ETSI The Standards People

# 5G and beyond: from research to standardization

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**CTO ETSI**

For: **WWRF#45, Kuala Lumpur, Malaysia**

19 January 2021

# 5G: where are we right now?

## Release 15

- NR
- The 5G System – Phase 1
- Massive MTC and Internet of Things (IoT)
- Vehicle-to-Everything Communications (V2x) Phase 2
- Mission Critical (MC) interworking with legacy systems
- WLAN and unlicensed spectrum use
- Slicing – logical end-2-end networks
- API Exposure – 3rd party access to 5G services
- Service Based Architecture (SBA)
- Further LTE improvements
- Mobile Communication System for Railways (FRMCS)

## Release 16

- **The 5G System – Phase 2**
- **V2x Phase 3:** Platooning, extended sensors, automated driving, remote driving
- **Industrial IoT**
- **Ultra-Reliable and Low Latency Communication (URLLC) enh.**
- **NR-based access to unlicensed spectrum (NR-U)**
- **5G Efficiency:** Interference Mitigation, SON, eMIMO, Location and positioning, Power Consumption, eDual Connectivity, Device capabilities exchange, Mobility enhancements
- **Integrated Access and Backhaul (IAB)**
- **Enh. Common API Framework for 3GPP Northbound APIs (eCAPIF)**
- **Satellite Access in 5G**
- **Mobile Communication System for Railways (FRMCS Phase 2)**

## Release 17

- NR MIMO
- NR Sidelink enh.
- 52.6 - 71 GHz with existing waveform
- Dynamic Spectrum Sharing (DSS) enh.
- Industrial IoT / URLLC enh.
- Study - IoT over Non Terrestrial Networks (NTN)
- NR over Non Terrestrial Networks (NTN)
- NR Positioning enh.
- Low complexity NR devices
- Power saving
- NR Coverage enh.
- Study - NR eXtended Reality (XR)
- NB-IoT and LTE-MTC enh.
- 5G Multicast broadcast
- Multi-Radio DCCA enh.
- Multi SIM
- Integrated Access and Backhaul (IAB) enh.
- NR Sidelink relay
- RAN Slicing
- Enh. for small data
- SON / Minimization of drive tests (MDT) enh.
- NR Quality of Experience
- eNB architecture evolution, LTE C-plane / U-plane split
- Satellite components in the 5G architecture
- Non-Public Networks enh.
- Network Automation for 5G - phase 2
- Edge Computing in 5GC
- Proximity based Services in 5GS
- Network Slicing Phase 2
- Enh. V2x Services
- Advanced Interactive Services
- Access Traffic Steering, Switch and Splitting support in the 5G system architecture
- Unmanned Aerial Systems
- 5GC LoCation Services
- Multimedia Priority Service (MPS)
- 5G Wireless and Wireline Convergence
- 5G LAN-type services
- User Plane Function (UPF) enh. for control and 5G Service Based Architecture (SBA)

These are some of the Rel-17 headline features, prioritized during the December 2019 Plenaries (TSG#86)

Start of work: January 2020

Full details of the content of Rel-17 are in the Work Plan: www.3gpp.org/specifications/work-plan

# 5G: where are we going?

## 5G industrial expansion e.g.,

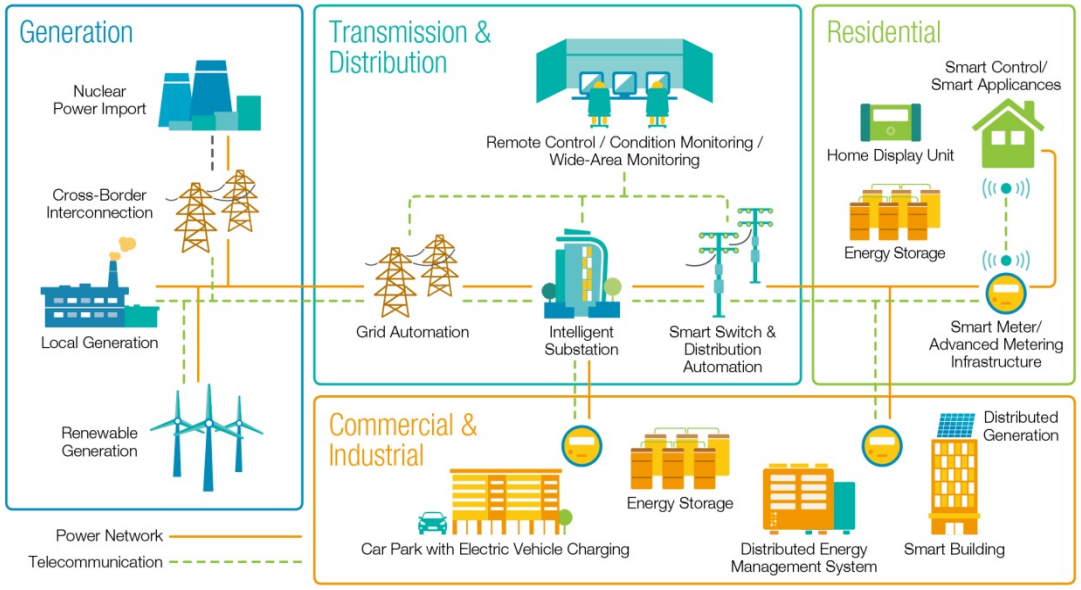
- Smart energy & infrastructure
- Health
- Maritime
- Asset tracking
- Factory automation
- Wearables

## 5G capability/efficiency improvements e.g.,

- Non-public networks
- Non-terrestrial networks
- Time-sensitive networks
- Extended reality
- Coverage enhancements
- Positioning accuracy
- Reduced capability

# 5G for smart energy and infrastructure

- Communication infrastructure is essential for managing  power generation, transmission, distribution, and consumption
- Currently served by a mixture of private networks, 5G presents an opportunity for considerable improvement




## 3GPP TR 22.867 (Release 18)

Study of potential new service requirements for 5G system to support smart grid including the following topics:

Smart Grid services, e.g. IEC standards, and their communications requirements including capacity, latency, availability, end-to-end QoS, resilience/redundancy and security.

Deployment requirements when considering constraints e.g. service lifetime, coverage (ubiquity), electromagnetic applicability (e.g. penetration, ability to operate in high EM environments,) etc.

Additional requirements due to operational manageability – e.g. the ability to configure and monitor the real (achieved & up to date) availability of virtual network topologies

New Smart Grid use cases and potential service function requirements: e.g. on-demand power supply, distributed power supply system, distribution automation, higher accuracy power load measurement and control, meter automation, etc.

Communication KPI and service requirements for enabling micro-grids, DER and specifically distributed generation (DG) that require 5G wireless communication (e.g. wind and solar energy generation, including scenarios at or near residential / consumer premises, etc.)

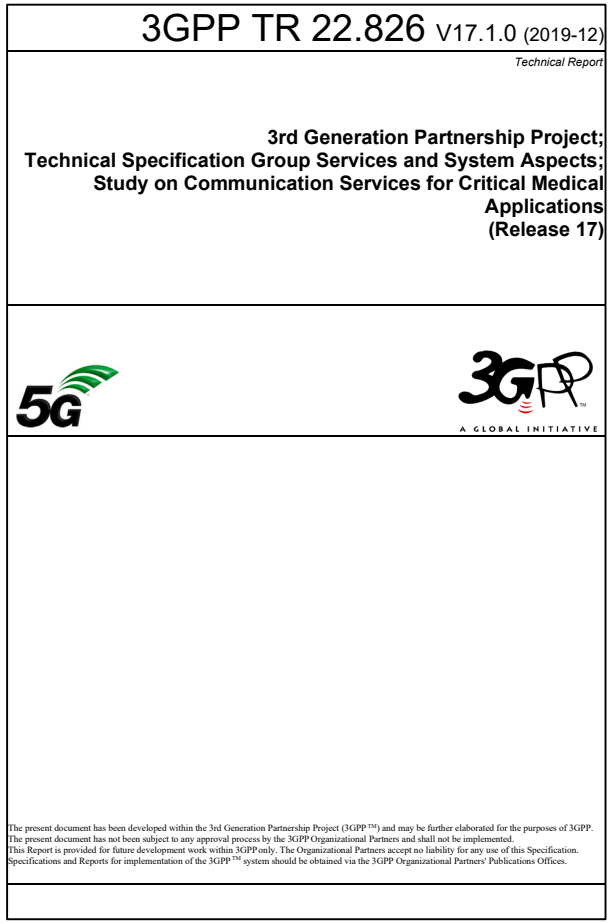
# 5G in the health sector

- Average spending in the healthcare sector is around 10% of GDP worldwide, with a $7,200 billion market in 2015 according to the World Health Organization
- According to Goldman Sachs, savings of $650 billion can be expected by 2025 through a shift in focus from volume-based healthcare to value-based healthcare
- 5G will assist that shift in focus, opening the door to:
  - cost-effective telemedicine services
  - patient-centric medical data collection
  - enhanced medical data storage and fast sharing of large size images
  - a wider use of AI in diagnostics and patient real-time monitoring
  - improved tracking and control of apparatus and medicines (*cf* 3GPP TR 22.836 on 5G asset tracking)
- ….. and many other health related services

