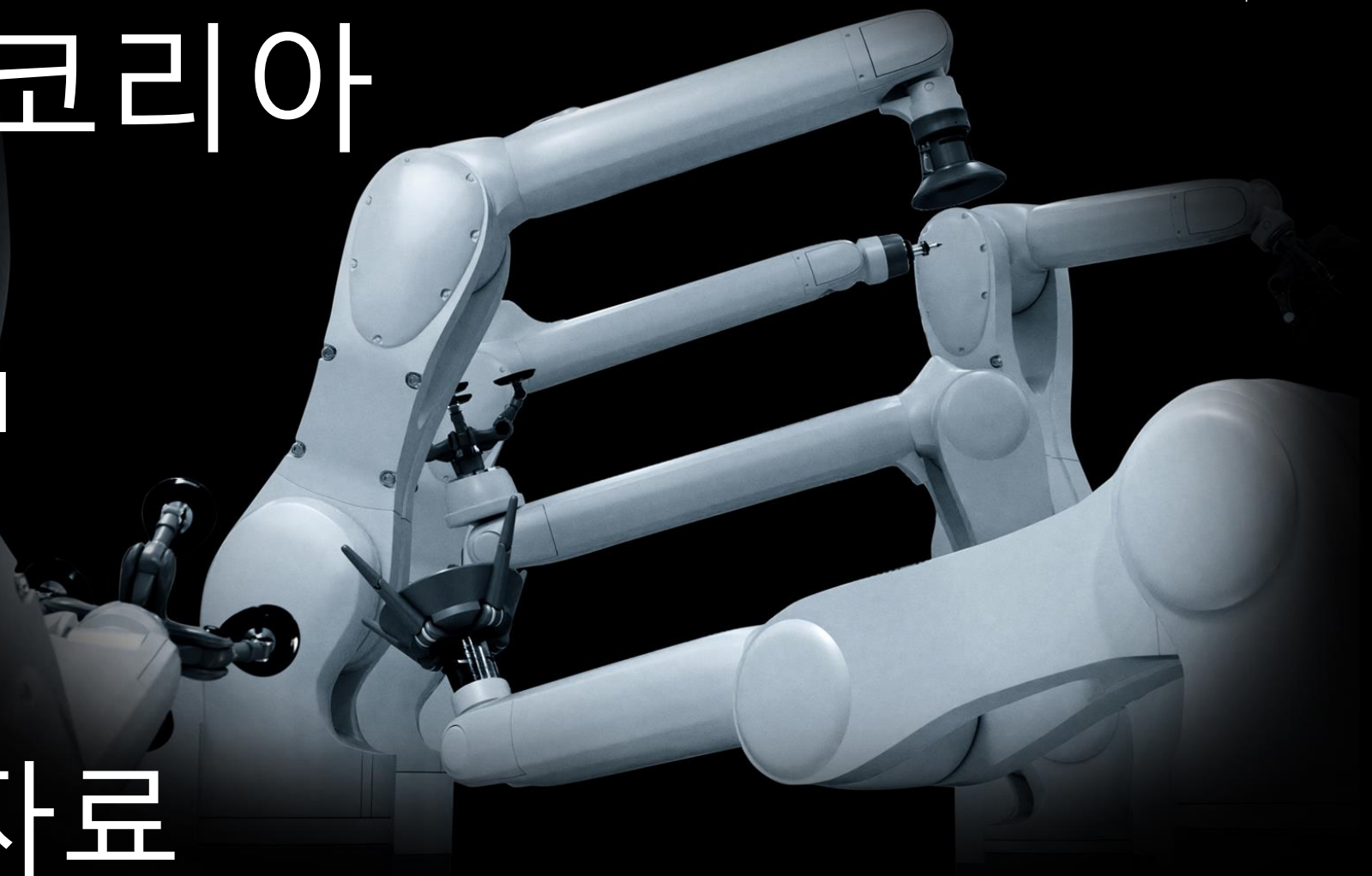
언박스드 코리아 2021

A better 5G for all



오전 발표 자료

저주파수 FDD 대역 활용과 에릭슨 스펙트럼 쉐어링

박병성 수석네트워크컨설턴트

A complete 5G RAN network

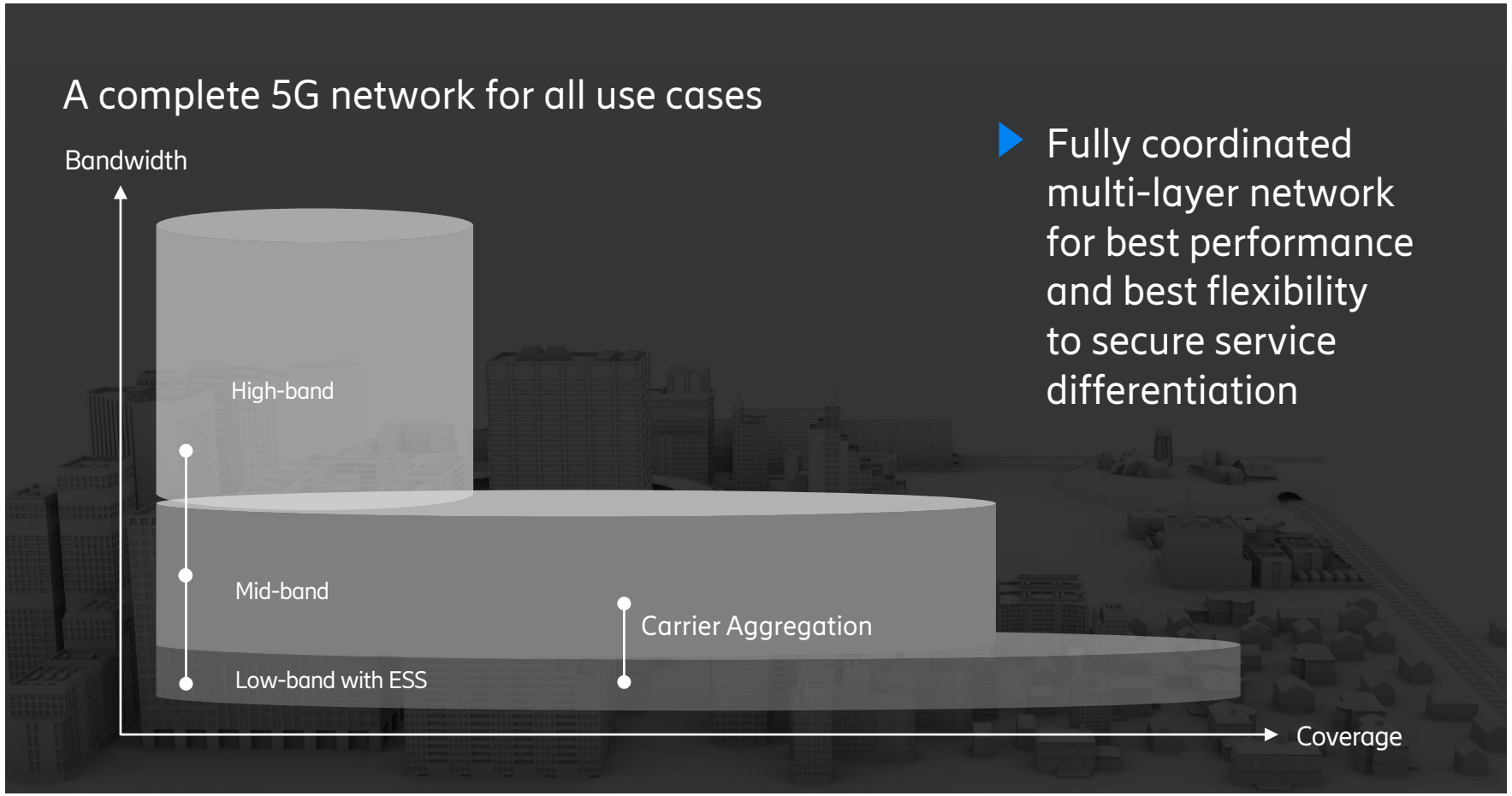
An integrated high-performance network for all uses cases including MBB and Enterprise

Low-band for nationwide coverage and indoor penetration

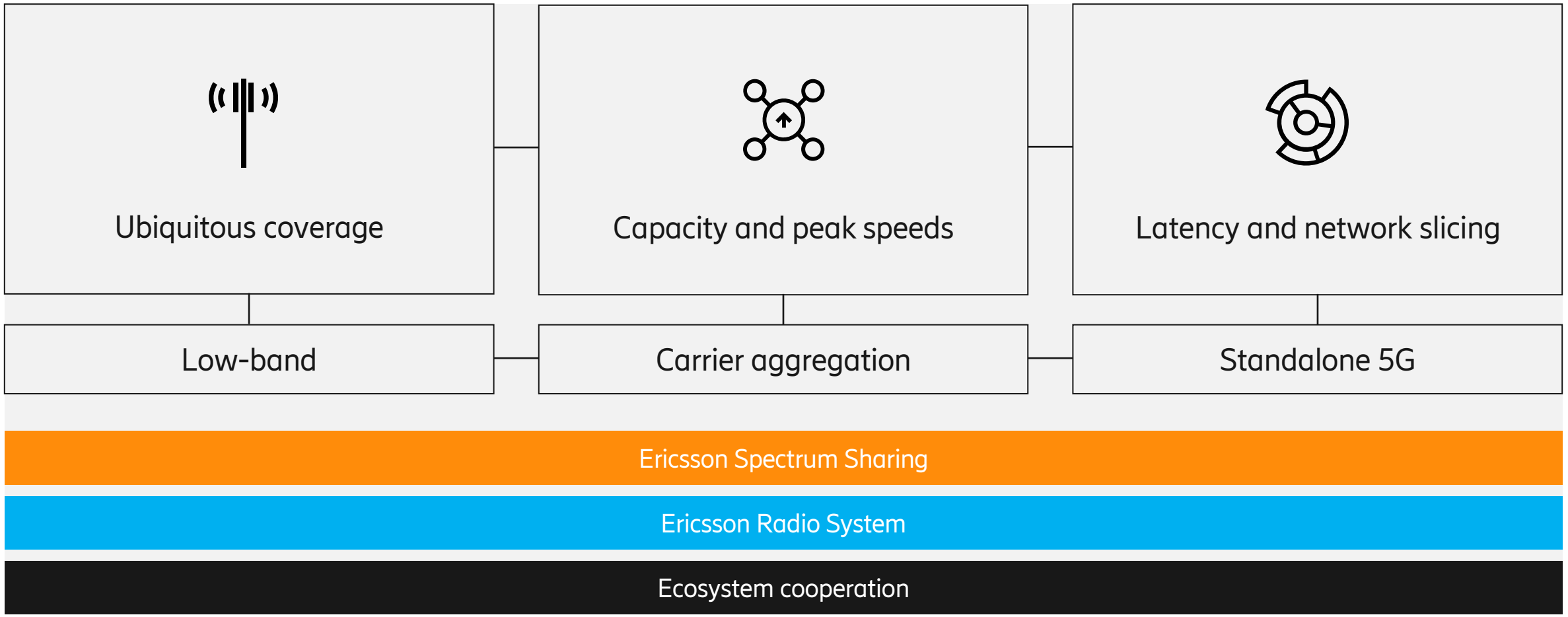
Mid-band TDD to provide universal 5G experience

- Global spectrum availability
- Large bandwidth
- Leveraging low band coverage through Carrier Aggregation

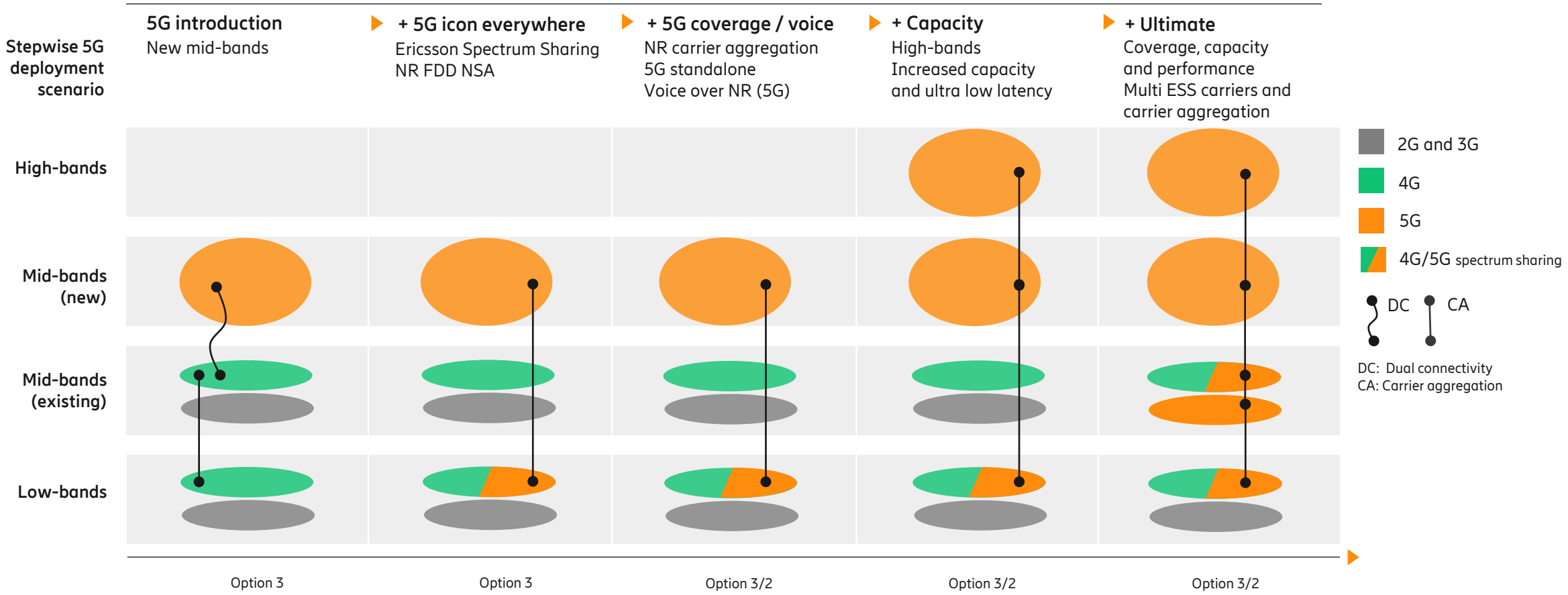
High-band for high-speed areas & services



5G network strategy

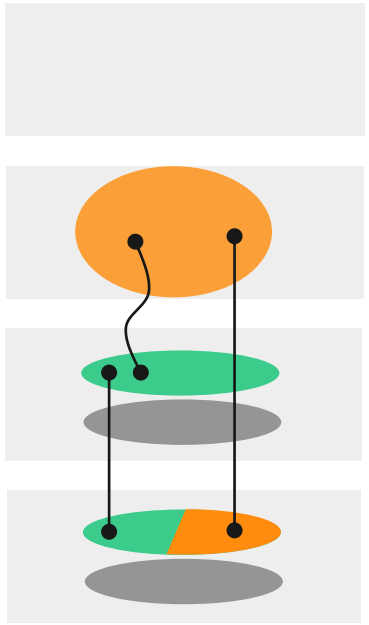


Evolution to 5G



5G icon everywhere – quickly

5G introduction



Option 3

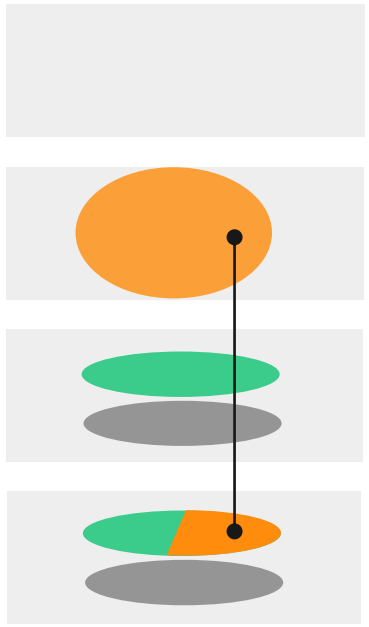
5G

5G introduction on mid/high-band
→ limited coverage

Ericsson Spectrum Sharing – Software update → wide area coverage

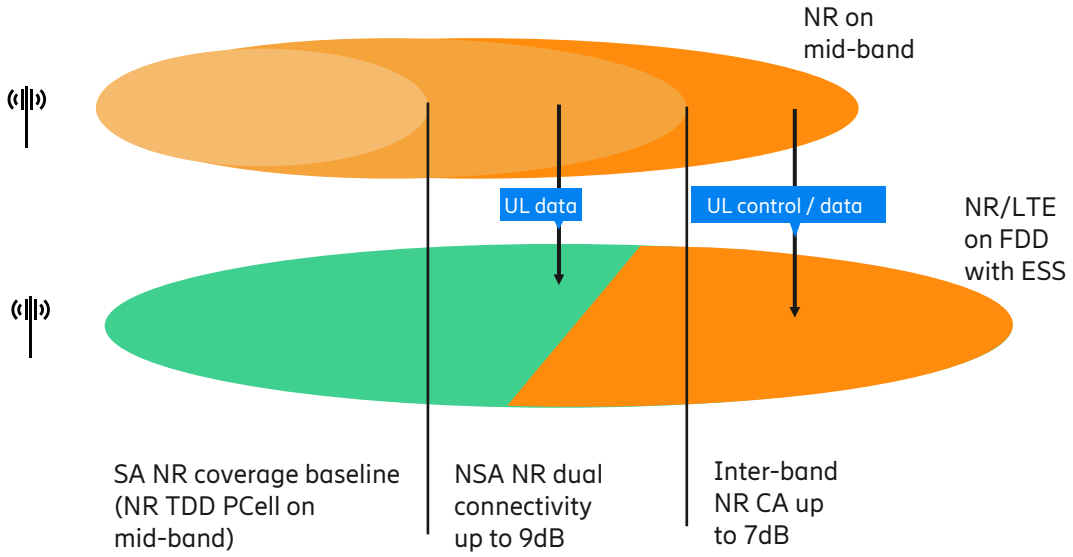
Boost coverage

+ 5G coverage



Option 3/2

Boost coverage and capacity with NR carrier aggregation



27% Increase in network capacity

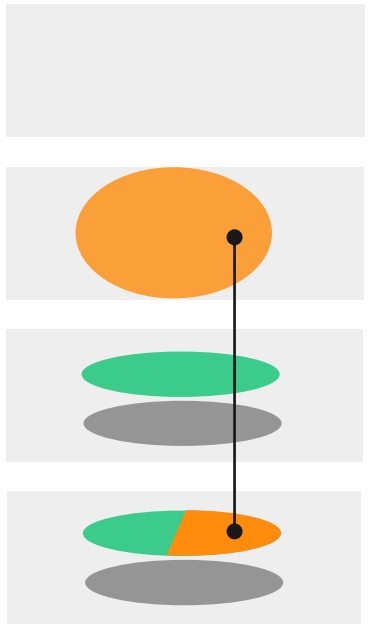
3–7dB

Using 5G NR Carrier Aggregation can provide up to 3–7dB gain in link budget on the downlink

Extended coverage on 3.5GHz spectrum with NR carrier aggregation of shared FDD bands

Minimize network complexity

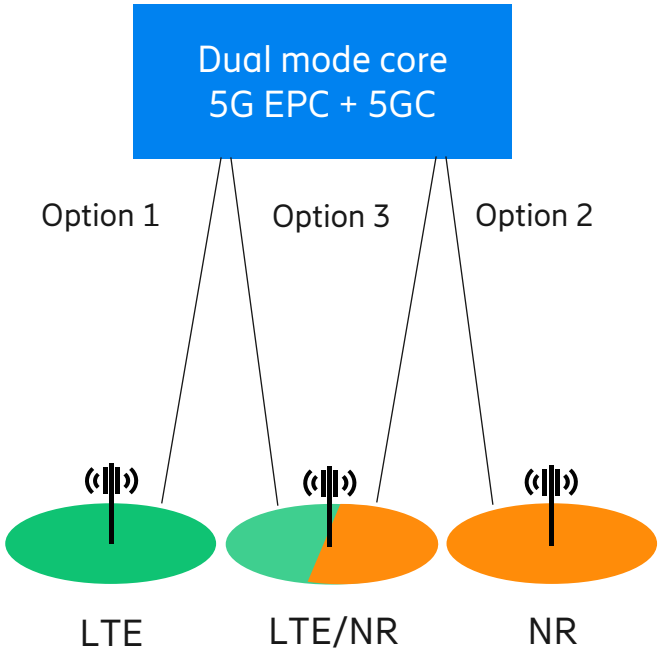
+ 5G stand-alone



Option 3/2

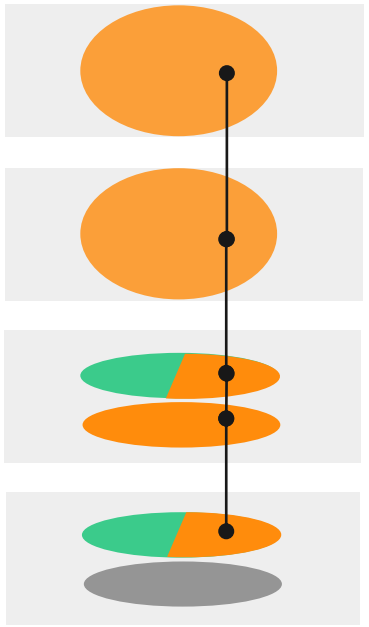
No need for complicated options:

- 5G standalone coverage secured with 5G FDD bands.
- Reduced network complexity.
- Low latency and network slicing.
- Explore new use cases.
- Voice over NR on FDD bands.



Ultimate—5G goes mainstream

+ Ultimate



Option 3/2

5G goes mainstream.

Decrease of LTE traffic and devices.

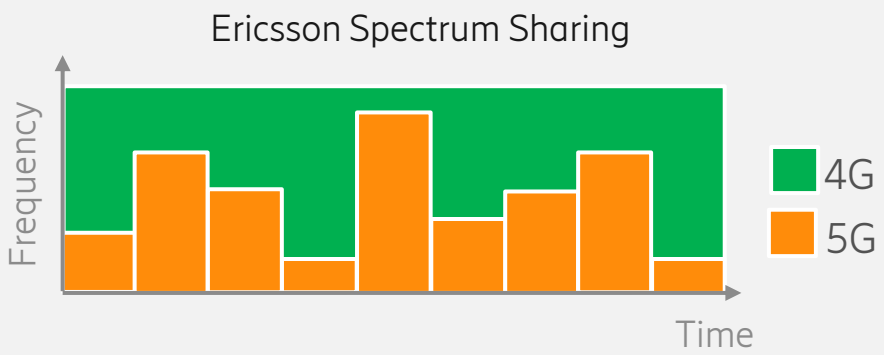
Increase throughput and peak speed with 5G carrier aggregation over many bands.

5G on multiple bands with Ericsson Spectrum Sharing .

Explore new use cases.

Increased capacity and ultra low latency.

