORK FOR MULTIPLE INDUSTRIES



Slices enable “isolated” use cases
in one radio and transport network

ONE 5G NETWORK ARCHITECTURE



REQUIREMENTS

- Capacity 1000x
- Latency <1ms
- Peak 10Gbps
- Coverage >100Mbps
- Massive amount of devices

Full-length HD movie in seconds

Smart Vehicles & Autonomous Cars

Fixed wireless broadband

Virtual Reality / Augmented Reality

10 Year Battery Life for Remote Sensors

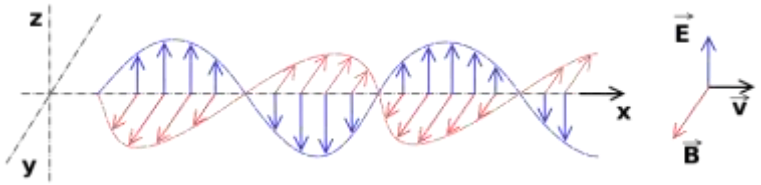
Remotely Operate Robots

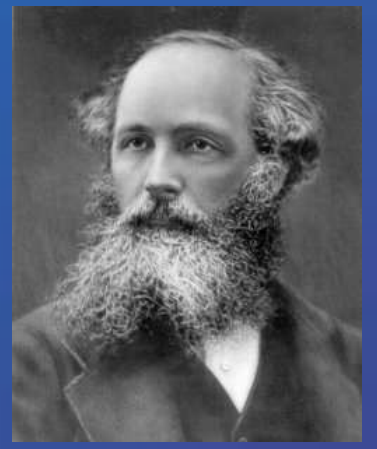
BACKGROUND

(THEORY)

ELECTROMAGNETIC WAVES

- Generated by accelerating electric charges
  - Such as a time-varying current in a transmitting antenna
- Time-varying coupled electric and magnetic fields
  - Propagates at speed of light
- Can induce currents in conducting materials
  - Such as in a receiving antenna





James Clerk Maxwell (1831-1879)

$$\nabla \cdot \mathbf{D} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

CHANNEL CAPACITY

- The amount of information C [bits/s] that can be reliably transmitted over a channel is a function of the bandwidth B and the signal to noise (and interference) ratio S/N

- What can we do?

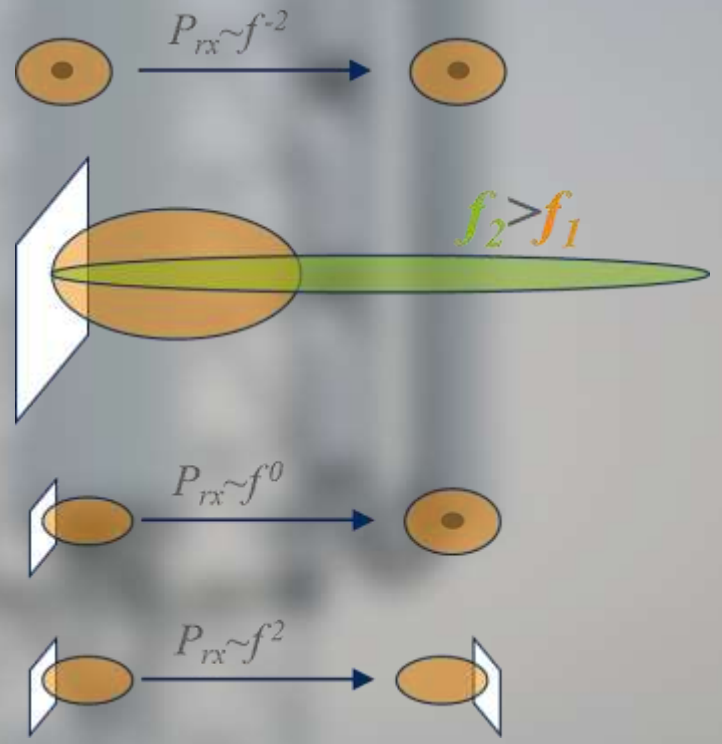
1. Increase the bandwidth
2. Improve the signal quality

Claude Shannon (1916-2001)

$$C = B \cdot \log_2\left(1 + \frac{S}{N}\right)$$

WHERE CAN WE FIND ADDITIONAL BANDWIDTH?

- Quite crowded at <5 GHz
- Higher frequency bands being considered, all the way up to 70 GHz
- Path loss will be an issue, or will it?
- Highly directive antennas may be the solution <u>if we can make sure they are pointed in the right direction</u>
  - Massive antenna arrays and adaptive beamforming needed
  - Angular spread and mobility will be large challenges



MIMO OR BEAMFORMING
HOW TO USE THE ANTENNA APERTURE

- Back to Shannon $C = \log_2(1 + SNR)$
  - No more bandwidth

Low SNR:

log(1+SNR) ≈ SNR

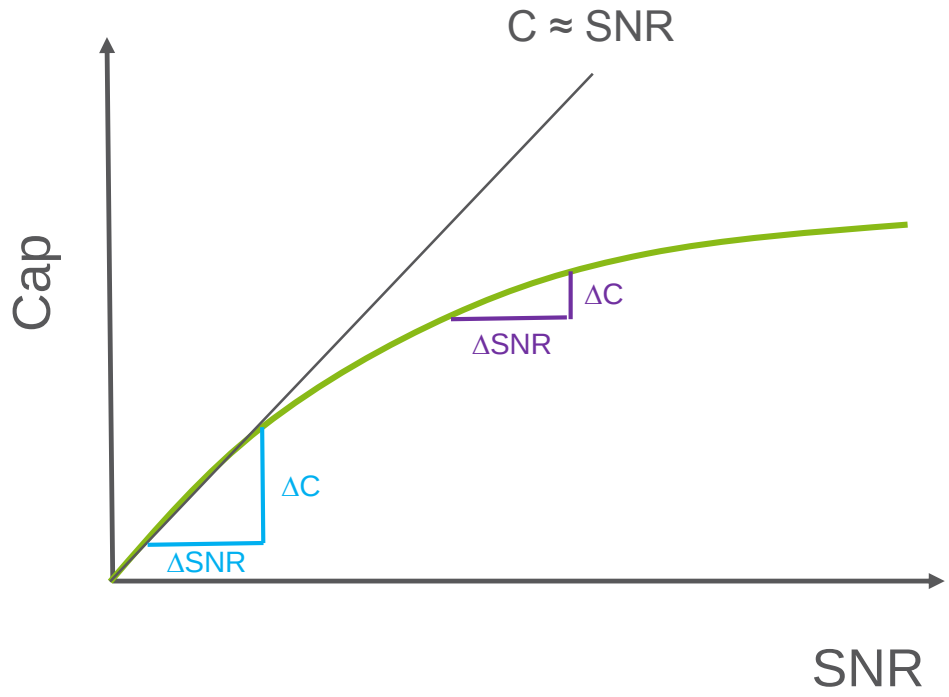
Beamforming and/or Rx diversity

High SNR:

log(1+SNR) ≈ log(SNR)