World Health Organization

# 3GPP study into critical medical applications

- 3GPP Study into Communications Services for Critical Medical Applications (TR 22.826) investigates:
  - Duplicating Video on additional monitors
  - Augmented Reality Assisted Surgery
  - Robotic Aided Surgery
  - Moving Cardiac telemetry both inside and outside hospitals
  - Remote Emergency Care
  - Remote Ultrasound and remote interventional support
  - Remote robotic surgery
  - Mobile specialist practice
  - Patient monitoring inside ambulances



3GPP TR 22.826 V17.1.0 (2019-12)

*Technical Report*

**3rd Generation Partnership Project;**
**Technical Specification Group Services and System Aspects;**
**Study on Communication Services for Critical Medical Applications**
**(Release 17)**

5G

3GPP
A GLOBAL INITIATIVE

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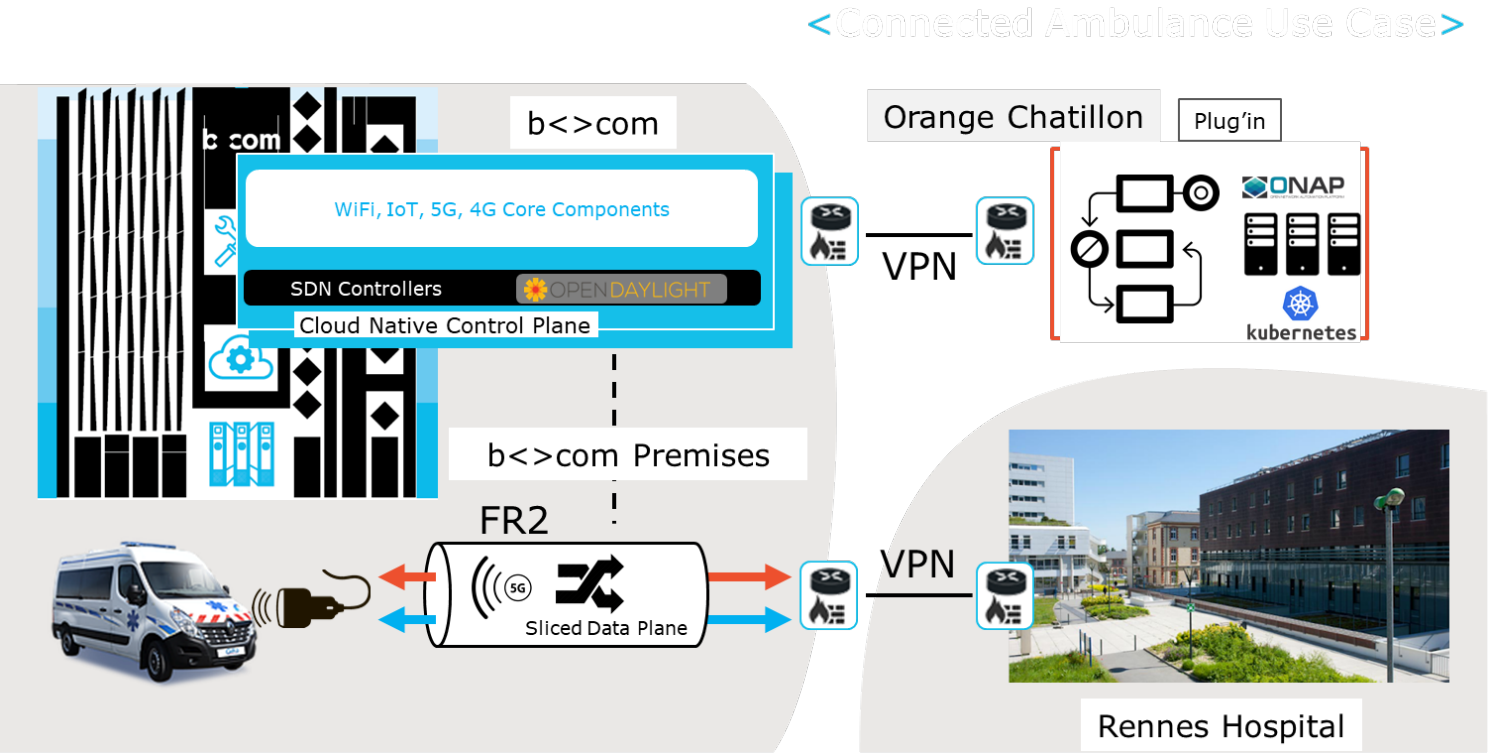
# European research project: 5G Tours




Source: b<>com

Performance requirements captured in 3GPP TR 22.826

## 5G Connected Ambulance

Cardiac arrest by driver of a vehicle

Point of care ultrasound with images relayed to remote specialist

Guidance and interpretation received from remote specialist

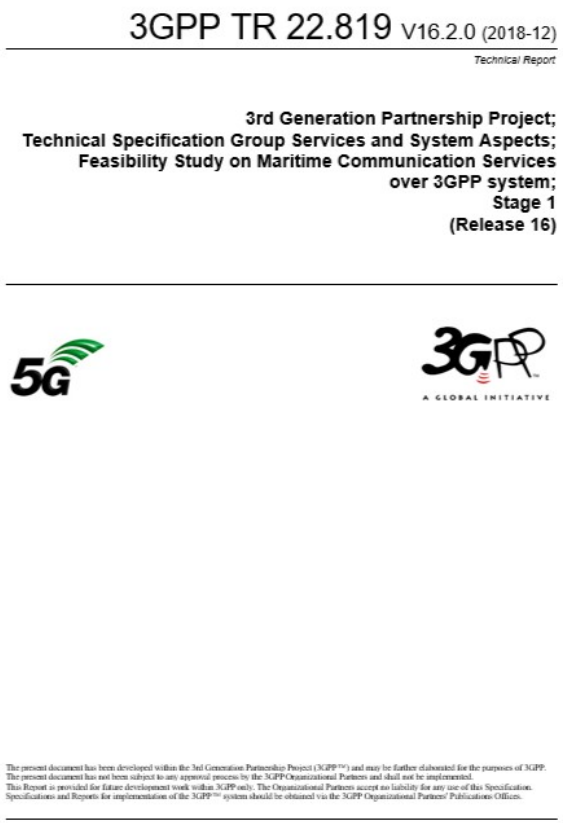
Teleguidance using video imaging and Augmented Reality

Advanced computer imaging gives richer contextual information

**More at https://5gtours.eu/**

# Critical maritime communications services

- 3GPP Study on Maritime Communications Services (TR 22.819) aimed at reducing maritime casualties caused by human error (especially small ships and fishing vessels)
- Investigates issues such as:
  - Use of Mobile Broadband on vessels
  - Interworking between terrestrial and non-terrestrial (satellite) services
  - Transition from Isolated Operations (IOPS) to on-network mode
  - Communications between Authorities and Users (e.g., Machine-type communications from wearable devices to maritime recue services)
  - Coordination of search and rescue operations
  - Telemedical assistance
  - Coastal and local warning services
  - Urgent alarms
- Performance requirements captured in 3GPP TR 22.819


