



5G FOR CONNECTED INDUSTRIES



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5G USE CASES



Broadband
experience
everywhere
anytime



Mass market
personalized
media and
gaming



Meters and
sensors,
“Massive MTC”



Remote
controlled
machines



Smart
Transport
Infrastructure
and vehicles



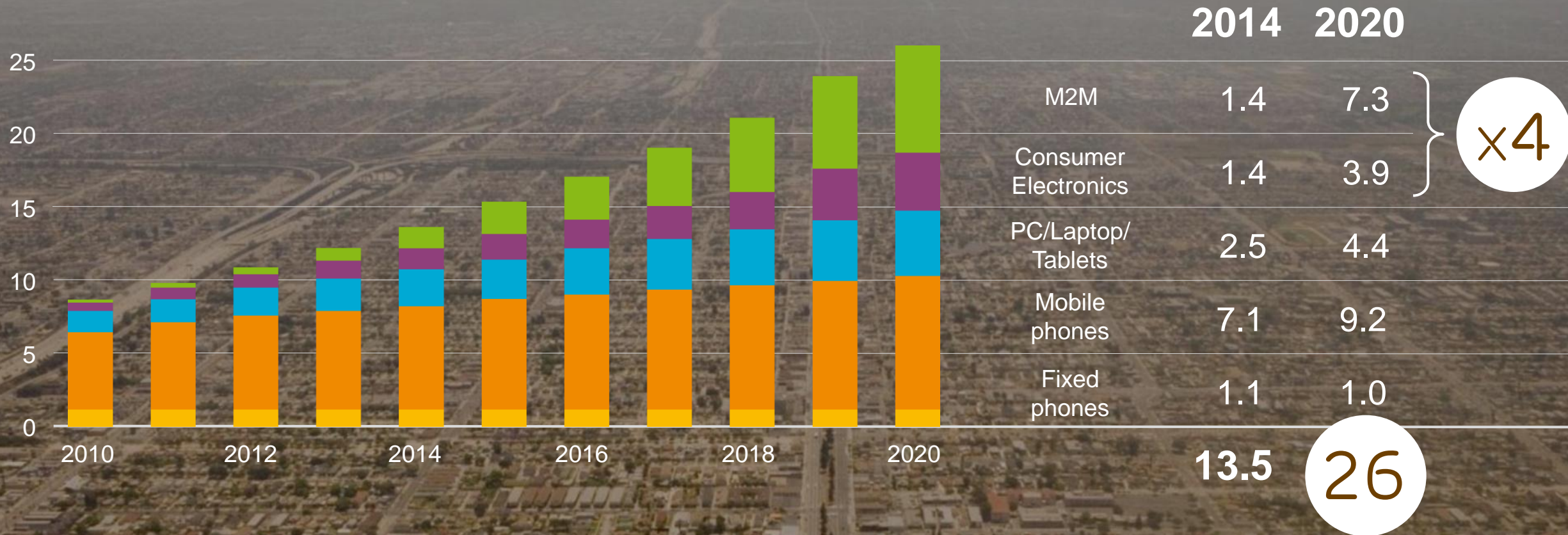
Human
machine
interaction



And much
more

Multiple use-cases supported by a common network platform

26B CONNECTED DEVICES IN 2020



Source: Ericsson Mobility Report
Figures in Billions

WIDE RANGE OF REQUIREMENTS



MASSIVE MTC



SMART BUILDING



LOGISTICS, TRACKING AND FLEET MANAGEMENT



SMART METER