Ericsson Spectrum Sharing is a ‘revolutionary’ concept



NR carrier scheduled over LTE carrier

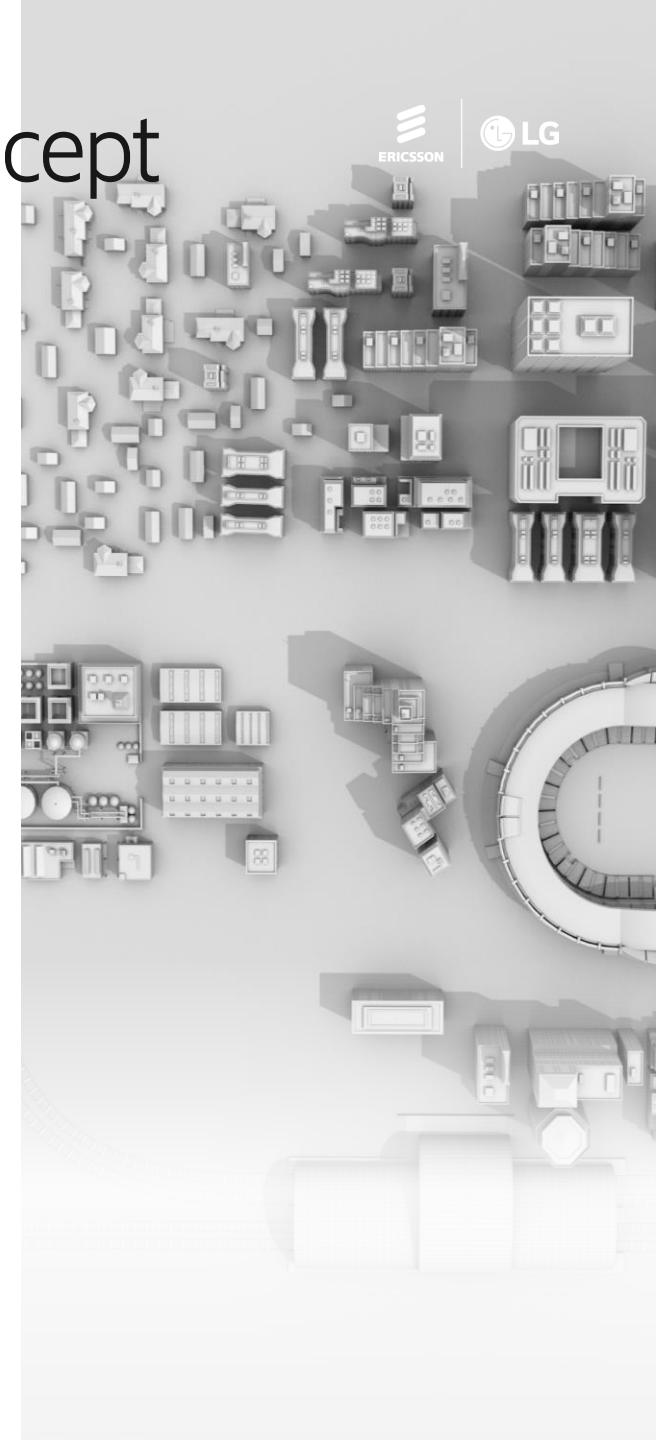
LTE scheduler “lends” resources to NR based on traffic

NR avoids symbols used in LTE for cell specific signals

Unique scheduler to dynamically share spectrum between 5G and 4G

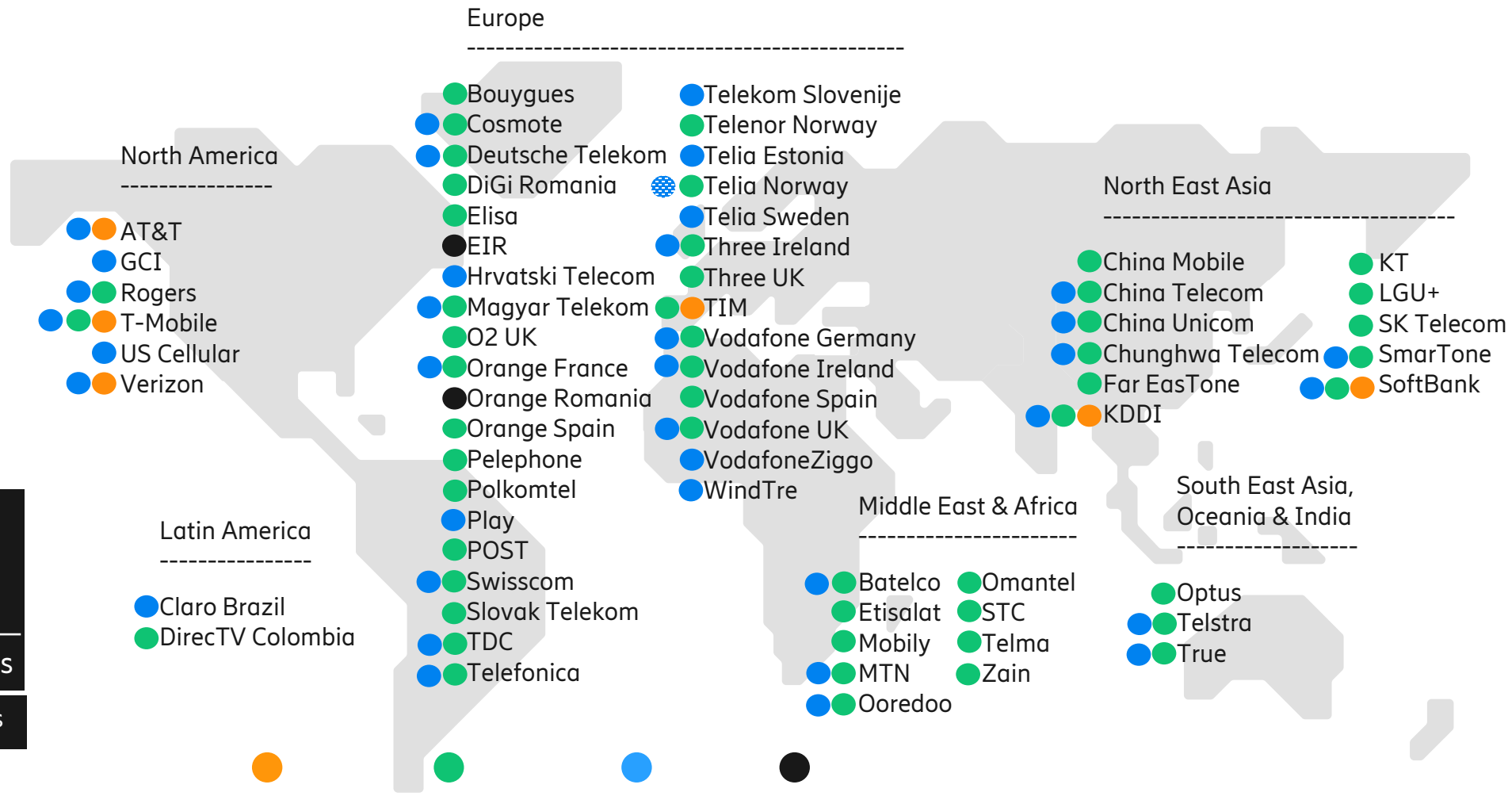
Nationwide 5G coverage – with minimum impact to LTE performance

Increase the value of mid/high-band spectrum - increase coverage and capacity



Ericsson 5G global experience

Presence in 5 continents with high, mid and low bands



85 Live Networks

41 5G Countries

138 5G commercial agreements

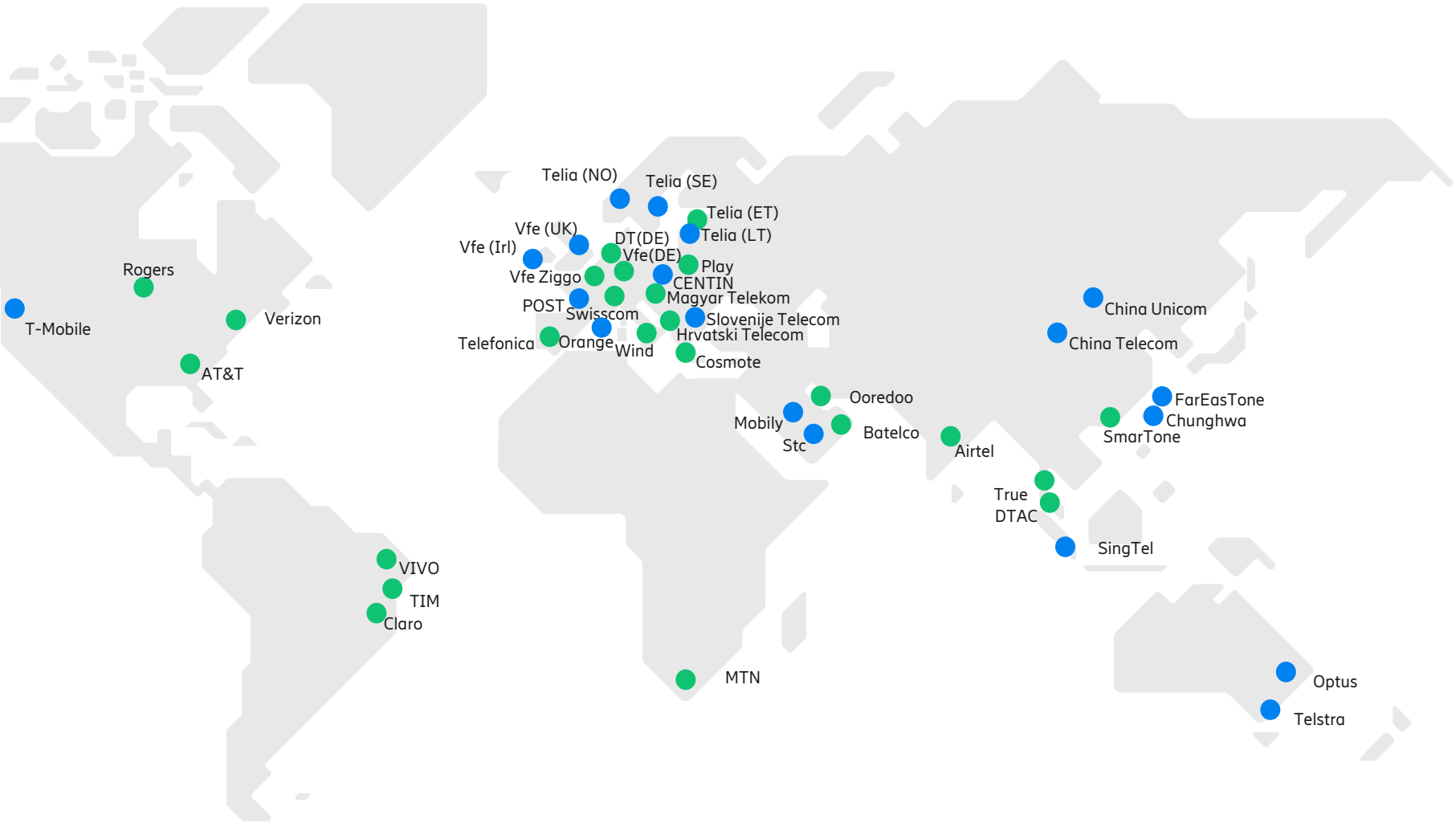
*As of May 2021, public announced or disclosed live networks

Ericsson Spectrum Sharing
Customer plans - publicly announced

24
Commercial Networks*

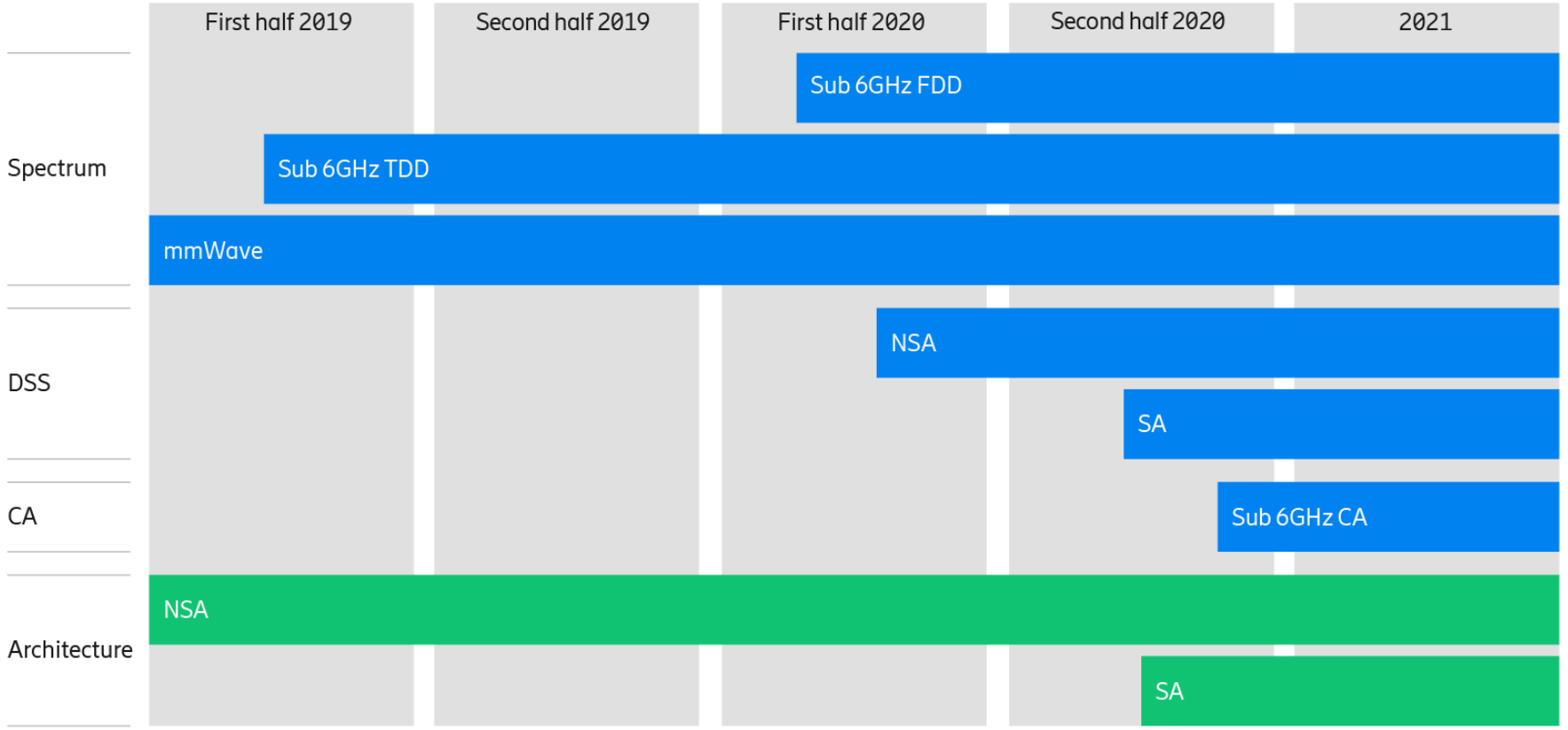
20
Operators with publicly announced ESS plans*

+
More customers to be announced



5G device outlook

5G technology market readiness

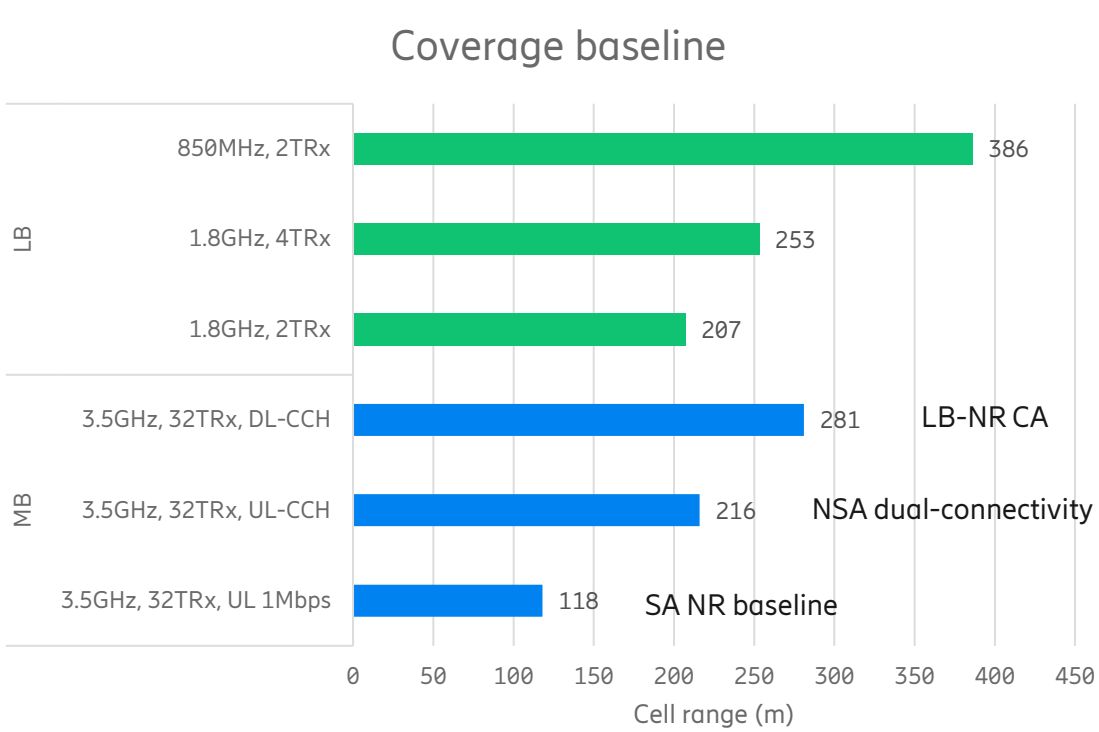


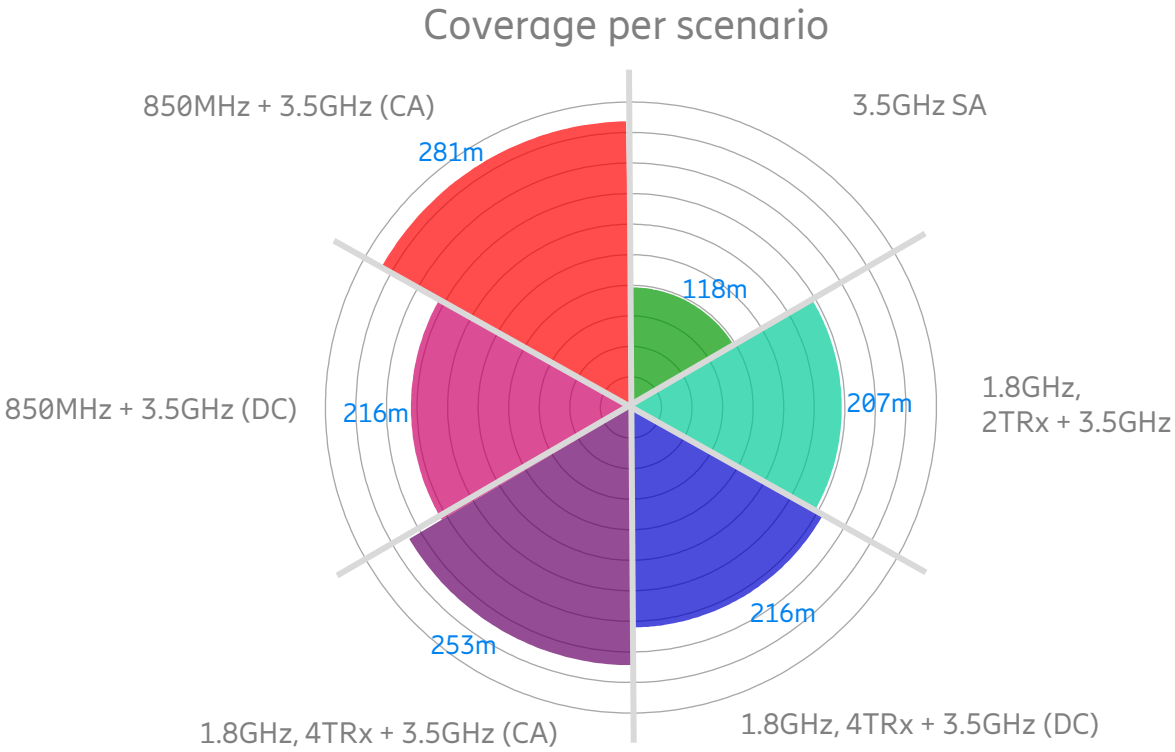
Note: The graph illustrates availability of network functionality, as well as support in devices.

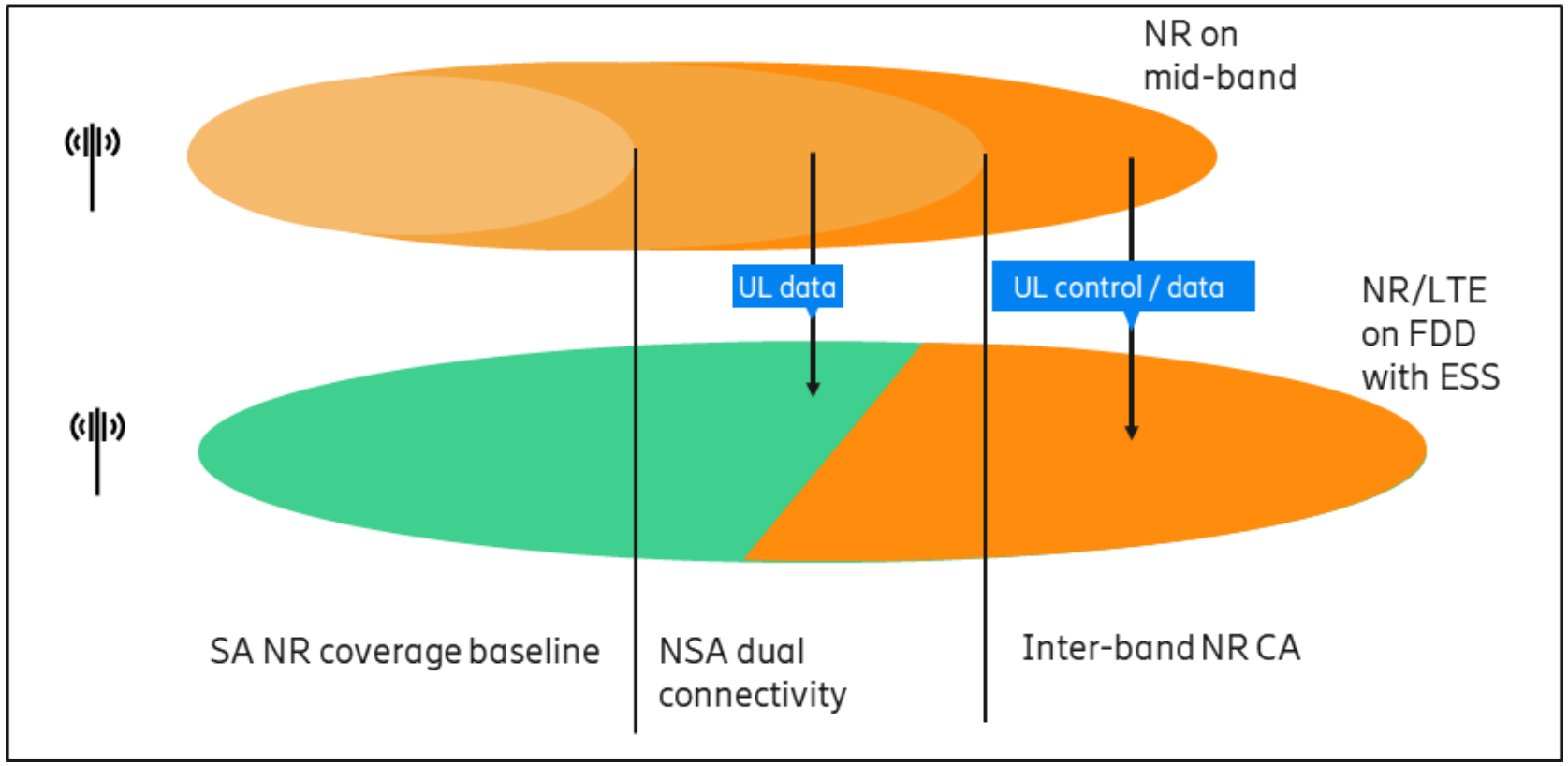
Ericsson Mobility Report (Nov. 2020)

