WIRELESS WORLD
RESEARCH FORUM

WWRF building the vision for the next-generation mobile network

10th November 2022

one6G Summit 2022

Nigel Jefferies, WWRF Chairman

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About WWRF

The Wireless World Research Forum is the place where the global wireless research community meets to explore and develop the research challenges that confront us as we look beyond current 5G deployments

A world leading Forum creating a **smart future**

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What is WWRF?

- Founded in 2001
  - Through WSI an EU-funded research landscaping project
- Based in Switzerland
- Independent and owned by its members
- Promoting visions of the wireless future

Working Groups

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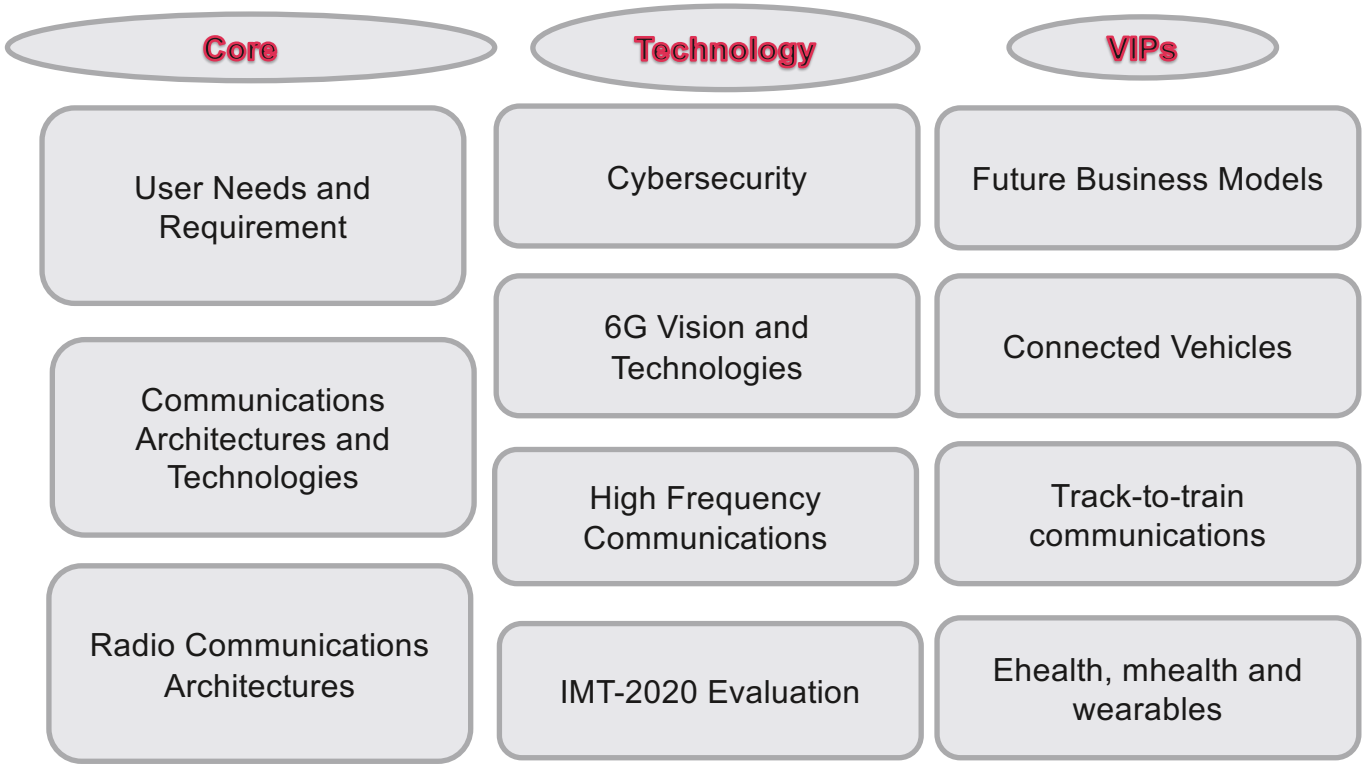

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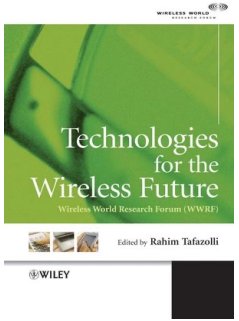
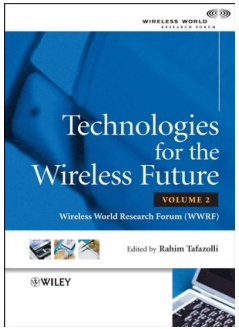
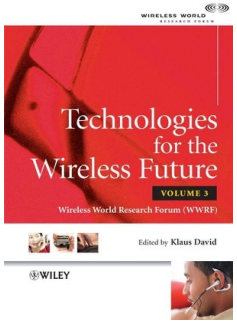
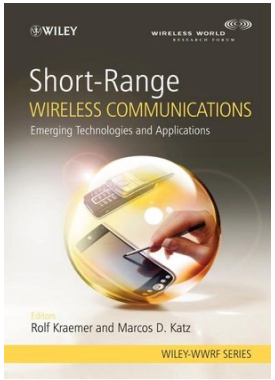
WWRF outputs

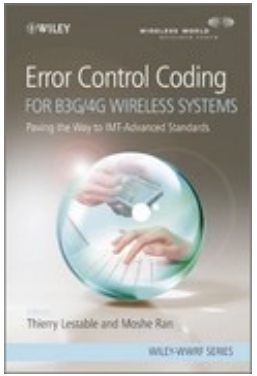
- WWRF Outlook – published version of White Paper
- WWRF Library – proceedings of each meeting
- WWRF – Wiley and River book series