3GPP TR 22.819 V16.2.0 (2018-12)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Feasibility Study on Maritime Communication Services
over 3GPP system;
Stage 1
(Release 16)

5G

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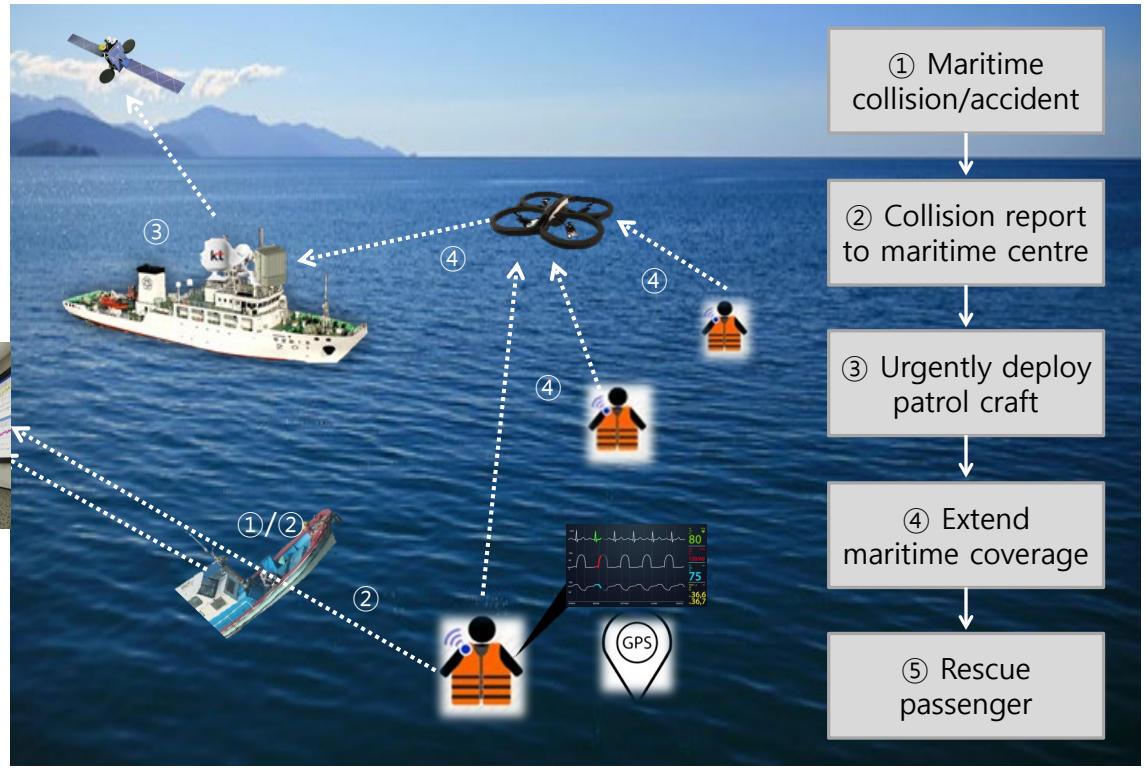
# Critical maritime service scenario

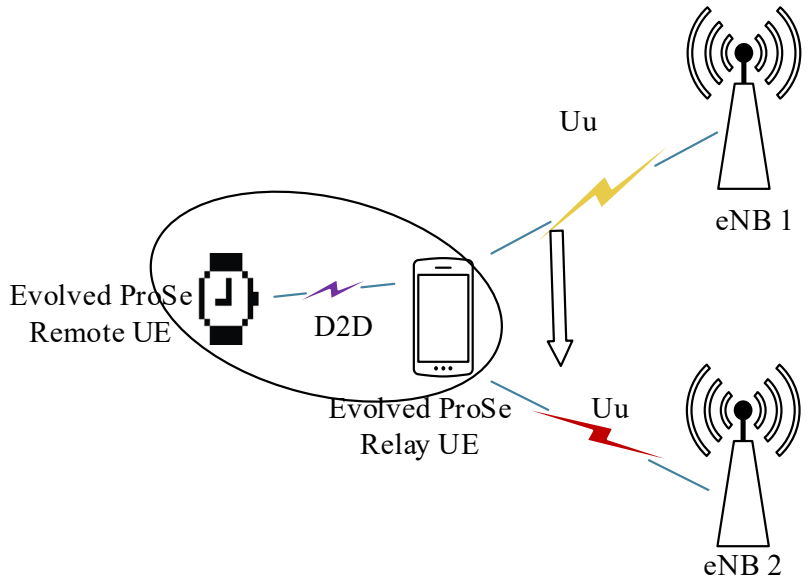

Maritime rescue coordination centre




Maritime Service Scenario

# 5G for wearables

- Using LTE evolved technology to connect and manage low cost MTC devices (such as wearables)




In this scenario, both of the evolved ProSe Remote UE (wearable device) and the evolved ProSe UE-to-Network Relay UE are moved (i.e. in case of mobility) from one eNB to another eNB. The evolved ProSe Remote UE remains connected to the same evolved ProSe UE-to-Network Relay UE

## 3GPP TR 36.746 (Release 15 publication)

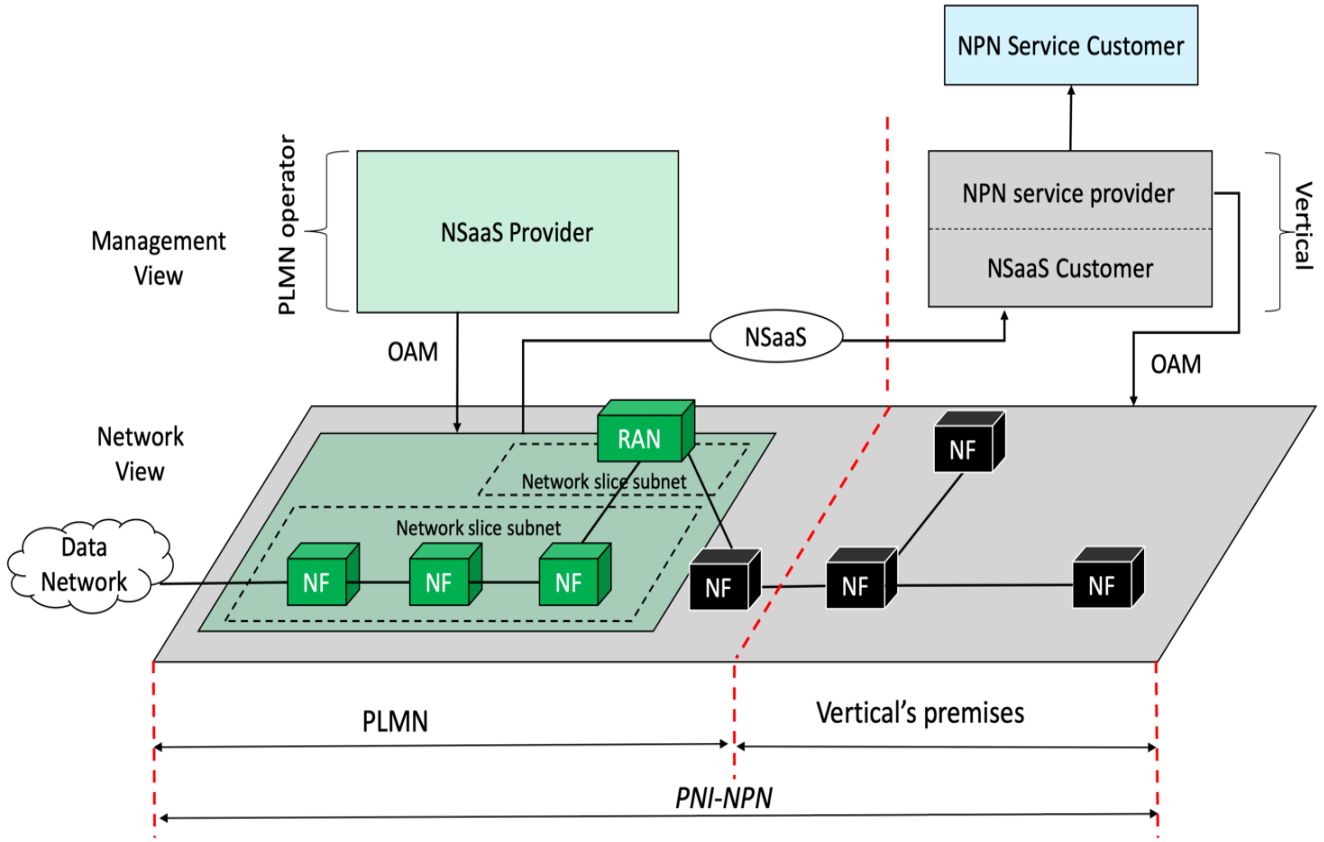
Wearables have the benefit of almost always being in close proximity to a smartphone that can serve as a relay.