Power inefficient transmission

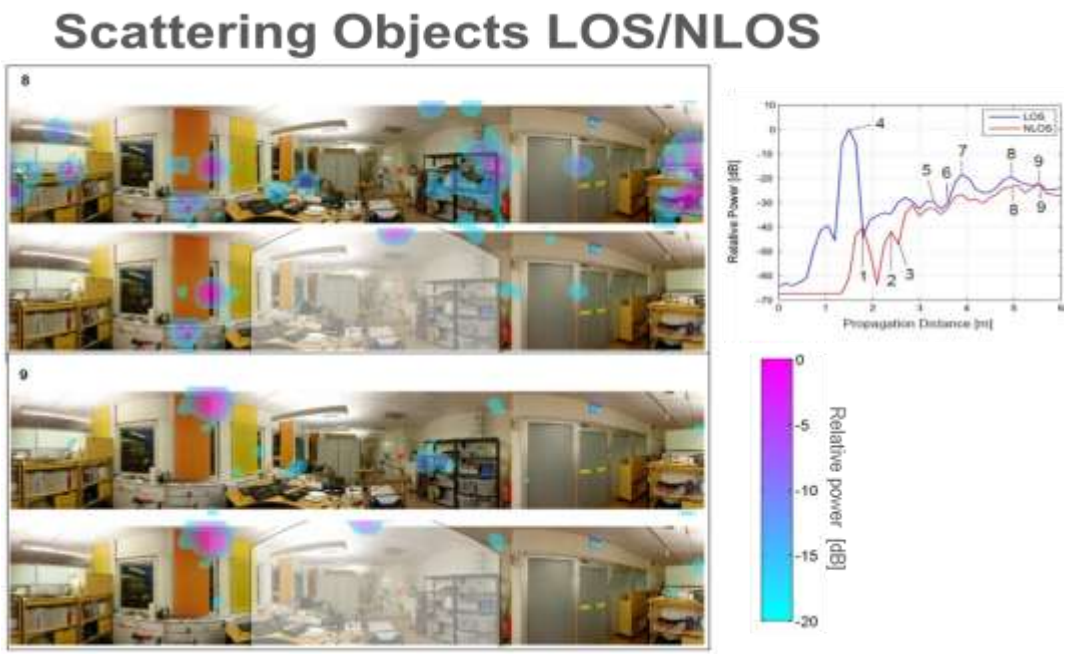
Transmit parallel layers

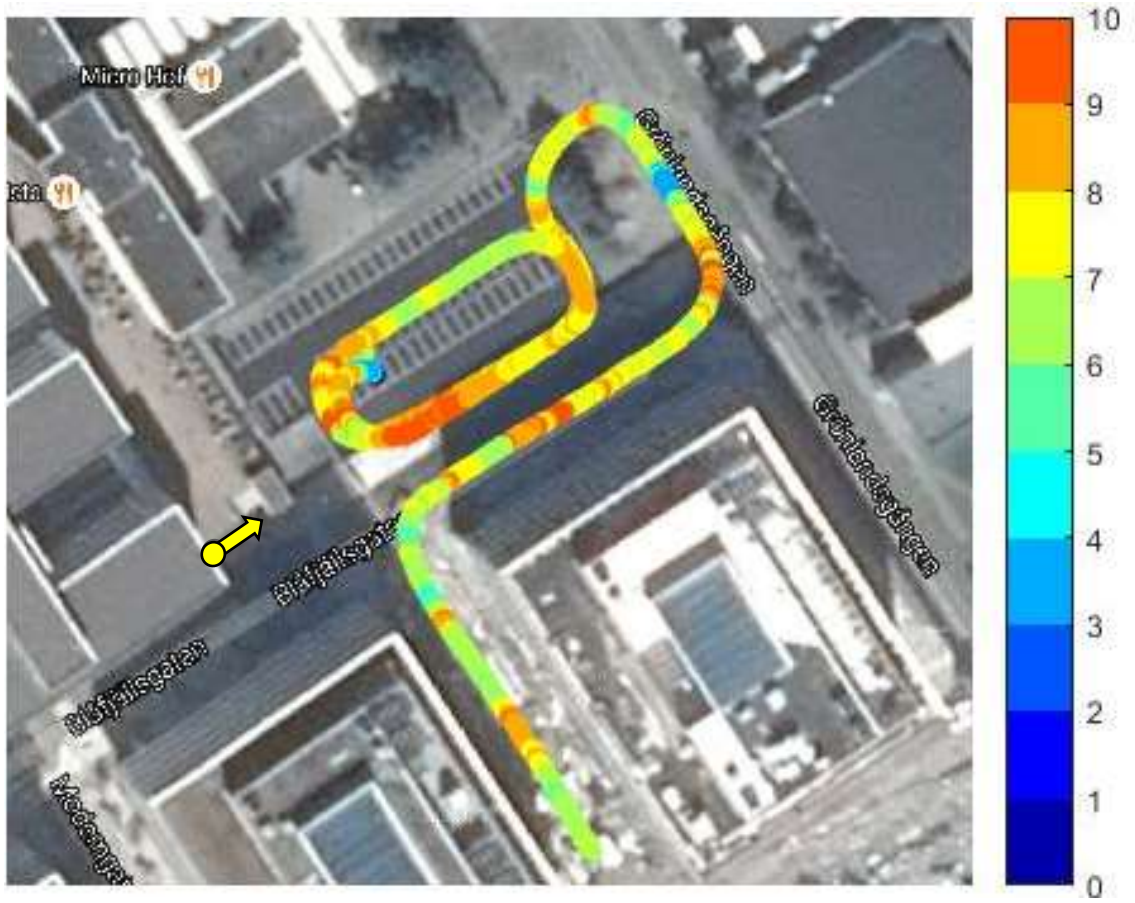


Spatial multiplexing

Transmit in several beams using the same physical resource

SCENARIO IMPORTANT





- Cubic virtual array 25x25x25 (15625)
- 800 freq samples in 2GHz BW

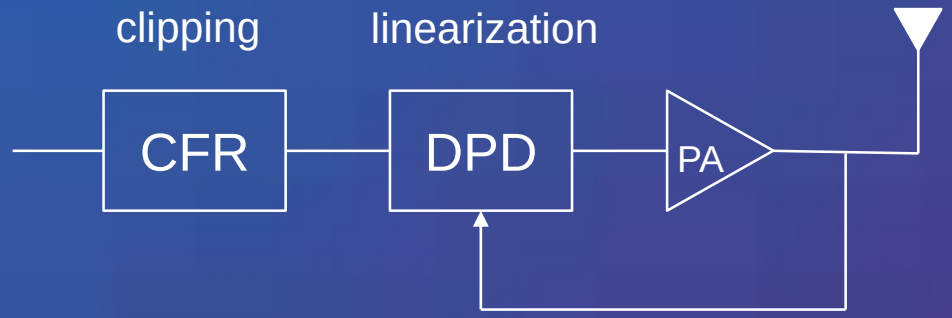
CHALLENGES

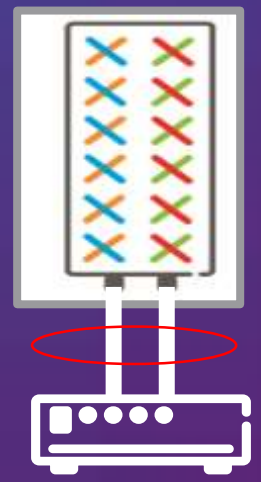
HIGH FREQUENCIES
LARGE BANDWIDTHS
MANY BRANCHES
INTERCONNECT

MMAS (MASSIVE MULTI ANTENNA SYSTEMS)

- Radio signal processing overhead
  - Pout = 100W
  - Digital processing = 1W
- MMAS with 100 branches
  - Pout = 1W
  - Digital processing 1W
- New technology needed
