Ασύρματες Επικοινωνίες 5ης Γενεάς και Ασύρματα Δίκτυα Αισθητήρων ως Σπονδυλική Στήλη του Διαδικτύου των Πραγμάτων

Γεώργιος Κυριακού, Καθηγητής Δημοκριτείου Πανεπιστημίου Θράκης.

SAMSUNG

Immersive Services

Can we really forecast traffic in 2030?

Ubiquitous Health Care

Wearable/Flexible Mobile Device

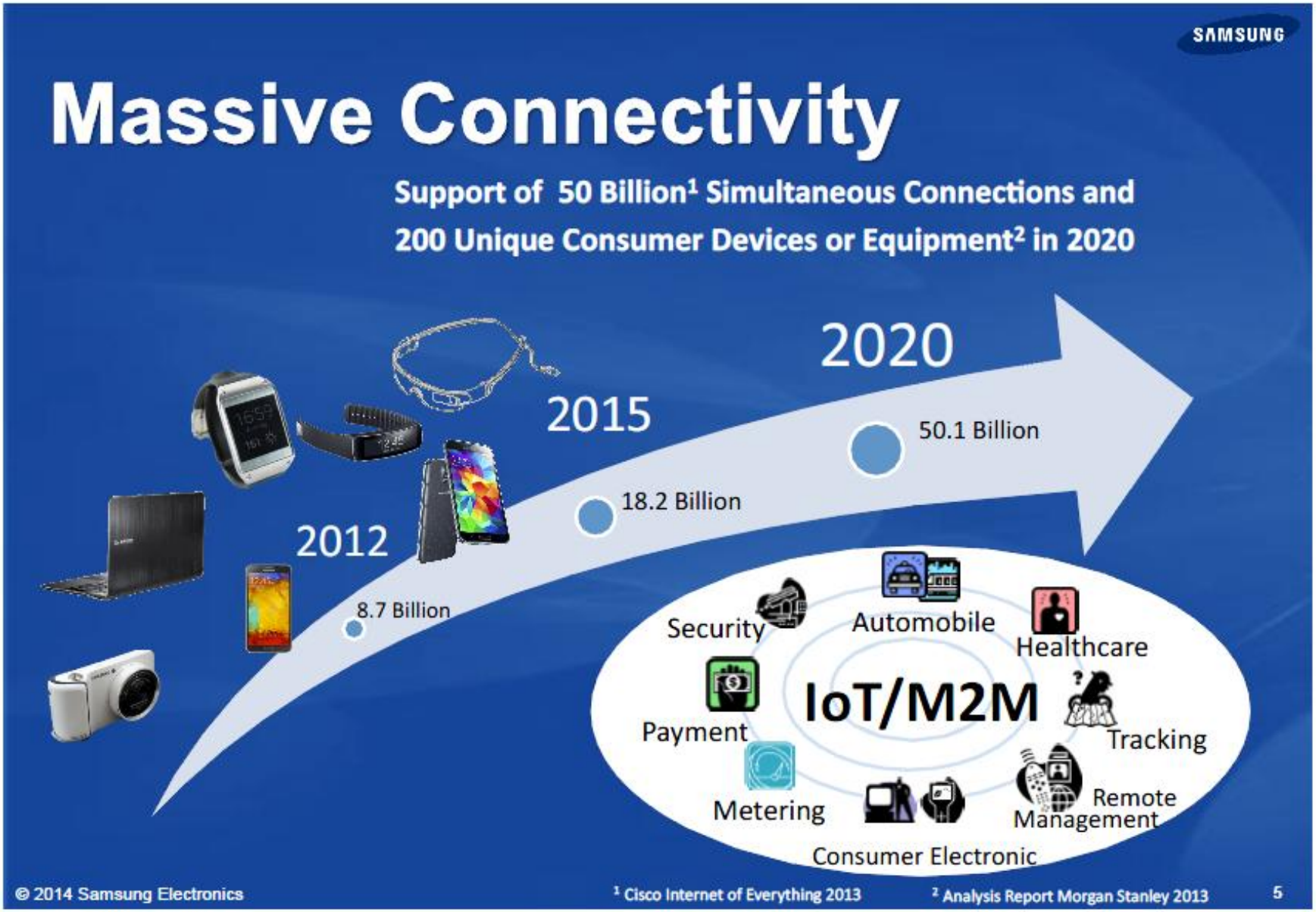
Mobile Cloud

UHD Video Streaming

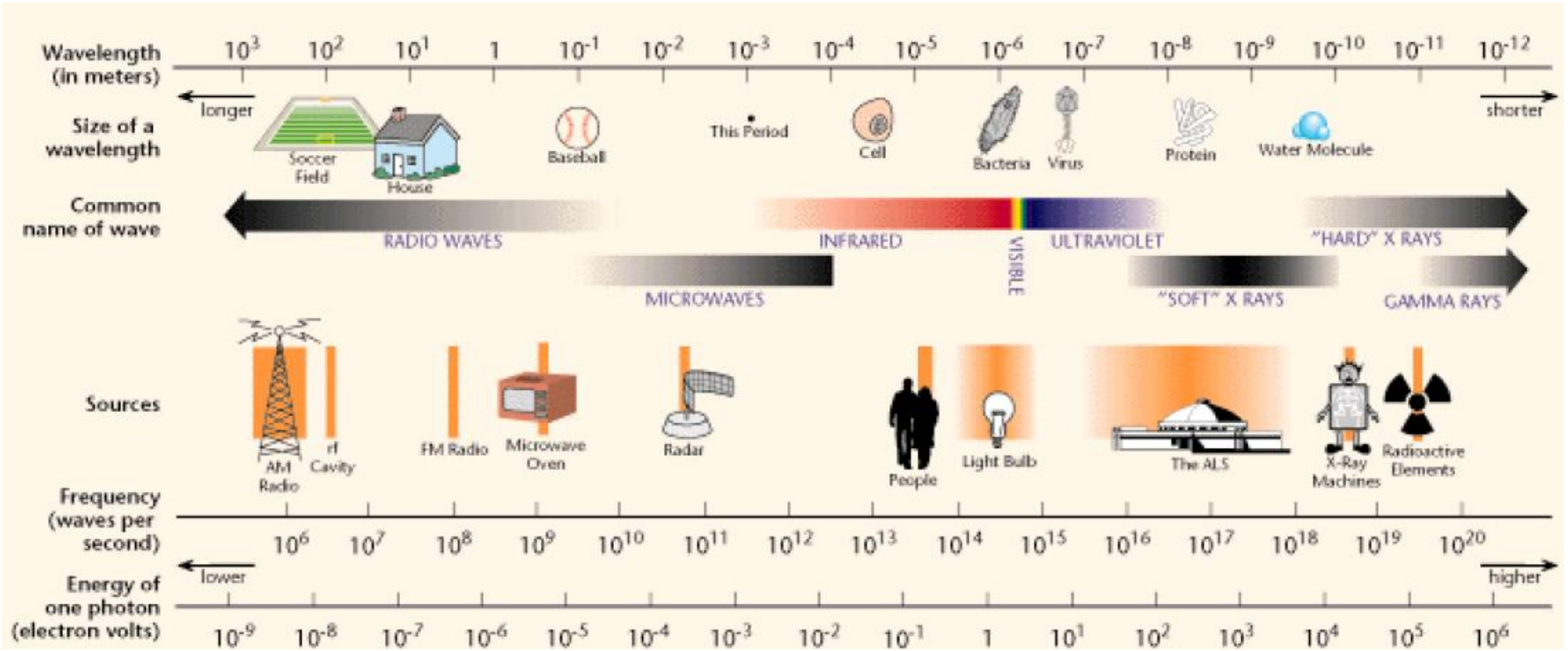
Smart Map/Navigation

Real-Time Interactive Game

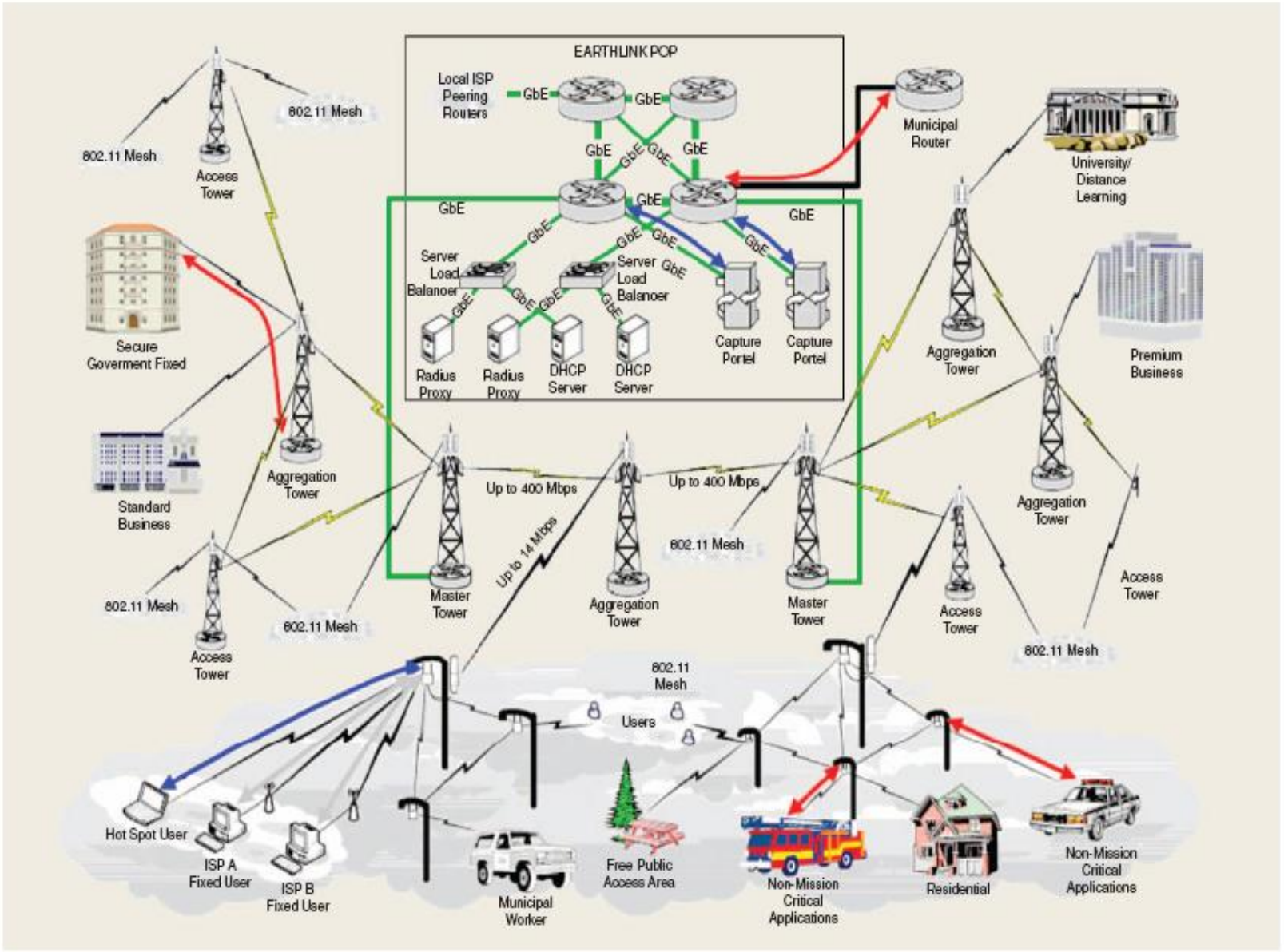
Μαζική Διασύνδεση



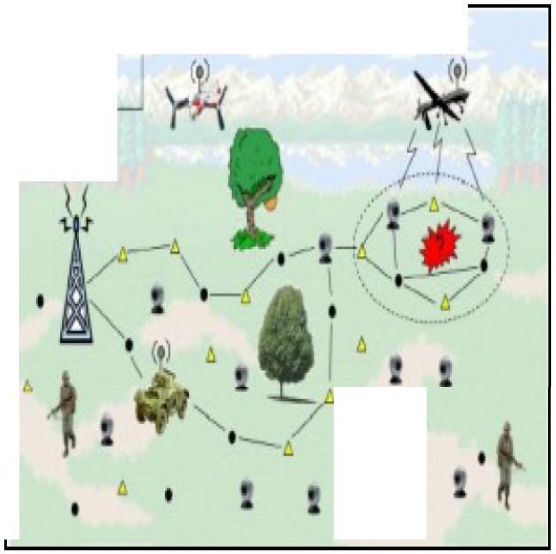
Ηλεκτρομαγνητικό Φάσμα - Εφαρμογές

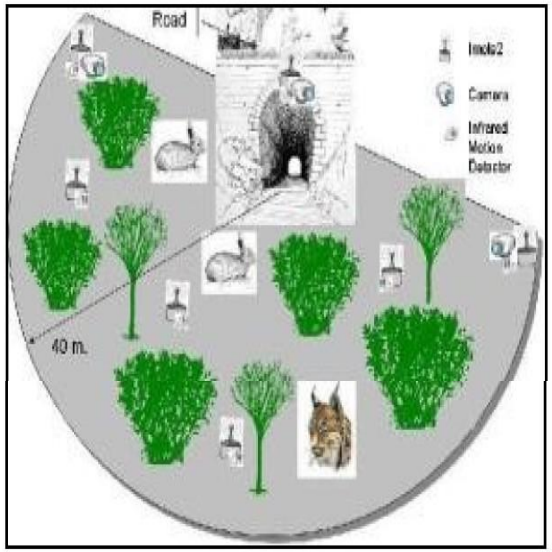


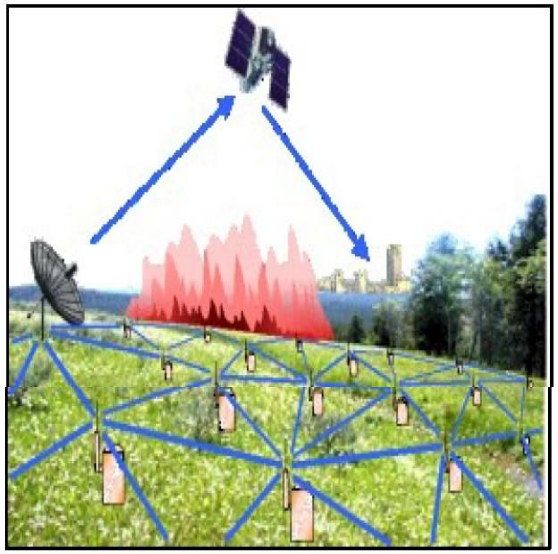
Ασύρματα Μικροκυματικά Δίκτυα