This study item aims to evaluate and study the benefits of enhanced UE-to-network relaying, and of using an enhanced form of the LTE sidelink air-interface, for D2D aided services focusing on wearable and MTC applications. In order to enable these use cases, the sidelink air-interface should be optimized for energy efficient communication supporting various data rates.

Sidelink enhancements include:
**Synchronization**;
Evolved ProSe UE-to-Network Relay UE serving as a synchronization source for in-coverage evolved ProSe Remote UE.
**Discovery**;
Sidelink discovery design enhancements to support more efficient discovery and communication/connection establishment with evolved ProSe UE-to-Network Relay UE by bandwidth limited evolved ProSe Remote UEs.
**Communication**;
Enabling sidelink communication for bandwidth limited low complexity evolved ProSe UEs;
Sidelink power control enhancements;
Sidelink semi-persistent transmissions/scheduling;
Evolved ProSe UE-to-Network Relay UE assisted resource allocation and eNB controlled resource allocation modes and sidelink resource allocation modes;
Sidelink measurements and reporting / feedback.

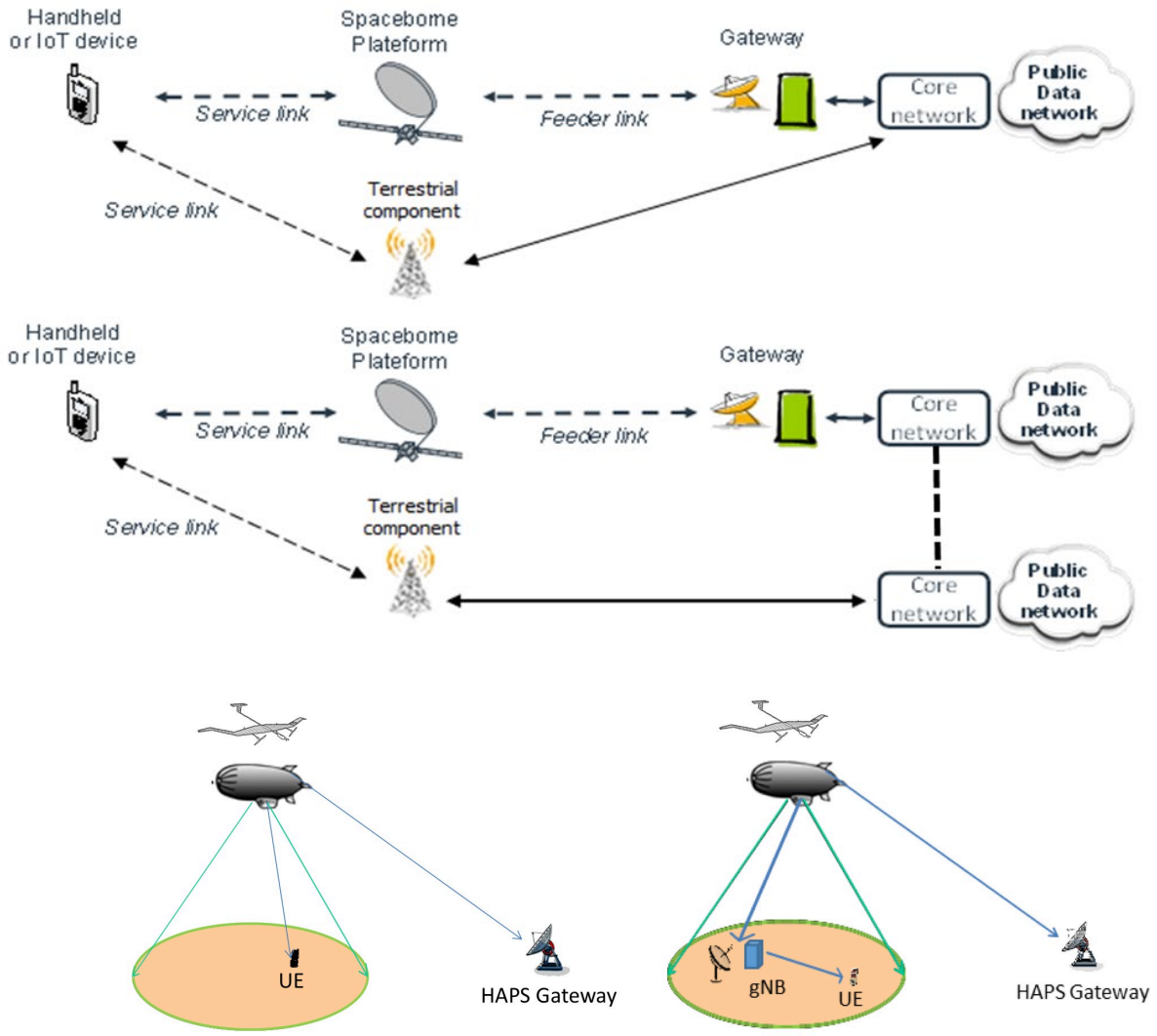
# 5G public and non-public networks

- A Non-public network (NPN) may be deployed in a variety of configurations, using both virtual and physical network functions. Specifically, a NPN may be deployed as:
  - a Stand-alone Non-Public Network (SNPN), i.e. operated by an NPN operator and not relying on network functions provided by a PLMN; or
  - a Public network integrated NPN (PNI-NPN), i.e. a non-public network deployed with the support of a PLMN
  - (see 3GPP TR 28.807)




NSaaS =Network Slice as a Service

# 5G non-terrestrial networks




## TR 38.811 (Release 15)

Non-Terrestrial Networks are expected to

- foster the roll out of 5G service in un-served areas that cannot be covered by terrestrial 5G network (isolated/remote areas, on board aircrafts or vessels) and underserved areas (e.g. sub-urban/rural areas) to upgrade the performance of limited terrestrial networks in cost effective manner,
- reinforce the 5G service reliability by providing service continuity for M2M/IoT devices or for passengers on board moving platforms (e.g. passenger vehicles-aircraft, ships, high speed trains, bus) or ensuring service availability anywhere especially for critical communications, future railway/maritime/aeronautical communications, and to
- enable 5G network scalability by providing efficient multicast/broadcast resources for data delivery towards the network edges or even user terminal.

The benefits relate to either Non-Terrestrial networks operating alone or to integrated terrestrial and Non-Terrestrial networks. They will impact coverage, user bandwidth, system capacity, service reliability or service availability, energy consumption, connection density.