- High degree of integration

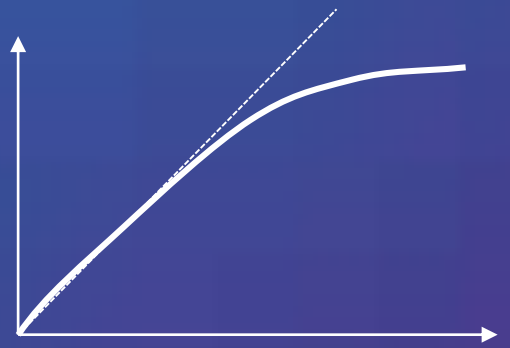
- Front haul transmission (CPRI)
  - 1 branch, 20 MHz => ~500Mbps
  - 64 branches, 200 MHz => 320Gbps
- Move part of PHY to radio/antenna
  - MIMO/beamforming expansion

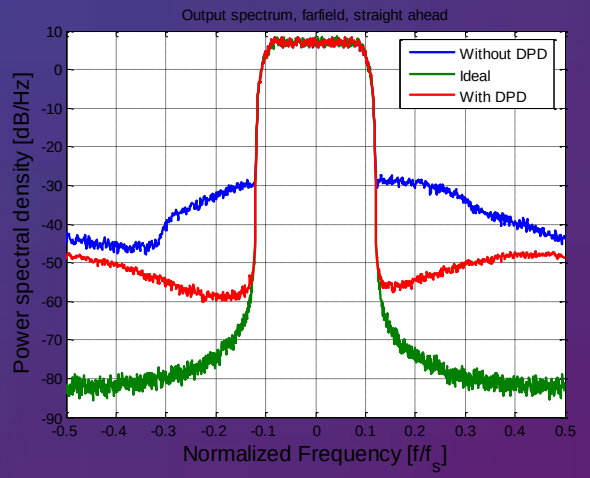




HIGH FREQUENCIES
CM-/MM-WAVES

- High pathloss
  - High EIRP (Equivalent Isotropic Radiated Power) = PA power + antenna gain
- High power difficult
  - Large losses (material)
  - Routing, filters, etc…
- Large bandwidths available
  - Several GHz BW
  - Linearization complex (3rd, 5th order)
  - Large back-off (OFDM high PAR)
- High frequency => small geometries
- Power dissipation problem