ESS performance

Coverage analysis with low-band NR







— 3.5GHz: 32TRx, 100MHz

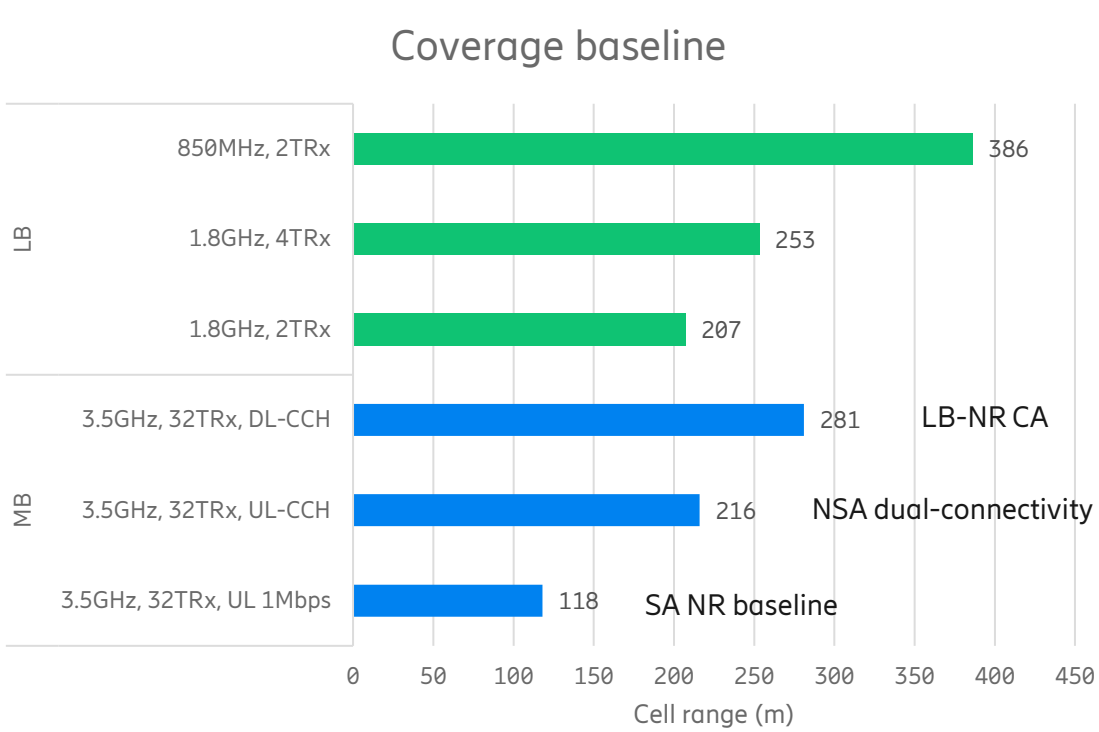
— 1.8GHz: 15+20MHz

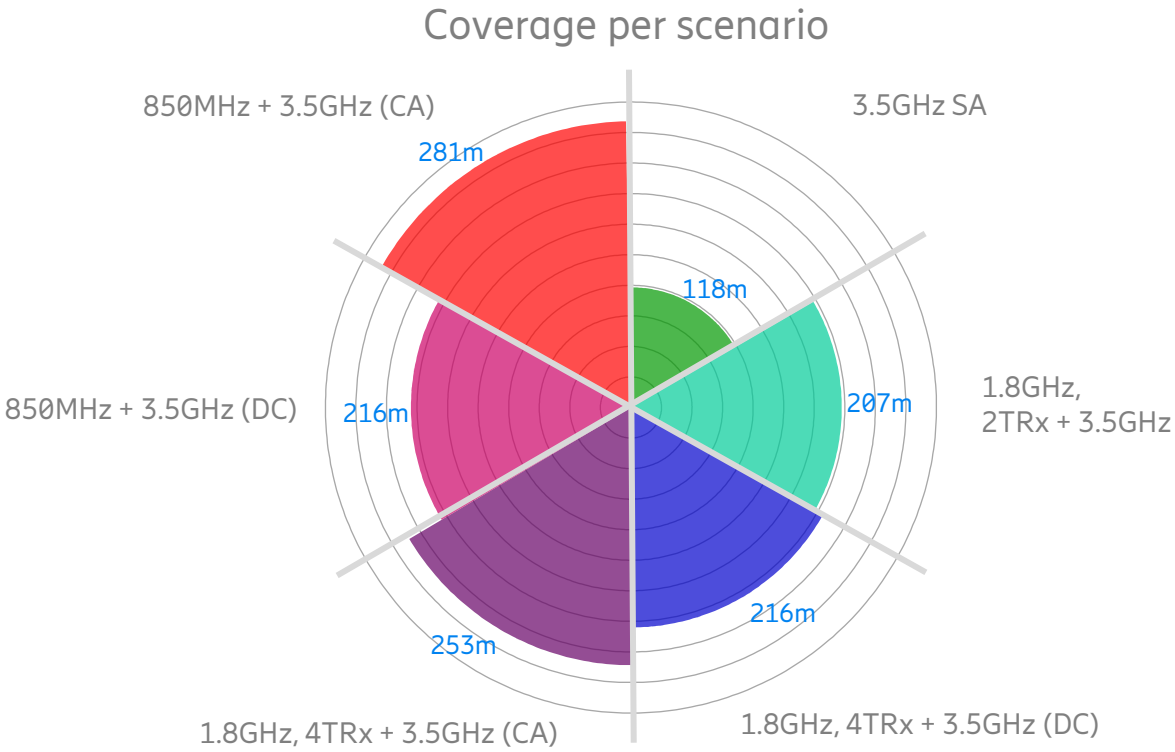
— 850MHz: 2x10MHz

— 3GPP UMa-NLOS,

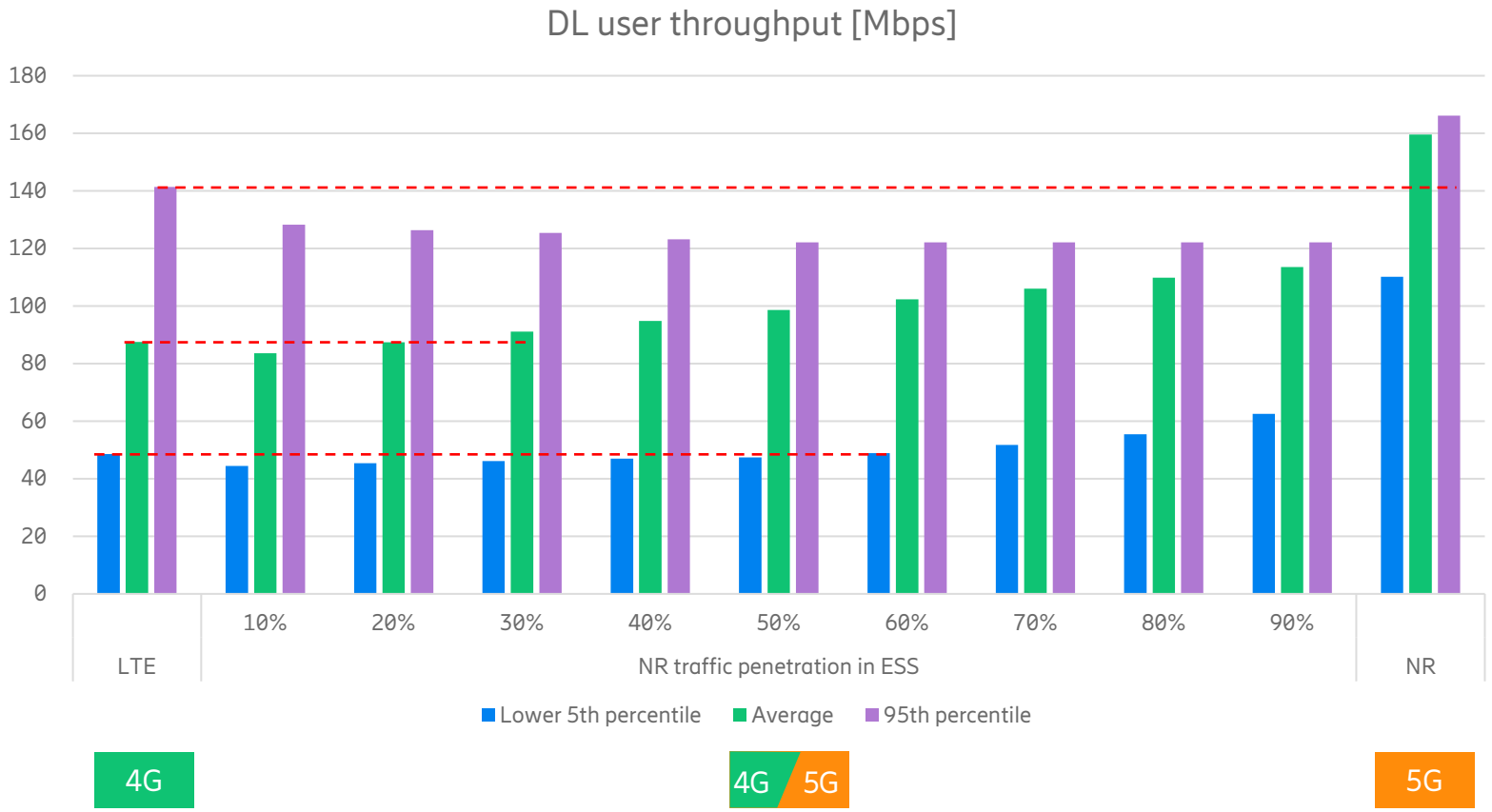
— High wall-loss O2I model

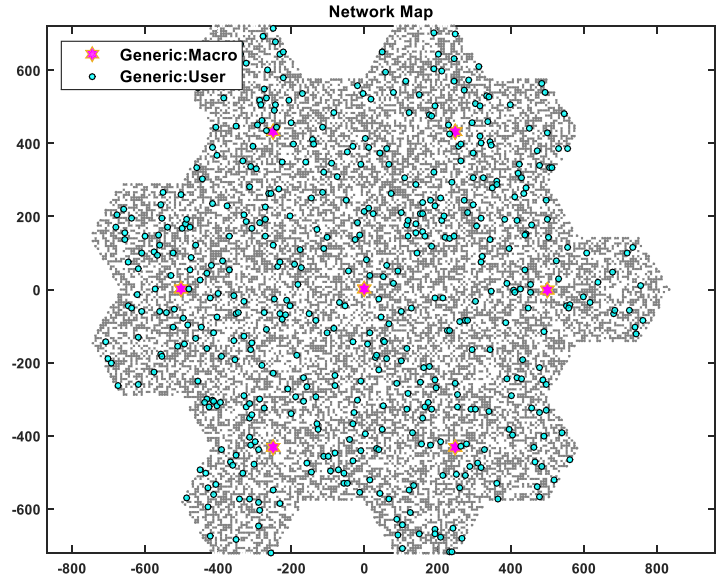
Coverage analysis with low-band NR





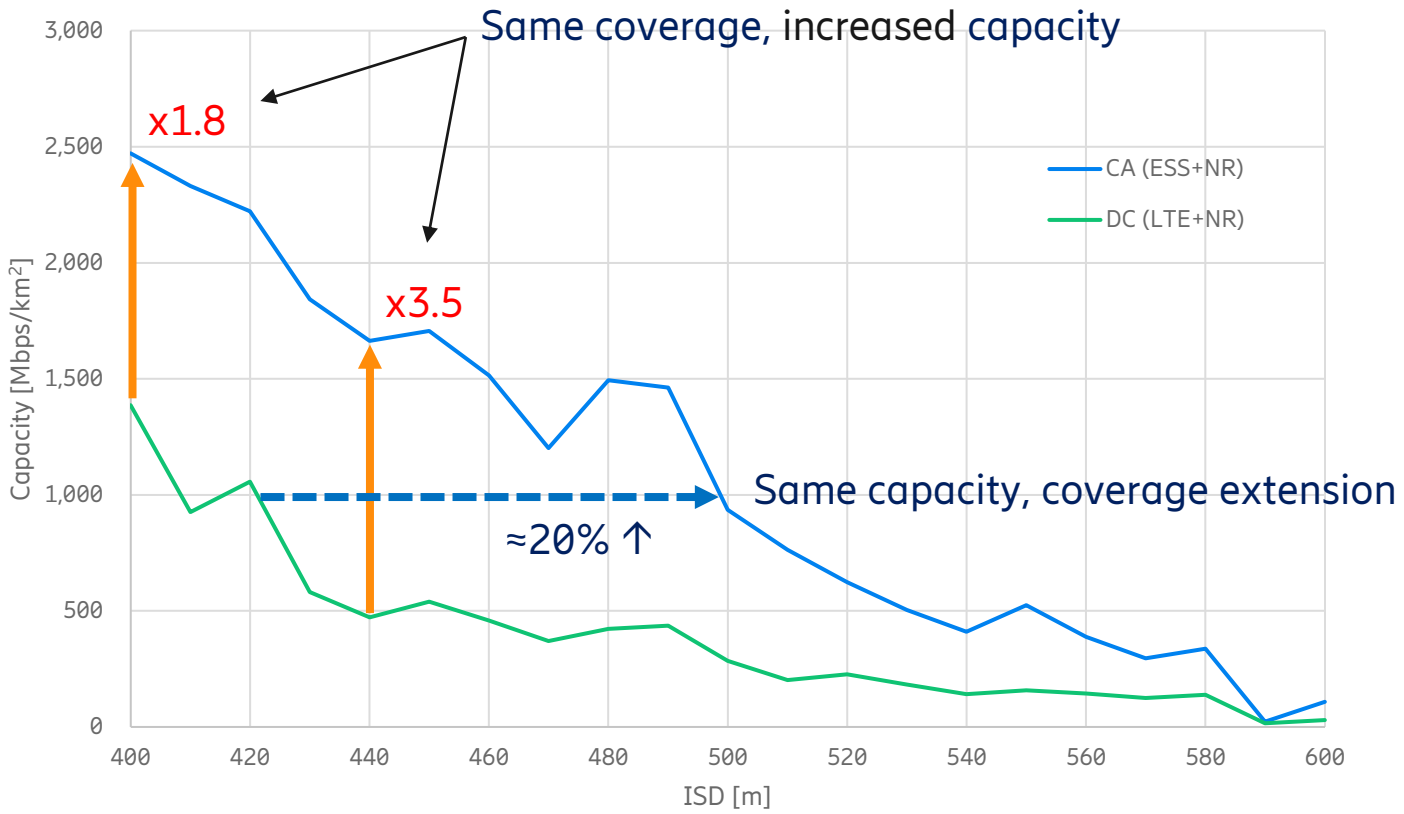
ESS performance





2T2R, 20MHz system bandwidths @ 1.8GHz
3GPP UMa-NLOS
ISD 300m
Low-load traffic condition

DC(LTE+NR) vs. CA(ESS+NR)

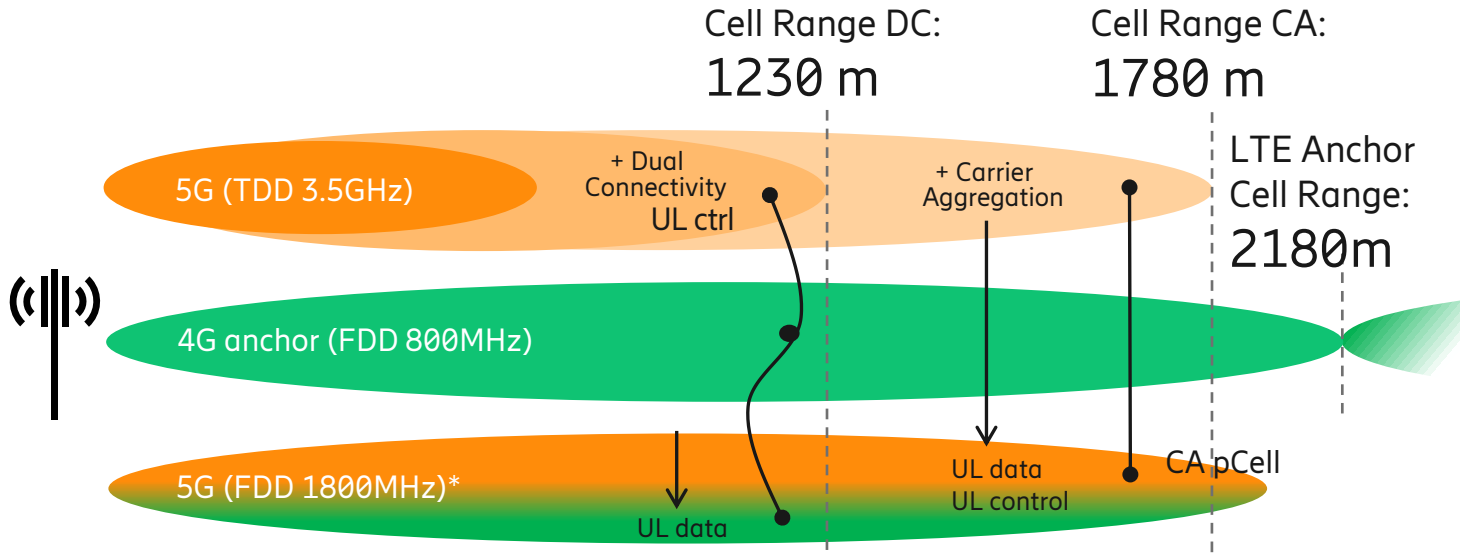


The Capacity is defined as the maximum amount of served traffic by the networks while maintaining a cell edge (5th percentile) user throughput requirement of 20Mbps

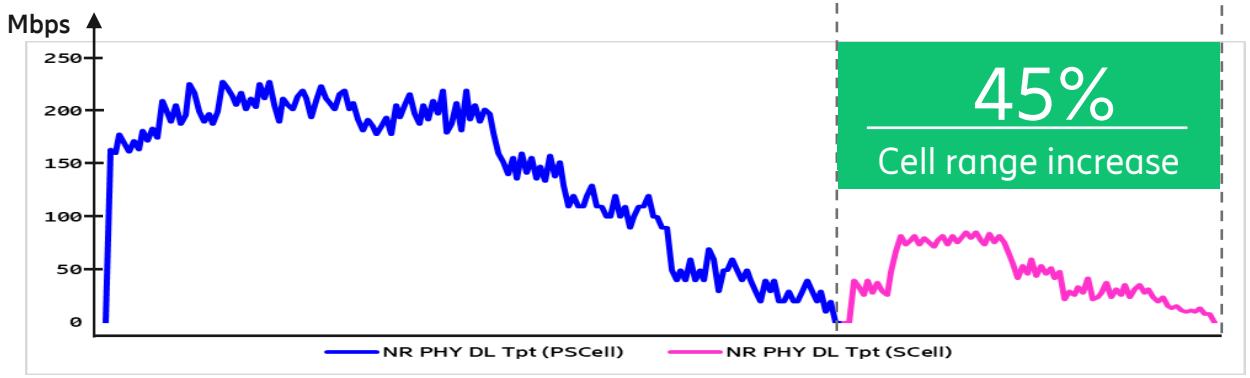
- Dual connectivity:
  LTE 1.8GHz (2TRx, 20MHz)
  + NR 3.5GHz (32TRx, 100MHz)

- Carrier aggregation:
  NR/ESS 1.8GHz (2TRx, 20MHz)
  + NR 3.5GHz (32TRx, 100MHz)

5G NSA FDD-TDD Carrier Aggregation trial



* 5G on FDD 1800MHz enabled with ESS



Sharing for the best performance

Ericsson Spectrum Sharing

Unique solution

- Highest spectrum efficiency
- Fastest – 1ms 5G/4G spectrum sharing
- Full eco-system support

A smarter way to build 5G

- Reuse of spectrum
- Reuse of installed base
- Reuse of sites

Take the full advantage

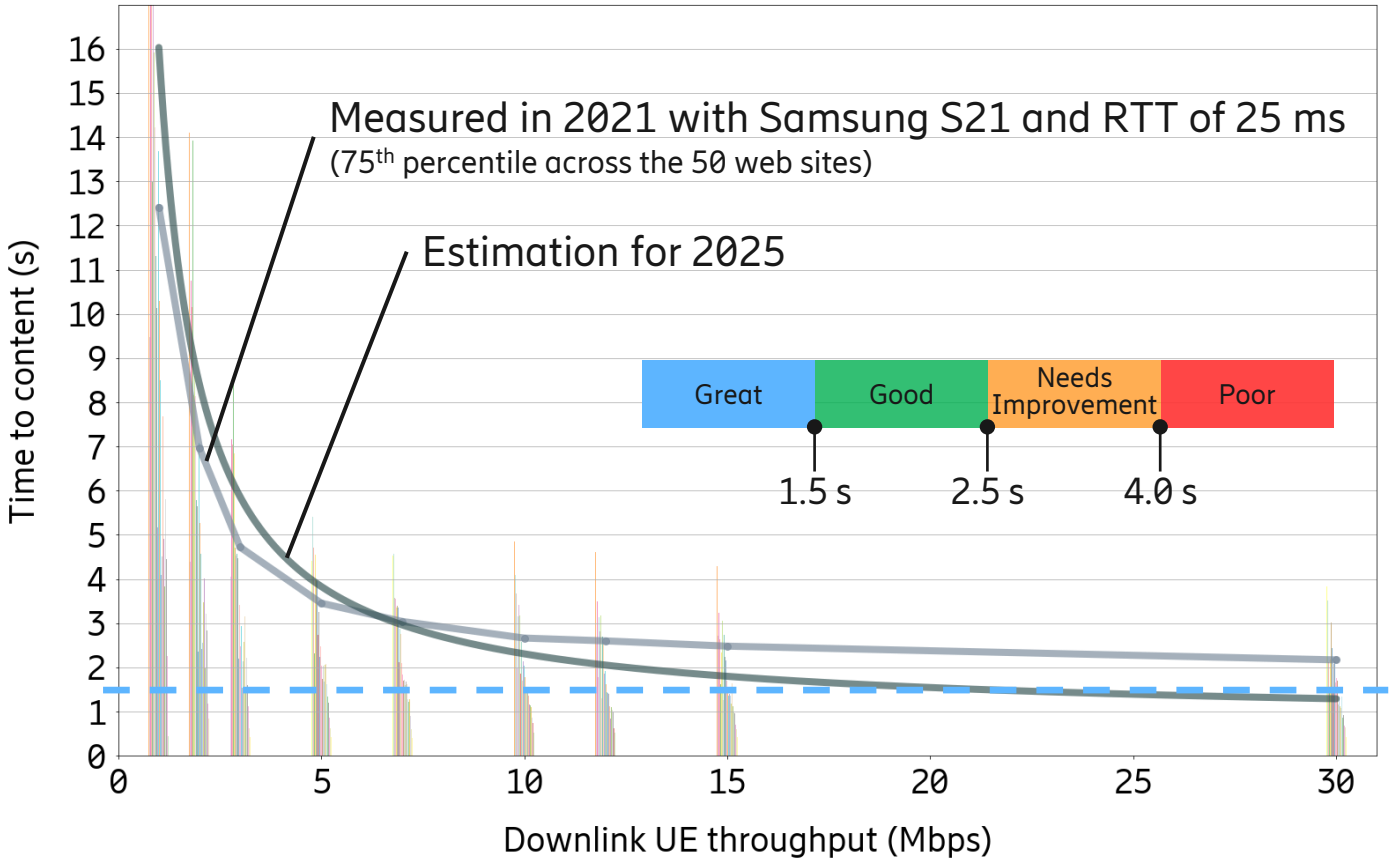
- 5G wide area coverage
- Boost coverage and capacity with CA
- Smooth migration to 5G SA

ERICSSON
LG

에릭슨 Massive MIMO

김진양 RAN HW 솔루션 매니저

Web requires 20 Mbps in 2025 for great experience and 0.5 Mbps in uplink

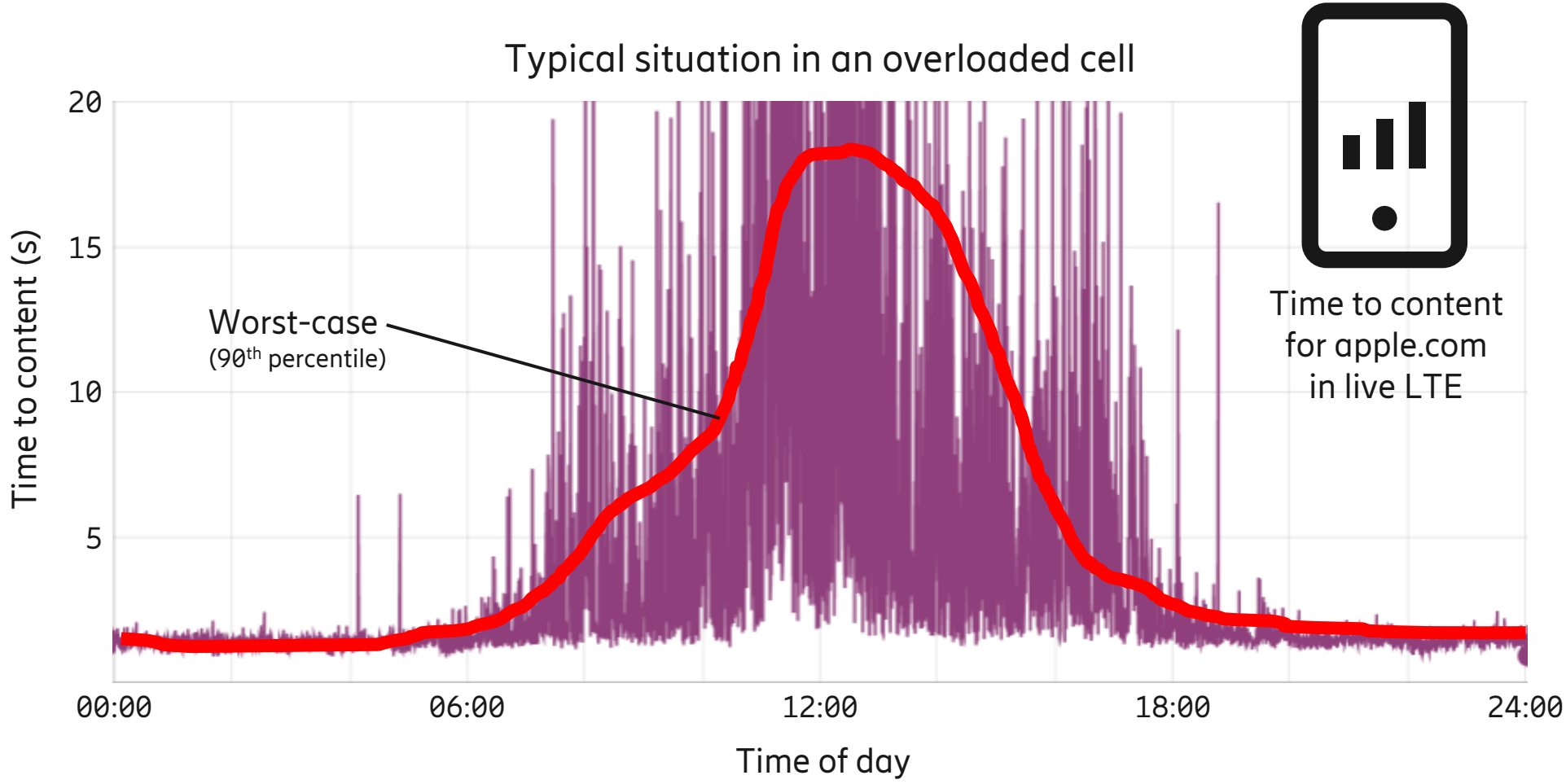


50 web sites that are popular in Sweden and globally

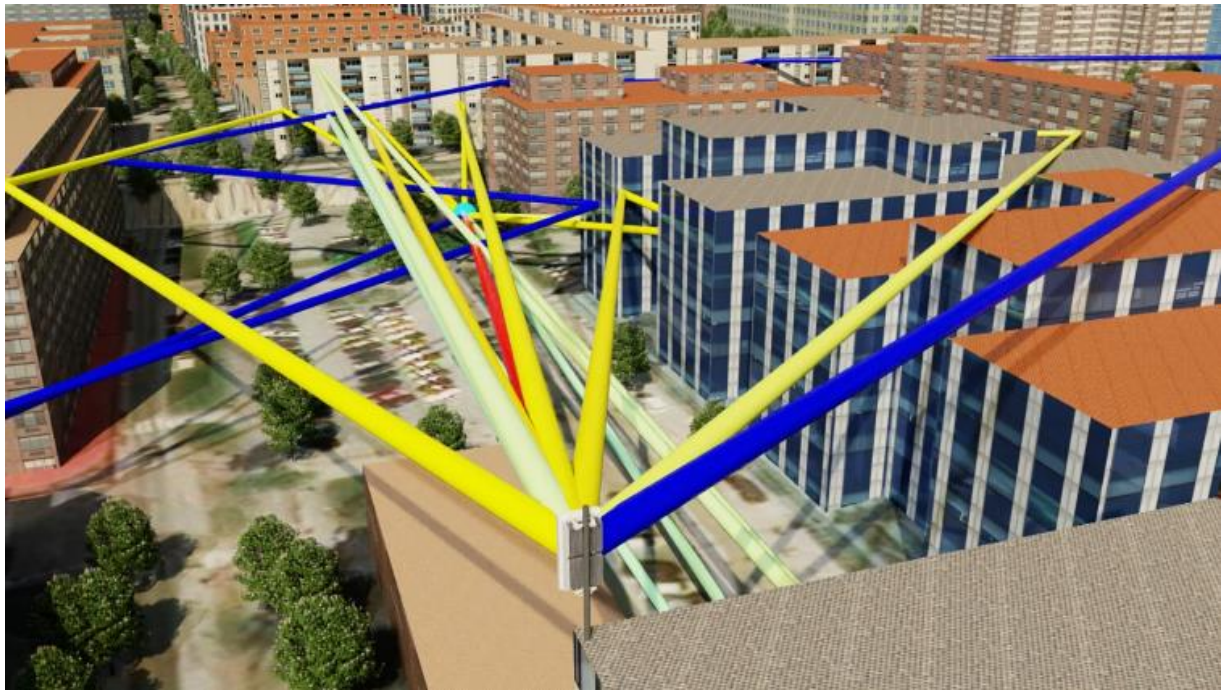
- bbc.com
- uber.com
- imdb.com
- tradera.com
- cnn.com
- reddit.com
- imgur.com
- zalando.se
- avanza.se
- live.com
- pinterest.com
- viaplay.se
- lufthansa.com
- ica.se
- aftonbladet.se
- svtplay.se
- netflix.com
- booking.com
- schoolsoft.se
- msn.com
- blocket.se
- zoom.us
- ikea.se
- hitta.se
- twitter.com
- yandex.ru
- apple.com
- yahoo.com
- youtube.com
- 1177.se
- airbnb.com
- duckduckgo.com
- facebook.com
- bing.com
- twitch.tv
- fandom.com
- kth.se
- trustpilot.com
- nordea.se
- ebay.com
- office.com
- swedbank.se
- github.com
- microsoft.com
- amazon.com
- svt.se
- hemnet.se
- wikipedia.org
- expressen.se
- google.com