A role for Non-Terrestrial Network components in the 5G system is expected for the following verticals: transport, Public Safety, Media and Entertainment, eHealth, Energy, Agriculture, Finance, Automotive

# 5G coverage enhancements

- 5G services are of no value if there is no coverage!
- Study underway into 5G radio improvements to improve coverage

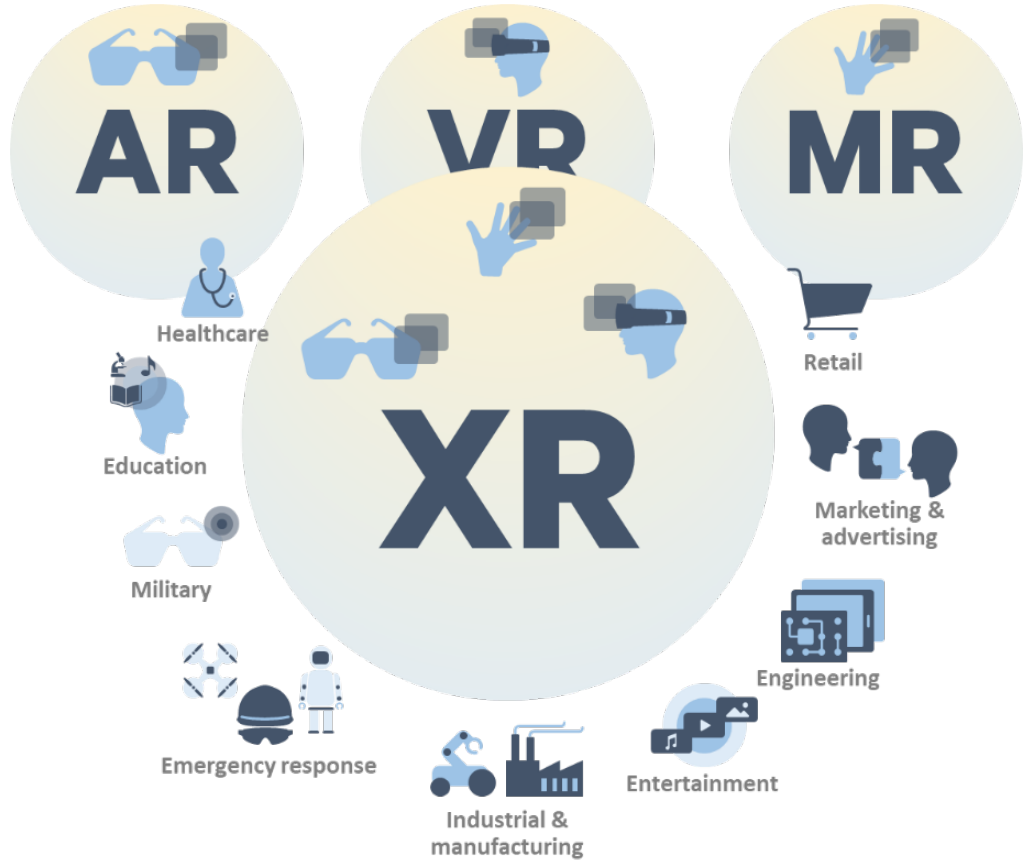
## TR 38.830 (Release 17)

The objective of this study item is to study potential coverage enhancement solutions for specific scenarios for both FR1 and FR2. The detailed objectives are as follows.

- Urban (outdoor gNB serving indoor UEs) scenario, and rural scenario (including extreme long distance rural scenario) for FR1
- Indoor scenario (indoor gNB serving indoor UEs), and urban/suburban scenario (including outdoor gNB serving outdoor UEs and outdoor gNB serving indoor UEs) for FR2.
- TDD and FDD for FR1.
- VoIP and eMBB service for FR1.
- eMBB service as first priority and VoIP as second priority for FR2.
- LPWA services and scenarios are not included.
- Identify baseline coverage performance for both DL and UL for the above scenarios and services based on link-level simulation
- UL channels (including PUSCH and PUCCH) are prioritized for FR1.
- Both DL and UL channels for FR2.
- Identify the performance target for coverage enhancement, and study the potential solutions for coverage enhancements for the above scenarios and services
- The target channels include at least PUSCH/PUCCH
- Study enhanced solutions, e.g., time domain/frequency domain/DM-RS enhancement (including DM-RS-less transmissions)
- Study the additional enhanced solutions for FR2 if any
- Evaluate the performance of the potential solutions based on link level simulation.

# 5G extended reality

- There are numerous applications that could benefit from XR



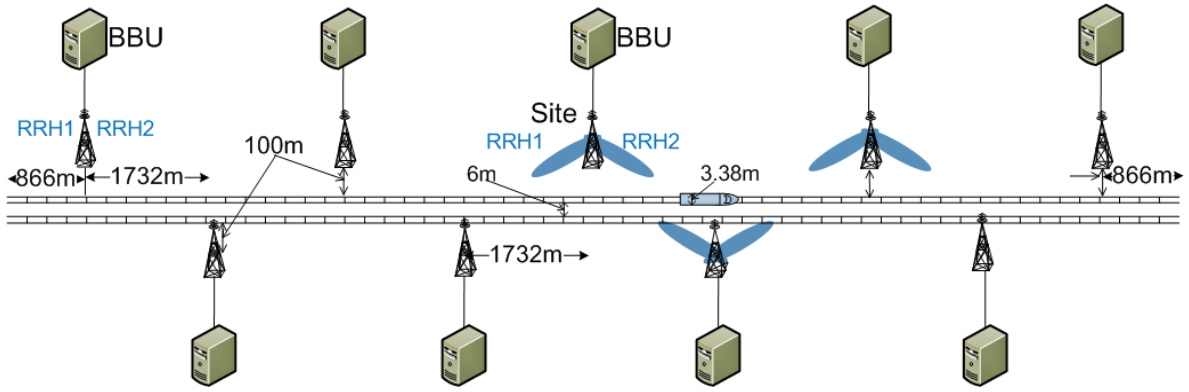

## 3GPP TR 22.968 (Release 16)

Study of eXtended Reality (XR) in the context of 5G radio and network services. The primary scope is the documentation of the following aspects:

- Introducing Extended Reality by providing definitions, core technology enablers, a summary of devices and form factors, as well as ongoing related work in 3GPP and elsewhere,
- Collecting and documenting core use cases in the context of Extended Reality,
- Identifying relevant client and network architectures, APIs and media processing functions that support XR use cases,
- Analysing and identifying the media formats (including audio and video), metadata, accessibility features, interfaces and delivery procedures between client and network required to offer such an experience,
- Collecting key performance indicators and Quality-of-Experience metrics for relevant XR services and the applied technology components,
- Drawing conclusions on the potential needs for standardisation in 3GPP.

# 5G high precision positioning

- Going beyond basic regulatory requirements (E911)
- Latency, capacity and coverage requirements
- Commercial and regulatory scenarios
- Indoor and outdoor
- Low (FR1) and high (FR2) frequency bands
- Accuracy to 0.5 metres




## TR 38.913 (upgraded in Release 16 publication)

5G will use state-of-art positioning techniques, such as RAN-embedded (Cell-ID, E-Cell ID, OTDOA, UTDOA, etc.) and RAN-external (GNSS, Bluetooth, WLAN, Terrestrial Beacon Systems (TBS), sensors, etc.).

5G positioning shall exploit high bandwidth, massive antenna systems, network architecture/ functionalities (e.g. heterogeneous networks, broadcast, MBMS) and deployment of massive number of devices. 5G positioning shall support indoors and outdoors use cases.

5G design targets for commercial positioning use cases include:

1. Support for range of accuracy levels, latency levels and device categories
2. Support accuracy and latency as defined in TR 22.862 for some (Critical comms) use cases
3. Reduced network complexity
3. Reduced device cost
4. Reduced device power consumption
5. Efficient signalling over the air interface and in the network
6. Support for hybrid positioning methods
7. Scalability (support for large number of devices)
8. High security
9. High availability
10. Support UE speed as defined in TR 22.862 (Critical Comms)

# 5G reduced capability

- Main motivation is to lower device cost and complexity as compared to high-end eMBB and URLLC devices of Rel-15/Rel-16. Especially the case for industrial sensors.
- A requirement for most use cases is that the device design has a compact form factor.
- Reduced capabilities include:
  - Reduced number of UE Rx/Tx antennas
  - UE bandwidth reduction
  - Half-duplex FDD operation
  - Relaxed UE processing time
  - Relaxed maximum number of MIMO layers
  - Relaxed maximum modulation order

## TR 38.875 (Release 17)

This is a study into support of reduced capability NR devices.