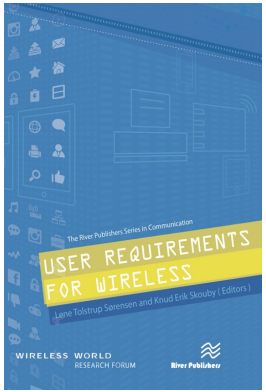












WWRF Vision of 2030

We Are Entering a Hyper-connected Intelligent World

All Things Sensed

Sensing the physical world, mapping it to digital signals

Temperature, space, and touch
Sense of smell, hearing, and vision

All Things Connected

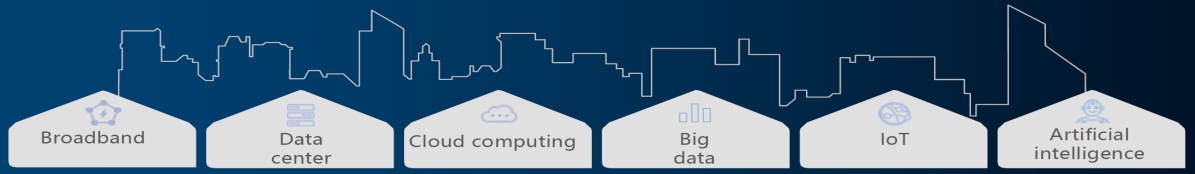
Data goes online to power machine intelligence

Ubiquitous connections, wide connections, multiple connections, and deep connections

All Things Computed

Network integrated AI to power new applications

Digital twins
Digital survival



HUAWEI

What about human mind + body in the architecture?

Vision 2030

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WWRF Objective

- address the key challenges for fostering the rapid adoption of wireless communications and develop strong research collaborations with the leading organizations in developing and developed economies

Objective for 2030

- **Connect the unconnected or under-connected at affordable cost**

Means

- Identify the key issues and challenges affecting the rapid adoption of wireless communication in the rural and remote communities
- Identify business issues, regulatory issues, technical issues, environmental issues for services and applications that affect society
- Identify and prioritize the requirements on architectures, services and wireless technologies in the emerging economies with sustainable business models that are not currently being met by the existing solutions being offered and/or under development for the global market for 2030

6G Drivers

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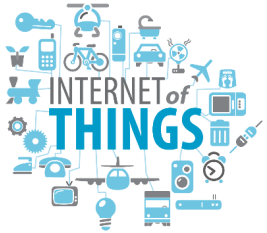
Wireless connectivity is driving major societal changes:

1G - 2G

1980s – 2000s
Millions of voice users

3G - 4G

– 2020s Billions of Mobile Broadband users



5G and beyond

– 2040s Trillions of connected objects

Applications range explodes and new value chains emerge:

Logistics

Retail

Agriculture

Industry 4.0

Health

Sustainable energy

Automotive & transportation

Vertical-specific service providers are needed to complement MNO's offerings.
URLLC type solutions will be tailored for different verticals.

6G Vision (1)