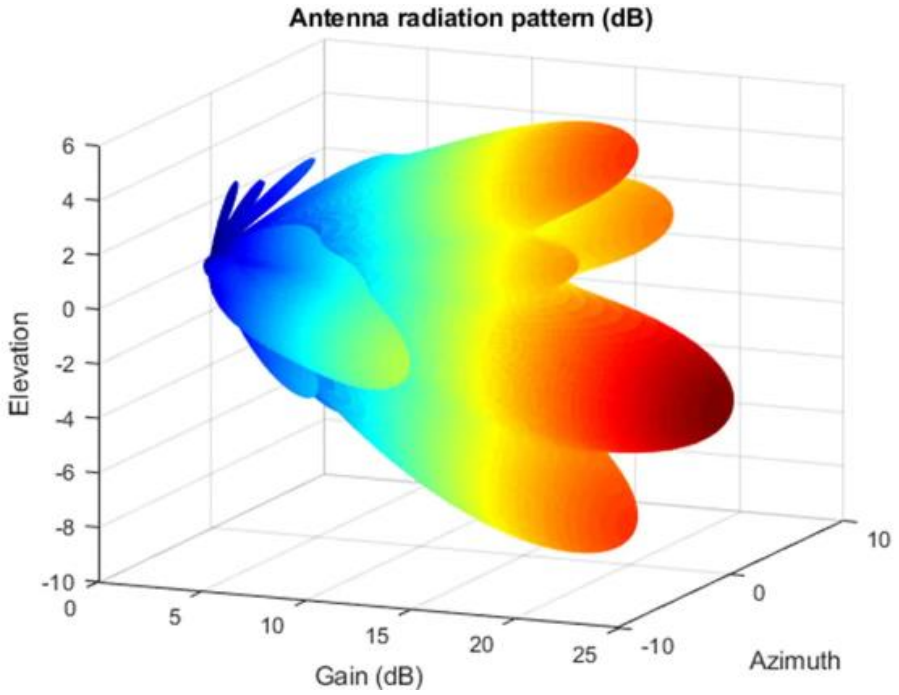
Source: Ericsson Smartphone Lab (2021)

Users expect great experience – anywhere & anytime



The clever ways to achieve the goal by Massive MIMO and Beamforming





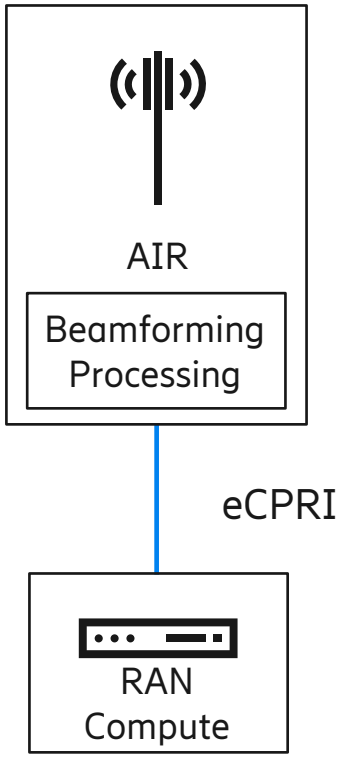
Which requires ...

—to create multiple beams at the same time

—to send and receive radio signals extremely quickly on a fraction of a millisecond basis

The art and science behind Ericsson Massive MIMO

- **Radio challenges:** Larger bandwidth and more antenna branches drive the need for increased processing capacity.
- **Beamforming challenges:**
  - The radio environment changes on sub-millisecond timeframes.
  - The beams must be continually reshaped every fraction of a millisecond.
  - To adapt the beams in a complex radio environment for many users simultaneously requires millions of mathematical calculations per second
- **To address the challenges:**
  - Access to the full channel info.
  - Algorithms which utilize this info.
  - Silicon for the processing power



Ericsson Superior Architecture

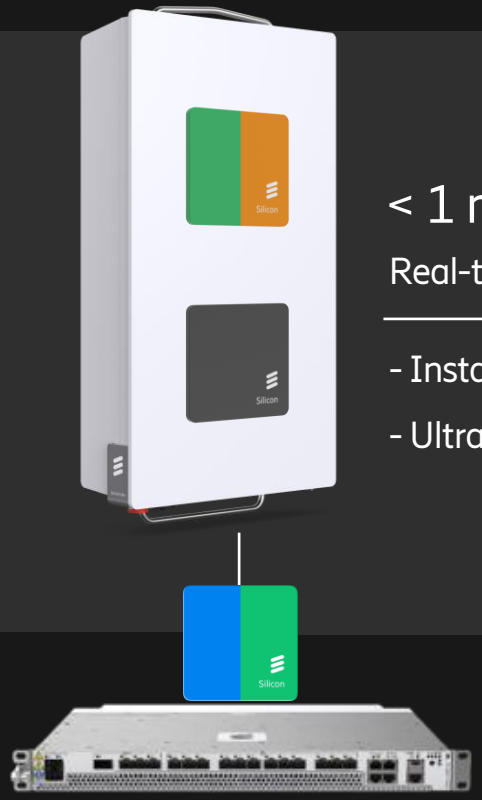
Ericsson Massive MIMO

Ericsson Silicon

Silicon

Enabler for high Massive MIMO processing needs

- Digital front-end processing
- Beamforming processing
- Layer 1 processing
- Layer 2 processing



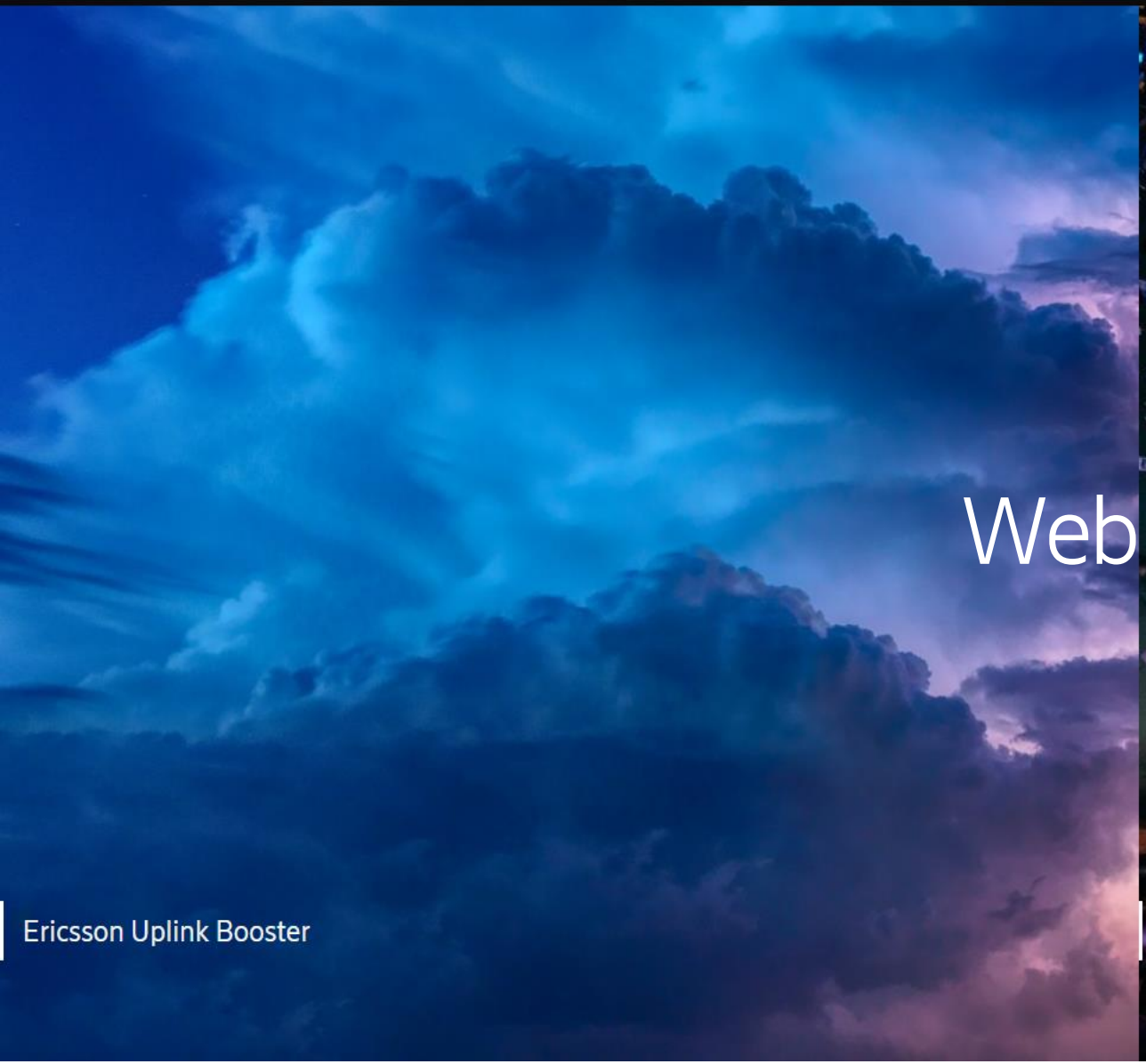
< 1 ms

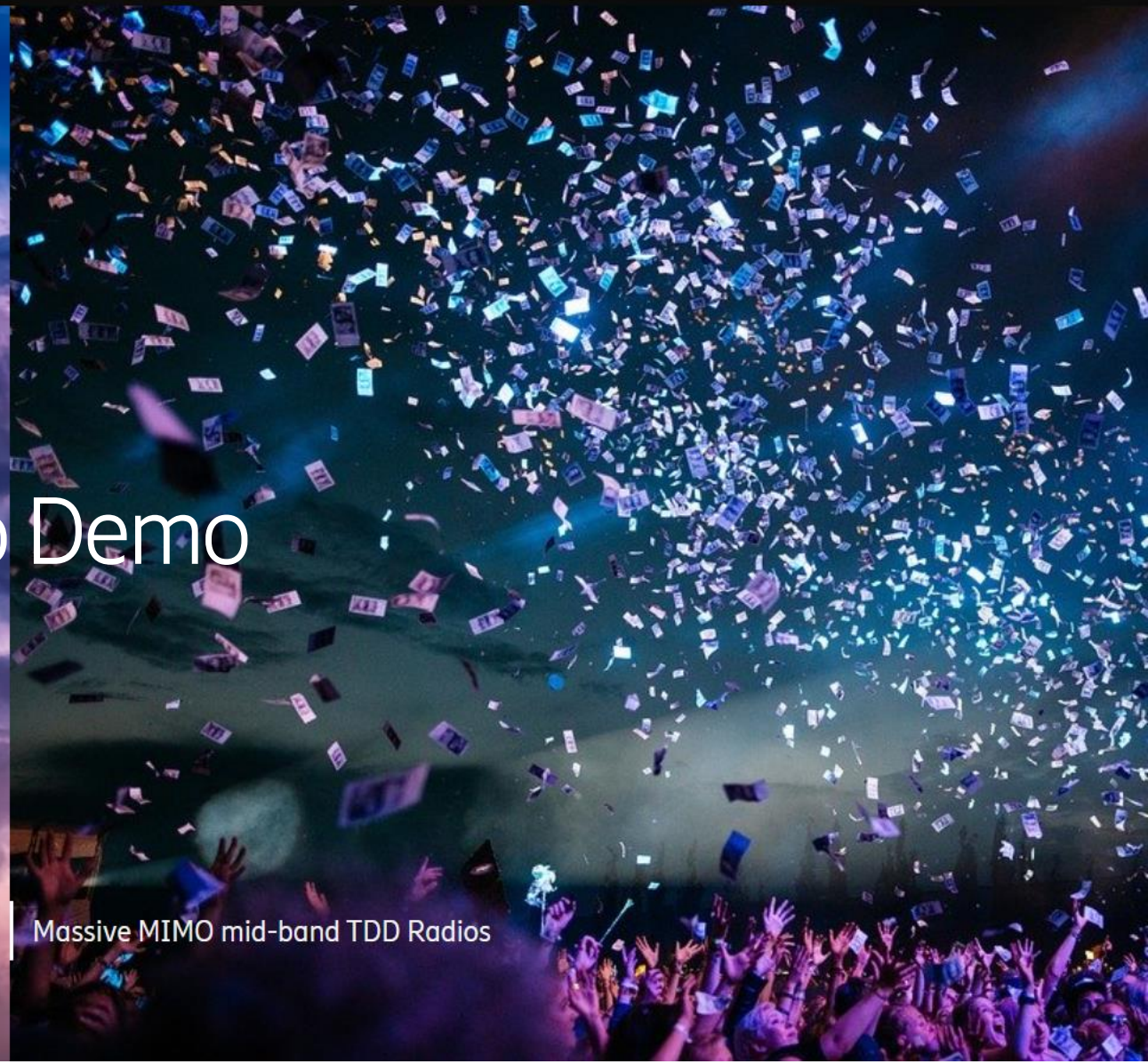
Real-time channel estimation

- Instant interference suppression
- Ultra-precise beamforming

- Ericsson Uplink Booster
- Multi-User MIMO 16/8 layers
- Footprint & Energy efficiency
- Wideband optimized

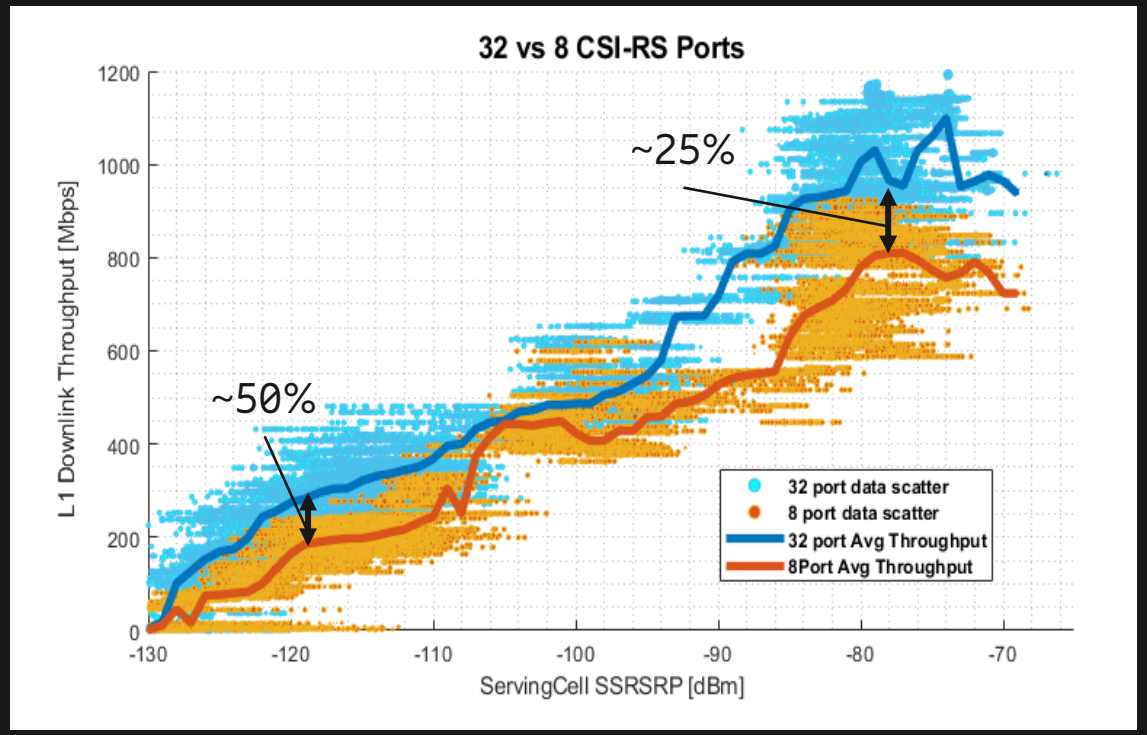
Web Demo

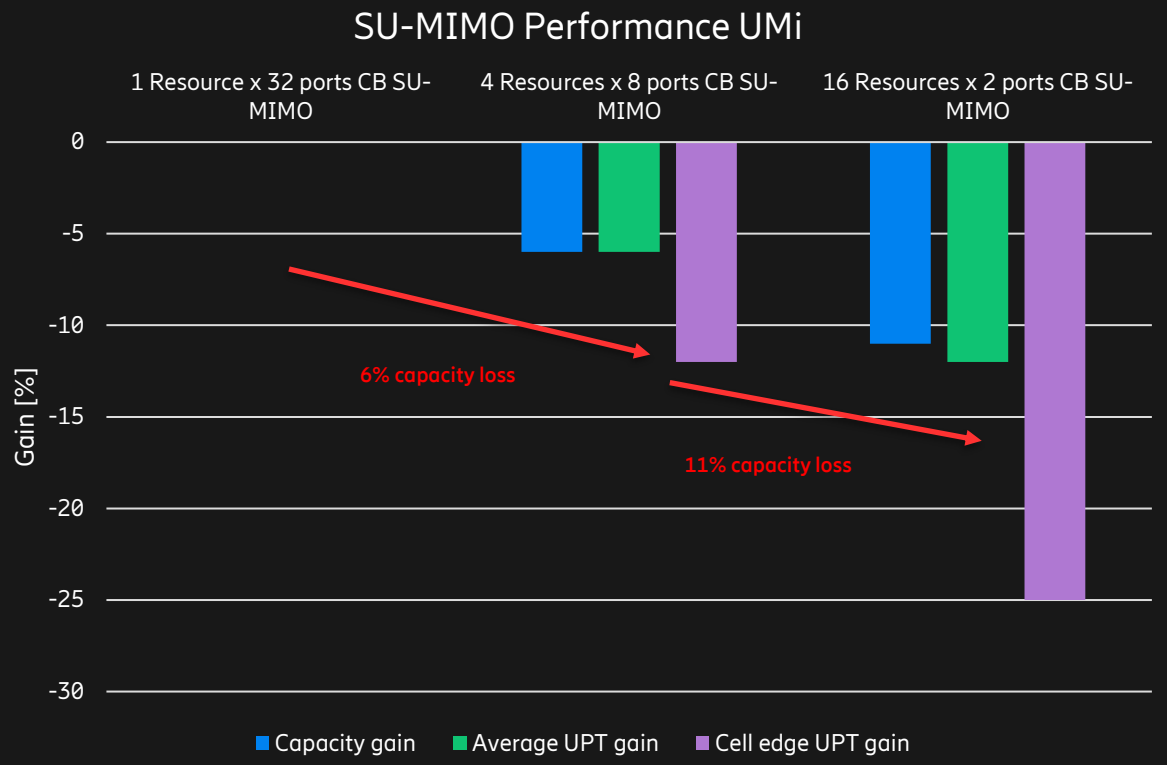




Downlink enhancements, 32 CSI-RS ports

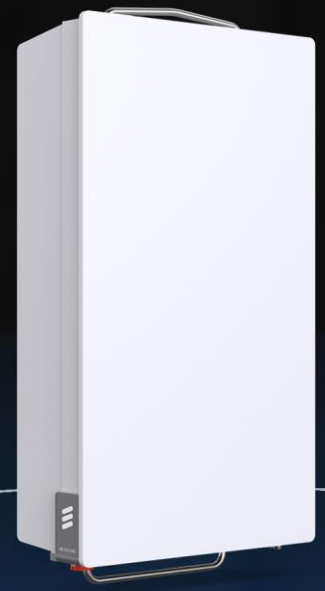
Field measurements throughput comparison





Significant throughput improvement observed mainly in medium-bad radio conditions, due to the better granularity of the channel conditions provided by the 32 CSI-RS ports

Uplink enhancements



Driving innovation
—Ericsson Uplink Booster

Boosting up to
10dB

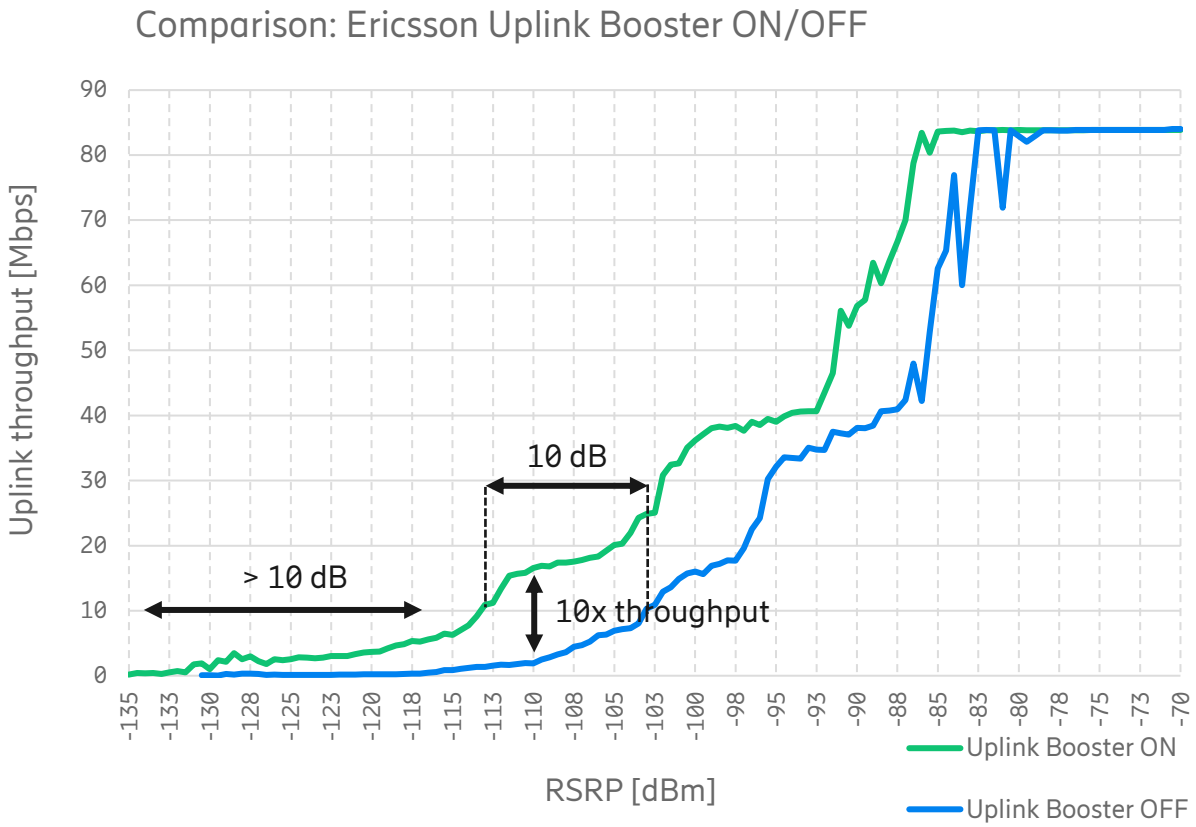
Ericsson Uplink Booster Drive test results