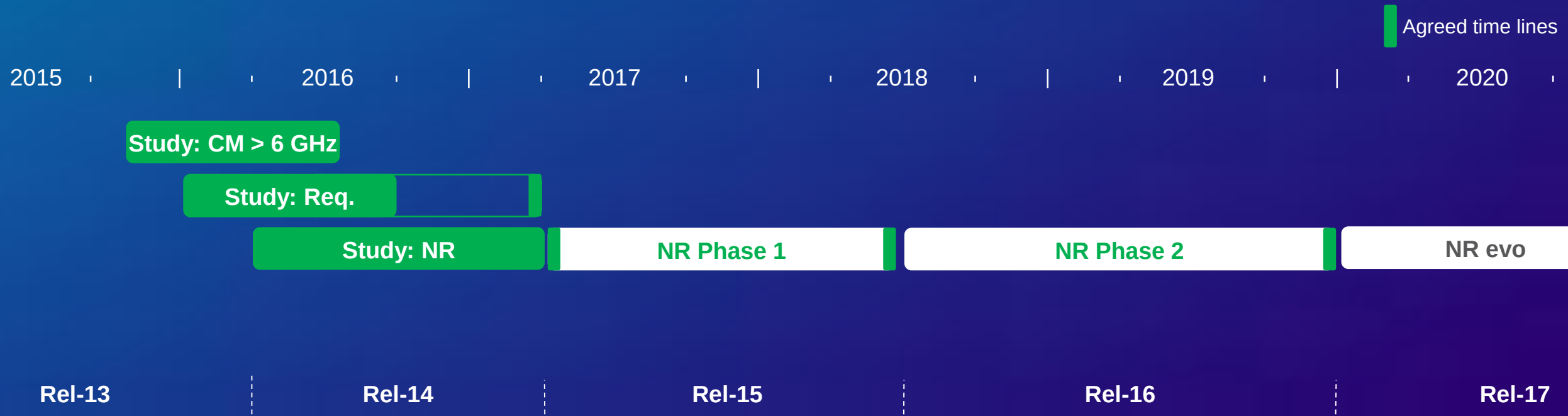
5G STANDARDIZATION

3GPP – 3RD GENERATION PARTNERSHIP PROGRAM

A GLOBAL INITIATIVE

3GPP OVERALL PLAN FOR NR

- 2 steps
  - Rel-15 ending H2 2018
  - Rel-16 ending Dec 2019
- First step includes a subset of use cases & requirements
  - should be forward compatible with the later phase
- Rel-15 scope
  - Support for both Standalone and Non-Standalone operation
  - eMBB, Low Latency, and High Reliability
  - <6GHz and >6GHz
- Discussions at June 3GPP RAN meeting on accelerated time-schedule

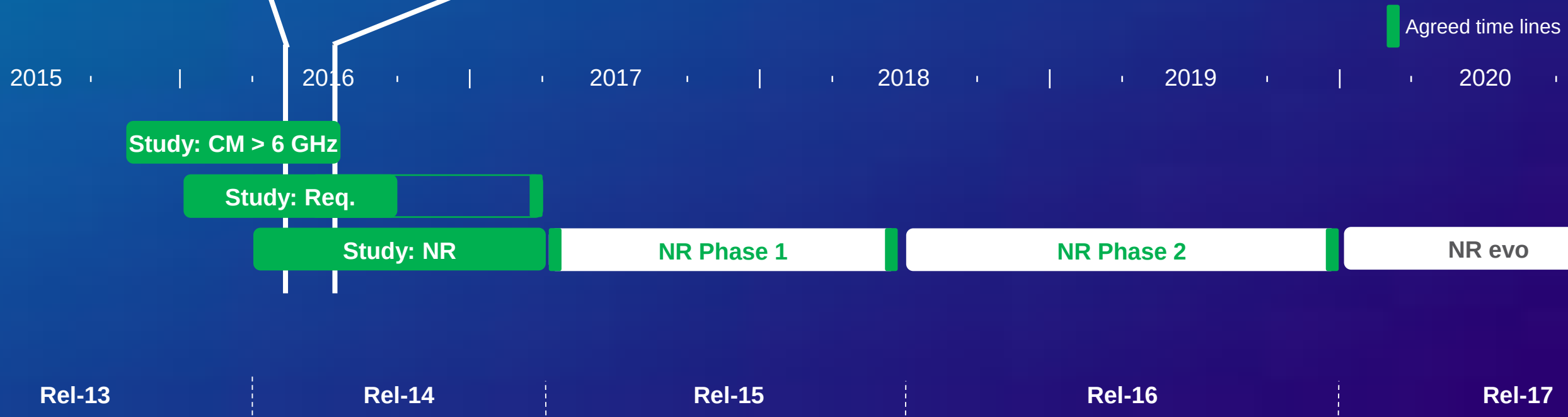


3GPP STATUS

Mid April 2016
- First technical discussions in WGs

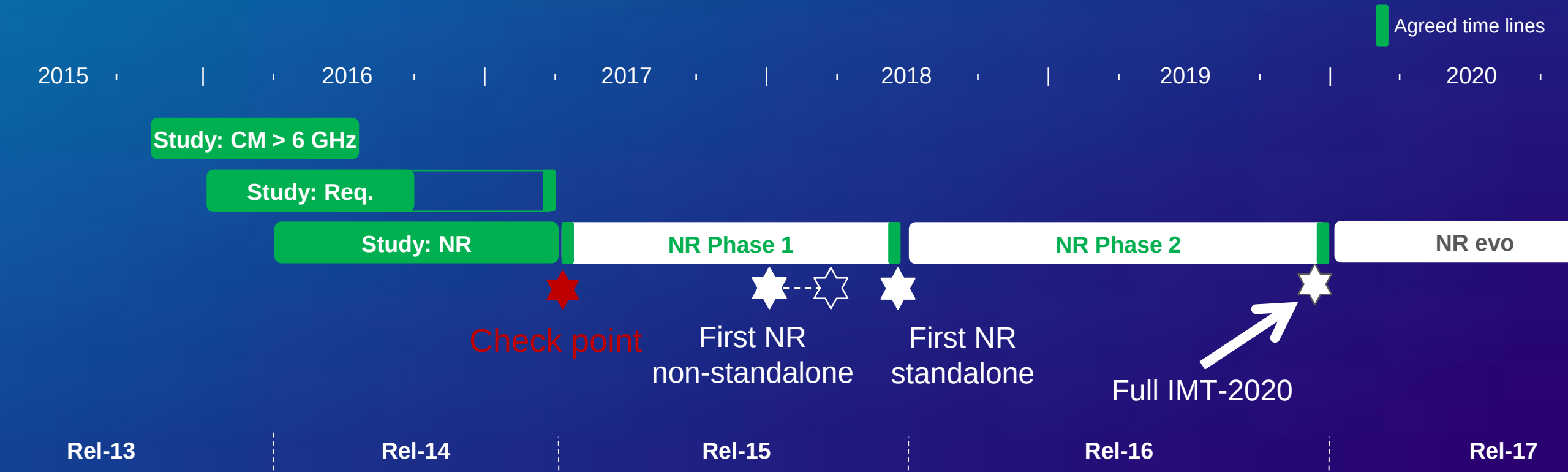
End May 2016
- Working assumption on numerology