SMART AGRICULTURE



CAPILLARY NETWORKS

CRITICAL MTC



REMOTE HEALTH CARE



TRAFFIC SAFETY & CONTROL



REMOTE MANUFACTURING, TRAINING, SURGERY

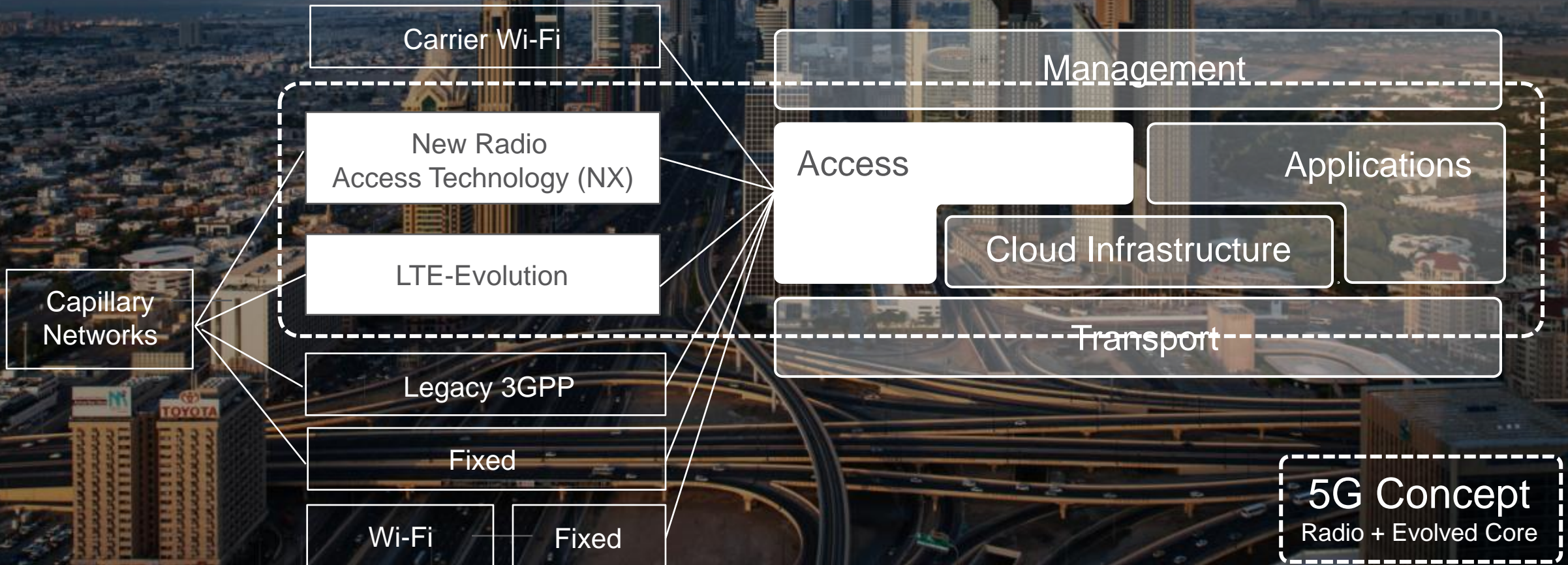


INDUSTRIAL APPLICATION & CONTROL

LOW COST, LOW ENERGY
SMALL DATA VOLUMES
MASSIVE NUMBERS

ULTRA RELIABLE
VERY LOW LATENCY
VERY HIGH AVAILABILITY

NETWORK BEYOND 2020

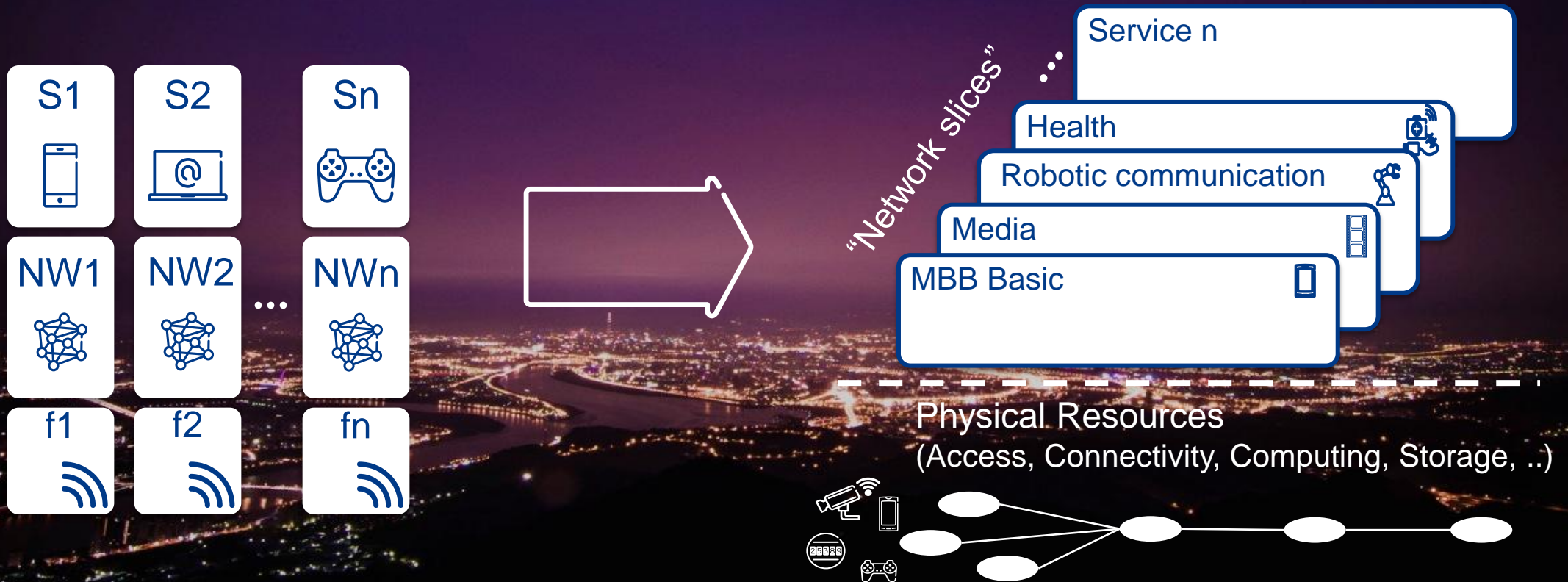


ONE NETWORK – MULTIPLE INDUSTRIES

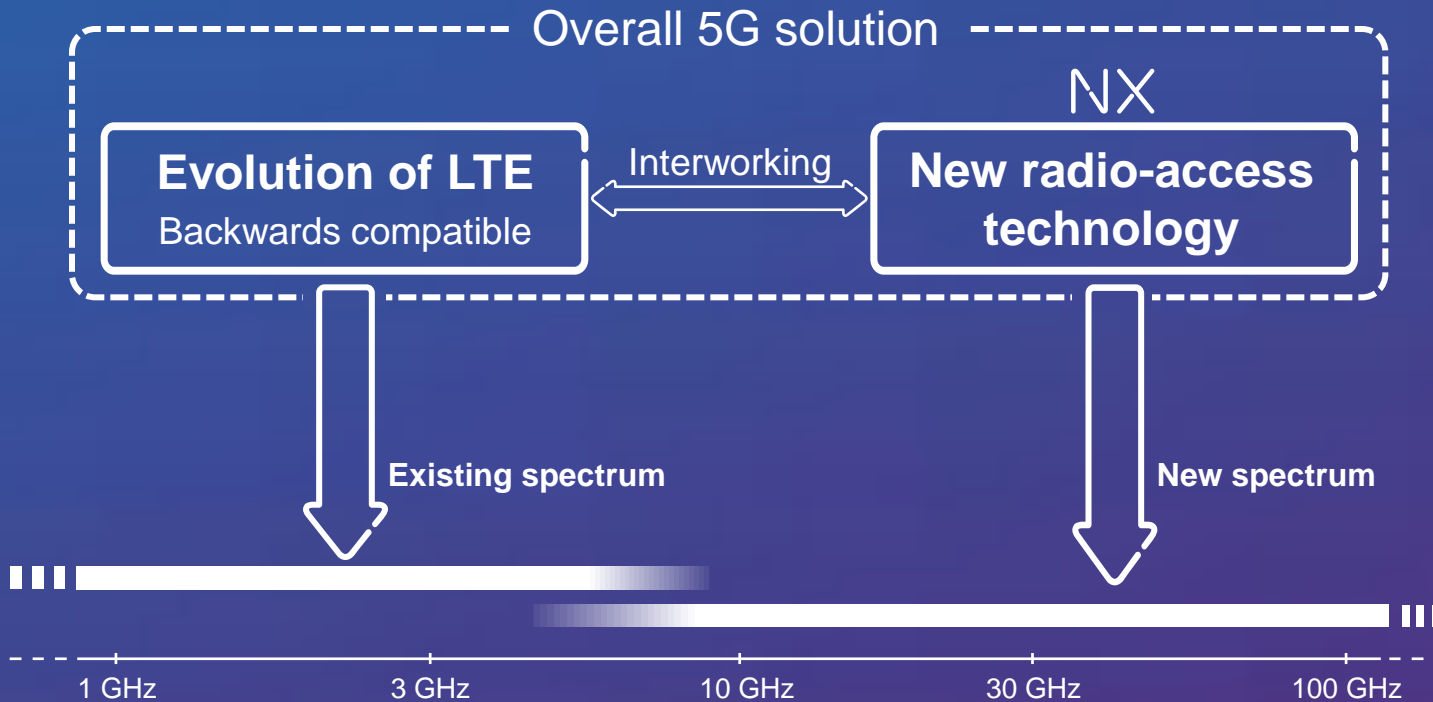


From dedicated physical networks and resources for different applications...

...to a “network factory” where new networks and architectures are “manufactured by SW”



5G RADIO ACCESS & SPECTRUM



Spectrum flexibility

Flexible duplex

FDD and TDD
Dynamic TDD
Full Duplex

Dedicated Licensed Spectrum

Complimented with spectrum sharing
Unlicensed
Shared licensed

LTE EVOLUTION



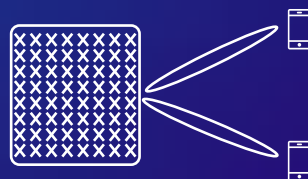
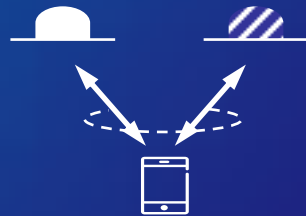
“Existing” spectrum



Licensed and unlicensed spectrum

- › Evolve LTE as far as possible taking backwards compatibility into account
 - Further enhanced mobile broadband, massive MTC, critical MTC, ...
 - Licensed and unlicensed spectrum
 - ...
- › Enable as many 5G use cases as possible in existing spectrum with retained support for legacy devices