Significant UL throughput gains at cell edge and bad radio conditions

- 8-10 dB gain in UL app coverage
- 5-15 Mbps gain in UL throughput
- > 10 dB at cell edge

Throughput and coverage gains also observed in good radio conditions

Maximize uplink performance through superior Massive MIMO architechture



Ericsson Massive MIMO mid-band TDD

Designed for real world performance

AIR 3219 AIR 3236 AIR 3258 AIR 3228 AIR 3278 AIR 3239 AIR 3227

AIR 6488 AIR 6449 AIR 6419

Ericsson innovation and design

Superior 5G architecture

- Optimal eCPRI plus physical layer split is the key

Sophisticated algorithms

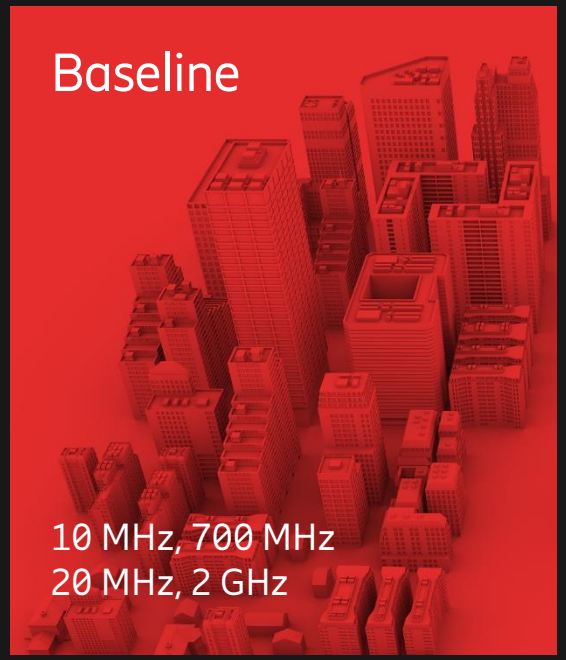
- Instantaneous channel estimation
- Full dimension Interference Rejection Combining

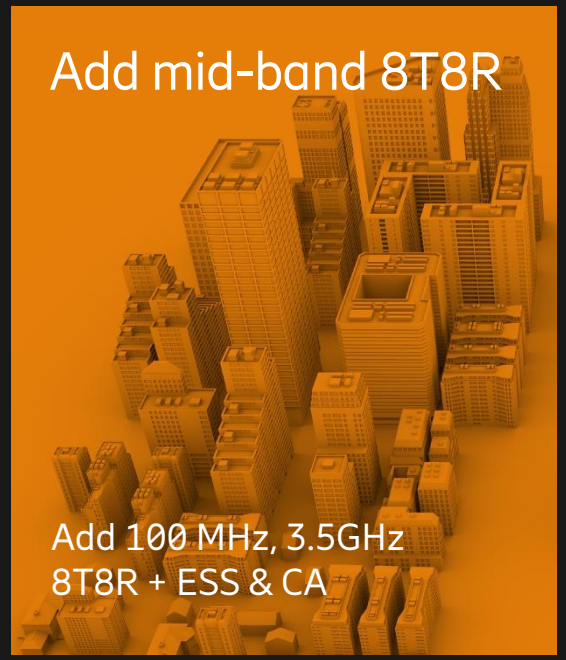
Maximize and secure uplink performance

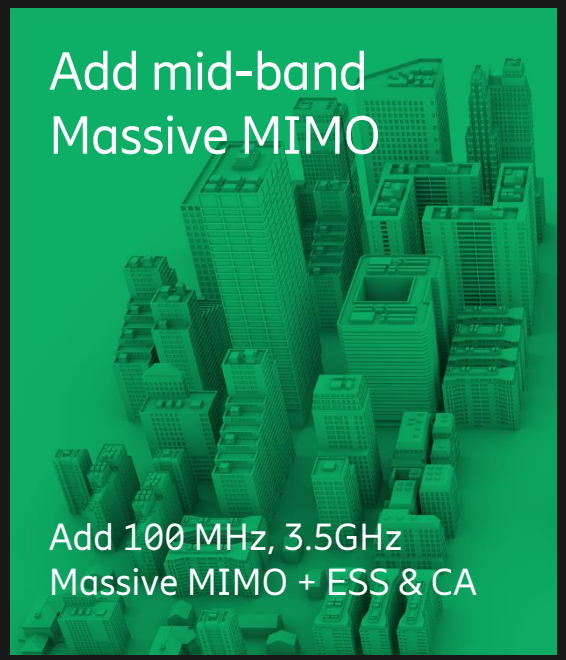
- Extended coverage
- Improved uplink throughput
- Higher spectral efficiency

Ericsson Massive MIMO provides a superior experience

2025 scenario







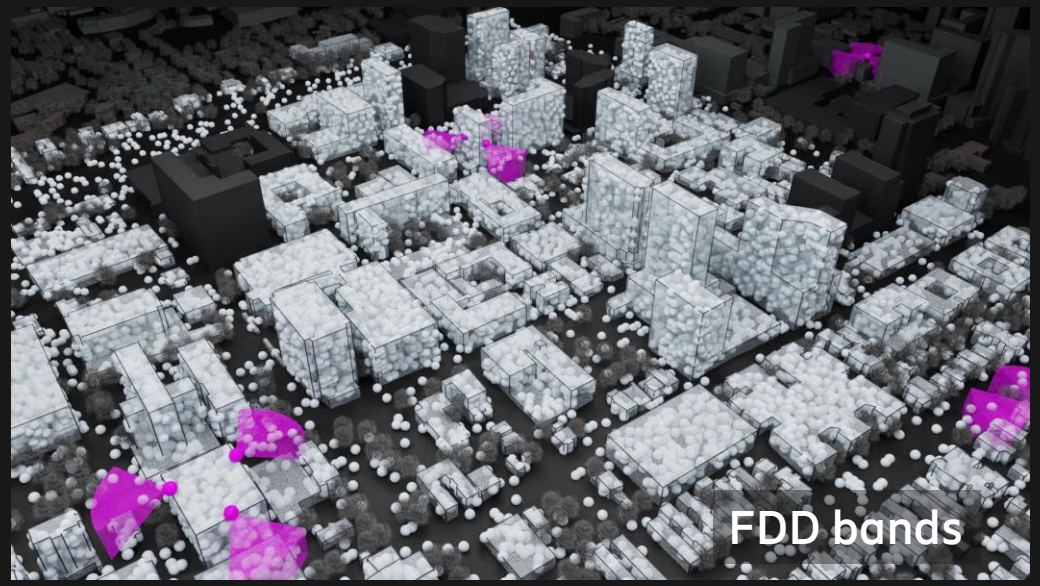
Speed

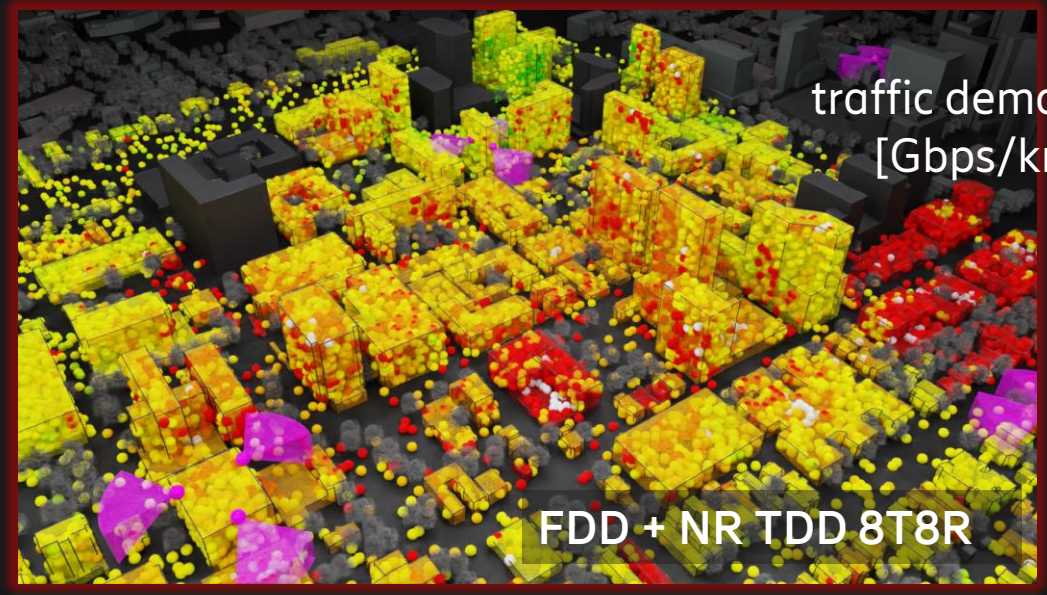
Massive MIMO more resilient to traffic growth

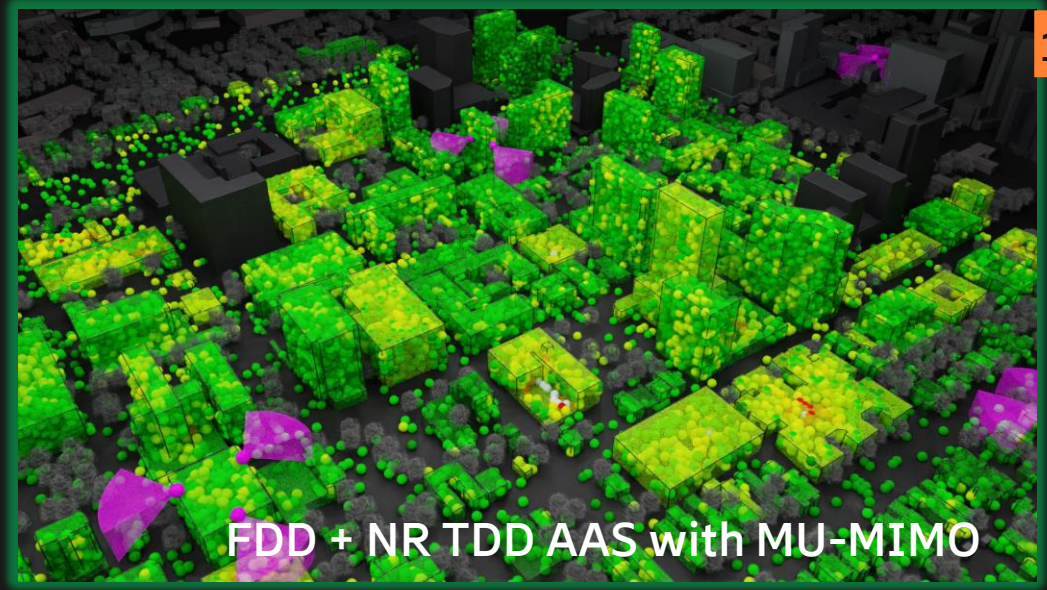
Beamforming for extended coverage and increased capacity

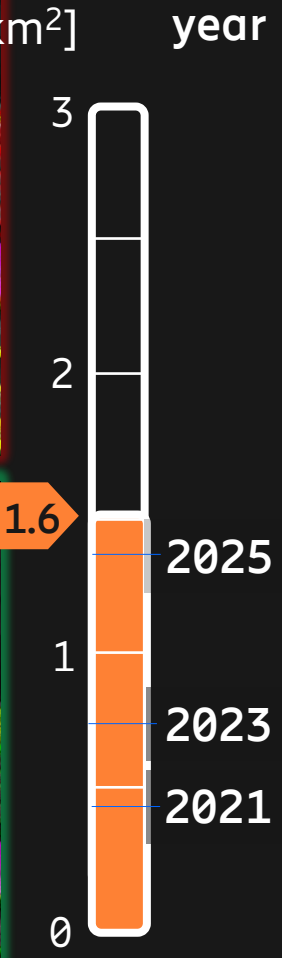
"Bring the spectrum to the user"

Downlink User Experience Visualized

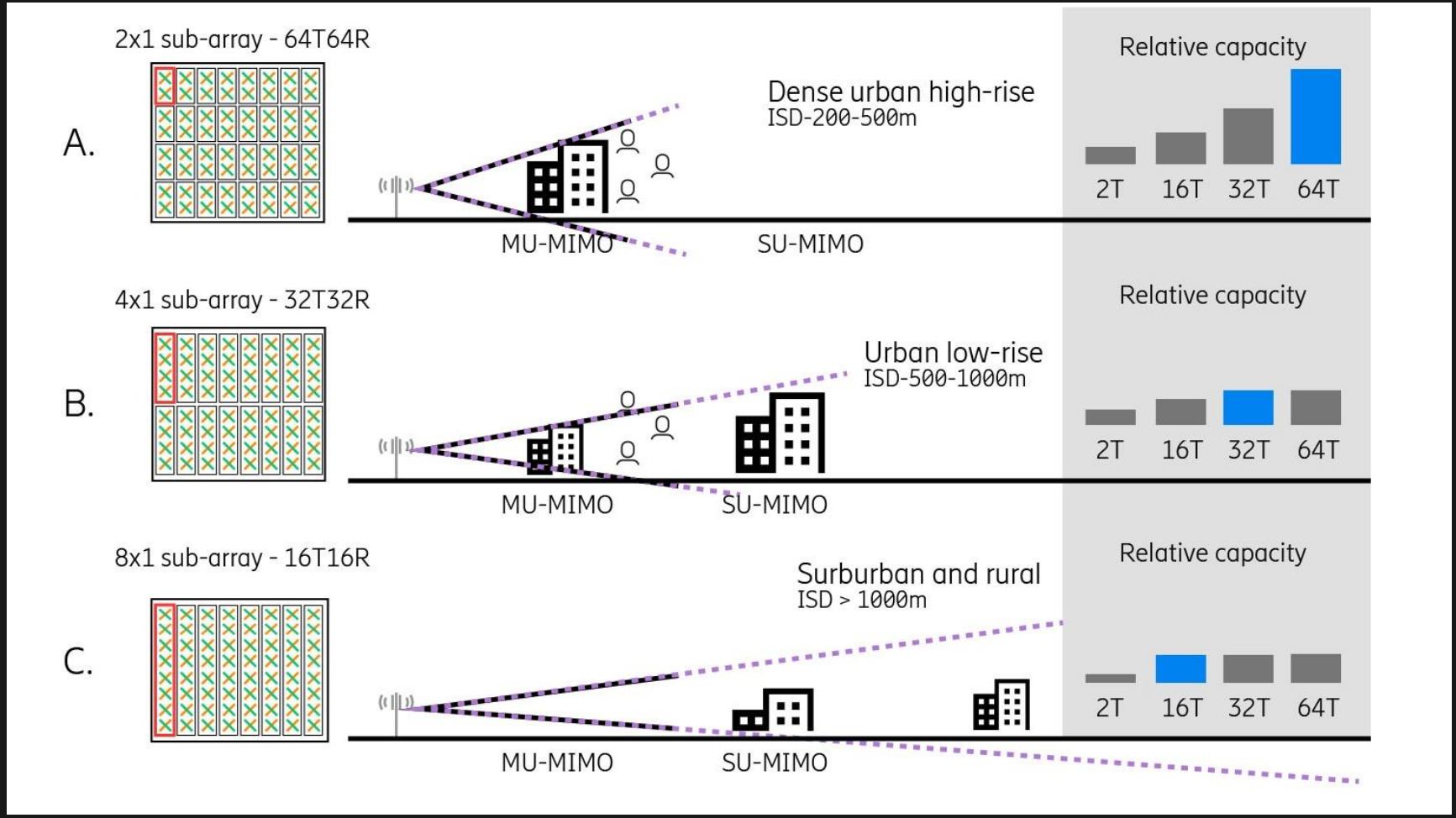








Deployment scenarios



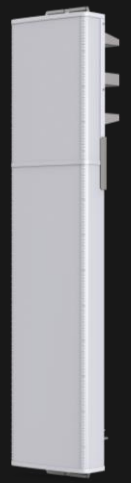
Different deployment scenarios call for different antenna configurations

Horizontal domain beamforming always brings gains while benefit of vertical domain beamforming is scenario dependent

New site solutions with Ericsson Massive MIMO

Hybrid AIR

- Combines one low band antenna with a Massive MIMO AIR on top, utilizing the wide range of passive antenna modules from KMC portfolio
- Option to use variants of 32TRx and 64TRx radio modules from the Ericsson portfolio



Interleaved AIR

- A single antenna form factor that uses interleaving technology for maintained low band antenna properties for same height of antenna
- Option to use Radio and connect to the top portion of the unit (enable 2 TX– 8 TX)
- Enable future expansion to M-MIMO mid band within the same site lease contract

Ericsson Massive MIMO provides best TCO

TCO for infrastructure is similar for RRU and M-MIMO

- CAPEX: radio, antenna, baseband capacity, SW, NRO
- OPEX: site rental, energy consumption

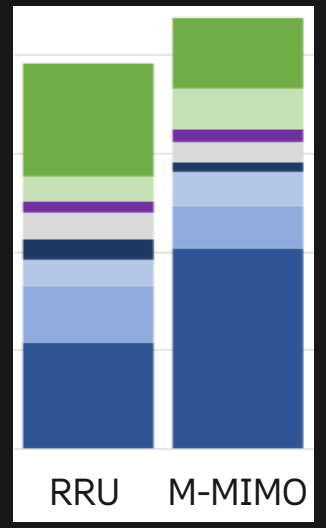
TCO per capacity is better for M-MIMO

- Deployment dependent M-MIMO typically 2-3 times more efficient
- M-MIMO bring down TCO/capacity> 40%

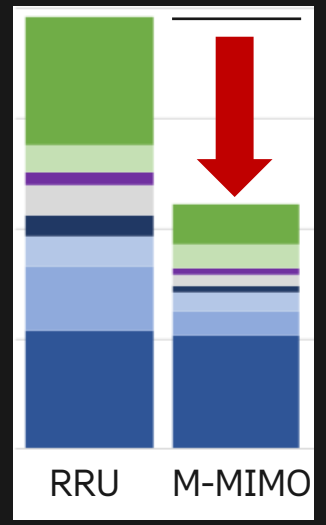
Secure future capacity demand

- Avoid demanding site expansion later by use of M-MIMO for valuable sites

TCO for infrastructure



TCO per capacity



Accelerate 5G with mid-band and Massive MIMO

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고대역 액세스 솔루션

권혁찬 5G 액세스 솔루션 아키텍트

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Highband In 2019

Efforts in recent 1 year

Example of Use cases

Summary

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High band in 2019

Highband gives new opportunities

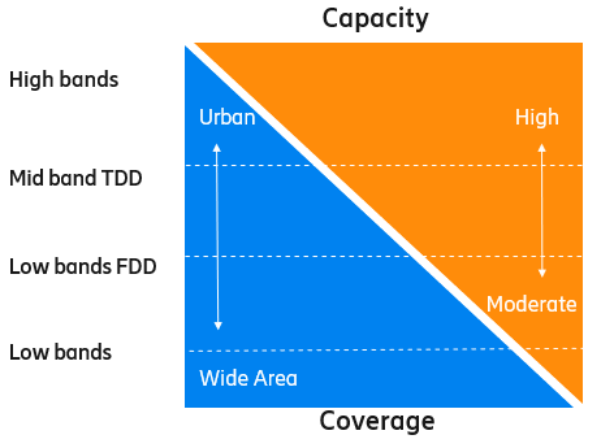
- New large spectrum assets
- High capacity, high peak rates

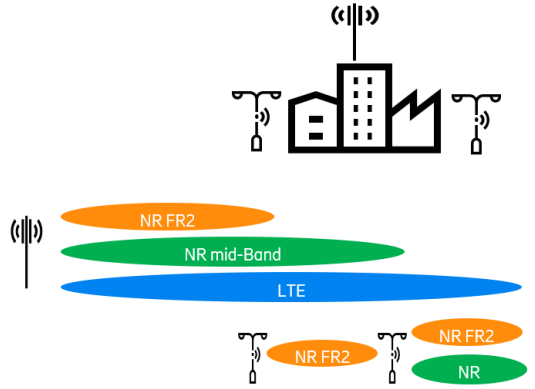
New deployment strategies needed

- LOS is important
- Beamforming is necessary for uplink
- Deploy where it makes sense
- Use with lower bands

Ericsson is leading highband industry

- Large experience on high band deployment
- Develop products that is needed for operators





AIR 1281

AAS for street
53-56 dBm
CPRI Fronthaul

Streetmacro 6701

RBS for street
53-56 dBm
Ethernet Backhaul

AIR 5322

AAS for roof top
59-62 dBm
CPRI Fronthaul

5G Street Portfolio in US

- Deploy where it makes sense

High band portfolio

Segments	Products	Evolution	
Capacity High EIRP, many beams Up to 62dBm EIRP AIR 7 liter, 8 kg	AIR 5322 62/59dBm EIRP	Higher output power Higher uplink performance	**General** Size/weight optimization Energy efficiency Fronthaul evolution Support for all 3GPP bands
Compact Low weight & size with or without integrated baseband AIR 7 liter, 8 kg Street macro 13 liter, 13 kg	Street Macro 6701 Integrated baseband AIR 1281 Compact and energy efficient design	Smaller size and lower weight Lower transport requirements	

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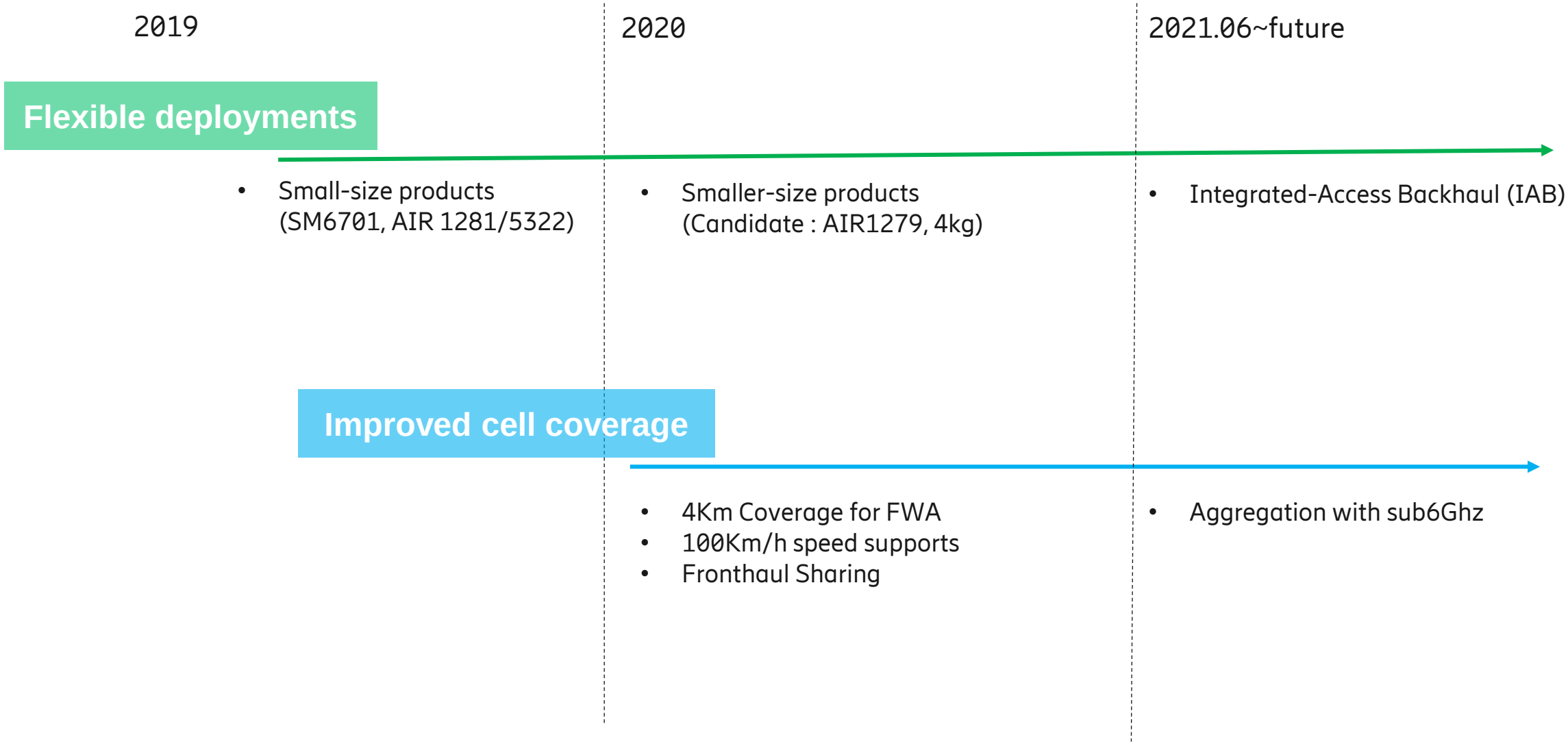
Requirements and supports



NR 28GHz Extended Range Field test result

- Ericsson x Hong Kong Reference Operators in NR 28GHz Extended Range Field testing/measurements : >1Gbps downlink throughput

- Test locations:
  1) KITEC 9/F (~3.7KM)
  2) Oi Tat House Rooftop (~4.3KM)

- Key contributors for extended cell range : upto 4km
  - General Mobile UE (high-power CPE)
  - NR PRACH receiver upgrade + Gap resource manipulation
  - Resource optimization