3GPP RAN meeting, mid June 2016
- Agreement on accelerated time-schedule
- The channel modeling SI for spectrum >6GHz was completed, TR 38.900 was approved
- New target to complete TR 38.913 on Requirements and related SI decided to be September 2016



3GPP ACCELERATION

- Early market requirements for deployments in late 2018
- Aim for a first version in Dec 2017 with non-standalone
- 3GPP agreement in mid June




ERICSSON
NX 5G TESTBED
Overview 2016

ERICSSON 5G RADIO TESTBED

Overview

2014/2015

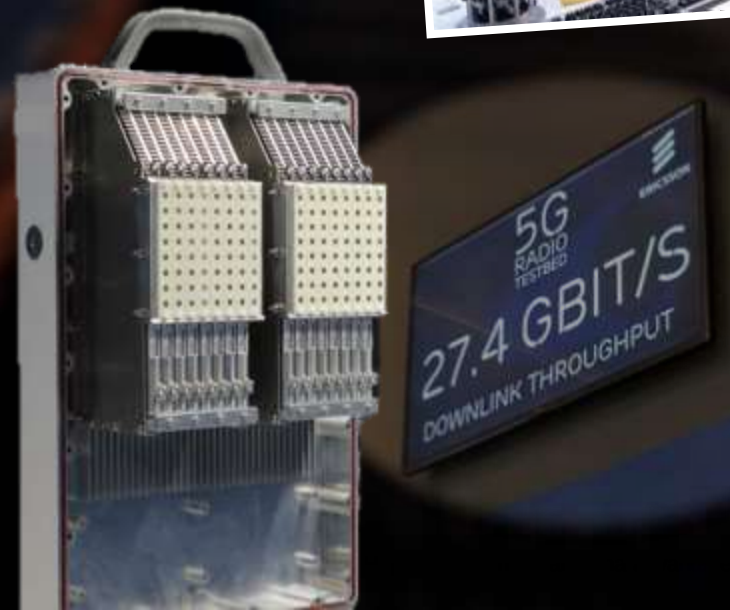
- World wide trials with selected 5G components
- World's first 5+ Gbps
- LTE-NR interworking

LTE ASIA AWARDS 2015

"Biggest Contribution to 5G Development"

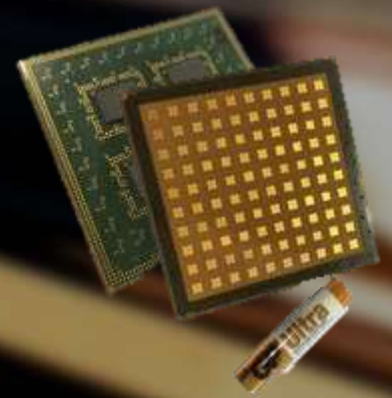
2015/2016

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



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



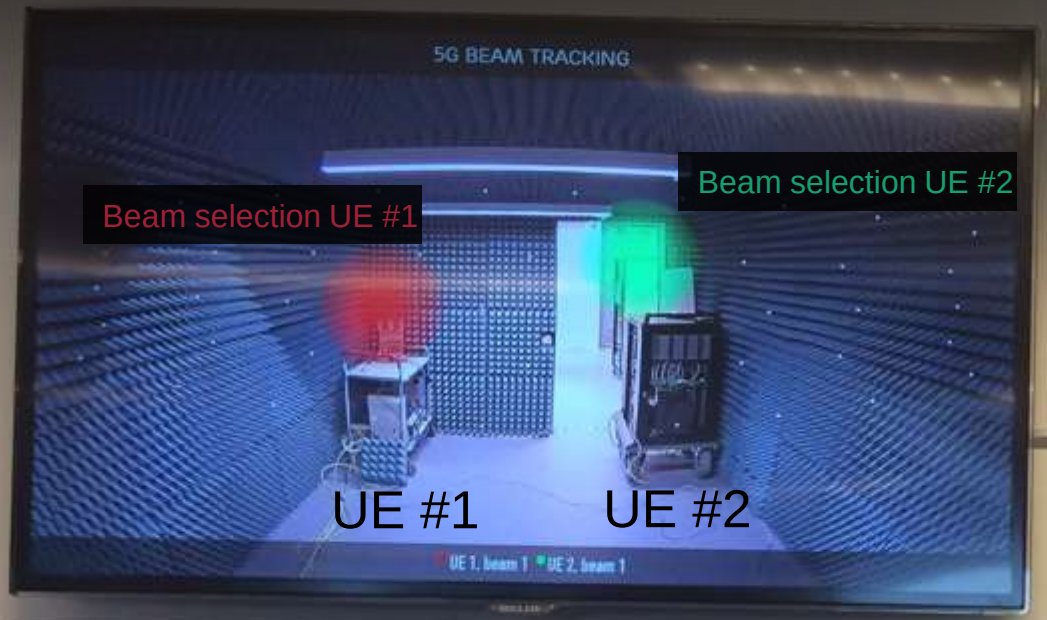
New phased array antenna module. AAA battery for size reference.