The study includes identification and study of potential UE complexity reduction techniques and UE power saving and battery lifetime enhancements for reduced capability UEs in applicable use cases, functionality that will enable the performance degradation of such complexity reduction to be mitigated or limited, principles for how to define and constrain such reduced capabilities, and functionality that will allow devices with reduced capabilities to be explicitly identifiable to networks and networks operators and allow operators to restrict their access if desired.

The scope of the study includes support for all FR1/FR2 bands for FDD and TDD and coexistence with Rel-15/16 UEs.

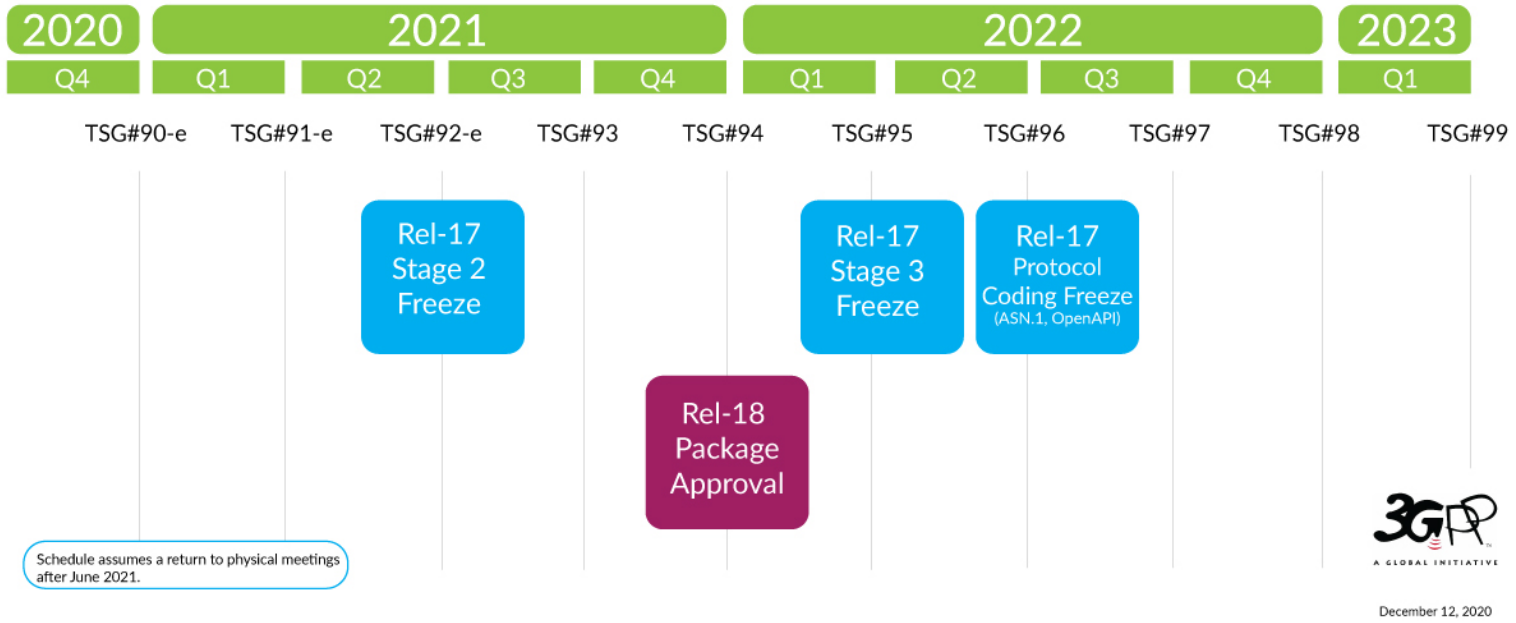
This study focuses on Stand Alone mode and single connectivity. The scope of the study does not include LPWA use cases.

Use cases include:
**Industrial wireless sensors**
**Video Surveillance**
**Wearables**

The intention is to study a UE feature and parameter list with lower end capabilities, relative to Release 16 eMBB and URLLC NR to serve the three use cases mentioned above

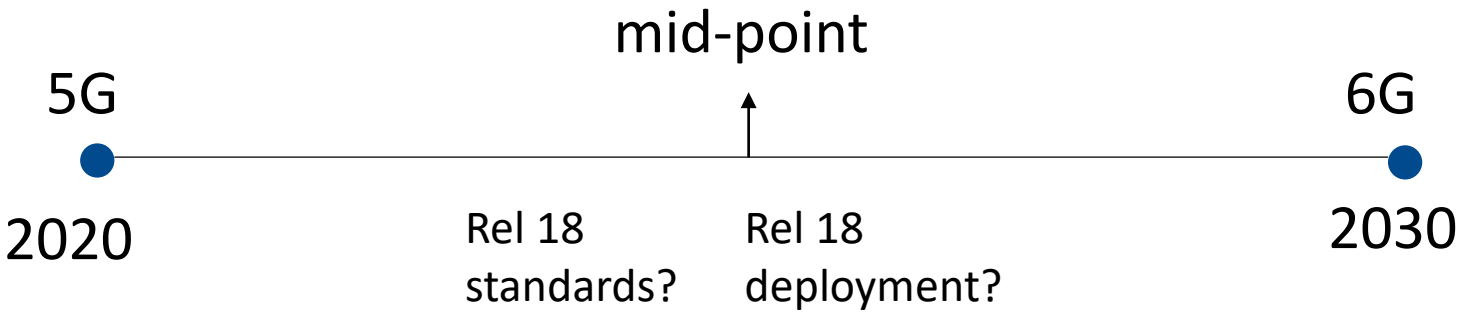
# Release 17 & 18 schedule

- Massive effort to complete Rel-16 on time in 2020.
- COVID-19 has challenged the ability to complete Rel-17.
- New Rel-17 schedule has now been set
- 3GPP Rel-18 studies underway. Rel 18 workshop to be held in September 2021. Timeline and content will be determined by December 2021.



# 5G mid-generation point hypothesis

- Traditionally, generations have a mid-point which is uniquely branded
- It is likely then that a marker will be introduced (e.g., 5G+, 5G-pro, 5G-advanced, Super 5G)
- If commercialization of mid-generation point is to be 2025, that implies standards availability by roughly 2023
- This could then be based on 3GPP Release 18 results



# But everyone is talking about 6G!

- The ink is still drying on the 5G standard and yet everyone is already talking about 6G!
- Here are just a few examples:

- **Nokia** (Communications in the 6G era) https://onestore.nokia.com/asset/207766
- **Samsung** (The next hyper-connected experience for all) https://cdn.codeground.org/nsr/downloads/researchareas/20201201_6G_Vision_web.pdf
- **Ericsson** (A research outlook towards 6G) https://www.ericsson.com/en/reports-and-papers/white-papers/a-research-outlook-towards-6g
- **NTT DoCoMo** (6G White paper) https://www.nttdocomo.co.jp/english/corporate/technology/whitepaper_6g/
- **Keysight technologies** (A New Sub-Terahertz Testbed for 6G Research) https://www.keysight.com/gb/en/assets/7120-1082/white-papers/A-New-Sub-Terahertz-Testbed-for-6G-Research.pdf
- **NGMN** (6G: why?) https://www.ngmn.org/highlight/6g-why.html
- **GSMA** (6G) http://www.gsmhistory.com/6g/
- **University of Oulu** (various 6G white papers) https://www.6gchannel.com/
- **University of Surrey** (6G Wireless: a new strategic vision) https://www.surrey.ac.uk/sites/default/files/2020-11/6g-wireless-a-new-strategic-vision-paper.pdf