Fronthaul Sharing

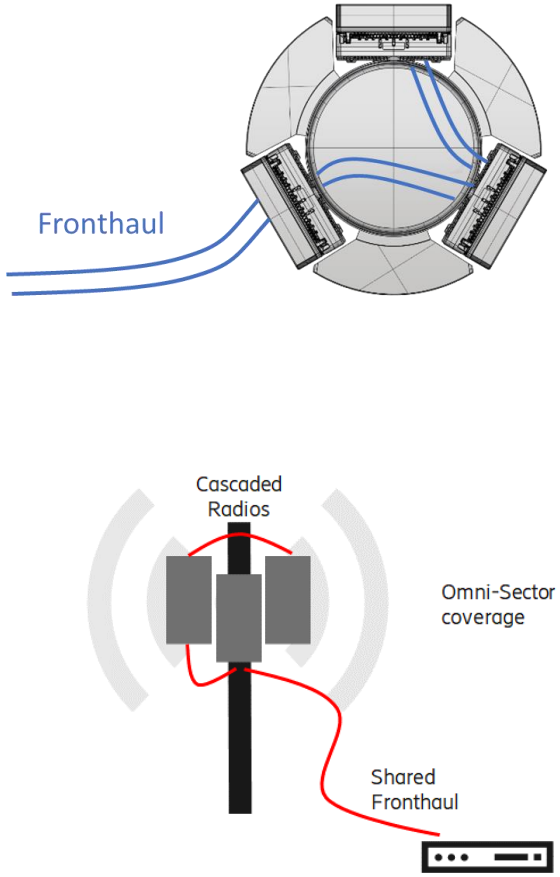
Description

— Enables a 240/360-degree omni cell configuration with reduced number of fibers to the site. The omni cell consists of multiple radios connected in cascade

— Up to 800MHz Carrier Bandwidth

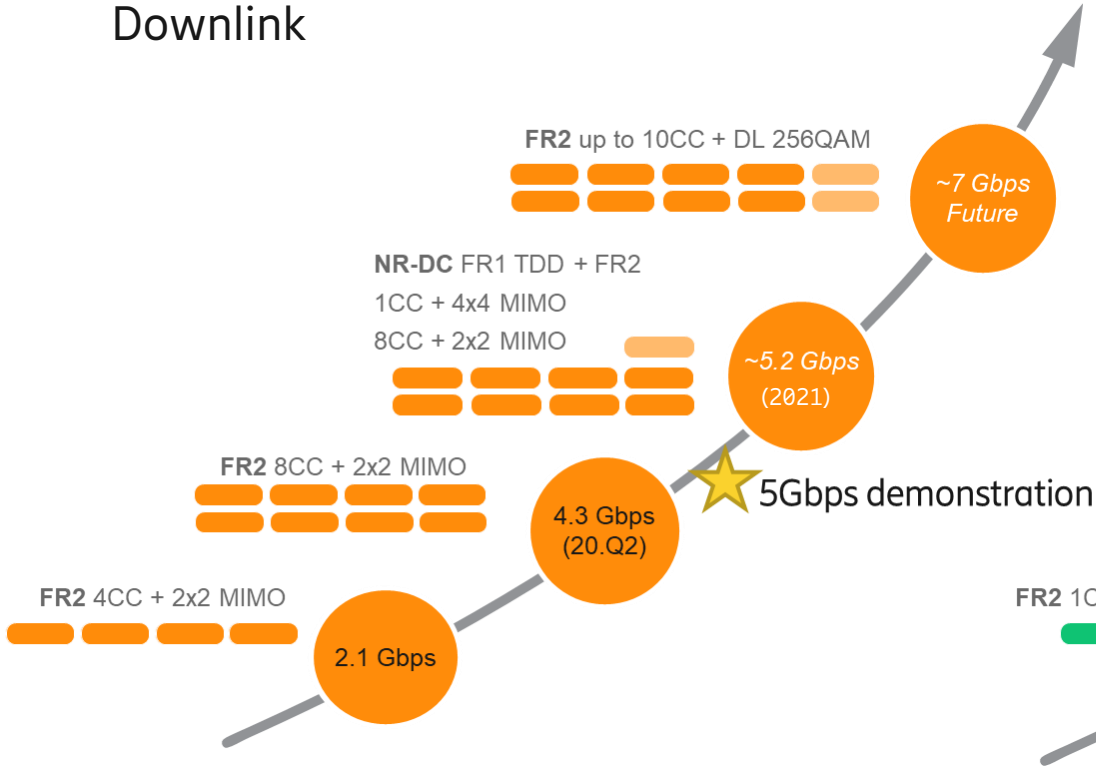
Benefit

— Reduced CAPEX reduced fibers to the site by a factor of 3 for similar configuration

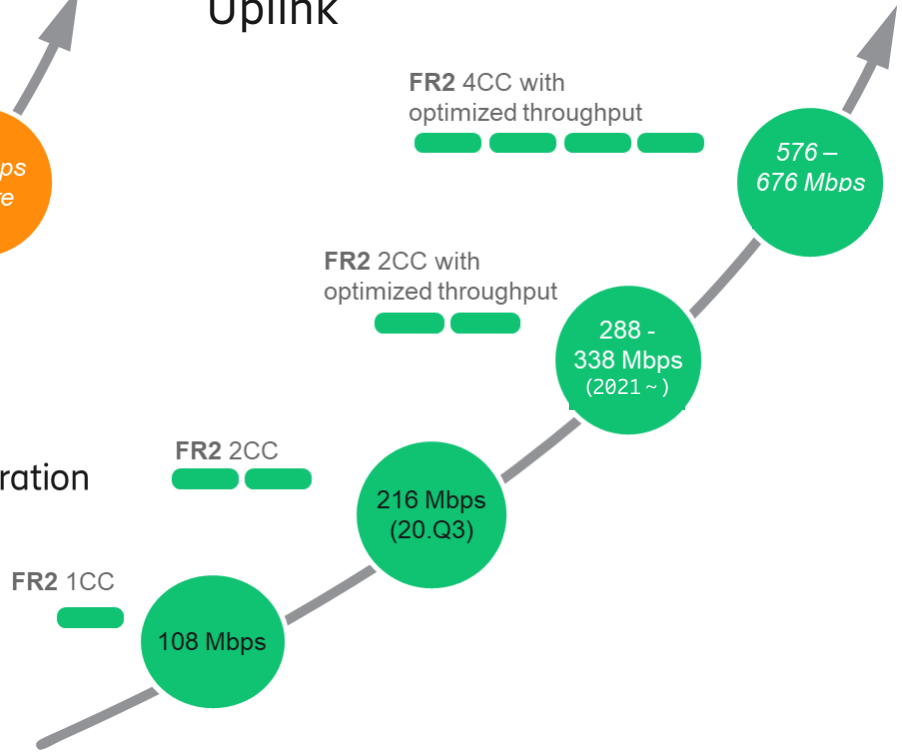


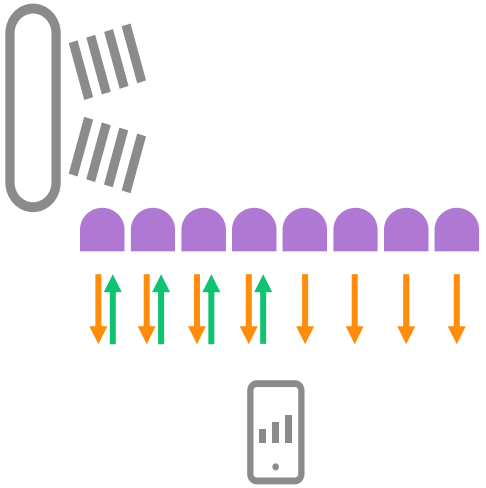
Peak rate evolution with aggregation

Downlink



Uplink





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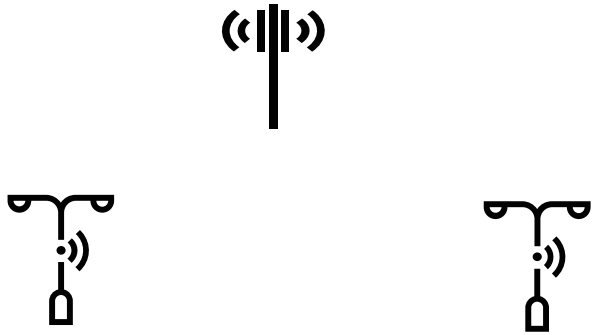
Mobile Broadband Deployment cases

Hot spots

- Dedicated coverage for high traffic area as stadiums or event sites
- Provide very high capacity
- Deliver high peak rates

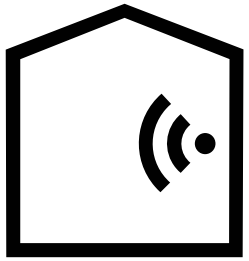
City deployment with street sites

- Outdoor and some indoor high band coverage in city
- Off-load capacity from lower bands
- Deliver high peak rates



Indoor

- Indoor high band coverage
- Deliver high peak rates
- Provide very high capacity

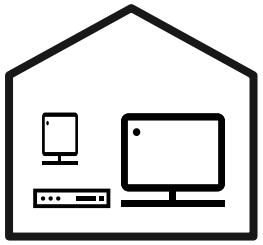


Special Deployment cases

FWA

— High capacity high peak rate alternative to fiber

— Outdoor CPE and antennas to provide for LoS need



Industry

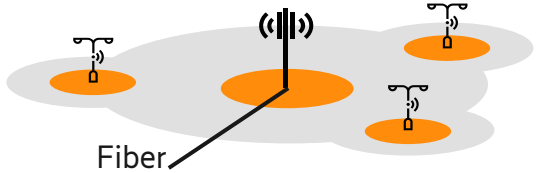
— High performance and low latency for industry applications

— Future potential to be developed in the industry connect segment

IAB

— High Band as backhaul for street sites with high band or mid band

— Future potential still being worked on in standardization



FWA

— Deliver alternative to fiber to households and small companies primarily in suburban areas

— 5G high band delivers high peak rates and high capacity thanks to very large spectrum allocations (typically 400-800 MHz) sufficient to fully replace fiber also for high volume usage

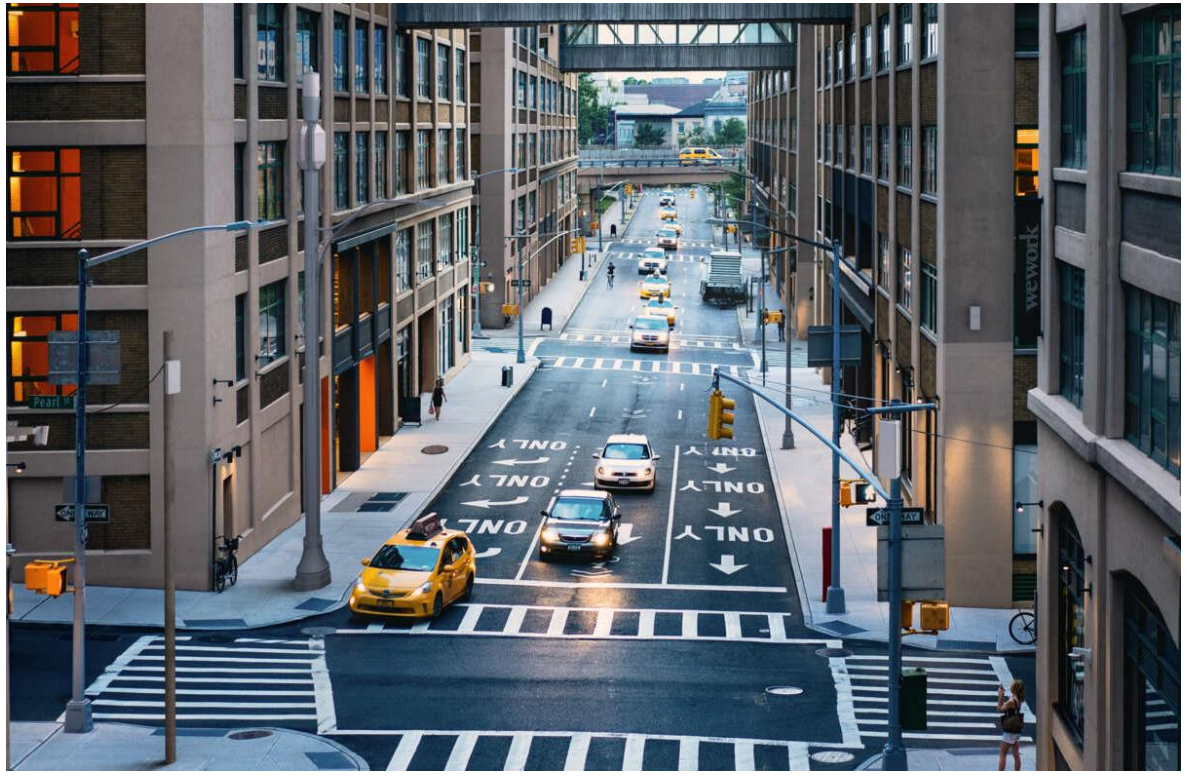
— With use of outdoor CPE and LoS to macro or street radios excellent performance is delivered

Industry applications

- Deliver high capacity low latency wireless connectivity for industry automation
- High band offers high speed, high capacity and can provide for low latency radio interface
- The limited radio propagation of high band can allow for radio coverage to be concealed to specific locations
- In some countries high band spectrum allocations are designated to industry applications
- Wireless connectivity offers flexibility in industry applications

Integrated Access and Backhaul (IAB)

- Use high band spectrum and radio nodes for backhaul together with access
- The large spectrum allocations on high band allow for enough capacity for both backhaul and access
- High band can provide backhaul also for radios on lower bands
- Major savings removing backhaul cost and quicker installation of new site can be achieved using IAB
- IAB is still being standardized and is not ready for commercial offers yet.



Pocket WiFi

- Huddles for introducing 28GHz services
  - Difficulty of 28GHz solution into UE side (power consumption, increased price and etc)
  - Difficulty of wide-area NW installation (smaller cell size and etc)

- Pocket WiFi rental services could be an example
  - Use legacy WiFi devices within small areas
  - Connect current smartphone/other devices via WiFi without any change
  - No WiFi Handover

- Examples of small areas
  - Riverside park / Amusement Park
  - Stadium / Golf Course / Museum
  - University / Junior High School
  - Special events (fireworks, performances, etc.)

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Example of Use cases

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Key Messages

From the beginning of highband commercial services, Ericsson is trying to improve the network

- Deployment flexibility
  - Smaller-size products, Integrated Access Backhaul (IAB)
- Performance enhancements
  - 4Km Coverage for FWA / 100Km/h speed supports
  - Fronthaul Sharing
  - Aggregation with sub6Ghz

Highband solutions would be applicable initially to small-area B2C or special purposes (e.g. B2B), and Pocket Wifi rent services over those areas could be a considerable example

- Riverside park / Amusement Park / Stadium / Golf Course / Museum / University / Junior High School
- Special events (fireworks, performances, etc.)
- FWA, IAB and Factory

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5G RAN 슬라이싱

전창범 시니어 솔루션 아키텍트

What is Slicing?

Network Slicing - 3GPP definition

New concept in 3GPP to allow differentiated handling depending on each customer requirements

*Customer = organization, agency or business entity

So what does that mean?

— The customer is guaranteed network resources through a predefined Service Level Agreement (SLA)

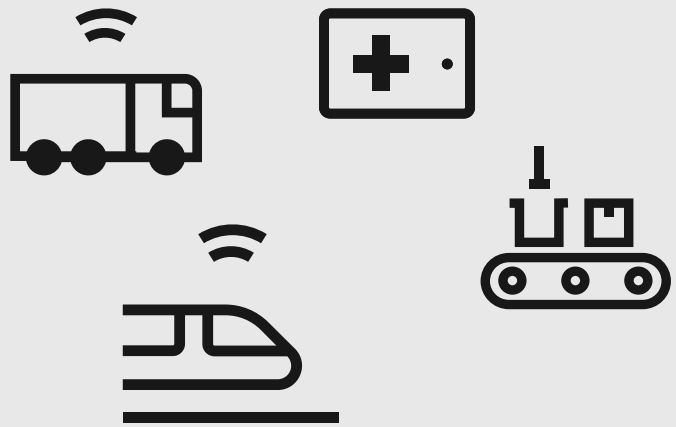
Formal 3GPP SA2 definitions (TS 23.501 5G System architecture)

— Network Slice: A logical network that provides specific network characteristics

Why Network Slicing?

DIFFERENT NEEDS

- Characteristics
- Functionality
- Local vs National vs Global
- Different Business Models/ agreements
- Security/Isolation
- Exposed control/management



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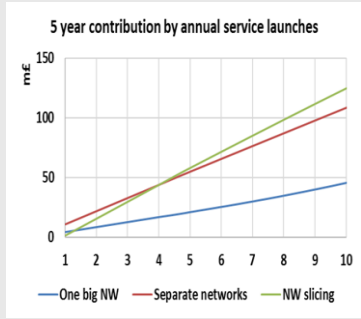
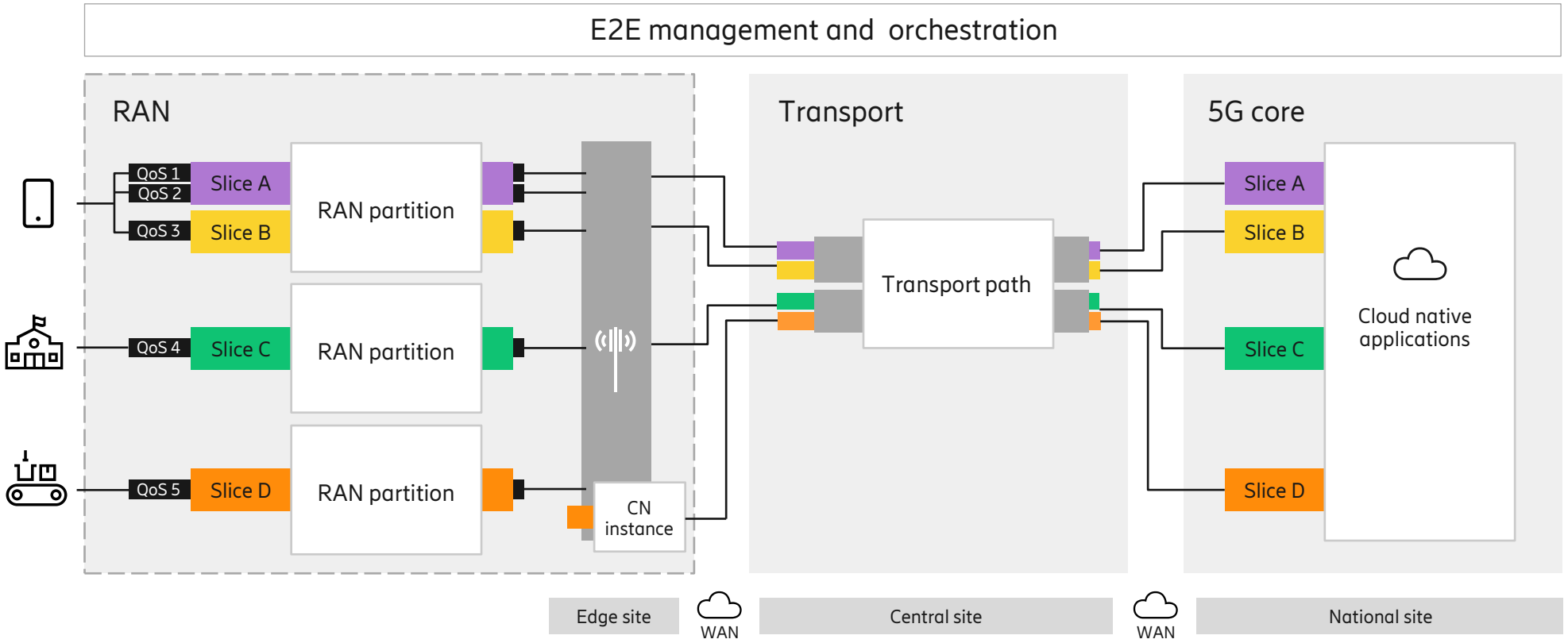
- Customer Experience
- Time to Market, Agility
- Operational Efficiency

+

- Economic aspects of network slicing
- New revenue, OPEX reduction
- Highest level of service scalability



5G network slicing is truly end to end



E2E Network Slicing with automation across business and operational processes

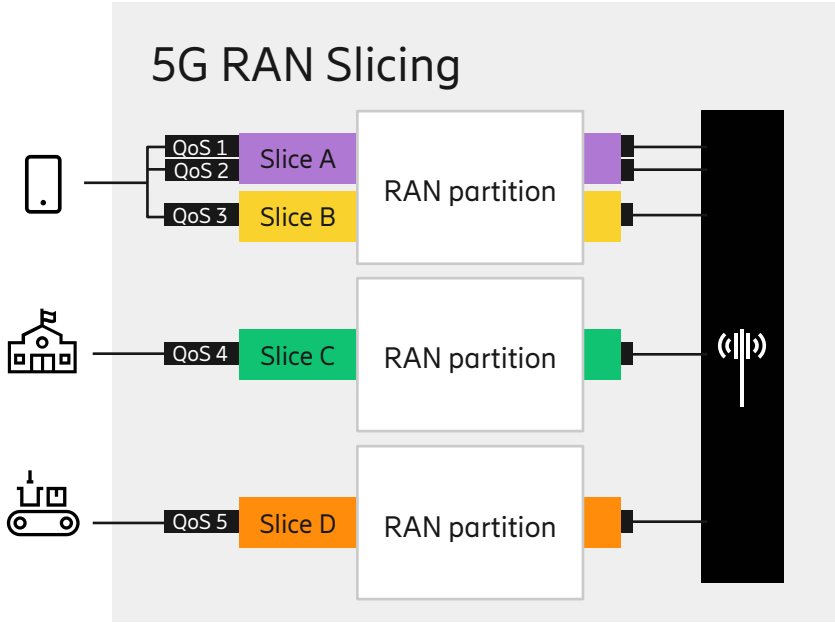
What can 5G RAN slicing offer?