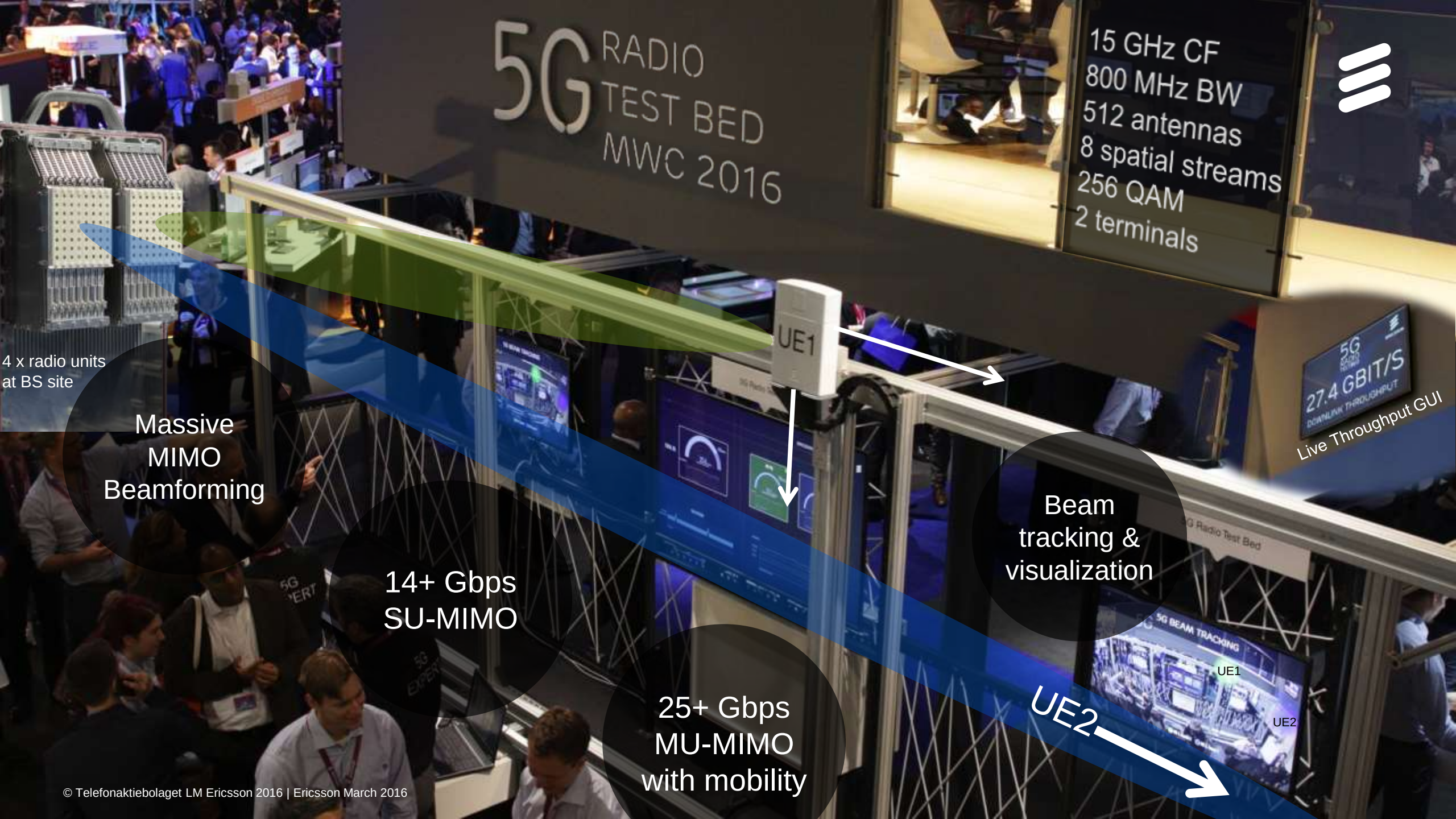
5G TESTBED CONCEPT OVERVIEW

Full L1/L2 concept with inherent support for e.g.

- Beam-forming & -tracking
- MU & SU MIMO
- Multi-site transmission
- Ultra Lean Design
- Dynamic TDD

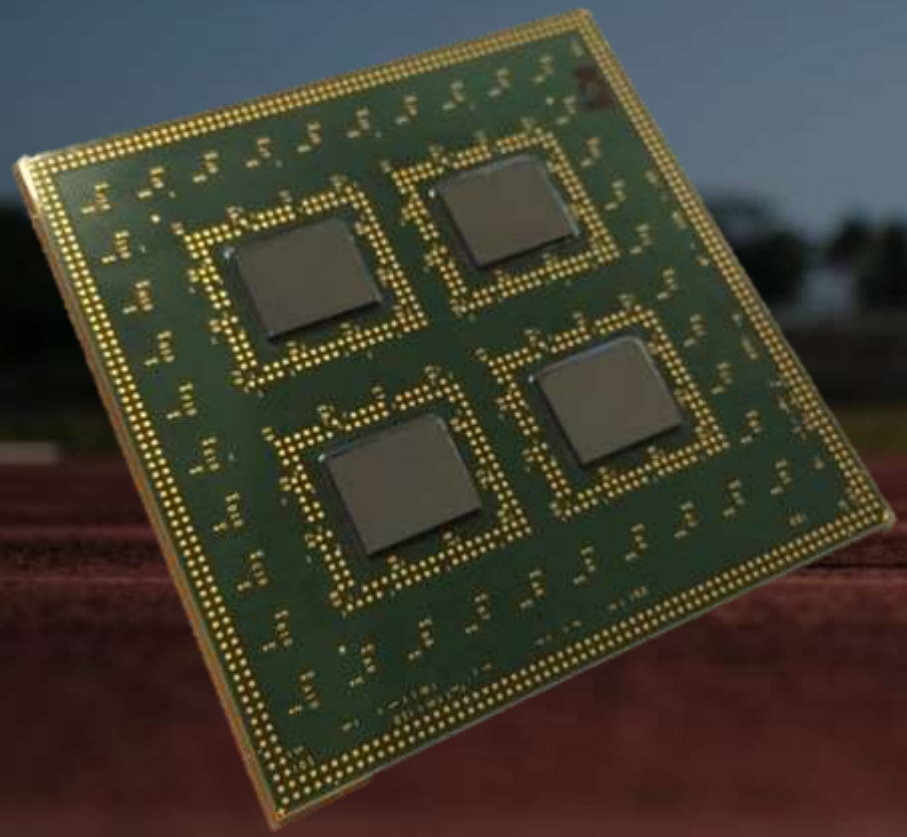
25 GBIT/S MU-MIMO





UPDATED 28 GHZ RADIO

› Updated 28 GHz radio with phased array antenna module



128 radio chains

AAA battery for size reference

ERICSSON FIRST TO DELIVER ALL COMPONENTS OF 5G ACCESS NETWORK

ERICSSON 5G ROADMAP

Moving 5G technology from test to commercial deployment

Ericsson 5G
Radio Test Bed Win!