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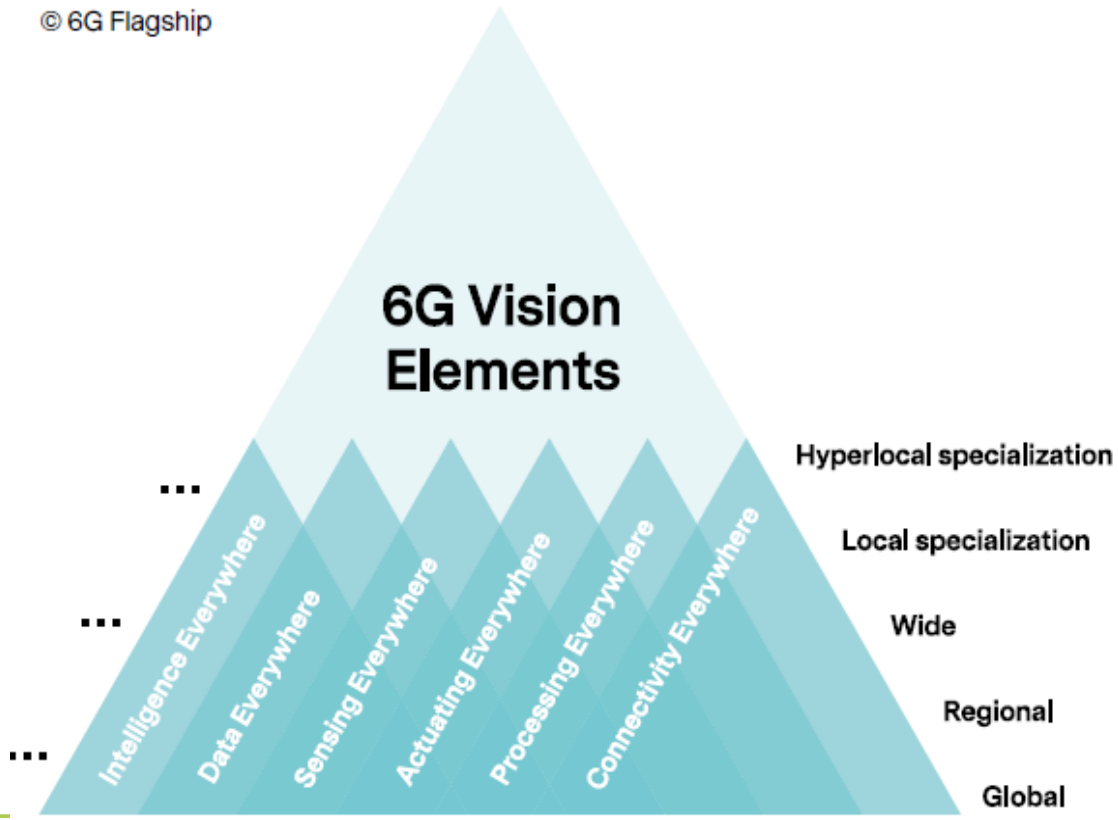
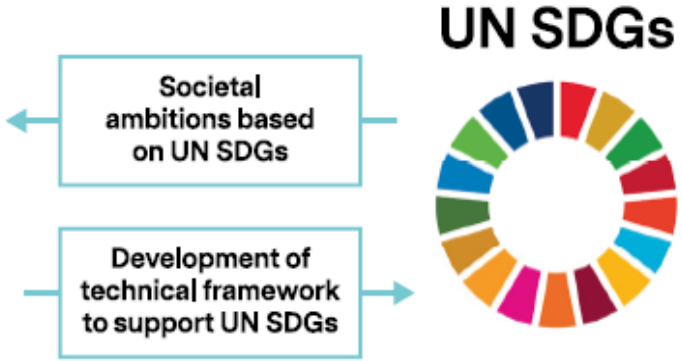
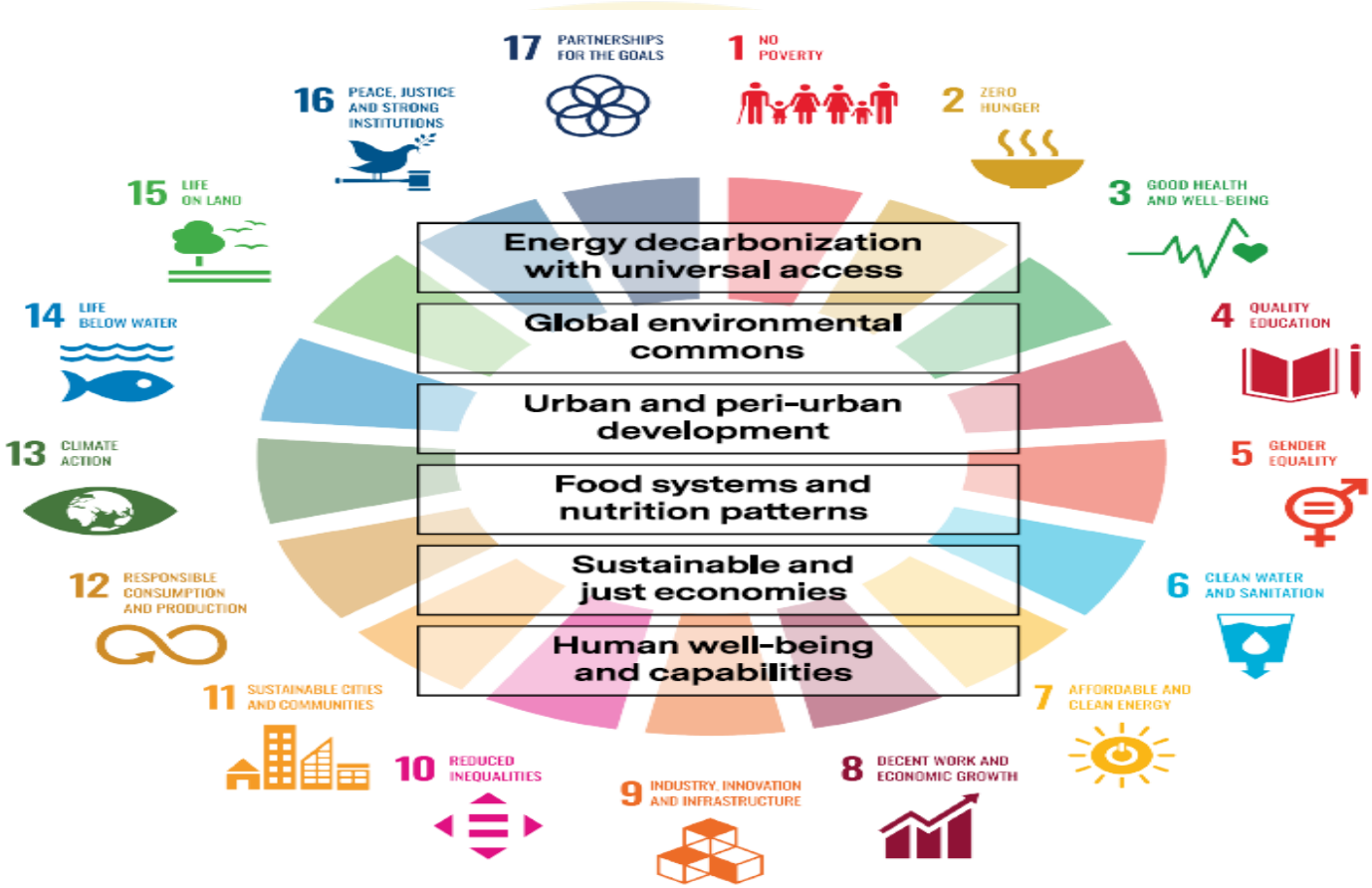
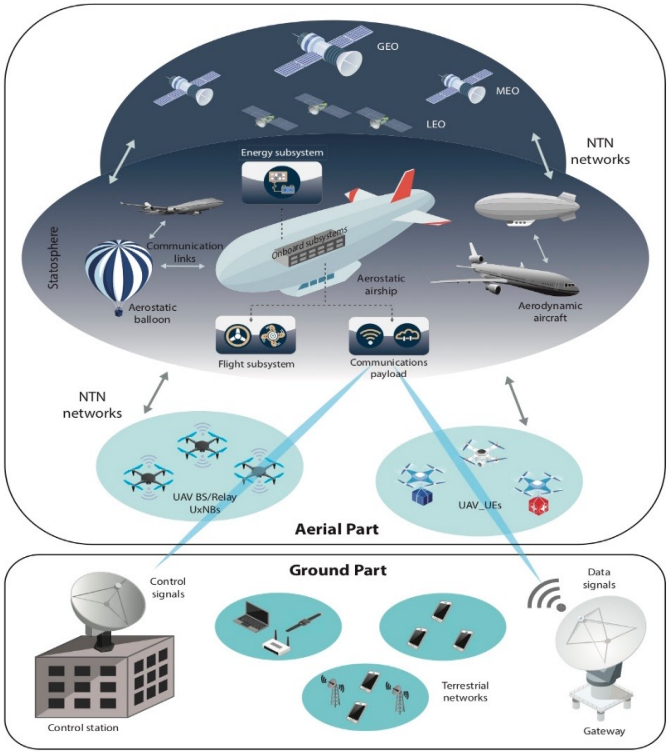