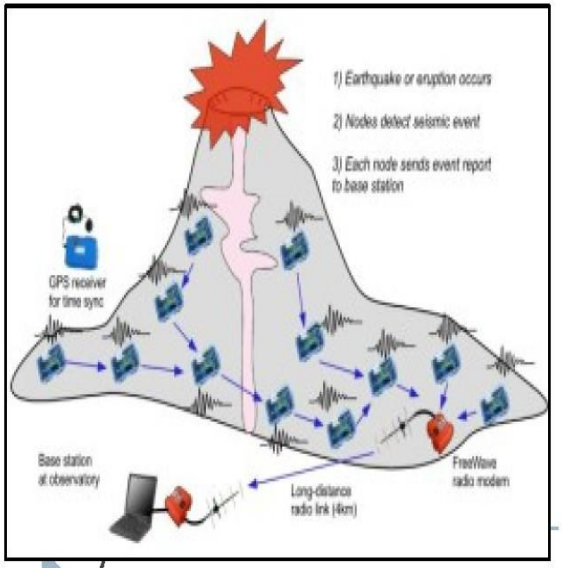


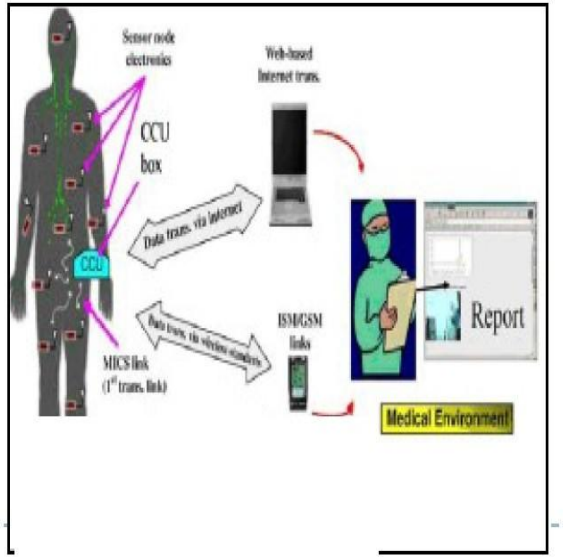
Ασύρματα Δίκτυα Αισθητήρων - WSNs Applications

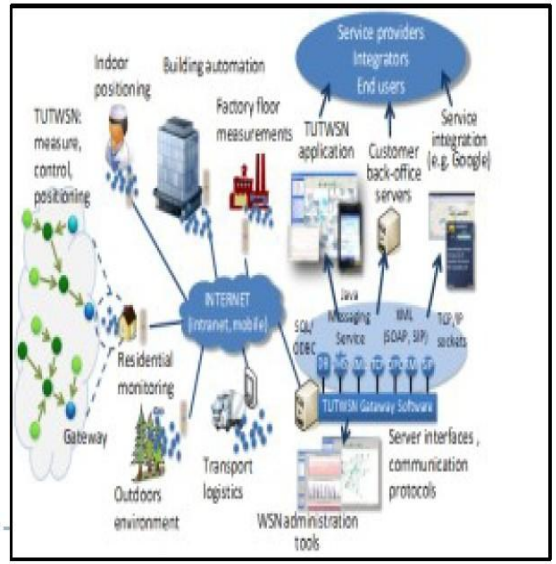




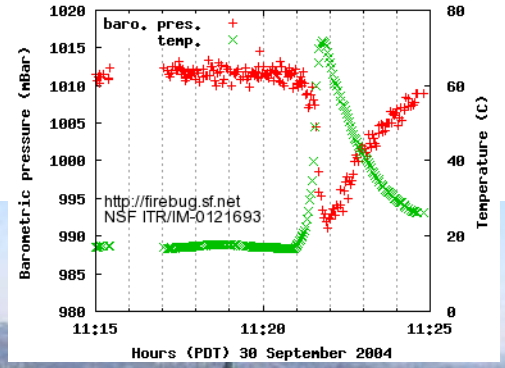


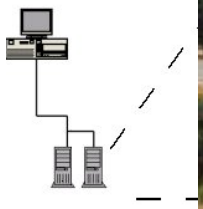






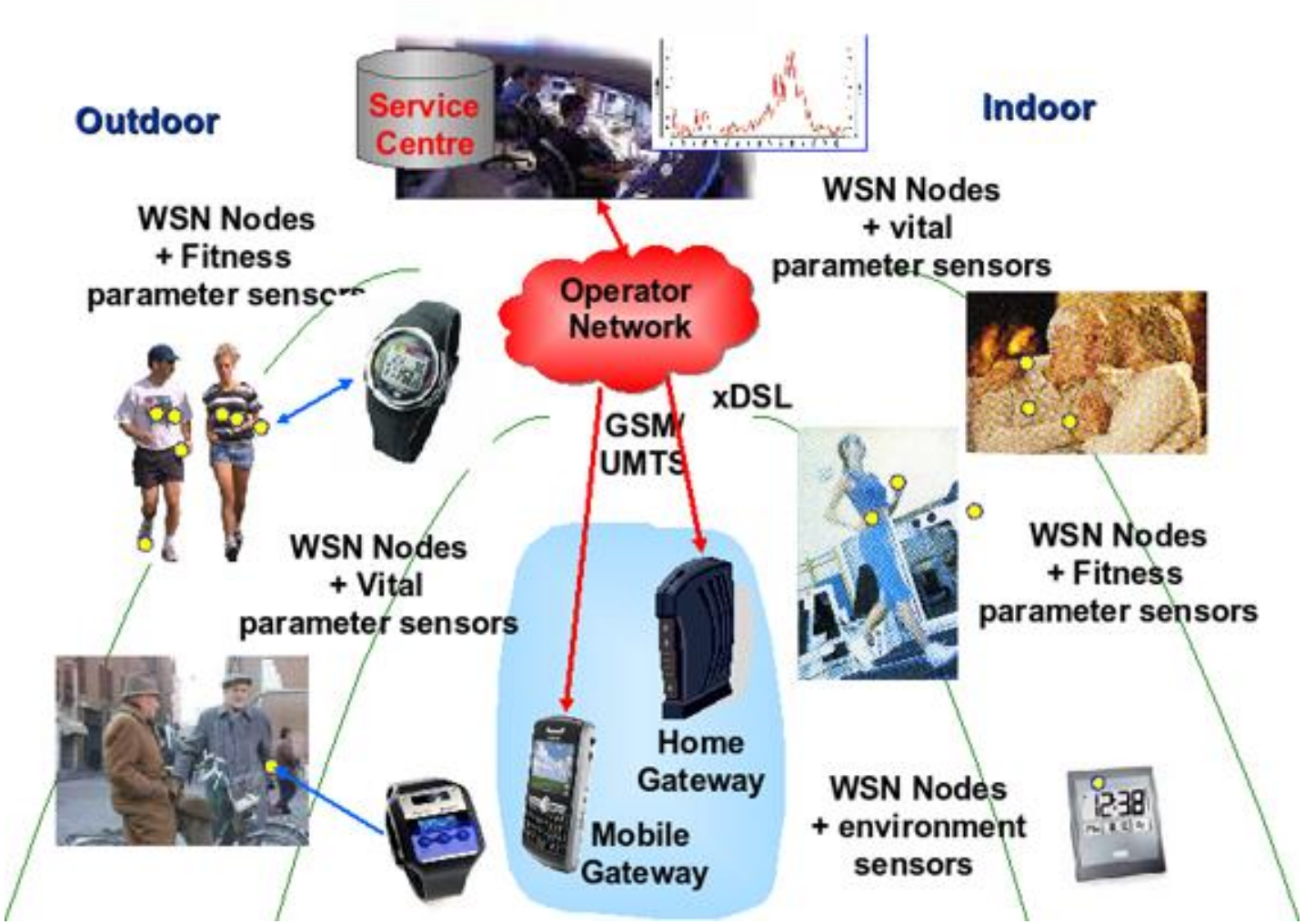
FireBug





- Wildfire Instrumentation System Using Networked Sensors
- Allows predictive analysis of evolving fire behavior
- Firebugs: GPS-enabled, wireless thermal sensor motes based on TinyOS that self-organize into networks for collecting real time data in wild fire environments
- Software architecture: Several interacting layers (Sensors, Processing of sensor data, Command center)
- A project by University of California, Berkeley CA.