LTE REL-14 FOCUS AREAS

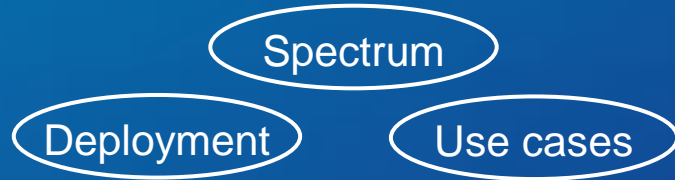


- › Latency reduction
 - Improved user performance, new use cases
- › LAA enhancements
 - Increased data rates and higher capacity
- › Enhanced MTC support
- › Massive MIMO (enhanced FD-MIMO)
 - Improved data rates, higher capacity
- › ITS/V2x support

NX – KEY TECHNOLOGY FEATURES



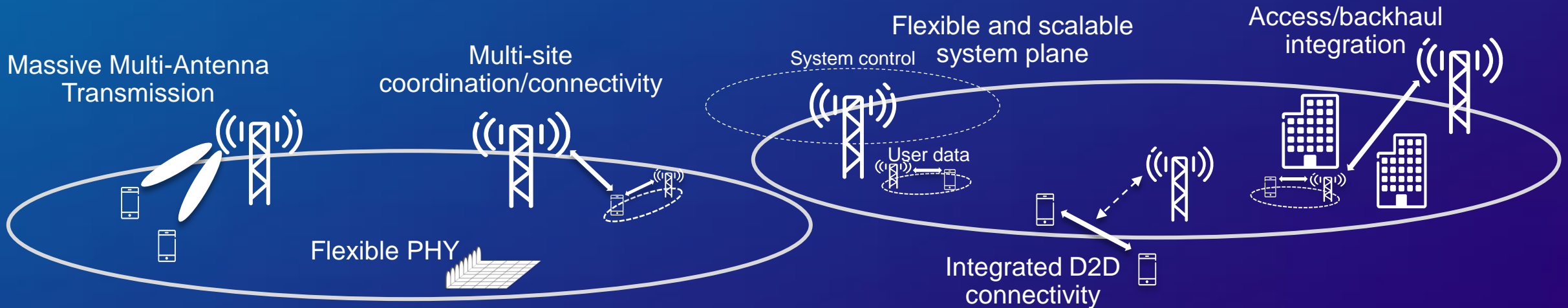
Flexible, scalable and future-proof design



Ultra-lean design



Energy efficient: minimize network transmissions not directly related to user data delivery



PHASED STANDARDIZATION



- › Phase 1 – early commercial deployments
- › Phase 2 – full IMT-2020 compliance



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KEYS TO ACCELERATE IOT



COST

BATTERY LIFE

QUALITY OF SERVICE
SECURITY

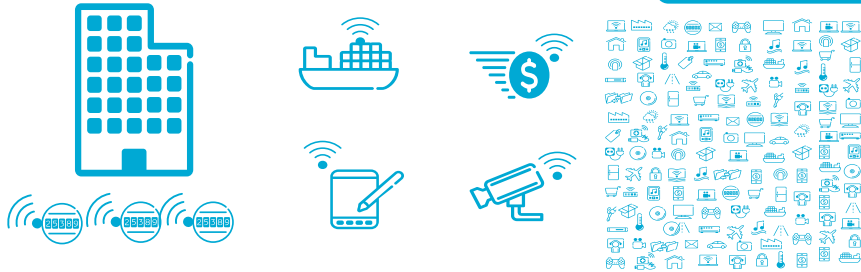
COVERAGE

MASSIVE MTC

TECHNOLOGY CHOICES



Internet of Things



- › Simple cheap devices
- › Low energy consumption
- › Can be massive numbers

Licensed spectrum

3GPP RAN (Rel-12/13)

- › LTE evolution for Massive MTC
- › New narrowband air interface (NB-IoT)

3GPP GERAN (Rel-13)

- › Extended coverage GSM (EC-GSM)

Unlicensed spectrum

Short Range

- › Bluetooth Low Energy
- › Wi-Fi, IEEE802.11ah
- › IEEE802.15.4
- › ZigBee
- › Z-Wave
- › ...

Long Range

- › Sigfox
- › Weightless
- › OnRamp
- › LoRa
- › ETSI LTN
- › ...

SOLUTIONS FOR CELLULAR IOT



GSM-EC

Global solution for Cellular IoT



Supported on legacy GSM equipment



Leverage existing module eco-system



- Reduced Device Cost
- Improved Coverage
- Improved Battery Life

NB-IoT

Part of LTE evolution to 5G

LTE CAT-M

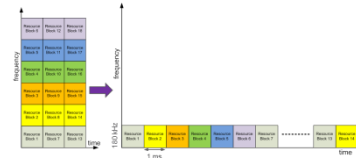
Scalable ultra low-end Cellular IoT solution



Ultra-low bit rates & extreme coverage



Native narrowband LTE solution



Broadest range of Cellular IoT capabilities



Wide range of bit rates enabling advanced applications



Efficient co-existence with MBB traffic



OPERATE AS ONE NETWORK

M-MTC EXAMPLE - WEARABLES



- › Wearables appearing for fitness, health, safety etc
- › Common approach to use short range technology paired with smartphone or GW
- › Direct cellular communication can enable new business cases
- › Possible barriers
 - Module cost?
 - Battery life time?