6G Vision (2)



A number of different technologies will be needed to achieve global inclusion (3)



WWRF Key Principles for Vision 2030

Technologies

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- 5G and Beyond technology enablers
- Spectrally Efficient transmission techniques
  - Radio resource management and interference management
  - Full Duplex Transmission (RF, PHY and Resource management aspects)
  - Dynamic Spectrum Sharing
- Beyond Shannon Information Theory Concepts in Wireless Communications
- Propagation and Channel Modelling for wideband transmission in mm Wave bands and THz
- Advanced Signal processing and Versatile Air Interface Design
- Integration of Terrestrial and Non Terrestrial technologies
- Security & Privacy

WWRF Views: IMT-2030 should set challenging sustainability requirements (1)

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- The challenges
  - Energy consumption reduction and more
- How?
  - convert into monetary challenges (such as carbon markets)
  - balance sustainability and affordability
  - look for ‘net zero’ for the network itself.
- Possible techniques
  - Network sharing
    - Softwarization and virtualization enable network sharing but may be less efficient
  - Avoiding duplication in the network
  - Ending the generational cycle - this is not sustainable! Make 6G the last hardware generation
  - Increase longer-lasting, recyclable and re-usable equipment and reduce reliance on scarce commodities

- ITU and regulators should
  - Set challenging targets that operators/vendors must conform to
  - Support better analysis of economic and social cost/benefits (cf. DESC)
  - Support a new generation of SDGs for the whole world
  - Educate and inform consumers, give them back control (Privacy, RF safety and other issues)
  - Give a central role to developing regions to set priorities: education, health provision, farming, industry

WWRF Views (2)

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- Ubiquitous Coverage will be a critical performance objective in IMT 2030 systems.
- IMT 2030 technologies and systems concepts must consider/address/target real world problems!
- IMT 2030 should bring value to the people in a human-friendly fashion. While viewing the added value for different stakeholders (operators, service providers and technology/ equipment makers), due consideration of cost efficiency, EMC/EMF awareness and alignment with UN Sustainability goals is important
- 'Network of networks' systems concept meaning the existence of 10's of thousands of networks in the same geographic area, including "individual cell networks"; private networks with heterogeneous Radio Access Technologies (RAT's) would play a catalytic role in the definition and technology specification of future radio interface.

WWRF Views: Radio (3)

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- No ‘one size fits all’ radio solution should be envisioned.
- Selection of use cases and usage scenarios and their specifications will help streamline the objectives/requirements and will play a - more than ever before decisive role.
- The diversity of real-world problems (including remote/rural areas in developing countries, urban high-tech apps in big cities and several other usage scenarios) clearly indicates the need for appropriate selection of KPIs, design approaches, technology priorities, modularity and scalability targets.
- “Network of Networks” implemented through interworking/interconnection of varied networks will
  - Be facilitated with increasing “softwarization” of network elements
  - Bring advantages of spectral efficiency e.g. through Dynamic Spectrum Allocation
  - Bring challenges related to User Authentication and Mobility and QoS management
  - Leverage virtualization and AI as much as possible.