Example of WSN



Ref:http://esd.sci.univr.it/images/wsn-example.png


ENABLING THE SMART AGRICULTURE REVOLUTION

FUTURE FARMS
small and smart

SURVEY DRONES

Aerial drones survey the fields, mapping weeds, yield and soil variation. This enables precise application of inputs, mapping spread of pernicious weed blackgrass could increasing Wheat yields by 2-5%.

FLEET OF AGRIBOTS

A herd of specialised agribots tend to crops, weeding, fertilising and harvesting. Robots capable of microdot application of fertiliser reduce fertiliser cost by 99.9%.

FARMING DATA

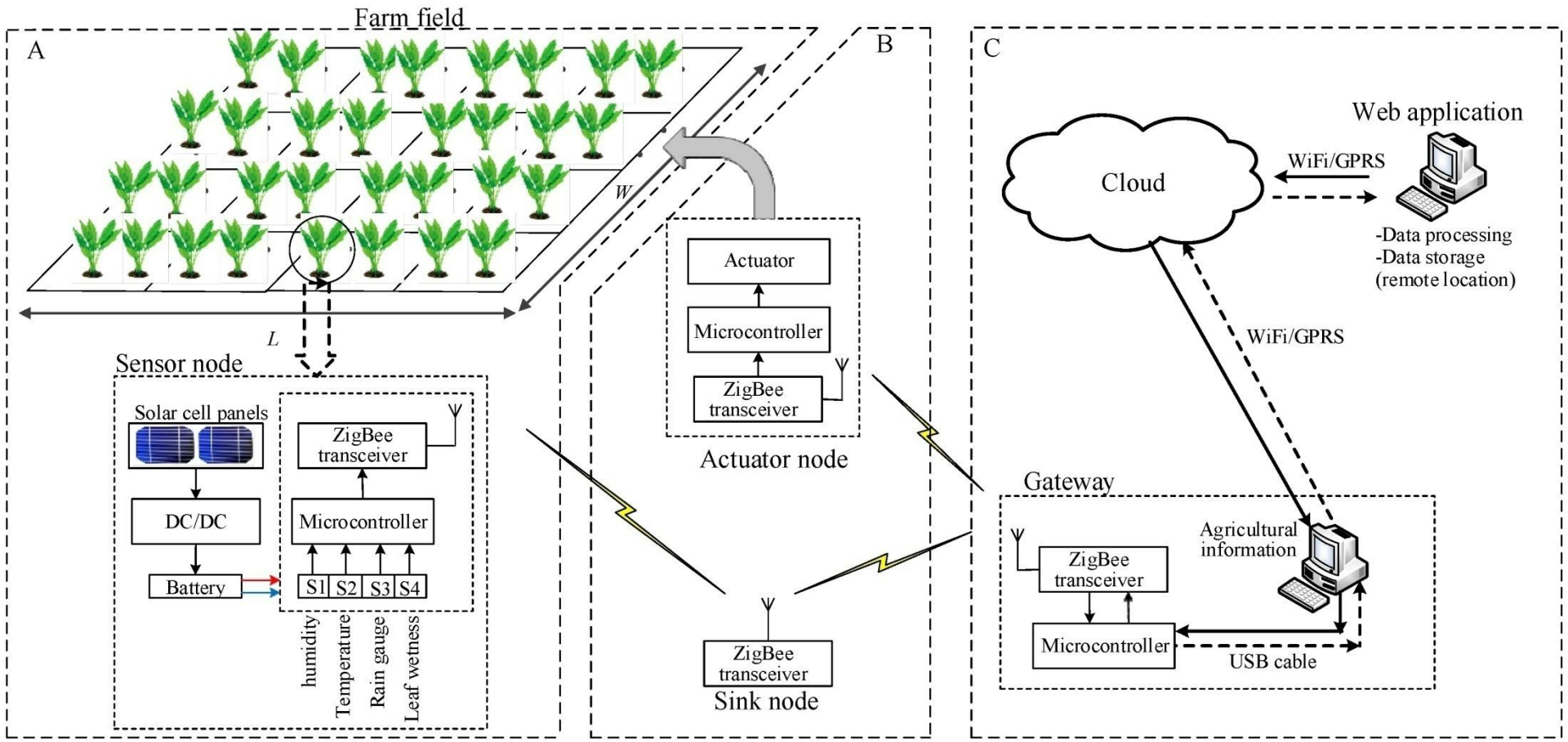
The farm generates vast quantities of rich and varied data. This is stored in the cloud. Data can be used as digital evidence reducing time spent completing grant applications or carrying out farm inspections saving on average £5,500 per farm per year.

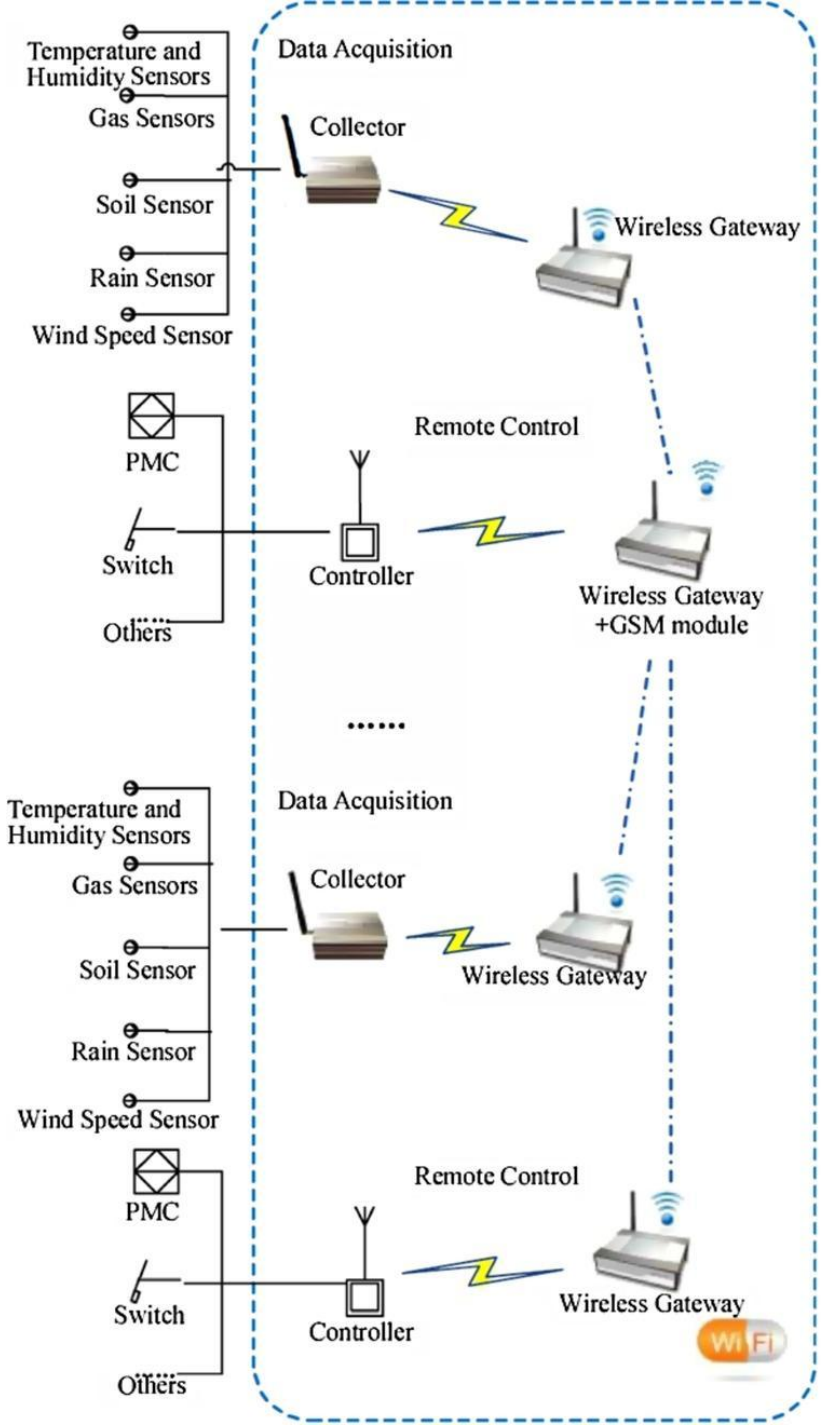
TEXTING COWS

Sensors attached to livestock allowing monitoring of animal health and wellbeing. They can send texts to alert farmers when a cow goes into labour or develops infection increasing herd survival and increasing milk yields by 10%.