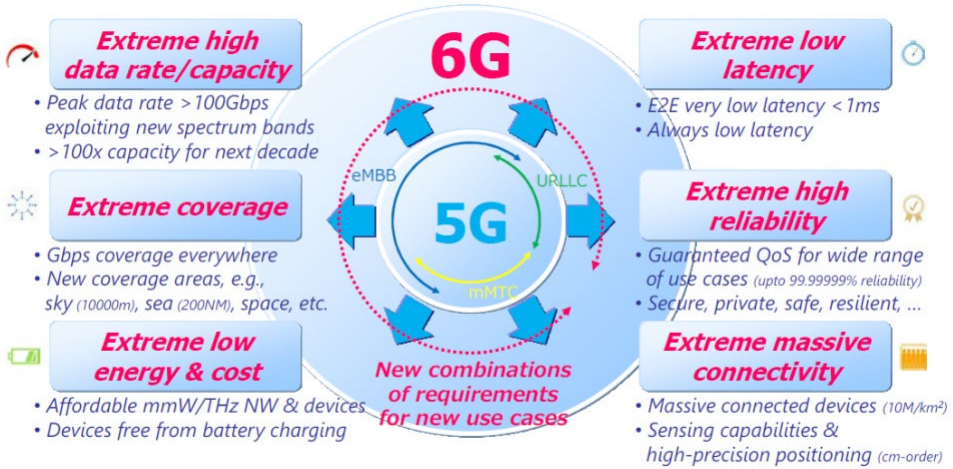
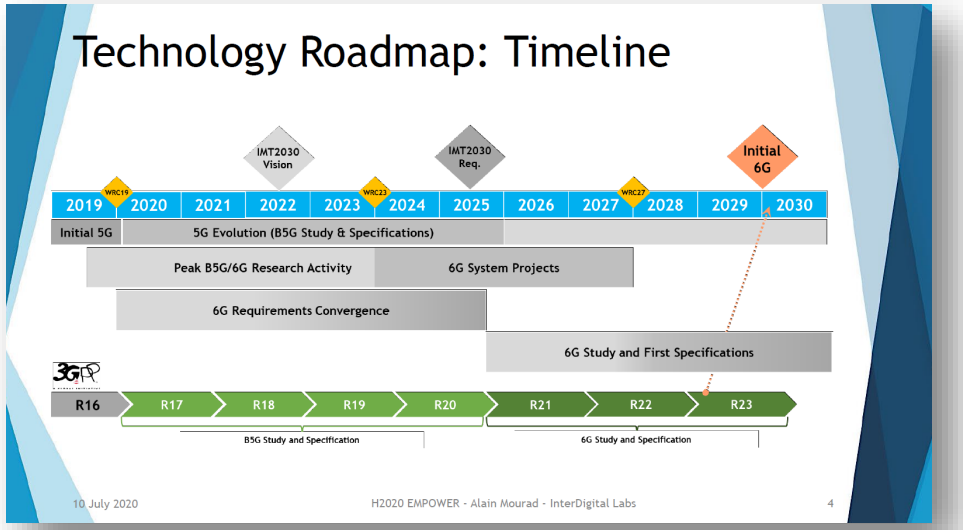


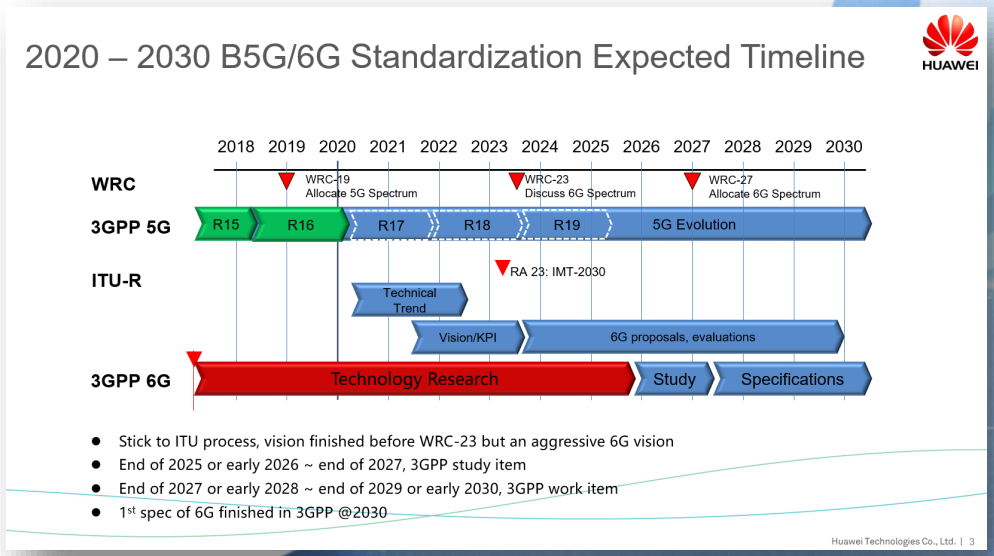

Figure 3-1. Requirements for 6G wireless technology

Source: NTT Docomo

# Research and standards for 5G evolution, B5G and 6G

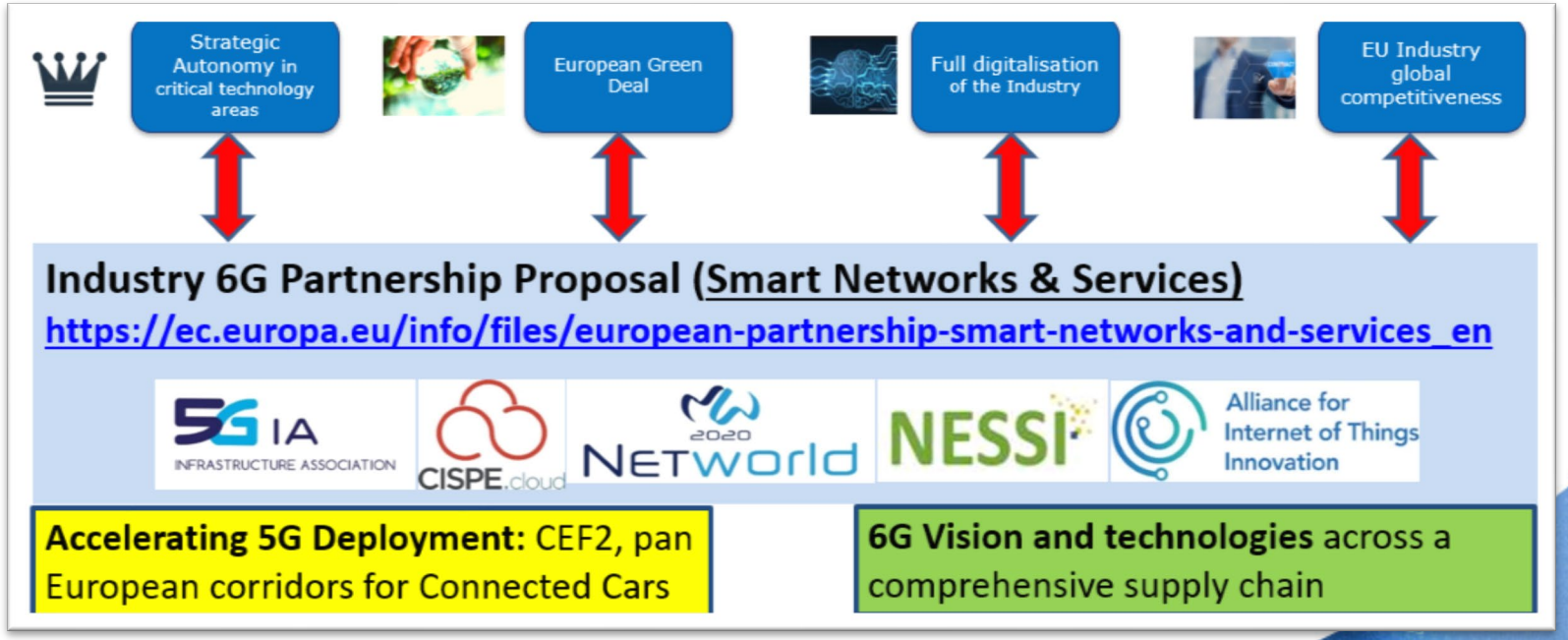
- It is important to use caution when using the term ‘6G’ in order to avoid diluting the impact of present day 5G rollouts
- At the same time, there is significant technology research that may be destined for 5G evolved, B5G, 6G
- Initial study items for 6G are not expected to be seen in 3GPP for sometime….
- …but of course expectations can, and often do, change due to market pressure