WWRF Views: Key IMT-2030 Technology Trends (4)

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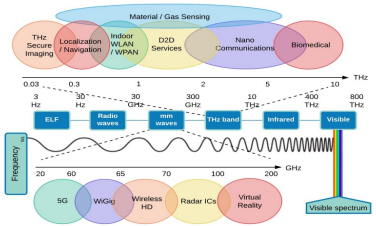
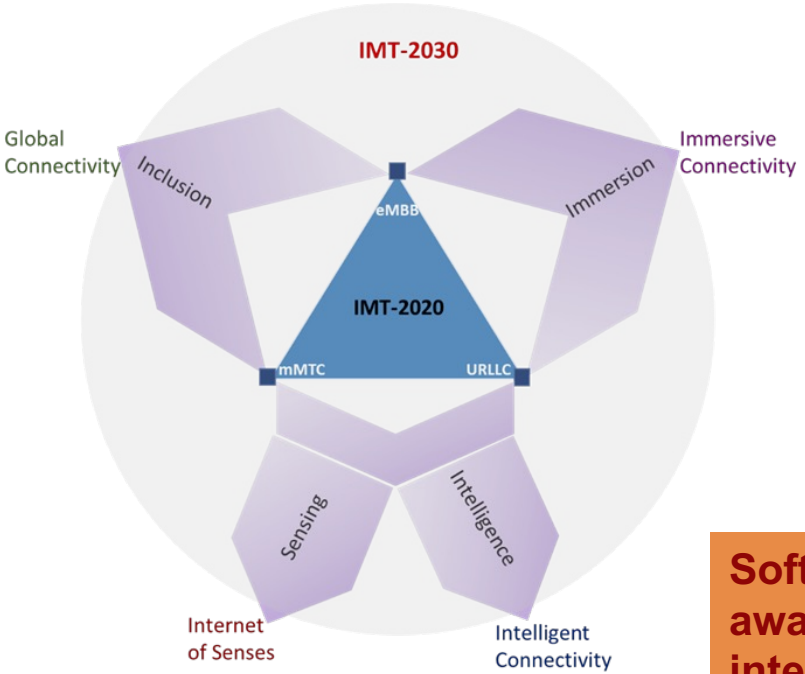
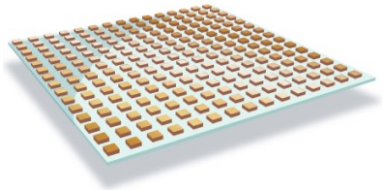
THz Communications



Integrated Communications and Sensing



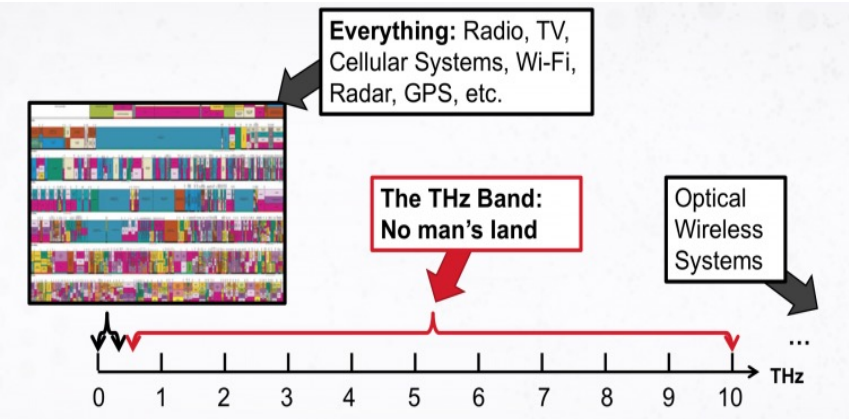
Reconfigurable Intelligent Surfaces and Holographic Radio



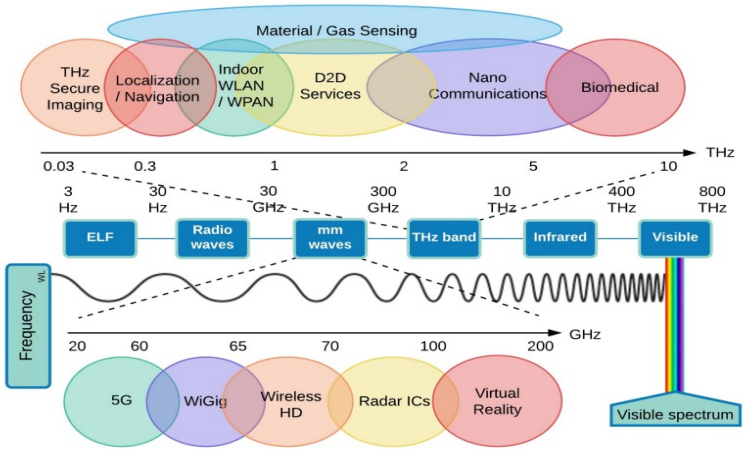
Artificial Intelligence and Machine Learning

Softwarization, context awareness. Embedded intelligence, Multi-sensing and biometrics

The THz Opportunity



J. M. Jornet, "Terahertz Communications: the Quest for Spectrum", https://www.comsoc.org/publications/ctn/terahertz-communications-quest-spectrum



A. Faisal, et al, "Ultramassive MIMO Systems at Terahertz Bands: Prospects and Challenges," EEE Vehicular Technology Magazine, Dec. 2020