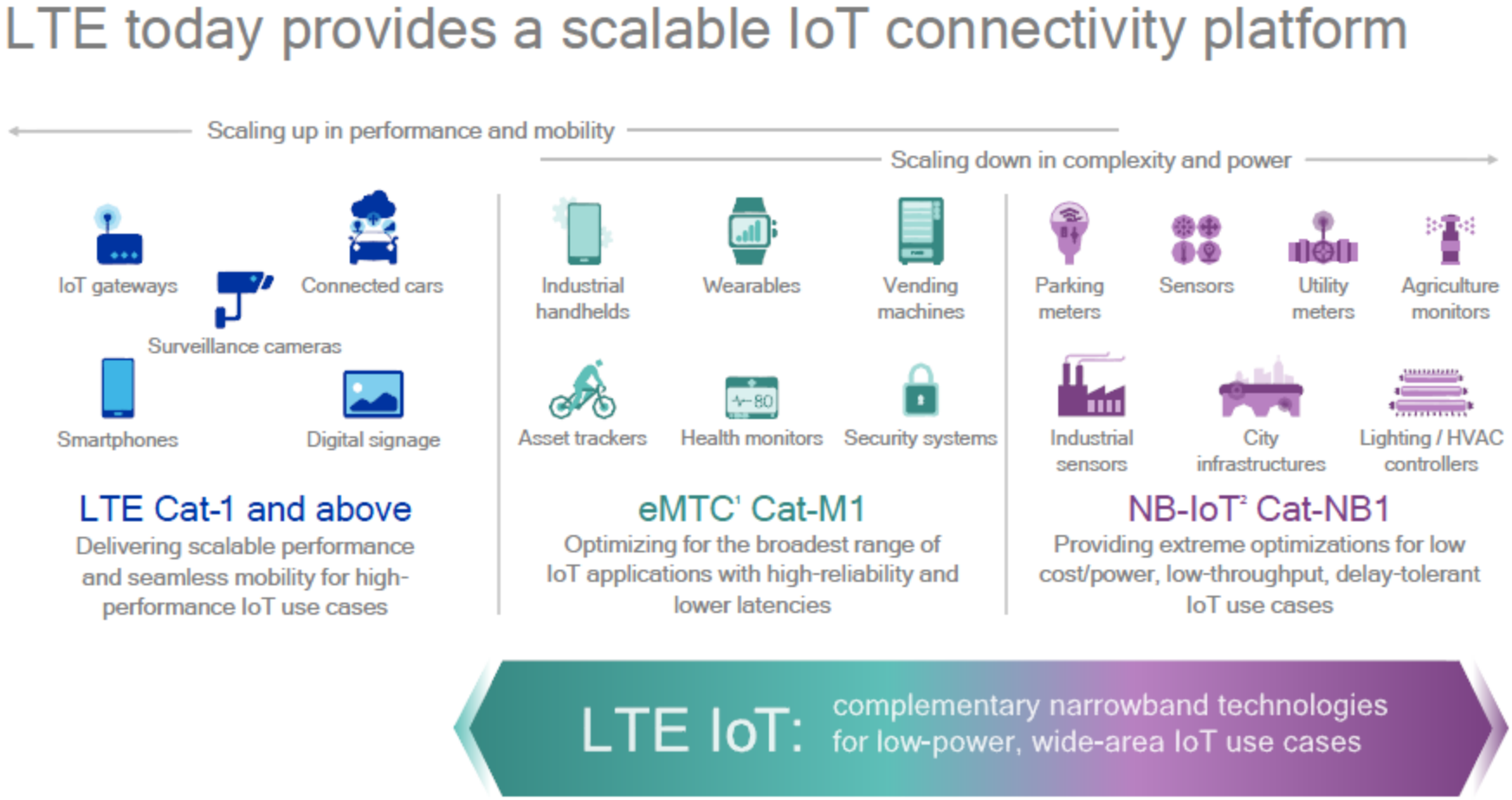
SMART TRACTORS

GPS controlled steering and optimised route planning reduces soil erosion, saving fuel costs by 10%.


Farm field
A
B
C
W
L
Sensor node
Solar cell panels
DC/DC
Battery
ZigBee transceiver
Microcontroller
S1
S2
S3
S4
humidity
Temperature
Rain gauge
Leaf wetness
Actuator
Microcontroller
ZigBee transceiver
Actuator node
ZigBee transceiver
Sink node
Cloud
Web application
WiFi/GPRS
-Data processing
-Data storage
(remote location)
WiFi/GPRS
Gateway
ZigBee transceiver
Microcontroller
Agricultural information
USB cable


Temperature and Humidity Sensors
Gas Sensors
Soil Sensor
Rain Sensor
Wind Speed Sensor
Data Acquisition
Collector
Wireless Gateway
PMC
Switch
Others
Remote Control
Controller
Wireless Gateway +GSM module
.....
Temperature and Humidity Sensors
Gas Sensors
Soil Sensor
Rain Sensor
Wind Speed Sensor
Data Acquisition
Collector
Wireless Gateway
PMC
Switch
Others
Remote Control
Controller
Wireless Gateway
WiFi

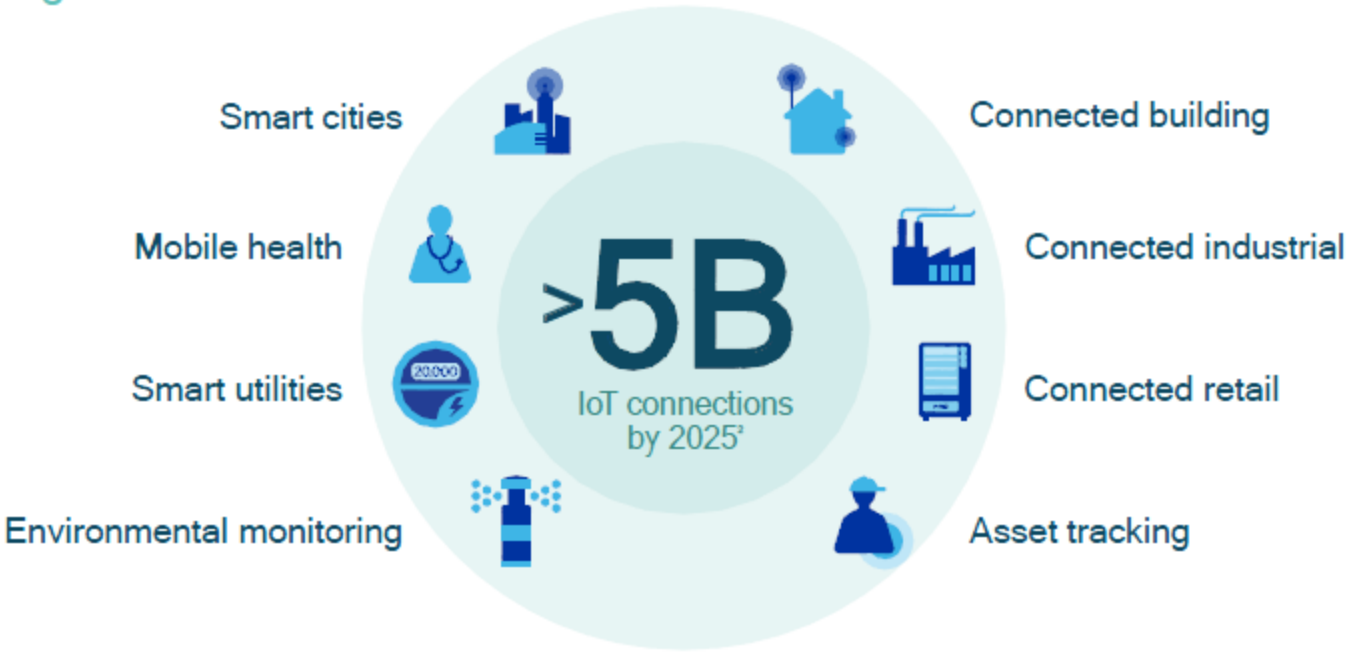
Σήμερα: LTE=Long Term Evolution: 2G+3G+4G



Ασύρματες Τεχνολογίες: Υποστηρίζουν «Έξυπνες ?»

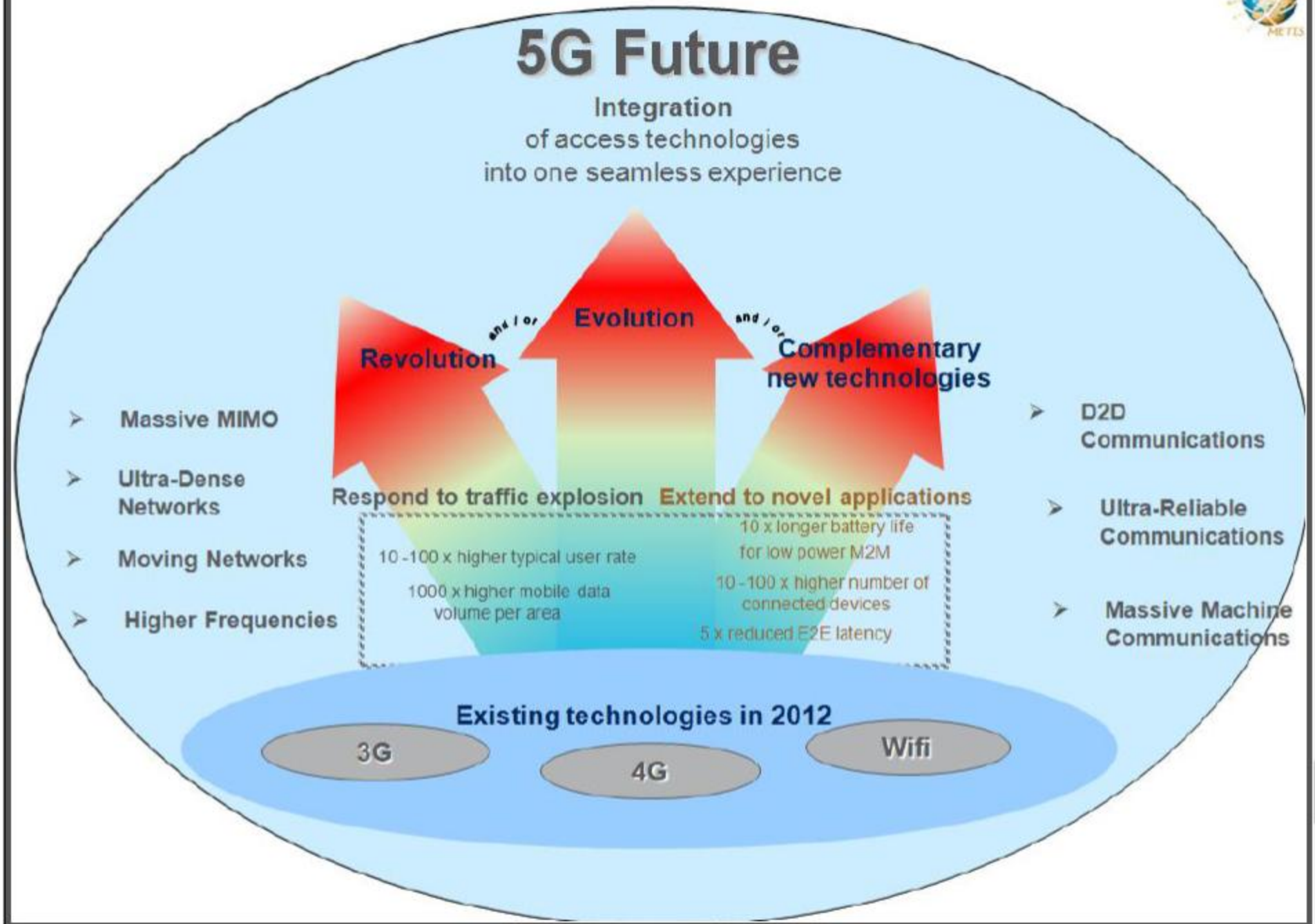
Cellular technologies enable a wide range of IoT services