Ericsson 5G RAN Slicing

e2e slicing support for resource management and orchestration

Software solution offers:

- Dynamic Radio Resource Partitioning
- Slice-aware QoS Differentiation
- Slice-aware observability



Dynamic RAN resource sharing with QoS differentiation and observability for SLA fulfillment

Dynamic Radio Resource Partitioning

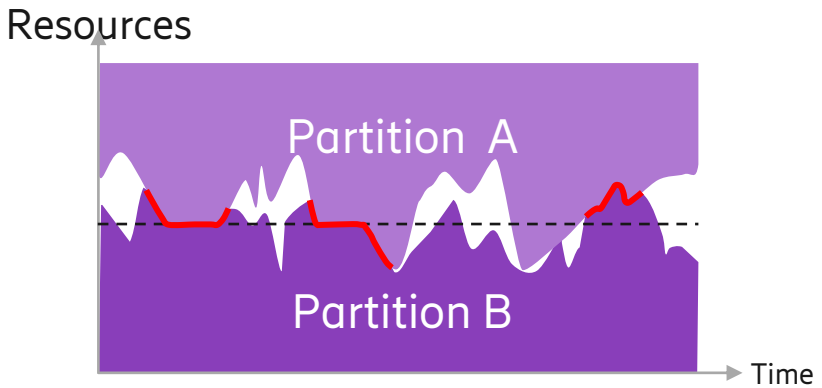
Resource sharing at 1mSec for best spectrum efficiency

Radio Resource Partitioning (RRP) distributes available spectrum resources across network slices

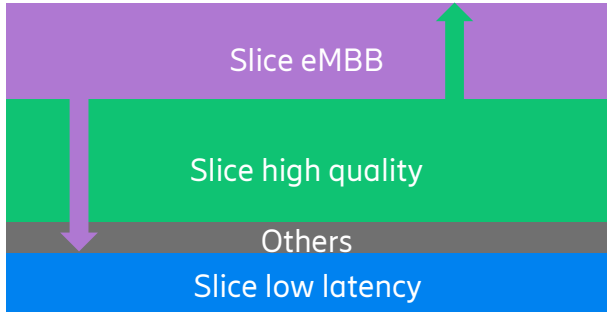
- Dynamically when there is no resource contention
- Enforces configured resource share during contention

Benefits

- Protection of services and business
- Provides services meeting SLAs
- Provides resource guarantees during times of contention



Dynamic resources sharing at 1ms level



Flexible partition sharing policy

Slice-aware QoS Differentiation

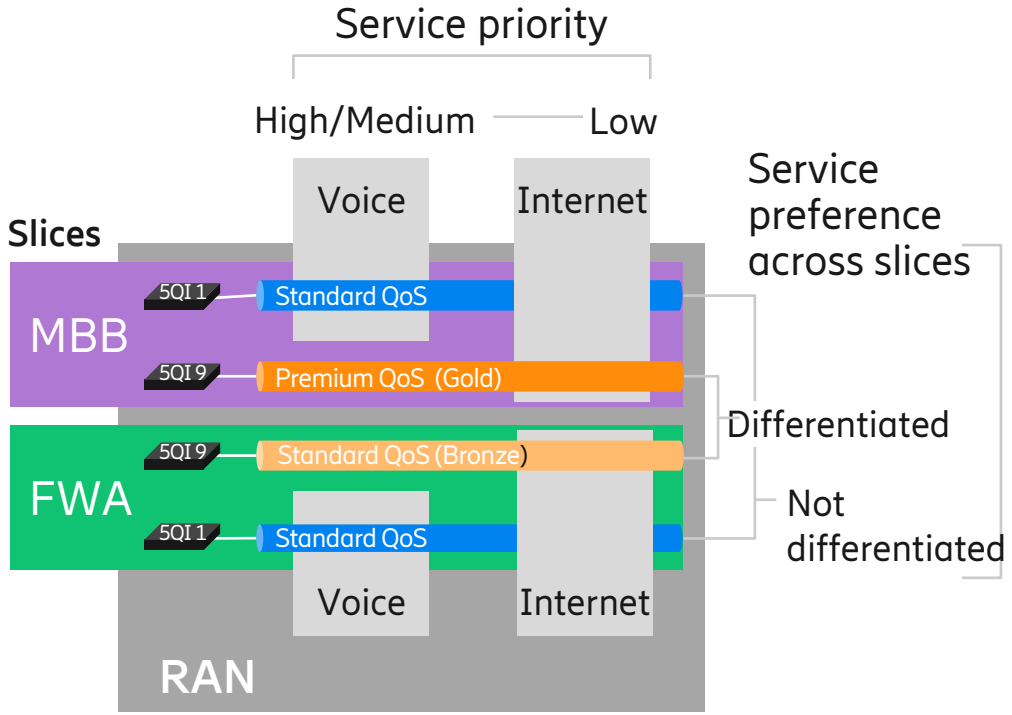
Resource allocation prioritization

Network slices can be associated with dedicated Quality of Service (QoS) characteristics per service (5QI) controlling traffic treatment in RAN

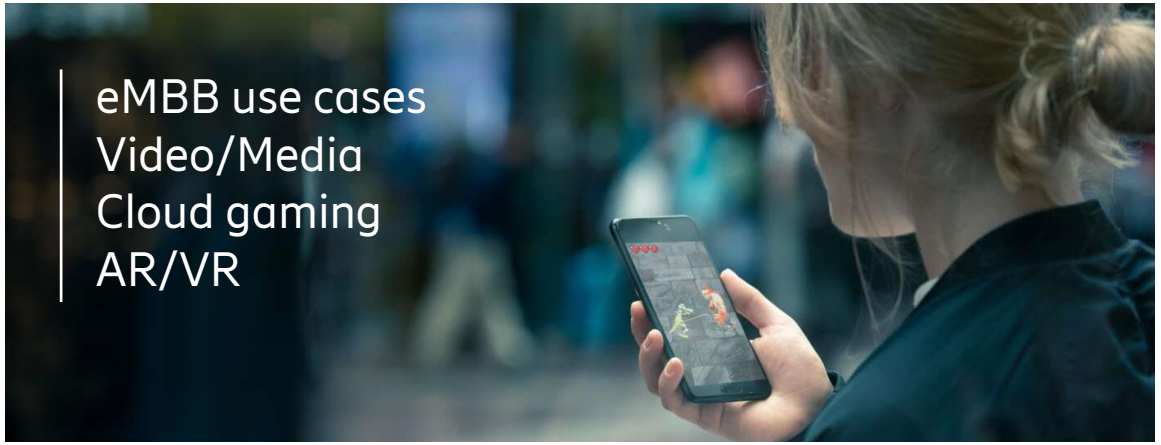
- Scheduling behavior

Benefits

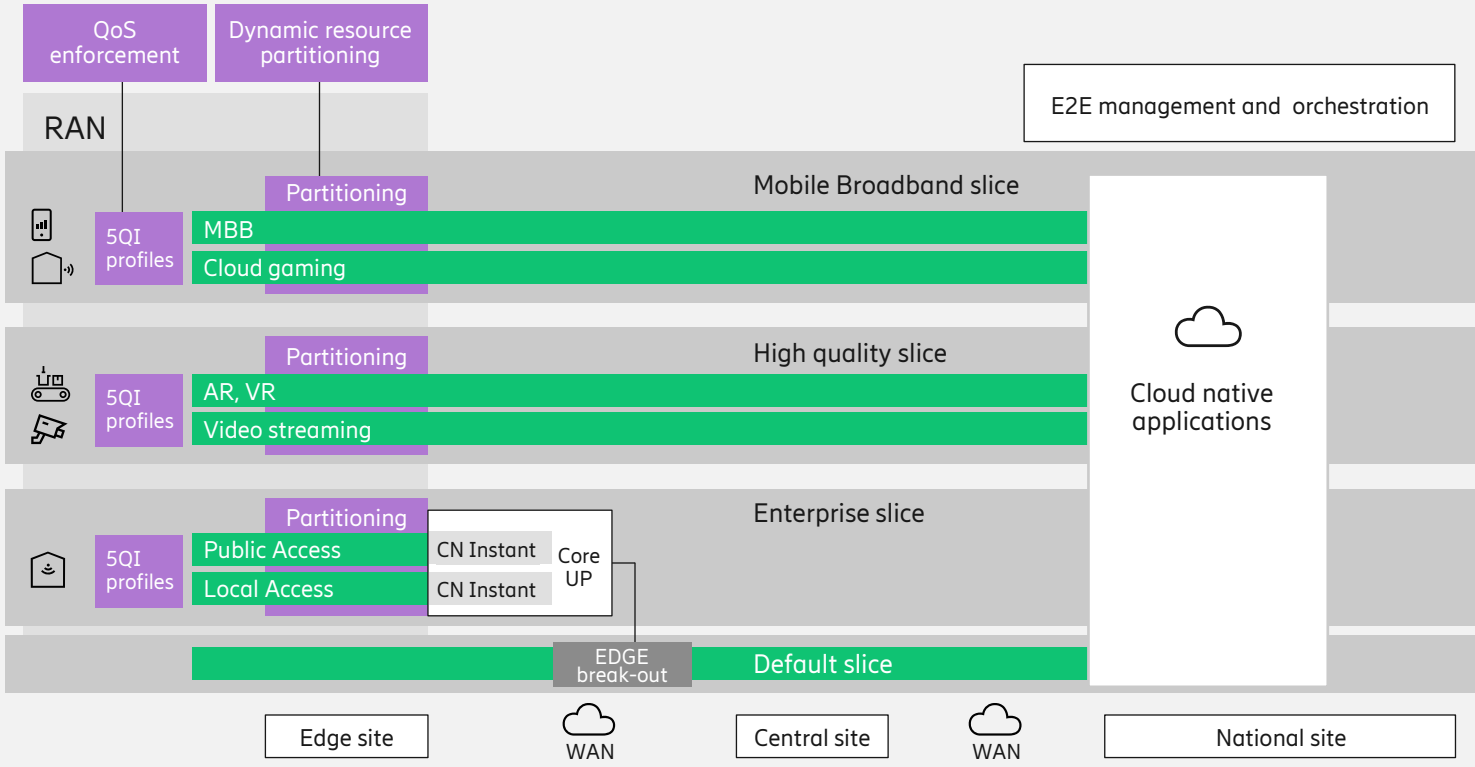
- Service differentiation within and between network slices
- QoS characteristics tuning per slice and service to meet SLAs
- Re-use of 5QIs across slices with different QoS characteristics

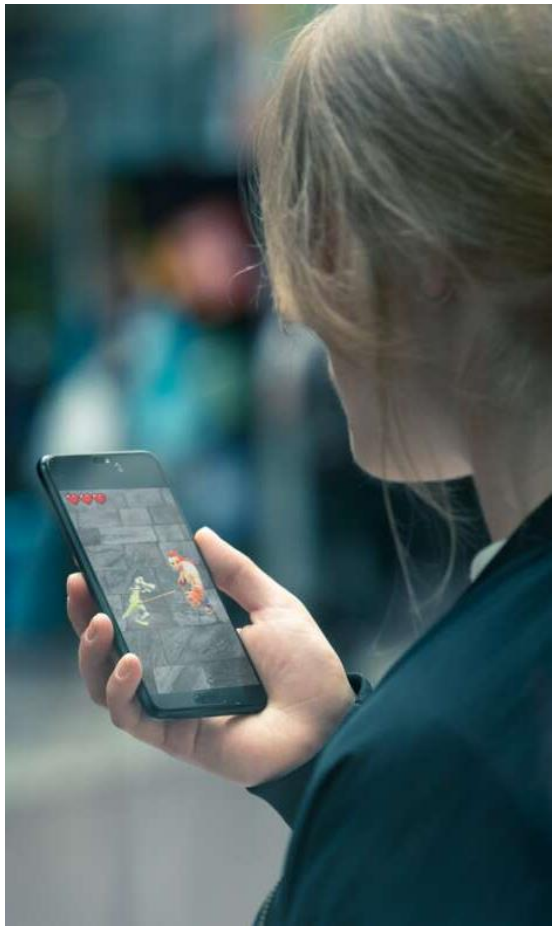


5G RAN slicing powers new and differentiated use cases



RAN slicing deployment model
Example of use cases





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5G 산업 적용 사례

박동주 테크니컬 디렉터

Industrial opportunity

For service providers, there's a lucrative opportunity to provide cellular connectivity to industries

4.3 billion

Number of wireless connections in smart factories by 2030

For industries, the ROI for moving to cellular-enabled Industry 4.0 is strong

1 yr vs. 2 mo

Time to reconfigure an automotive factory – wired vs wireless

Reliable wireless connectivity enables more automation to increase efficiency, productivity, accuracy.

5-25%

Efficiency gains from AR-enabled vision picking or guided product assembly

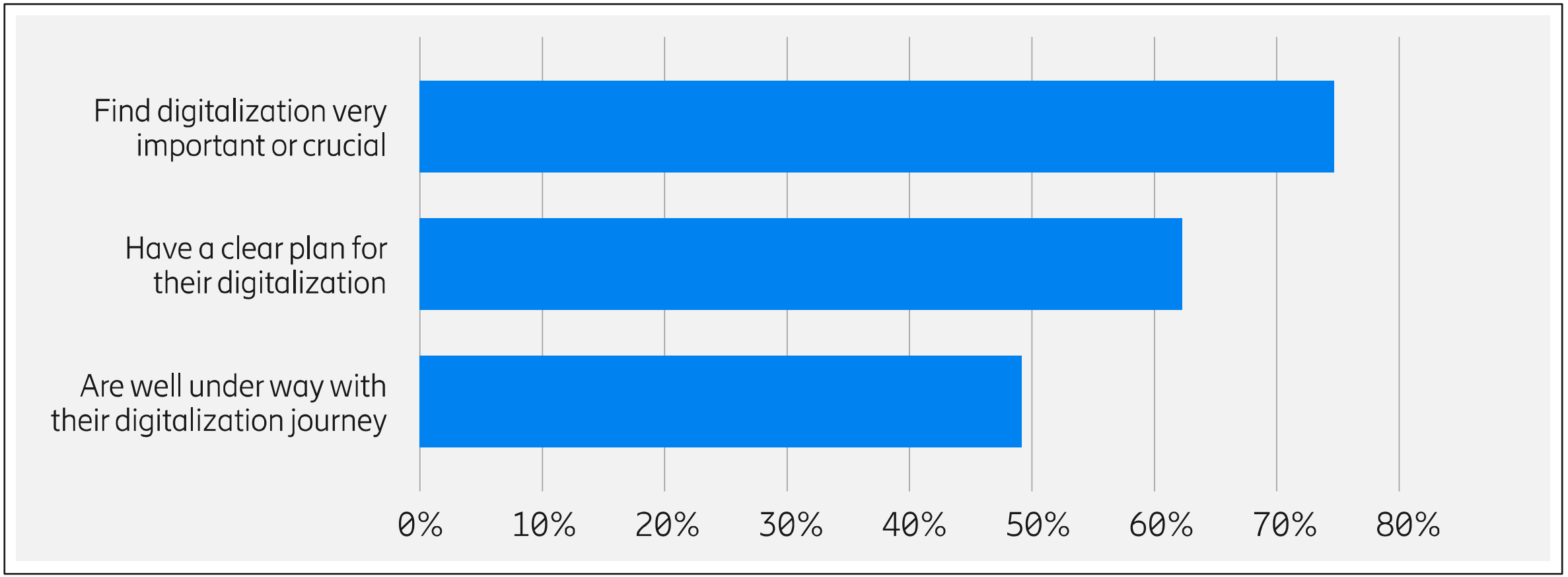
Dedicated cellular connectivity provides greater reliability and device density, predictable latency and robust security.

$30K per minute

Cost of downtime in an automotive factory

Source: ABI Research

Digitalization is a top priority for businesses



Summary graph with replies to three separate questions: "How important would you say digitalization is to the future of your company?", "How would you describe your company's plans for digitalization?" and "How far have you come in your company's journey towards digitalization?"
Base: 1100 enterprise IT decision makers in Australia, Brazil, Canada, France, Germany, Italy, Japan, South-Korea, Spain, UK and the USA
Source: Serving the 5G powered business, Insights for service providers to capture the enterprise digitalization opportunity (January 2020)

Cellular IoT evolution and segments

Commercial – Growth

Early pilots & standardization

Massive IoT	Broadband IoT	Critical IoT	Industrial Automation IoT

One network – multiple use cases and industries

Smart Metering

Asset management

Fleet Management

Drones/UAV

VR/AR

Automotive C-ITS

Traffic Safety & Control

Smart Grid Automation

Collaborative robotics

Advanced Automation & Control

Massive IoT	Broadband IoT	Critical IoT	Industrial Automation IoT
Low cost devices, low energy Small data volumes Massive numbers	High throughput Low latency Large data volume	Ultra reliability Ultra low latency Very high availability	Industrial protocols Time sensitive networks Precise indoor positioning
NB-IoT/Cat-M1 (LTE and NR)	LTE + NR	NR	NR

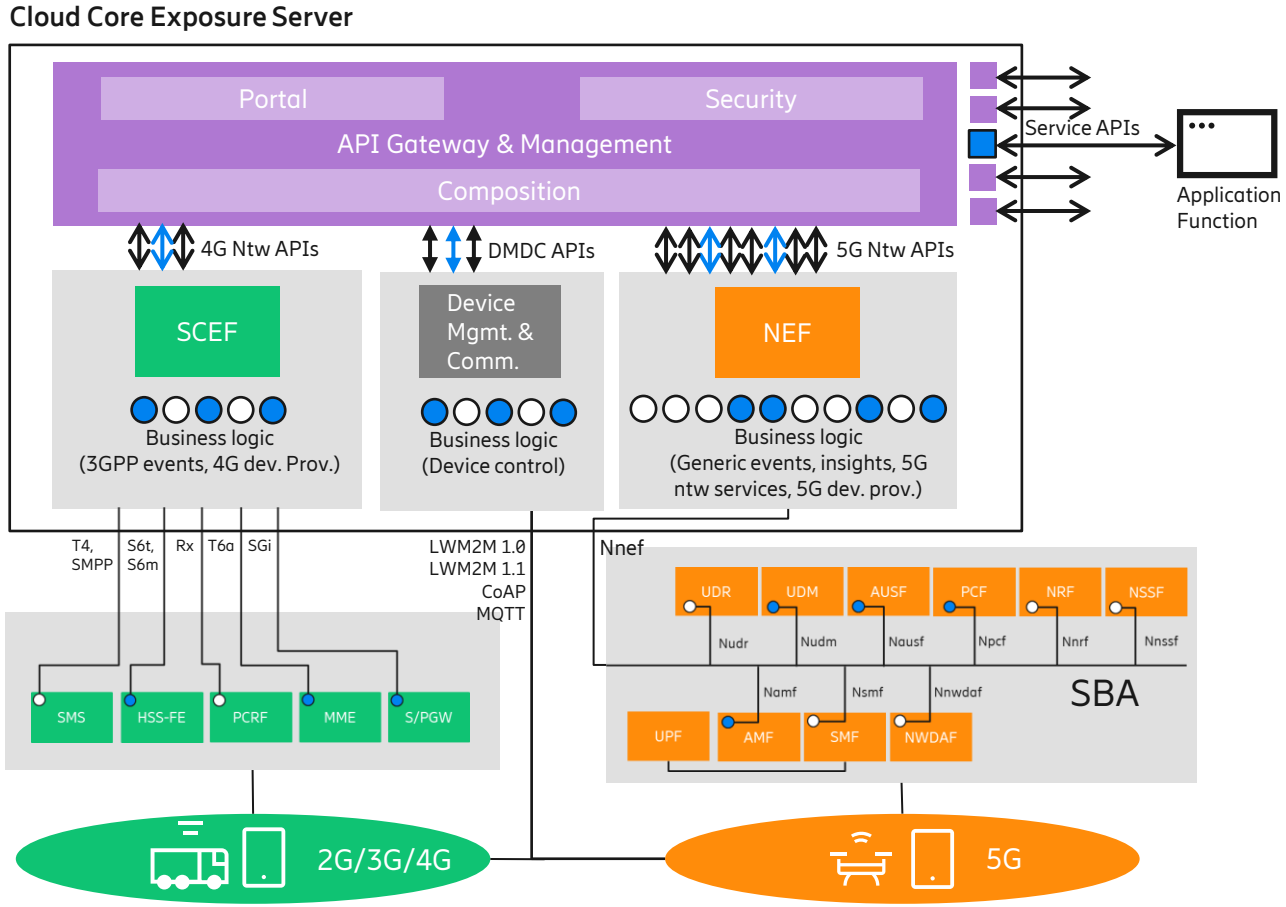
Foster business innovation – With core network exposure capabilities

Centralized API management, embedded API gateway and exposure capabilities, enabling:

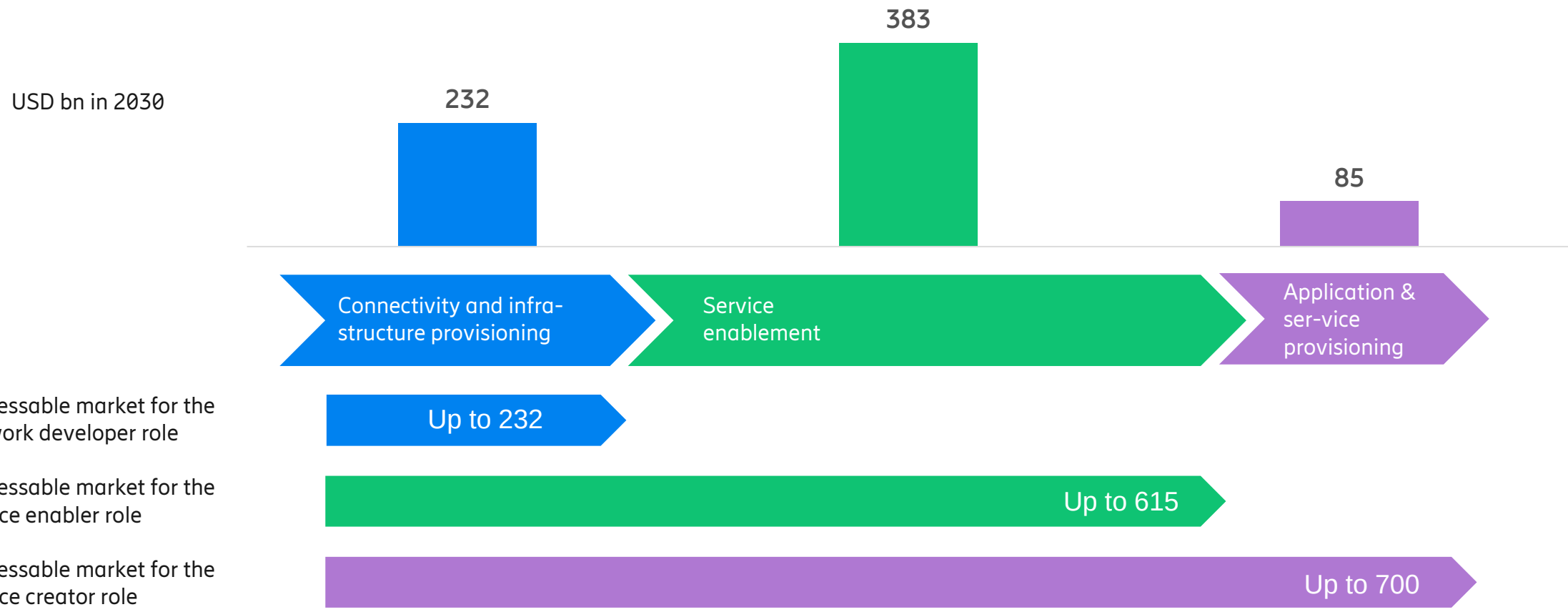
- Standard and tailored APIs per applications and use cases
- The ability to open 4G and 5G Core network capabilities to third parties.
- Increased network automation for operational efficiency.

New revenue	Network programmability

Read the Ericsson report: [Programmability in 5G Core networks]



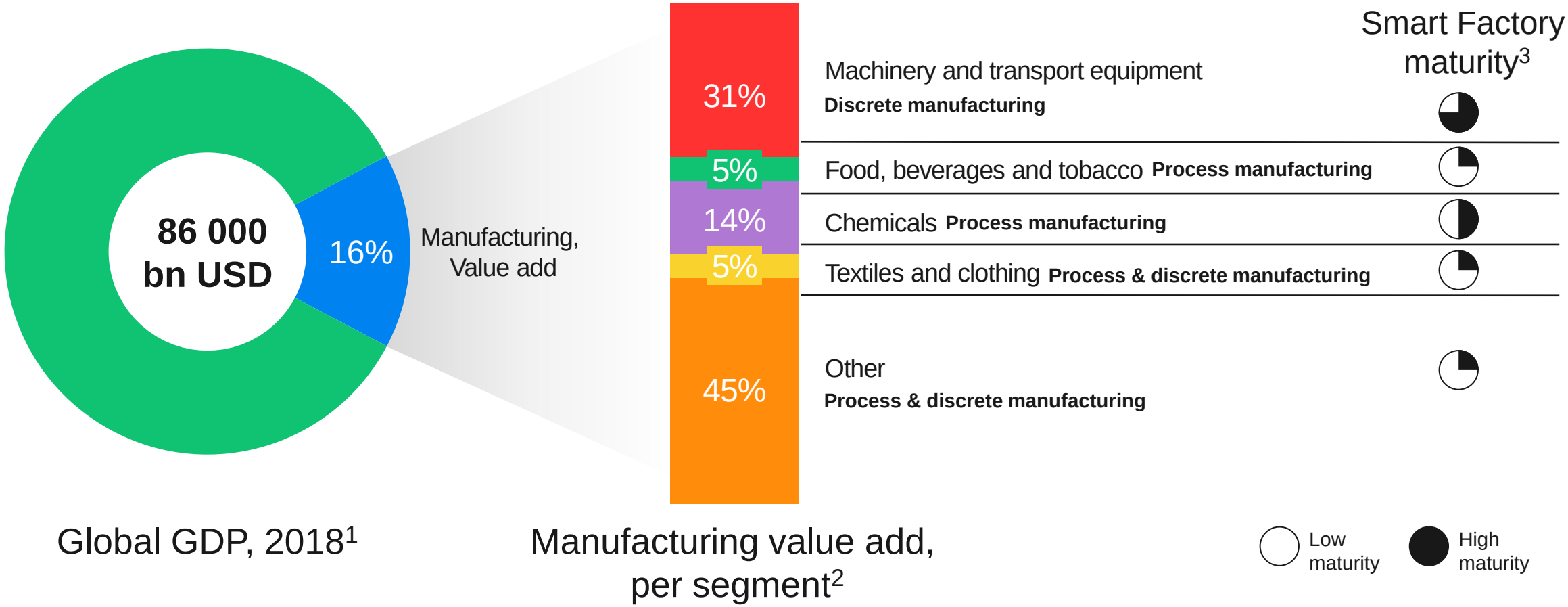
Addressable market to bring the 5G powered business to life



Source: Ericsson and Arthur D. Little

In
partnership
with

The manufacturing industry has a large potential to become smarter



Source: World bank, Grand View research, Arthur D. Little

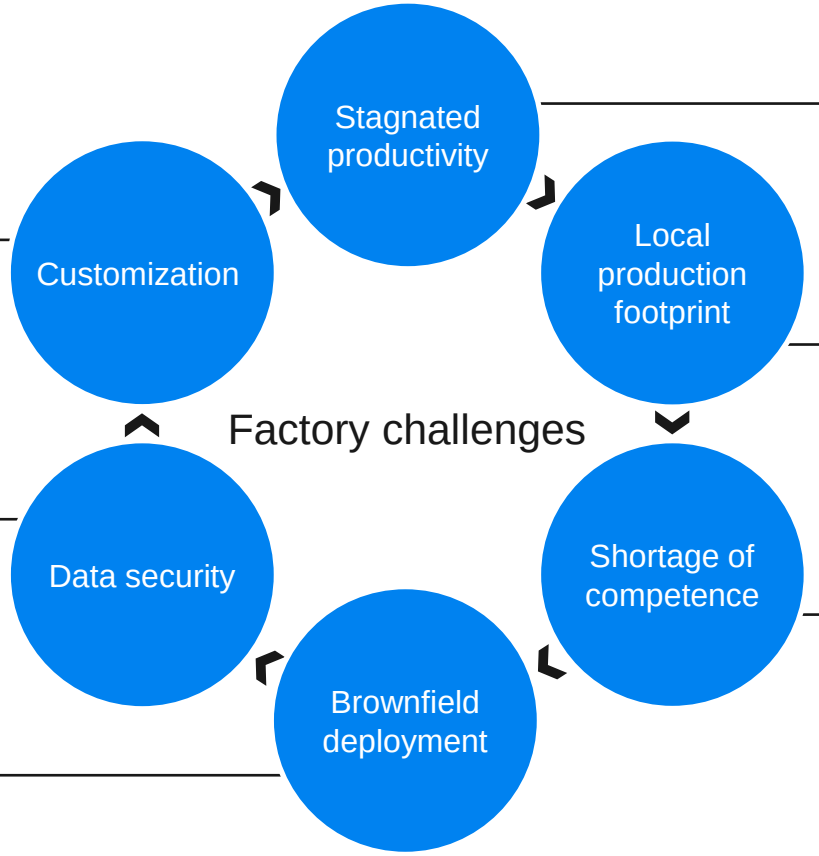
1. World Bank, Global GDP 2018, 2. World Bank, Structure of manufacturing 2016, 3. Smart Factory maturity assessed based on Smart Factory market size per segment related to contribution to GDP.