Biggest Contribution to 5G Development

LTE Asia Awards
October 2015

1st 5 Gbps throughput – June 2014

1st Dual Connectivity LTE-5G

1st Multipoint Connectivity with distributed MIMO

5G Radio Prototype field trials in 2016

Ericsson 5G field trial gear achieves peak downlink throughput over 25 Gbps with MU-MIMO

5G Plug-Ins

2014 | PHASE 1

- Key technology features testing
- System level evaluation
- Four 5G Radio Testbeds (US, Japan, Korea, Sweden)

2015-2016 | PHASE 2

- Test application of 5G for key use cases
- Advance technology development

2017+ | PHASE 3

- Complete trial network
- Form factor for pre-commercial deployment

ERICSSON 5G PLUG-INS

Software innovations applying 5G technology concepts

- MASSIVE MIMO
- MULTI-USER MIMO
- RAN VIRTUALIZATION
- LATENCY REDUCTION
- INTELLIGENT CONNECTIVITY

ERICSSON RADIO SYSTEM
SHIFTS TO NEXT GEAR

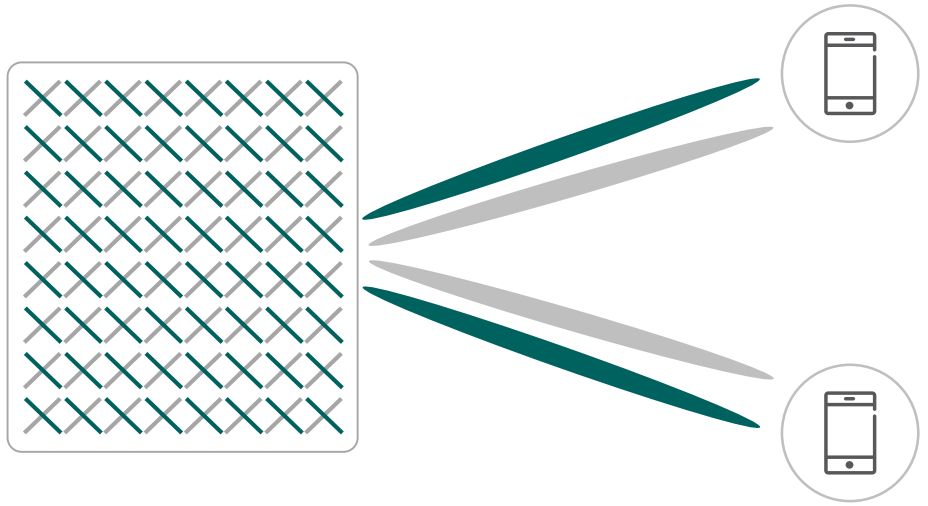
PERFORMANCE EVOLUTION // NETWORK DENSIFICATION // SPECTRUM OPTIMIZATION

MIMO PLUG-INS

Beamforming and beam steering for best user experience and network capacity

Massive MIMO

Multi-User MIMO



FIRST 5G NR RADIO: AIR 6468

5G NR RADIO

FIRST COMMERCIAL 5G NR MASSIVE MIMO RADIO

- 64T / 64R active antenna system
- LTE and 5G NR going forward
- Supports 5G plug-ins: Massive MIMO and Multi-user MIMO
- Beamforming as part of Cloud RAN split baseband architecture
- Works with today’s Ericsson Radio System Baseband
- 5–6 times capacity compared to 8T / 8R configuration
- First deployments mid 2017

SPECTRUM MANAGEMENT: UPLINK SPECTRUM ANALYZER

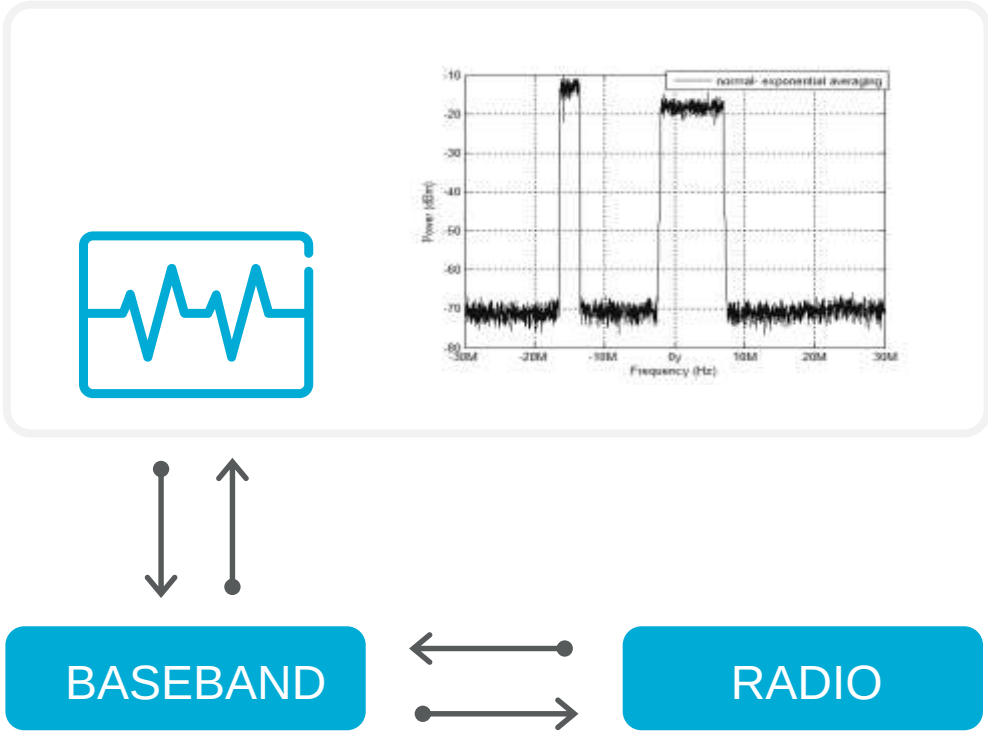
OPERATOR CHALLENGE:

Improve network quality and control the radio spectrum without costly site visits for measurements