Short Range Connectivity Becomes Vital

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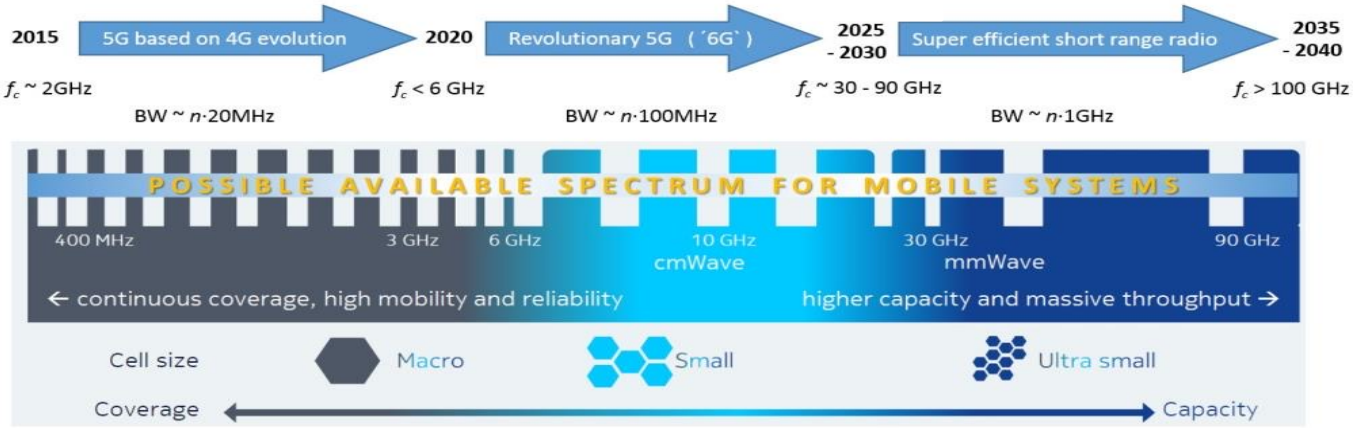
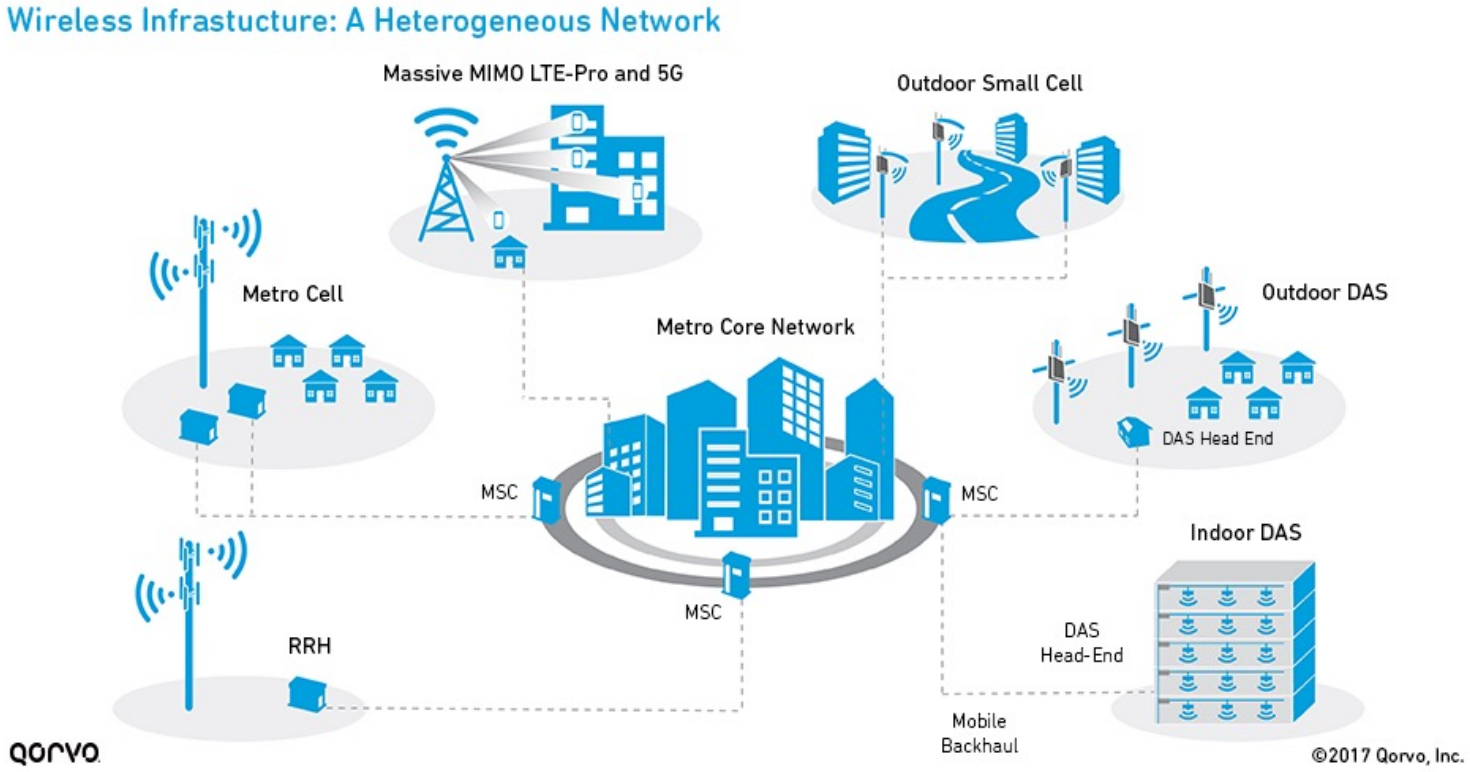


1) Higher frequencies needed => the physics of radio signal propagation means shorter link ranges
⇒ More basestations needed => **the role of short range connectivity** is drastically increasing.

2) Higher frequencies do not propagate through walls => **base stations must be installed indoors**
⇒ who does that and who pays the bill?? => new value chains / business models !

3) Spectrum regulation has to enable **local frequency licencing** for the benefit of
=> Radio Spectrum Policy Group (RSPG) in European Commission is pushing this.