Bringing significant value for LPWA[1] use cases over non-3GPP solutions



Always-available, ubiquitous connectivity | Mature, interoperable global ecosystem | Scalable performance | Seamless coexistence of different services | High reliability and proven security

1. Low-power, wide-area; 2. Including cellular and LPWA M2M connections, Machina Research, May, 2017


5G Future
Integration
of access technologies
into one seamless experience
Revolution
and / or
Evolution
and / or
Complementary
new technologies
Massive MIMO
Ultra-Dense Networks
Moving Networks
Higher Frequencies
D2D Communications
Ultra-Reliable Communications
Massive Machine Communications
Respond to traffic explosion
Extend to novel applications
10 -100 x higher typical user rate
1000 x higher mobile data volume per area
10 x longer battery life for low power M2M
10 -100 x higher number of connected devices
5 x reduced E2E latency
Existing technologies in 2012
3G
4G
Wifi

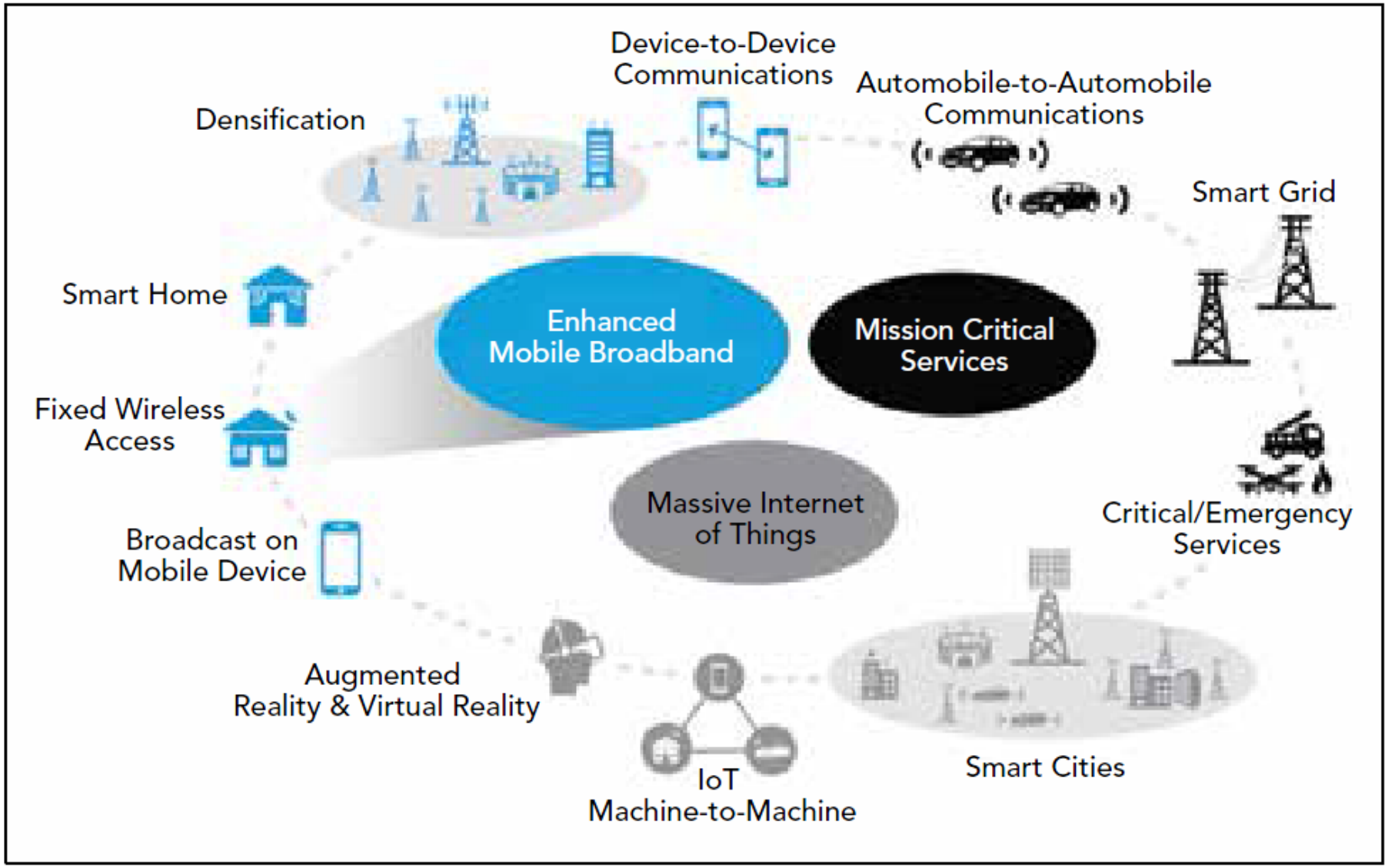
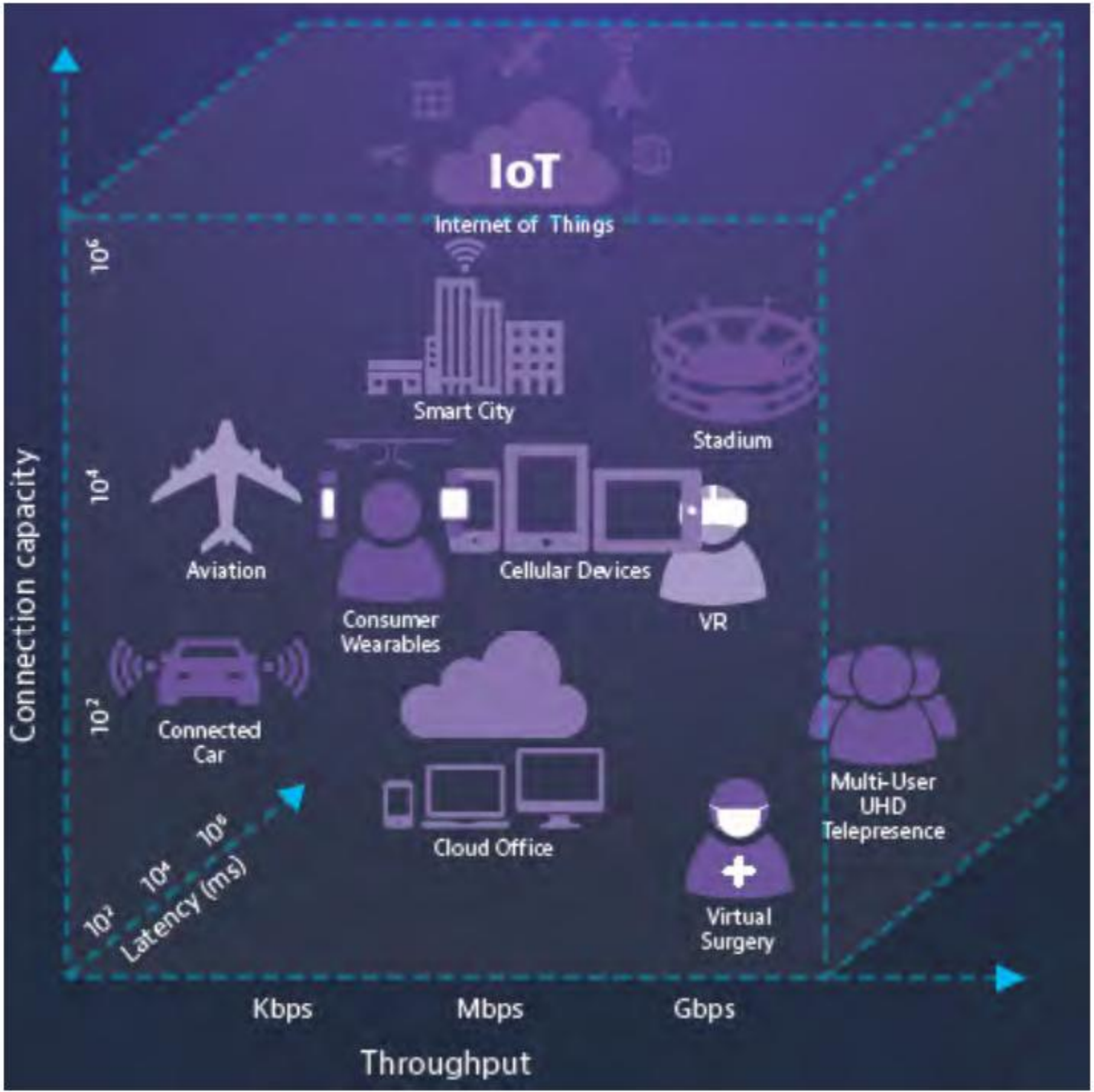


Fig. 1 **5G use cases.**

Government
Office for Science

The Internet of Things: making the most of the Second Digital Revolution

Figure 2:
Internet of Things ecosystem


IoT
Internet of Things
Smart City
Stadium
Aviation
Cellular Devices
Consumer Wearables
VR
Connected Car
Cloud Office
Multi-User UHD Telepresence
Virtual Surgery
Connection capacity
10^6
10^4
10^2
10^2 10^4 10^6
Latency (ms)
Kbps
Mbps
Gbps
Throughput