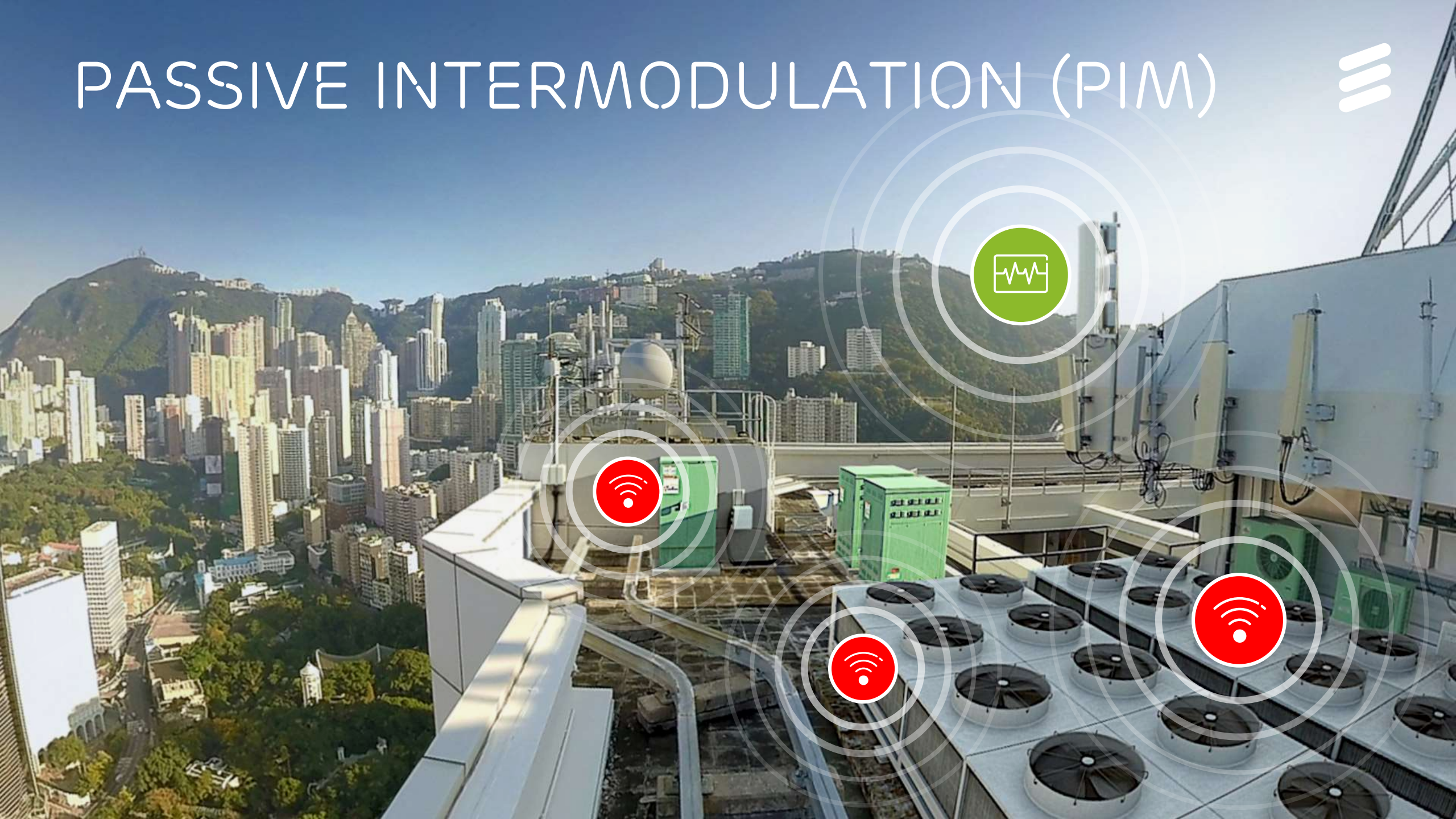
NEW UNIQUE SOFTWARE: DETECT PROBLEMS AND MAXIMIZE REVENUE

- Your Radio is your uplink spectrum analyzer
  - Without interrupting normal traffic
- Study uplink spectrum without site visit
- Fast trouble shooting to minimize revenue loss
- Unique way to position external interferes by triangulation from several sites
- Detect Passive Intermodulation issues

UPLINK SPECTRUM ANALYZER FUNCTION IN CENTRAL MANAGEMENT SYSTEM



PASSIVE INTERMODULATION (PIM)



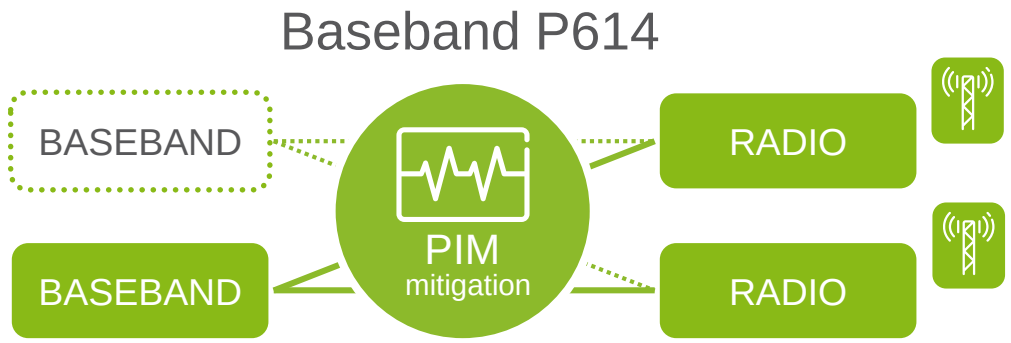
SPECTRUM OPTIMIZATION: PIM MITIGATION BASEBAND P614

OPERATOR CHALLENGE:

Address intermodulation issues from billboards, diesel generators, AC equipment, satellite dish equipment close to the antenna

PIM MITIGATION FOR THE BEST PERFORMANCE OVER TIME

- 19” unit, fully integrated in Ericsson Radio System
- Improves network performance
- Mitigates Passive Inter Modulation – inside and outside antenna system, from static and dynamic PIM sources – also for different band combinations
- Enables operators to use frequency bands that have notorious PIM issues



PIM CANCELLATION

- PIM signal function of Tx signals
- All your Tx signals known in baseband
- Potentially harmful PIM frequencies known
  - E.g f1 + 3(f1-f2) + f3 may end up in Rx band f2
- Estimate “leakage” filter
  - Transfer function of PIM signal
- Remove from Rx signal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