Manufacturers face several challenges in their current operations. . .

86% of consumers say customized products have some appeal[1], implying a need for flexible production

22% of manufacturers experienced a cyberattack to their Smart Factory initiatives in 2019[2]

Integration
challenges to current systems and problems with data silos



<1% The total labor productivity growth in EU and the US has been below 1% since 2005 [3]

>80% of US companies experienced some impact from trade tensions in 2019[4]

60% of unfilled manufacturing jobs are due to lack of applicants with sufficient science, tech, engineering and math skills[5]

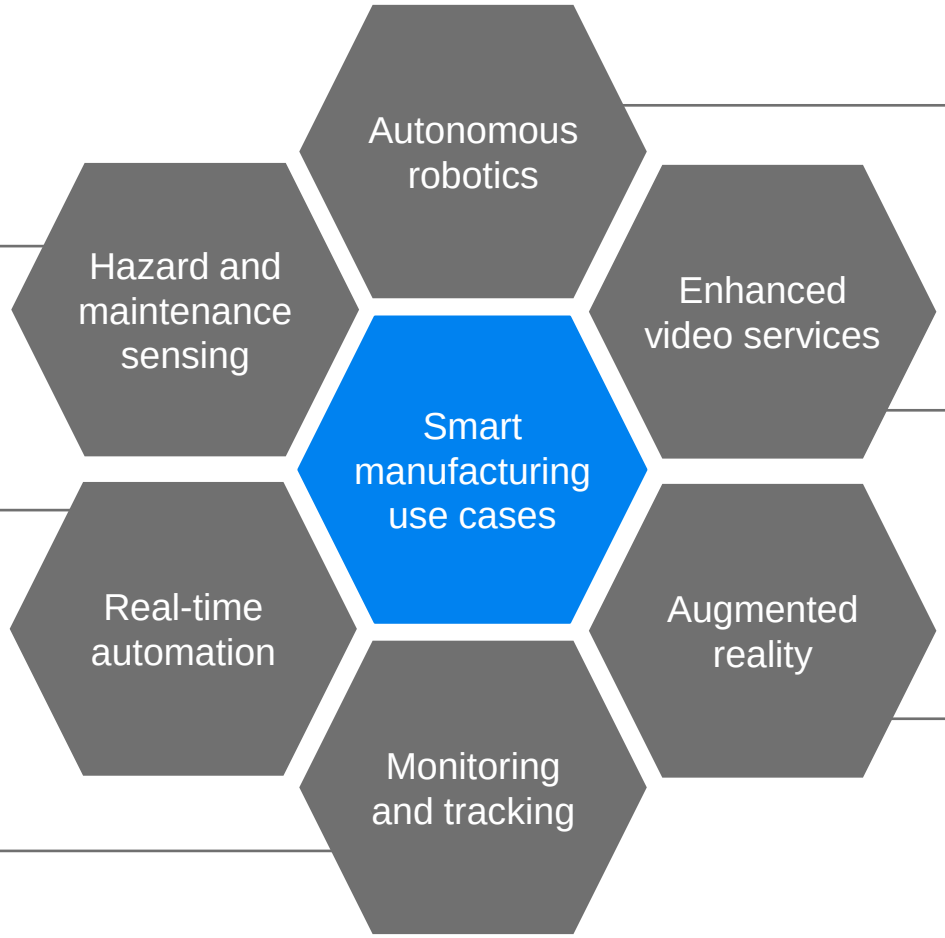
Source: Protolabs, Capgemini, WeatWork, VOX EU, The Manufacturing Institute/Deloitte, US-China business Council, interviews, Arthur D. Little
1. "The numbers reveal consumers want more options on demand"; Protolabs (2018); 2. Smart Factories @ Scale, Capgemini Research Institute (2019); 3. The industry anatomy of the transatlantic productivity growth slowdown: Similarities outweigh the differences, VOX EU (2019); 4. US-China business Council (2019); 5.The skills gap in U.S. manufacturing 2015 and beyond, Manufacturing Institute & Deloitte (2015).

There is a wide range of use cases within the concept of the Smart Factory…

- Real-time product monitoring
- Environmental monitoring

- Factory cell automation
- **Production chain automation**
- Industrial automation
- Distributed control systems

- Connected operational intelligence
- **Asset condition monitoring**



- Real-time closed loop M2M communication
- Untethered robotics
- **Collaborative robotics**

- 3D video-driven interaction between collaborative robots and humans
- Remote quality inspections/diagnostics
- **Digital twin**

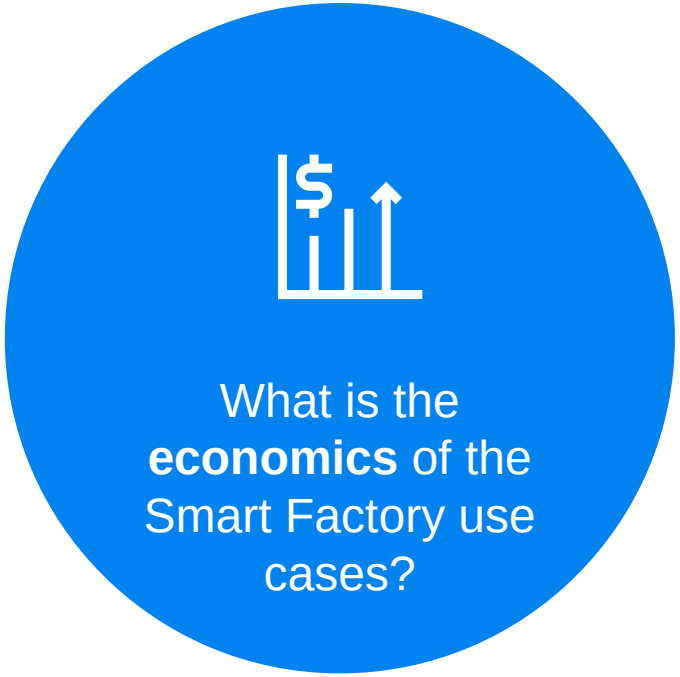
- AR support in training
- **AR for worker support**

Source: Ericsson, Arthur D. Little

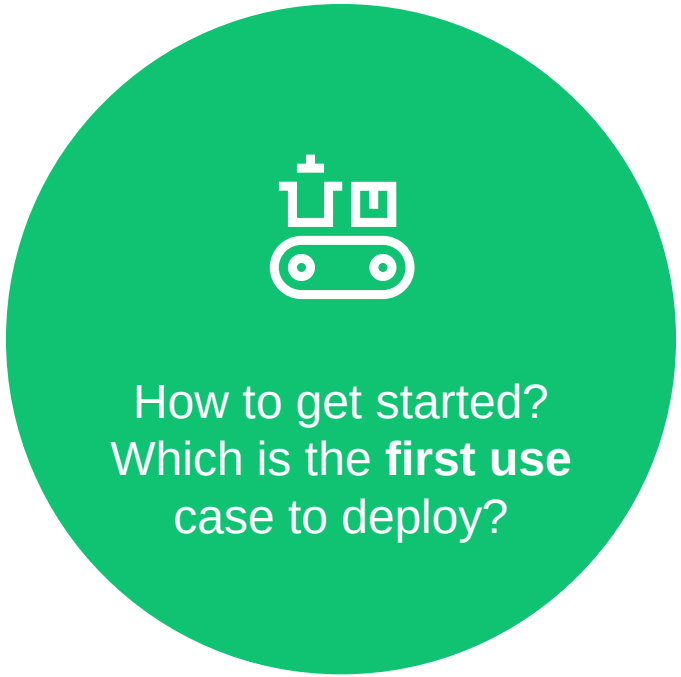
… but manufacturers experience some uncertainties in how to get started

Industry concern

We already have well functioning processes in our factory, why would I want to change these?



Which use case is the one that actually justifies the deployment of a cellular network in our factory?



How do we actually realize the benefits from the use cases?

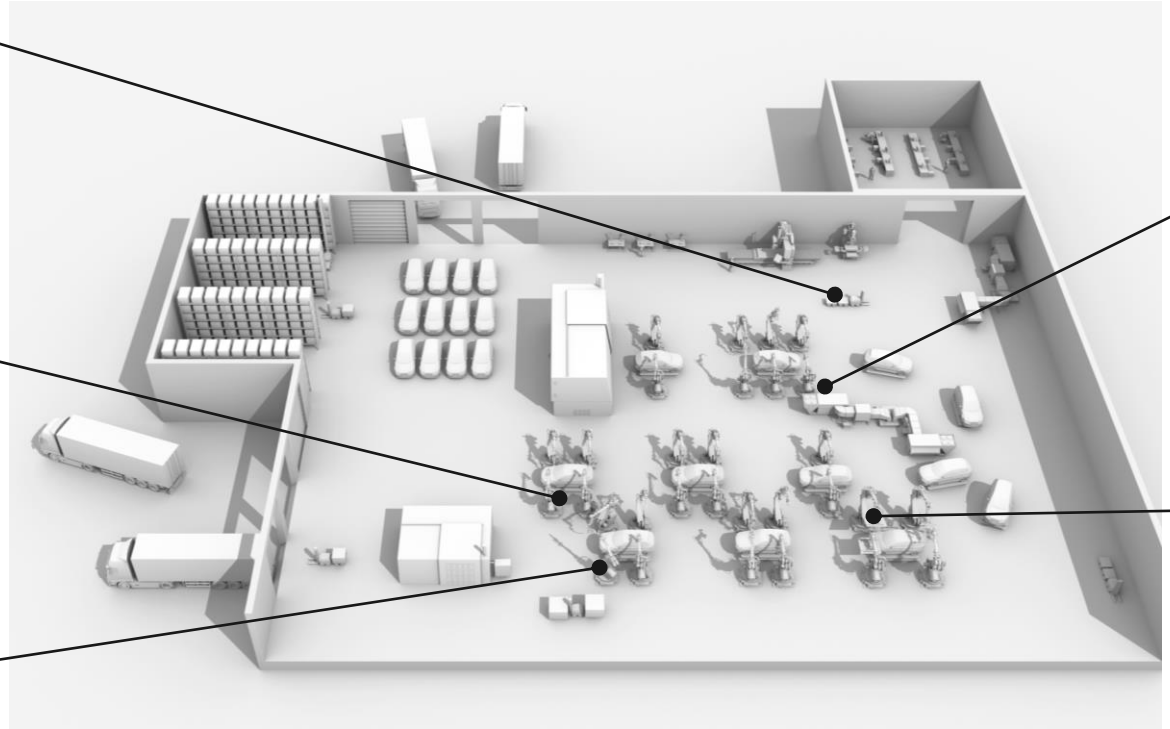
Source: Ericsson, interviews, Arthur D. Little

The five selected use cases could be your starting point

Autonomous mobile robots (AMR) for real time production chain automation

Collaborative robots for efficient operations

AR for efficient quality inspections



Use cases for discrete manufacturing

Asset condition monitoring for decreased downtime

Digital twin for optimized operations

Anchor use case

Source: Ericsson, Arthur D. Little

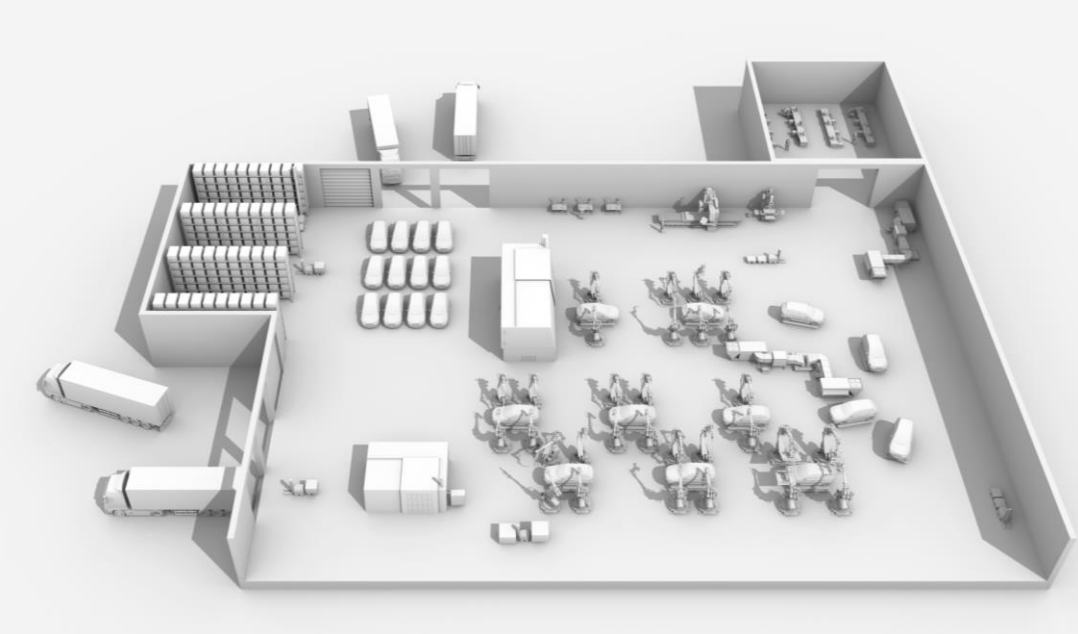
All use cases contribute to total value, but deployment plans differ based on maturity

The baseline factory

Automotive supplier

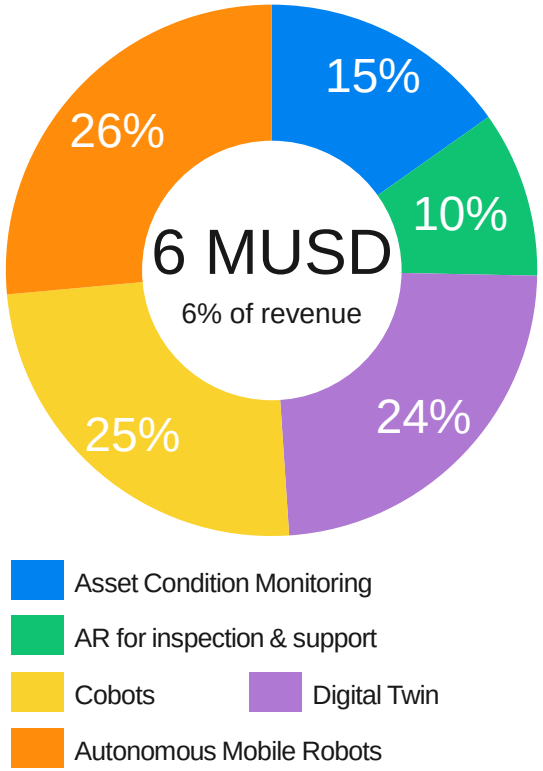
Mainly stamping & assembly operations

Revenue:100 MUSD
Gross profit:10 MUSD



All 5 use cases implemented

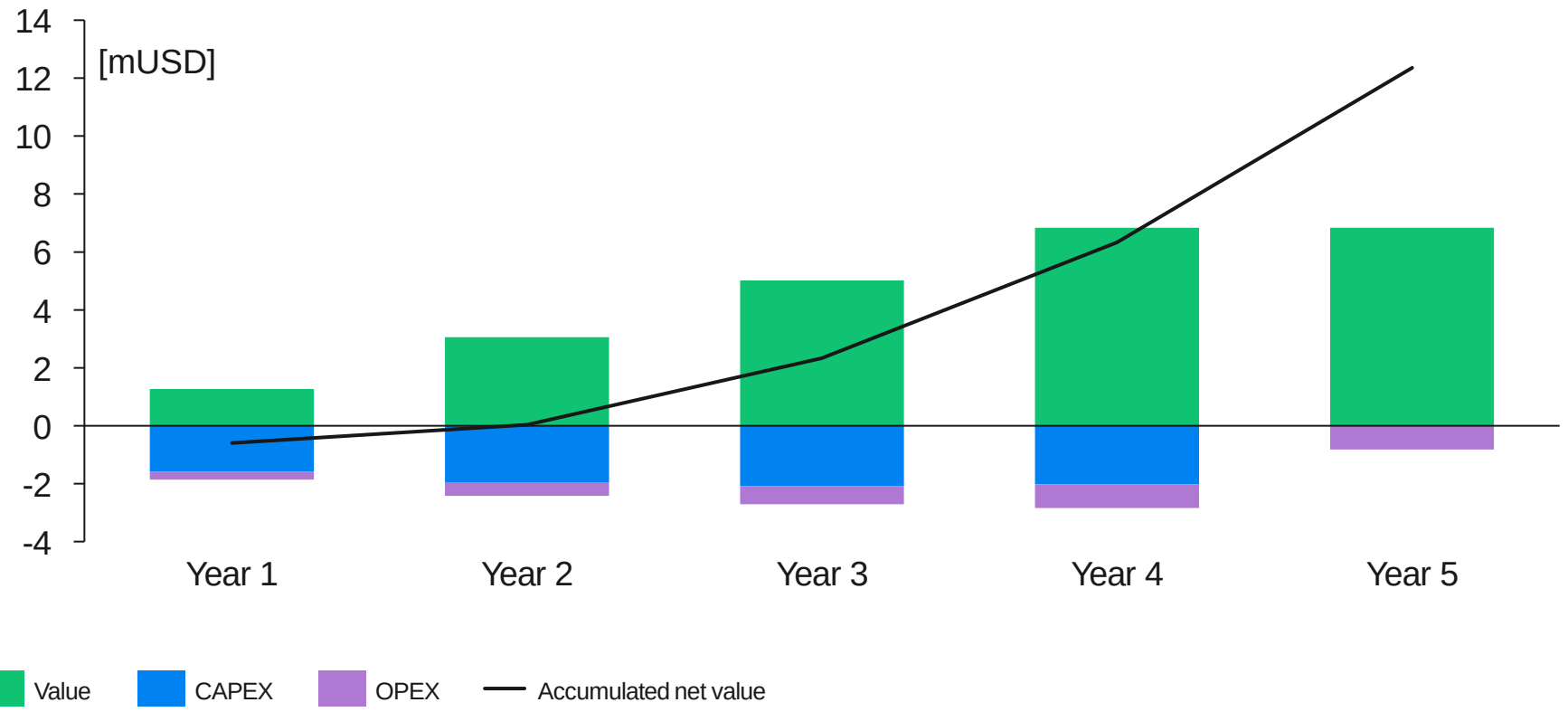
Yearly steady state value



Source: Ericsson, Arthur D. Little

Full smart factory implementation <2 years payback & 12 MUSD net value year 5

One factory full implementation



6 MUSD

6% of revenue

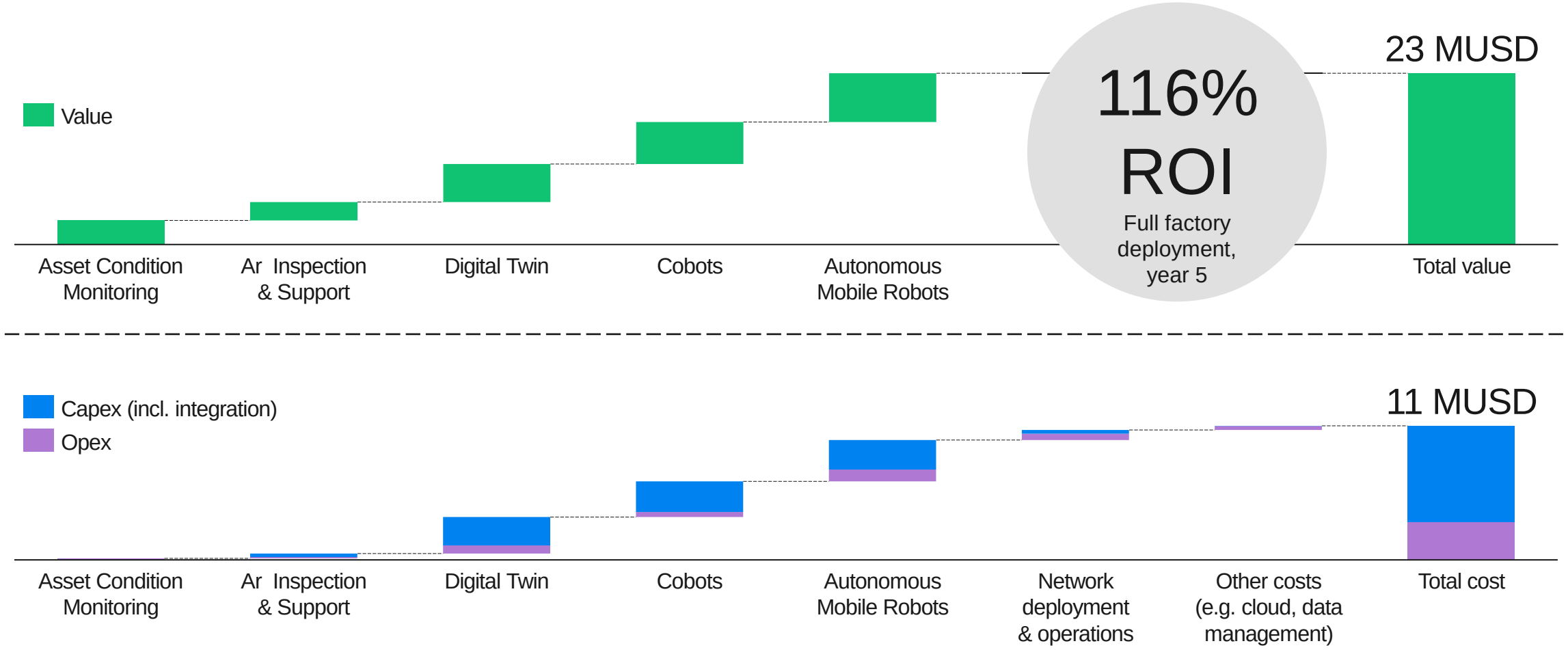
Yearly steady state net value

12 MUSD

Acc. Net value year 5

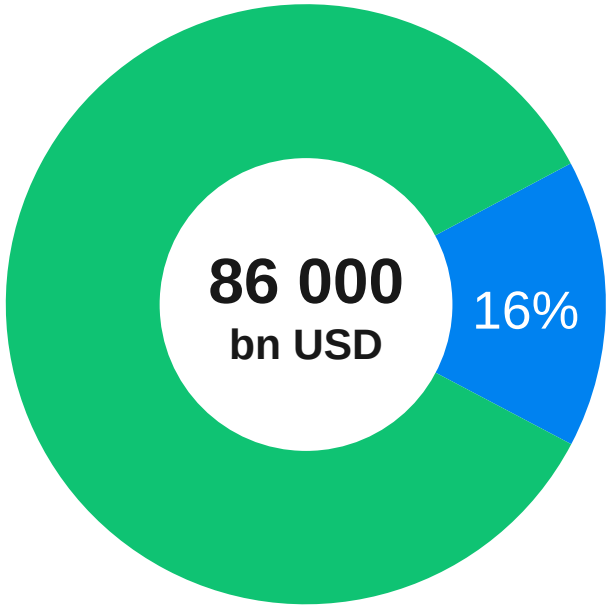
Source: Ericsson, Arthur D. Little

The full factory deployment has a ROI of 116% year 5, with total costs of 11 MUSD



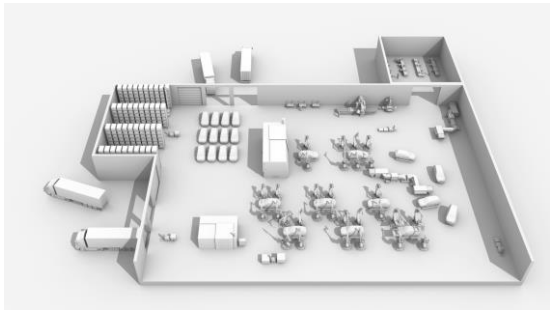
Source: Ericsson, Arthur D. Little

The global smart factory full potential value reaches 840 billion USD



Manufacturing, Value add

Global GDP, 2018[1]



~140 000 factories similar to the baseline factory

6 MUSD
Yearly steady state net value for baseline factory

840 BUSD
Global smart factory yearly net value potential

Source: World bank, Ericsson, Arthur D. Little

Summary

5G ready for industry

Massive IoT, Broadband IoT, Critical IoT, Industrial automation IoT
And Network capability exposure

Manufacturing

One of the promising industry for 5G

Showing value / investment

With 5 selected use cases for manufacturing

ERICSSON
LG