5G in Perspective

A Pragmatic Guide to What's Next

Figure 1. The 5G Ecosystem: Enabling a Mobilized Economy

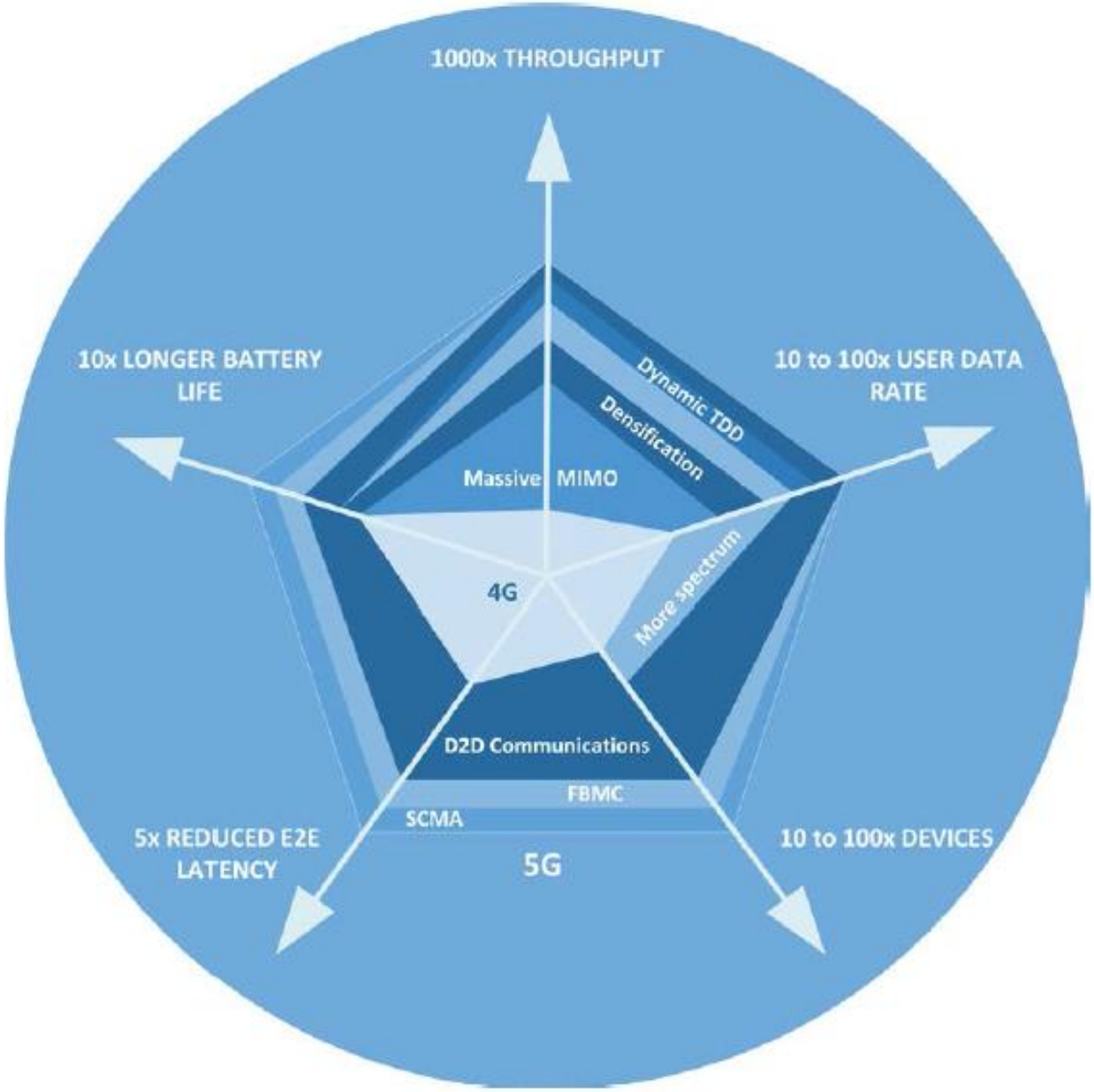
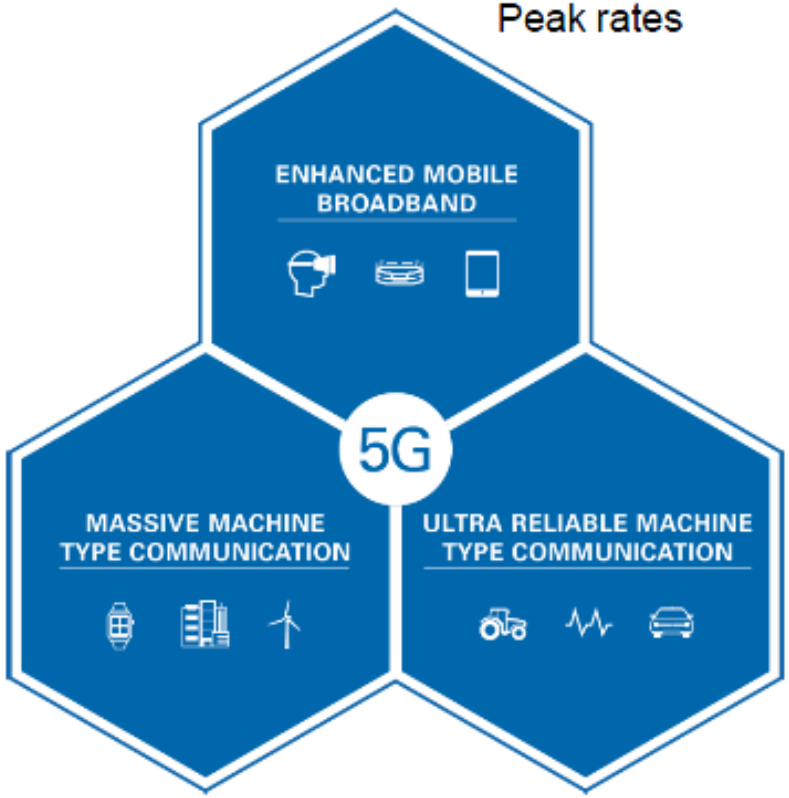


Figure 8.1: Main enablers to fulfil METIS goals represented by the pentagon. 4G refers to LTE Release 8 system with 20MHz bandwidth operating at 2.6 GHz, using 4x2 MIMO setup and 3 sectors per macro site.

ITU Vision for IMT-2020 and Beyond

> 10 Gbps
Peak rates



> 1M / km²
Connections

< 1 ms
Latency

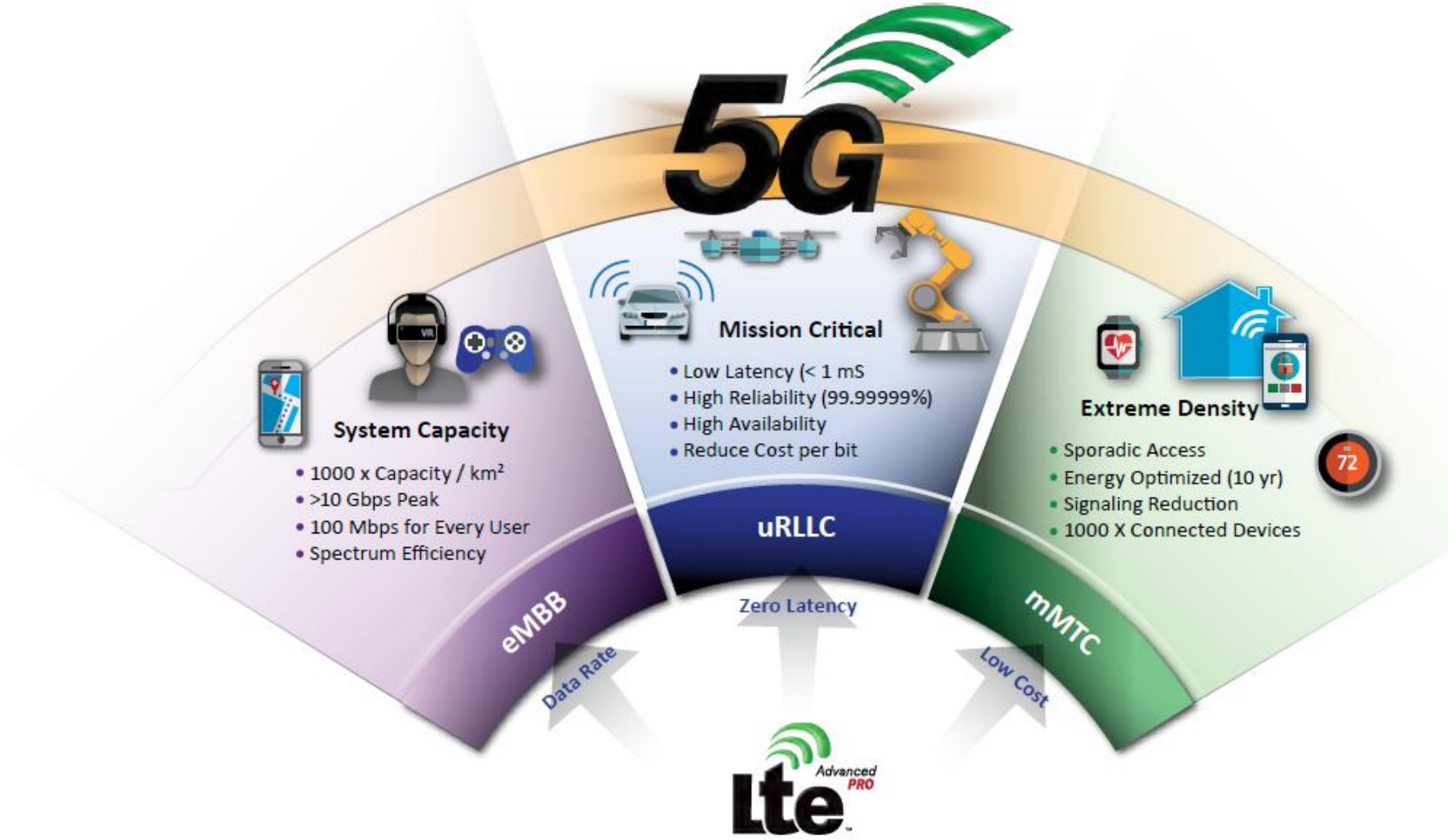
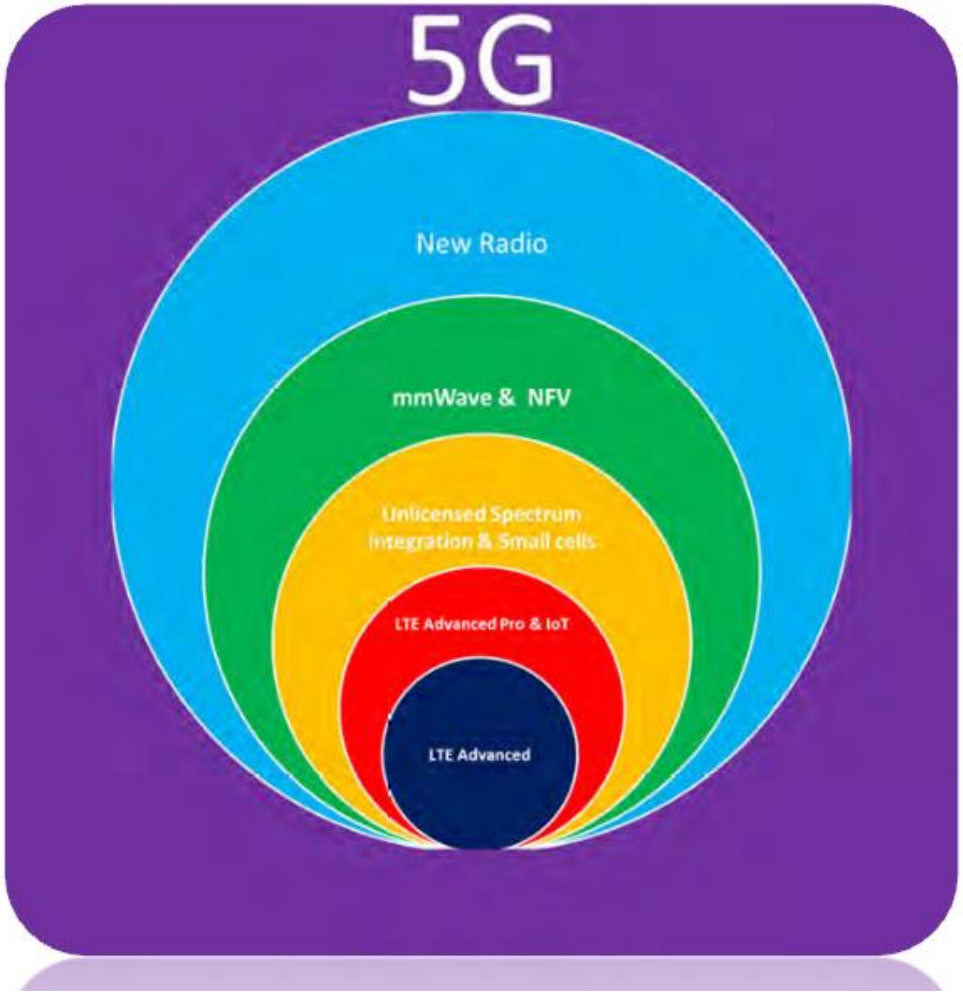