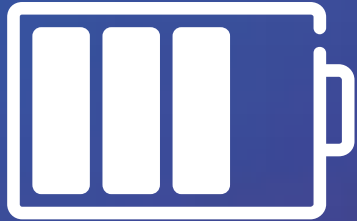


Communication via
Phone or GW



Direct Cellular
Communication

DEVICE ENERGY EFFICIENCY



Possibility for >10 years on a single AA battery



- › Deep sleep
 - Very long DRX periods
 - Quick wake-up

- › Energy-efficient signaling
 - Streamlined NAS messaging

DEVICE ENERGY EFFICIENCY

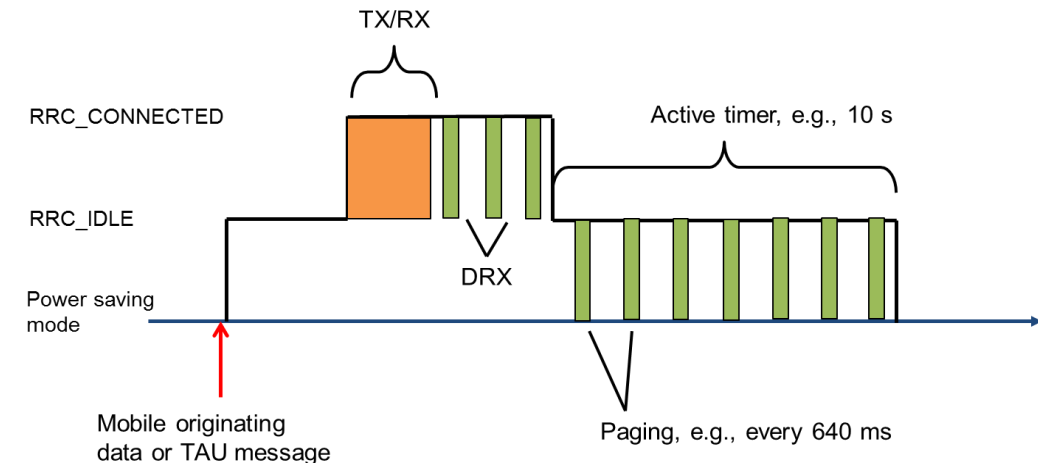


› Example: LTE Rel-12 power-saving mode

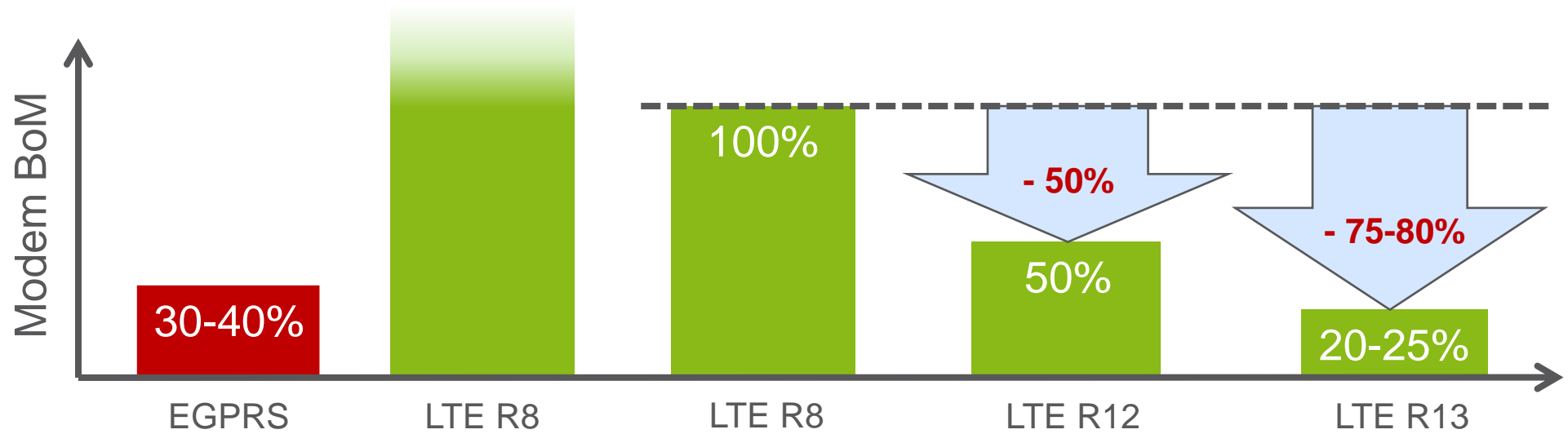
- UE performs periodic tracking area update (TAU) after which it stays reachable for paging during a configurable time
- Otherwise the UE stays in a power-off like mode, not reachable, but still registered