More Variety in Network Deployment



Cloud Distribution Across Network…

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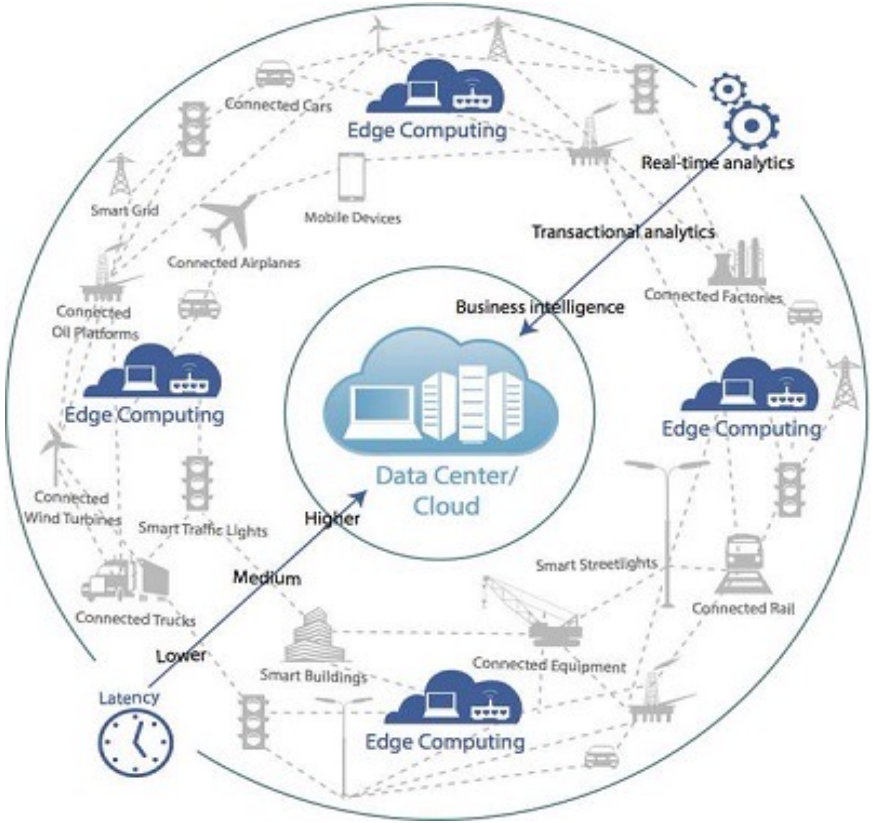

Smart society calls for distributed AI

AI solutions are driven by different verticals

Whole system architecture is changing: basestation densification, mobile edge computing, fog computing at devices…

What AI/ML brings to wireless systems and what wireless connectivity offers to AI/ML based applications?

Multiple Hierarchical Layer architecture or *the disappearing cell*

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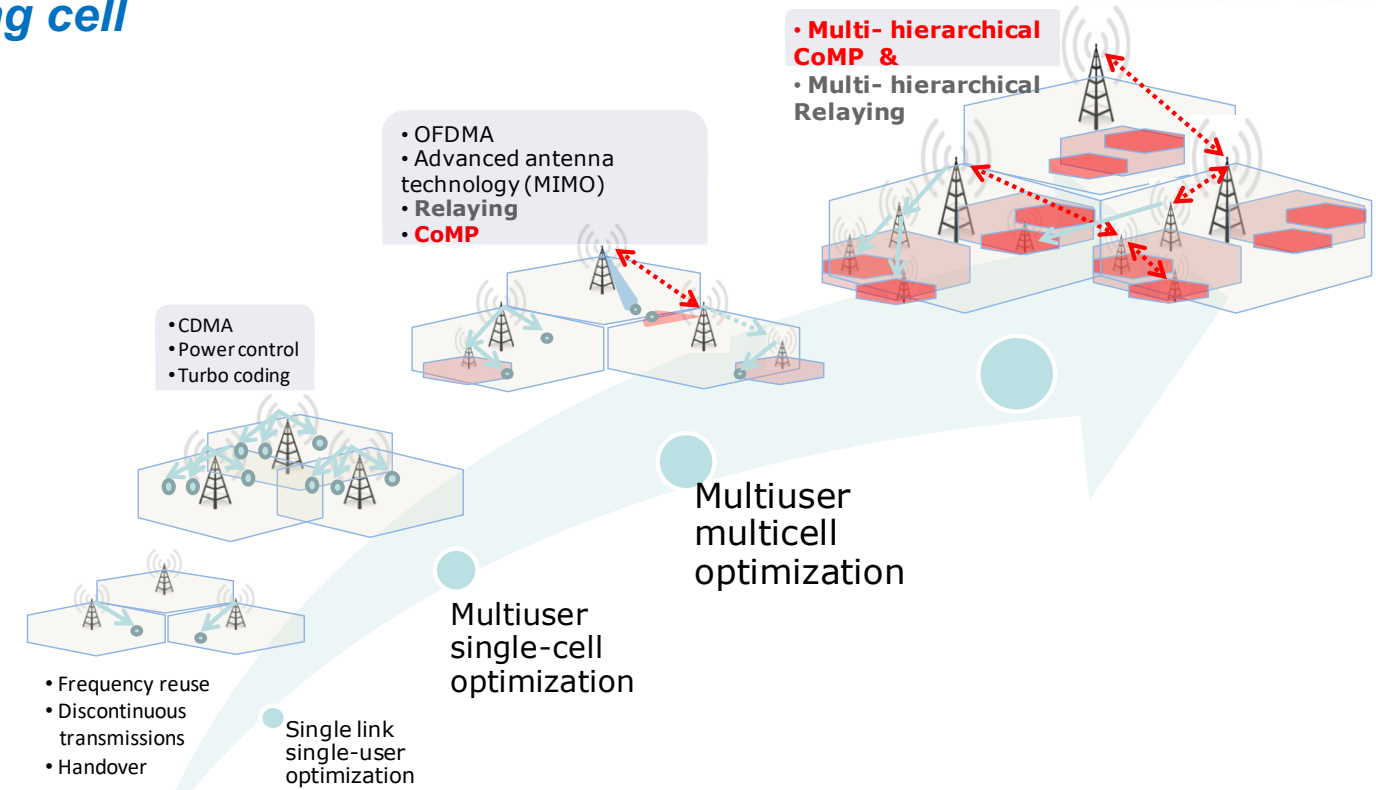