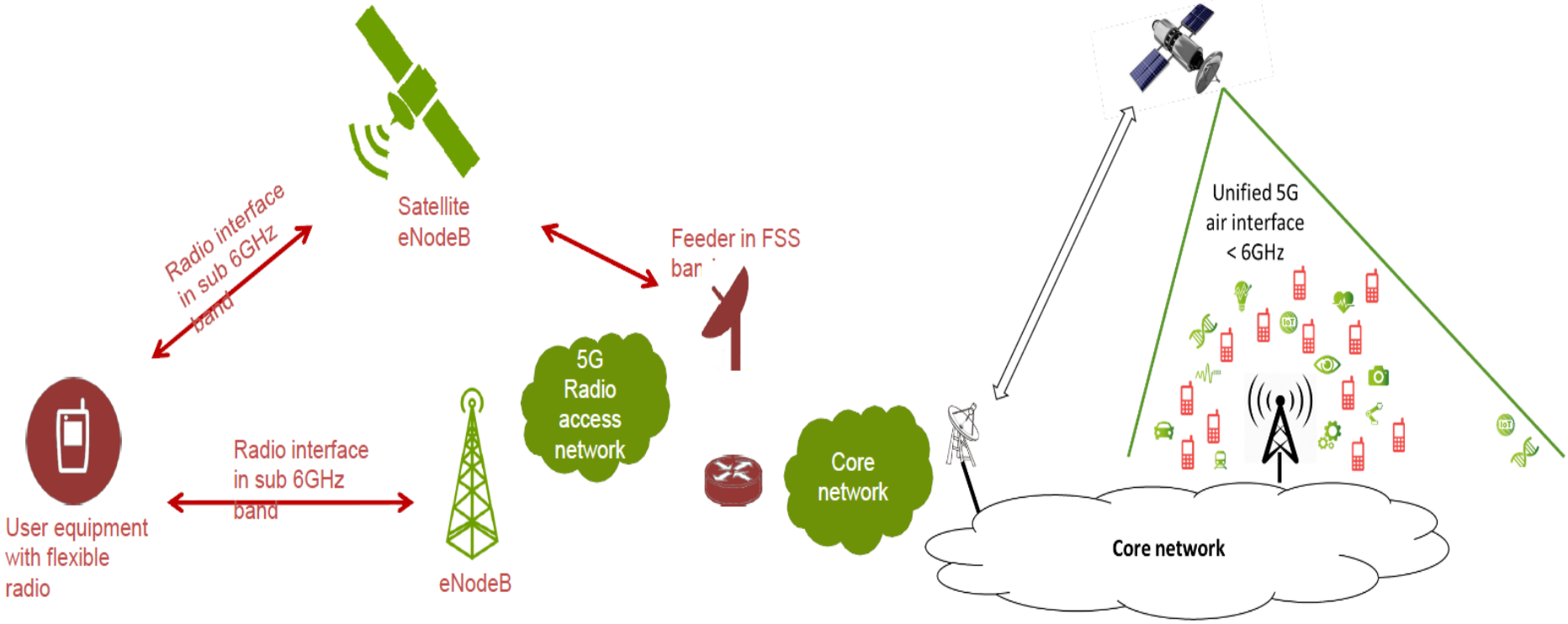
Figure 10. 5G Vision and Targets

How do we achieve that?

- Cell Densification
- mmWave, Massive MIMO and wider bandwidth
- Massive MIMO and Beam Forming



5G CHAMPION Developed Technologies: Satellite/"Terrestrial" cellular network interworking

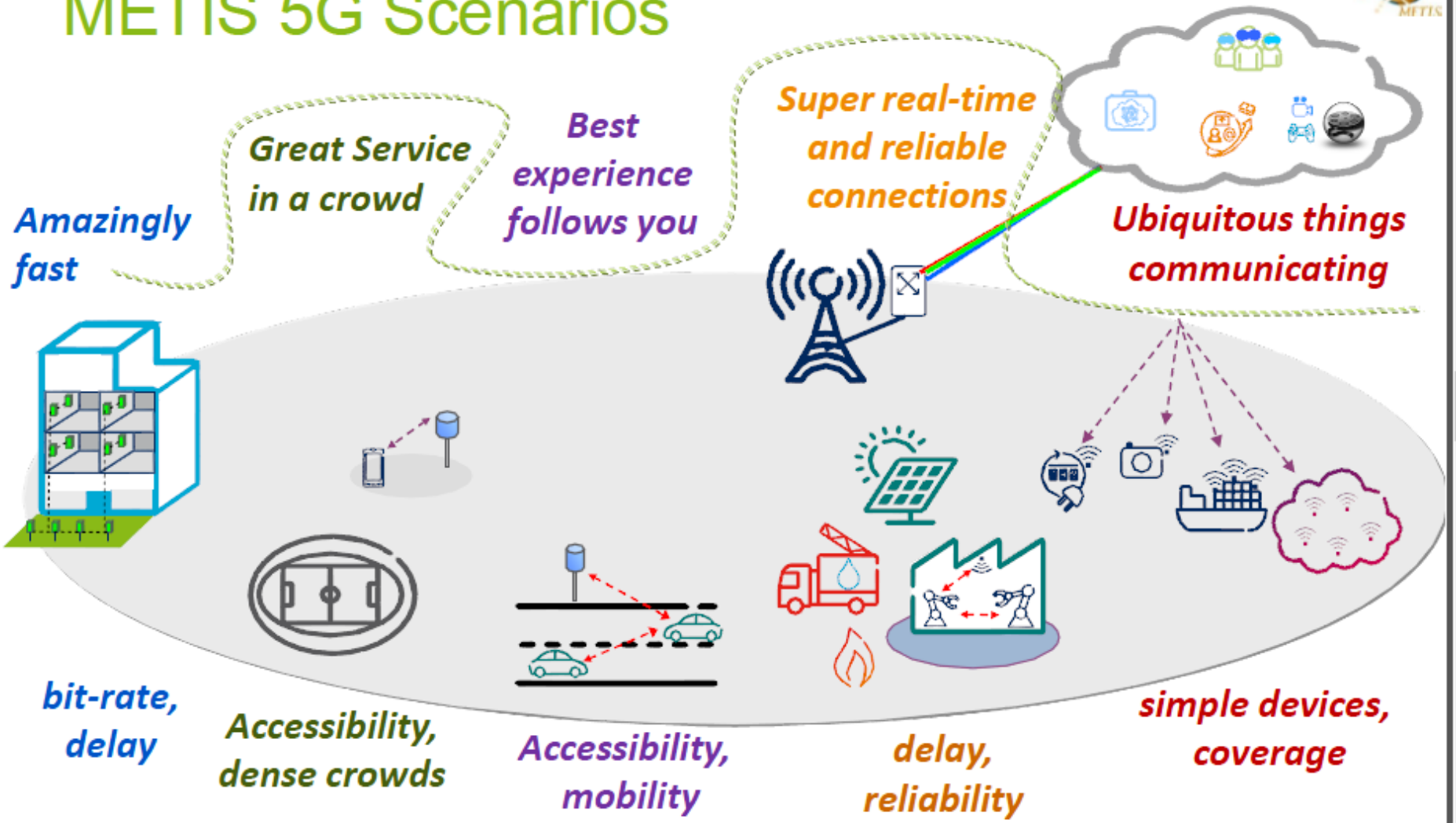


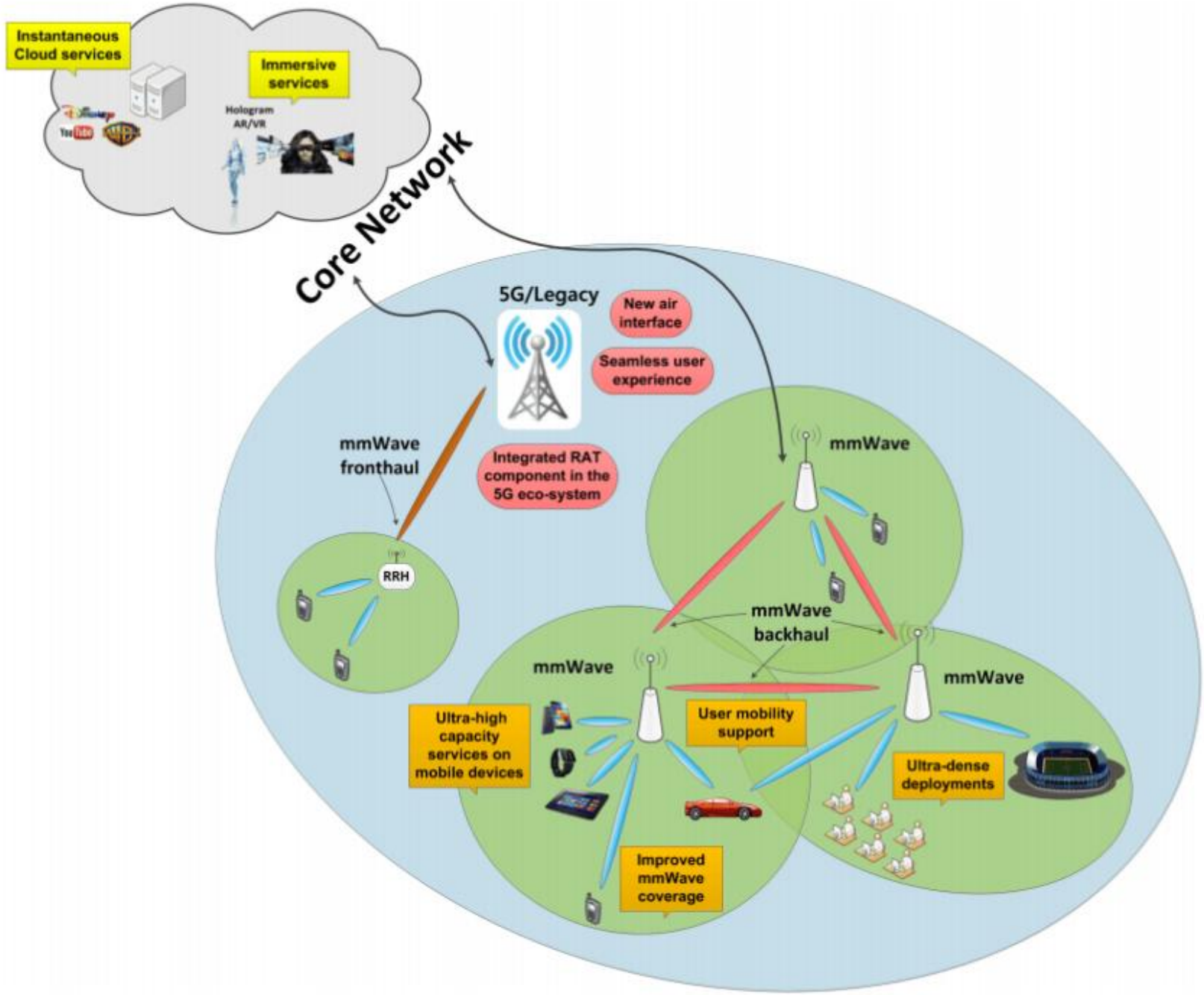
Support low bandwidth direct service to 5G devices with satellite channel bandwidth, MAC/PHY protocols settings without any hardware modification of the UE