Reachability (TAU cycle)	UL data inter-arrival time		
	15 min	1 hour	3 hour
15 min	9.2 years	10.0 years	10.2 years
1 hour	9.2 years	16.1 years	16.7 years
3 hour	9.2 years	16.1 years	19.4 years

Cell edge, 64/84 kb/s UL/DL, 2xAA with 4% self-discharge

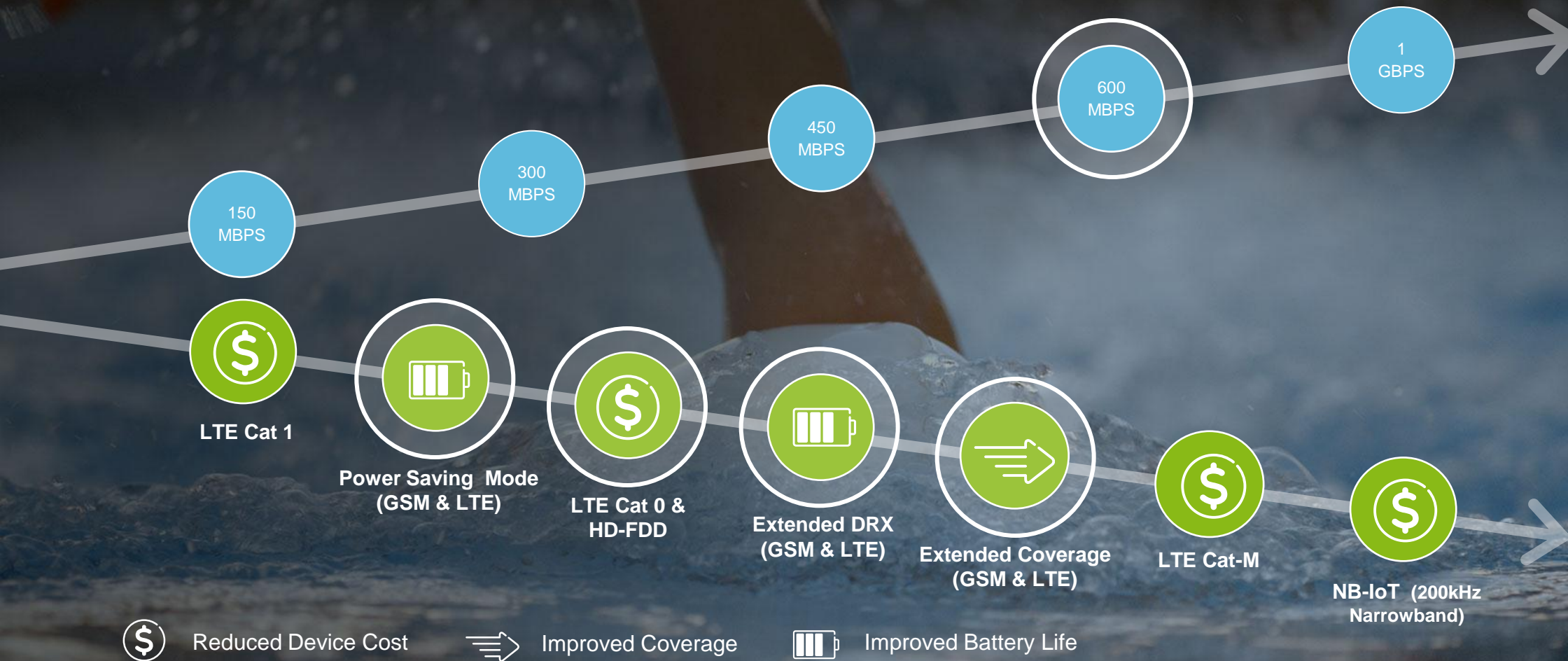


LTE MODEM COST REDUCTION



	R99	Cat 4	Cat 1	Cat 0	"Cat -1"
Downlink peak rate		150 Mbps	10 Mbps	1 Mbps	~1 Mbps
Uplink peak rate		50 Mbps	5 Mbps	1 Mbps	~1 Mbps
Max number of downlink spatial layers		2	1	1	1
Number of UE RF receiver chains		2	2	1	1
Duplex mode		Full duplex	Full duplex	Half duplex (opt)	Half duplex (opt?)
UE bandwidth		20 MHz	20 MHz	20 MHz	1.4 MHz
Maximum UE transmit power		23 dBm	23 dBm	23 dBm	~20 dBm