System concept..
..on the cloud

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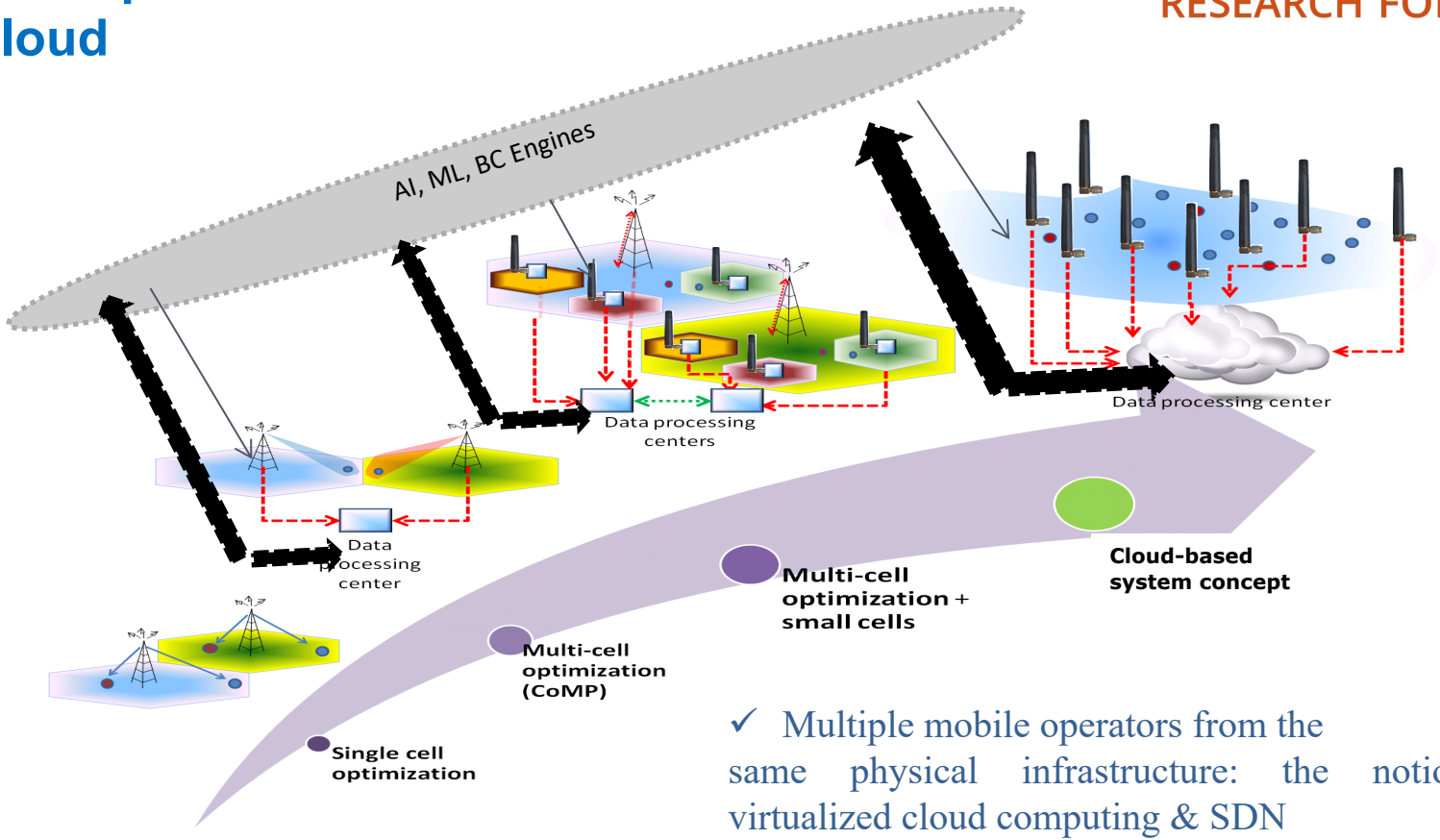

✓ Multiple mobile operators from the same physical infrastructure: the notion of virtualized cloud computing & SDN

Plans for WWRF Work on the Vision

Plans for Further WWRF work on the Vision

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- Further elaboration and requirements specification for the identified IMT 2030 USAGE SCENARIOS:
  - Global Connectivity with backward compatibility
  - Immersive Connectivity
  - Intelligent Connectivity
  - Internet of Senses
- Qualitative and quantitative specification of IMT 2030 Key Performance Indicators for
  - Sustainability/inclusion/energy efficiency
  - Auto-Reconfigurability, immersive intelligence and agility
  - Artificial and sensing intelligence (localization accuracy, sensing resolution, shape recognition, user tracking, gesture identification etc)
  - Social KPIs, Key Value Indicators (KVIs)

www.wwrf.ch