# EU funded research for B5G to 6G

- The related B5G / 6G research is in the early stages, and the corresponding European Funding programmes are just beginning (Horizon Europe 2020 – 2027)
- However, it is ‘never too early’ to consider the impact research results could have on standards
- On the contrary, the requisite standards can often be considered ‘too late’ and opportunities missed



# Potential areas of technology research

Indicative list of research areas and technical enablers from the **Networld2020 SRIA**

https://bscw.5g-ppp.eu/pub/bscw.cgi/d367342/Networld2020%20SRIA%202020%20Final%20Version%202.2%20.pdf

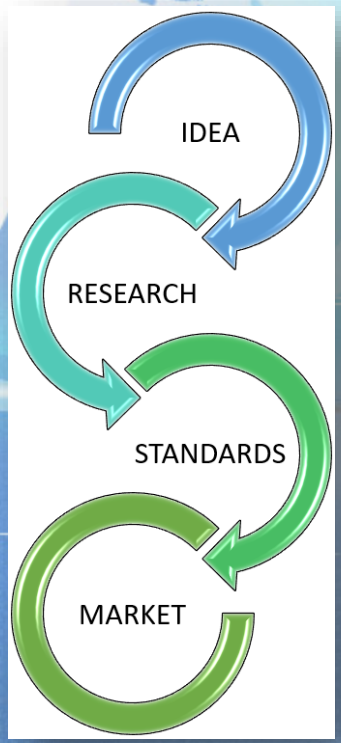
| Technological Areas | Indicative list of promising research areas |
|---|---|
| ubiquitous availability | Integrated fixed mobile architecture<br>Satellite communications |
| infinite network capacity | Spectrum re-farming and Reutilization<br>mmWave, Terahertz, VLC communications<br>Satellite communications<br>Ultra-massive MIMO<br>Flexible capacity scaling |
| Throughput | Ultra-massive MIMO<br>Enhanced modulation and coding<br>Optical wireless integration |
| Ultra-low e2e latency | Media access control<br>Edge/fog computing |
| Security | Software defined security<br>Network wide security<br>Slice-specific and convergence on common software defined patterns<br>Distributed trust systems |
| Energy efficiency | extended bandwidth adaptation<br>improved RF |
| Massive IoT Service management | Scalable management of massive deployment<br>Distributed autonomous and cooperative computing |

# ETSI approach to working with research and innovation

ETSI encourages the constant flow of research and innovation output into the ETSI work programme.

ETSI has made such interactions with researchers a priority at all levels, for example:

- The ETSI Strategy states "*ETSI works at the forefront of emerging technologies, having close relationships with research communities*",
- This is supported by a specific Board action "*Strengthening the links between R&D and standardization*",
- ETSI Board has produced the "Long Term Technical Roadmap" to identify emerging technology trends,
- Creation of a dedicated Department New and Emerging Technologies with the principle roles of :-
  - *Optimising the relations/links to research and innovation entities both in Europe and globally,*
  - *Tracking the evolution of new and innovative technology trends that may be of potential interest for standardization in ETSI,*
  - *Working with ETSI members (existing & new) capture & build the potential new technology areas in ETSI as new work areas in existing tech groups and/or as new technical groups.*

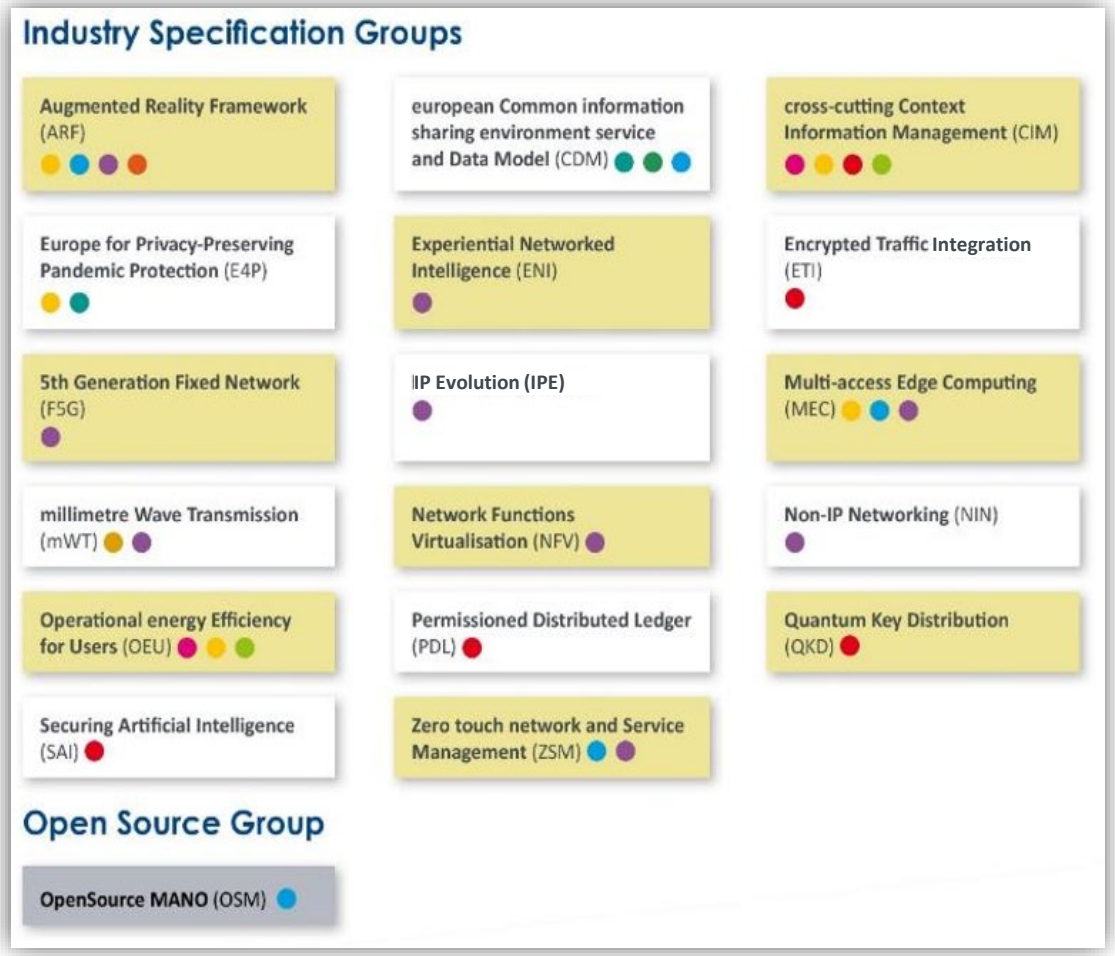


# 3GPP acceptance of research results: a dilemma?

- 3GPP is "*industry led*" and "*contribution driven*"
- This has proven to be a very successful formula over the past two decades
- Research results, by definition, represent the most advanced technical capabilities and may be reasonably described as "leading edge"
- As the rate of innovation increases, it becomes more important for future generations to incorporate leading edge solutions
- It is not always easy for research bodies to present their results directly into 3GPP

# ISGs – an early standards incubator for research results

- ETSI ISGs (Industry Specification Groups) are the perfect tool for developing ‘early’ standardization work resulting from innovative research projects
- An ISG may be established on the initiative of any group of, at least four (4), ETSI members (or applicant members) making a request to the ETSI Director-General and meeting the essential criteria for new ISGs in ETSI
- This tool has been used for many successful standards efforts on technologies that form the basis of 5G (e.g., NFV, MEC, etc)
- ETSI ISGs are open to both ETSI members and non-members



# Improve: cooperation, communication, coordination

Bridging the gap between Research and Standardization requires:

- Early interactions between research projects and standardization bodies
- Education by standardization bodies about their processes and current work programmes to both under/post graduates and researchers
- Outreach by standardization bodies on the value of standardization and the possibilities available to research communities
- Coordination between policy makers, research bodies, Industry and standardization in order to foster a Global and Open approach to innovation

# ETSI - bringing people together…

Thank you!

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Humbled to be appointed a WWRF Fellow