PERFORMANCE DIVERSIFICATION ON THE ROAD TO 5G



Reduced Device Cost



Improved Coverage



Improved Battery Life

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CRITICAL MACHINE-TYPE COMMUNICATION: GUARANTEED IN-TIME DELIVERY



Factory Automation
 ≤ 1 ms



Motion Control
 ≤ 1 ms



Remote Control
5-100 ms



Intelligent Transportation Systems
5 ms



Smart Grid
3-5 ms



Tactile Internet
1 ms



Process Automation
100 ms



Automated Guided Vehicle
15-20 ms

Numbers are examples, requirements vary within one application area

REMOTE CONTROLLED MACHINES



VOLVO L110G

RELIABLE REAL-TIME : EXAMPLE FACTORY AUTOMATION



- › Manufacturing cell with central controller communicating with sensors and actuators



Wireless communication enables more flexible configuration of manufacturing cells and communication with moving parts

Combination of high reliability and low latency not achievable with current wireless standards

Characteristics	Motion control	Alarms
Maximum end-to-end latency [ms]	0.5 to 1	1
Jitter [us]	<1	–
Packet size [bytes]	10 to 16	2 to 10
Packet loss rate	10 ⁻⁹	10 ⁻⁹
Application availability	99,999 %	

based on fixed links

- › Small message sizes
- › Periodic traffic
 - Time-triggered data generation (e.g. real time motion control)
- › Sporadic traffic and alarms
 - Event-triggered data generation

LATENCY



Possibility for less than
1 ms end-to-end delay



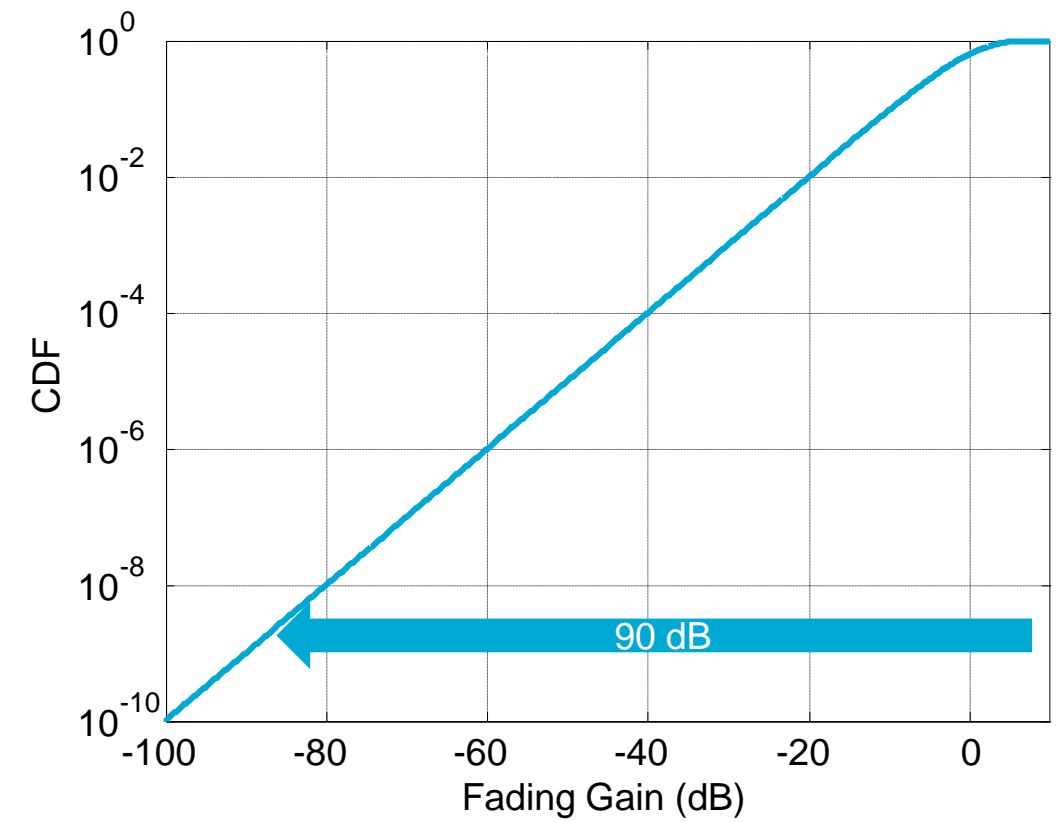
- › Short subframe duration
 - 0.1 – 0.2 ms
- › On-the-fly receiver processing
 - Reference signals early in the subframe
 - Simple, non-iterative decoding
- › Avoid retransmissions
- › Instant uplink access
 - Possibility to avoid request-grant cycle

COST OF GUARANTEEING HIGH RELIABILITY



High reliability (e.g. 10^{-5} – 10^{-9})
▶ 50-90 dB fading margin

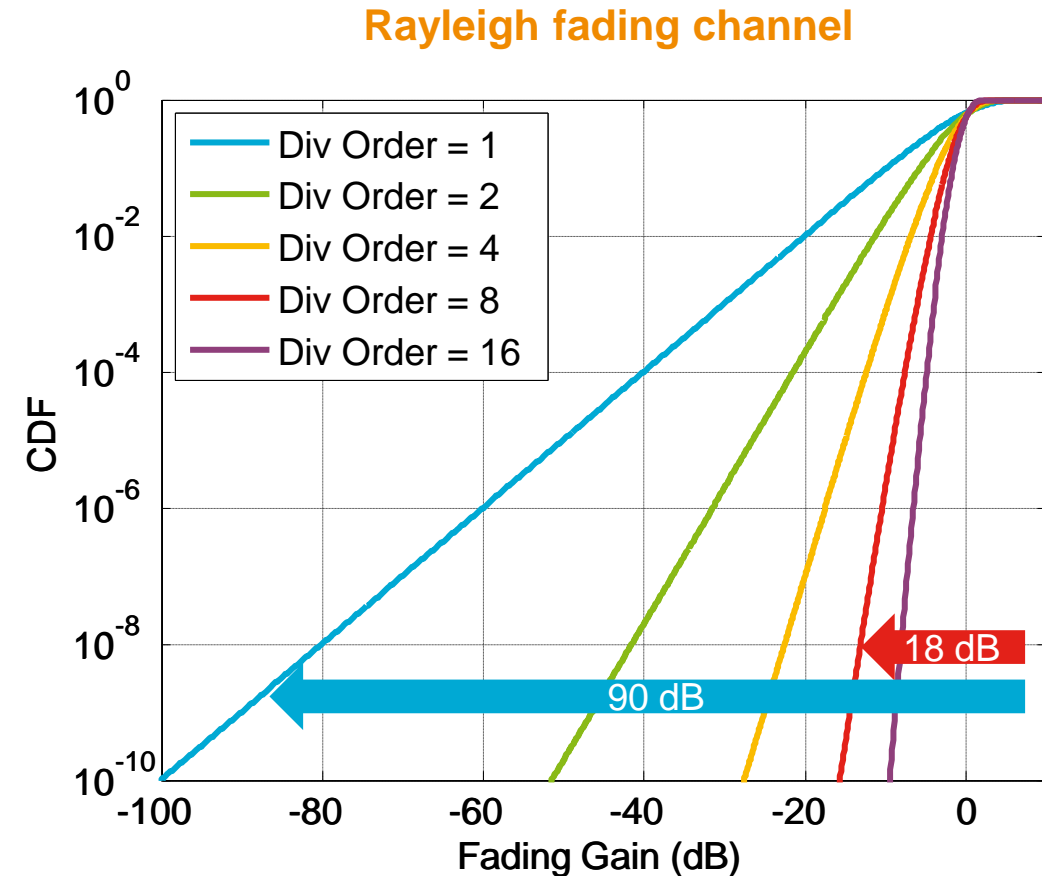
Rayleigh fading channel



REDUNDANCY THROUGH DIVERSITY



- › Diversity may be obtained through
 - spatial diversity, and
 - frequency diversity
- › Time diversity difficult due to latency constraint
- › Coding needed to fully exploit frequency and transmit diversity



Diversity is key for ultra-reliable communications



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5G FOR EUROPE

PROGRAM FOCUS



Strengthen
competitiveness of
European industry

INDUSTRY
PILOTS

- Transport & Automotive
- Industry 4.0 (IoT, Industrial Internet)
- Energy & Utilities
- Public Safety
- Retail
- Public Services and Infrastructures

Apply ICT in
Industrial processes,
products & services

INNOVATION
PLATFORMS

- Cooperate with larger industry players
- Interact & meet academia
- Early and affordable access to technology

Leverage current
and next
generation (5G)
mobile networks

RESEARCH
PROGRAMS

Establish a strong research community on ICT and its integration in industry process', products and services

SUMMARY

5G targets a wide range of requirements and use cases

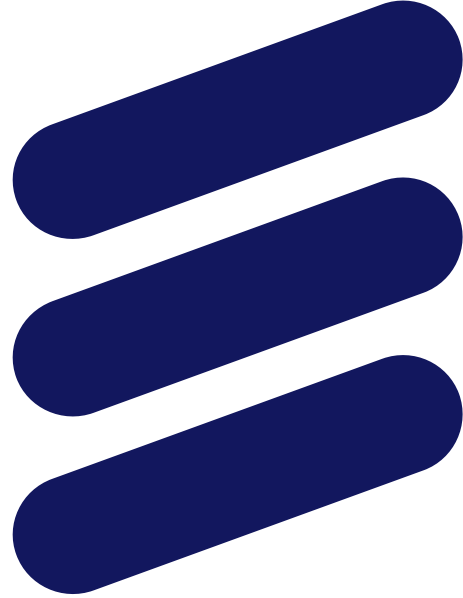
LTE evolution important part of 5G

Phased standardization

- P1 early commercial deployments
- P2 full IMT 2020 fulfillment

Collaboration across industries needed for successful deployment of 5G in industrial environments





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