- Vertical Handover
- Below 6 GHz (Low Power IoT)
- Evalutaion of 5G Waveform performance

Satellite Connectivity for MTC (Machine Type Communications)

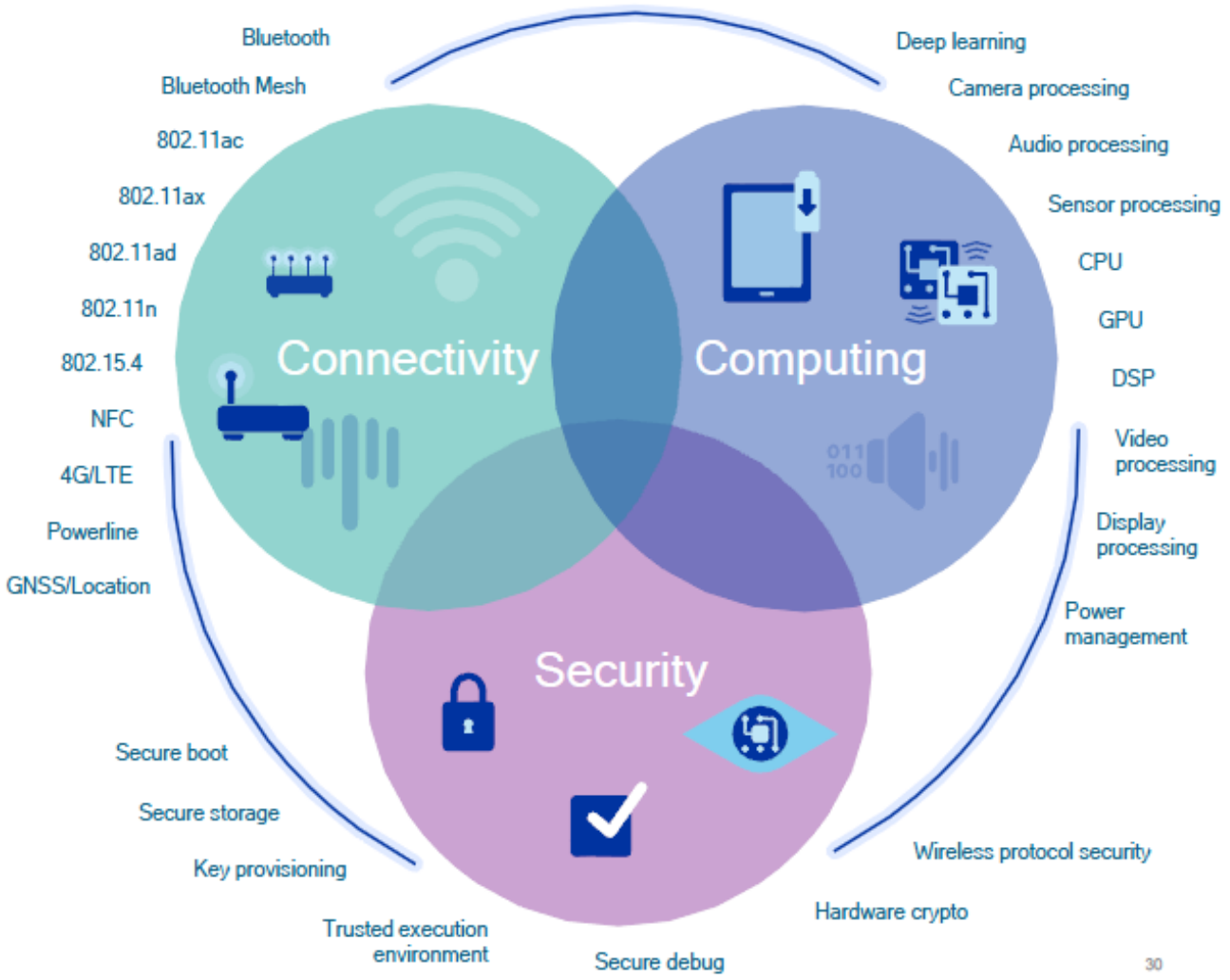
METIS 5G Scenarios




Instantaneous Cloud services
Immersive services
Hologram AR/VR
Core Network
5G/Legacy
New air interface
Seamless user experience
mmWave fronthaul
Integrated RAT component in the 5G eco-system
RRH
mmWave
mmWave backhaul
mmWave
mmWave
Ultra-high capacity services on mobile devices
User mobility support
Ultra-dense deployments
Improved mmWave coverage

Mobile technology drives the IoT

Building on our leadership in mobile inventions



5G Challenges

Avalanche of
Traffic Volume

Further expansion of mobile broadband

Additional traffic due to communicating machines

"1000x in ten years"

Massive growth in
Connected Devices
"Communicating machines"

"50 billion devices in 2020"

Large diversity of
Use cases & Requirements

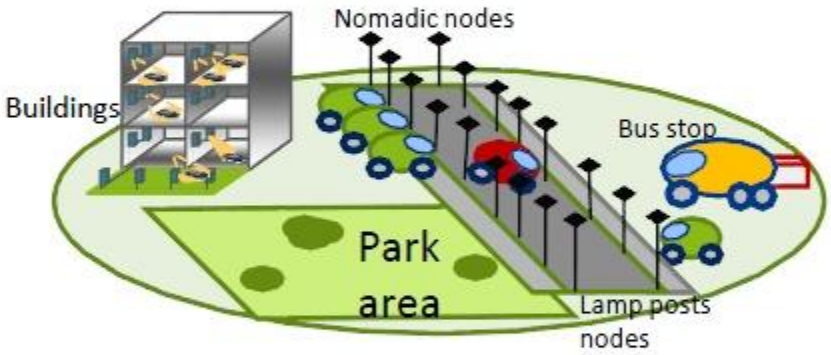
Device-to-Device Communications

Car-to-Car Comm.

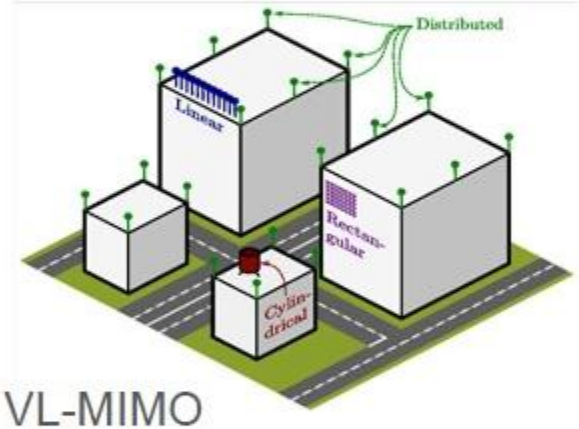
New requirements and characteristics due to communicating machines

Some 5G Technology Components

New spectrum bands and access methods

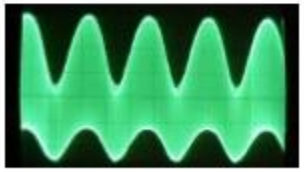


Dense and moving networks
Multi-hop wireless backhaul



VL-MIMO
Massive multi-antenna systems

Context-aware interference and mobility management



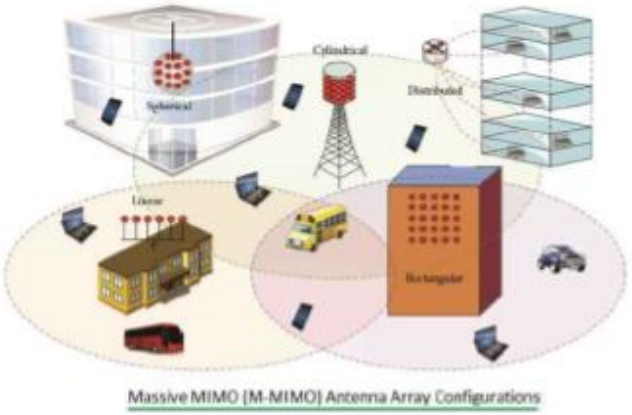
Air interfaces for new applications and reduced signaling

Device-to-device

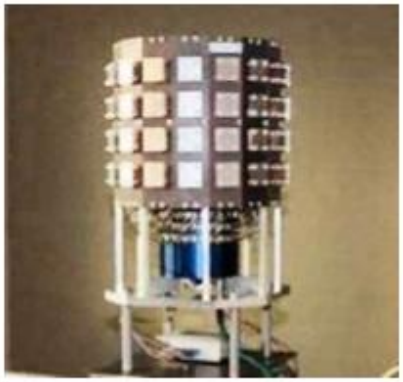
Purpose:

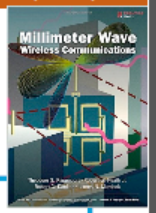
- Flexibility of phased array antenna makes it attractive for multi-beam applications
- Phased array was mostly used in military and space domain
- Cost reduction and new needs in telecommunication domain make phased-array viable
- Massive MIMO will be a major feature of 5G technology

- **One key parameter of phased array antenna is array element calibration**
- **Array topology may vary to better match the environment**

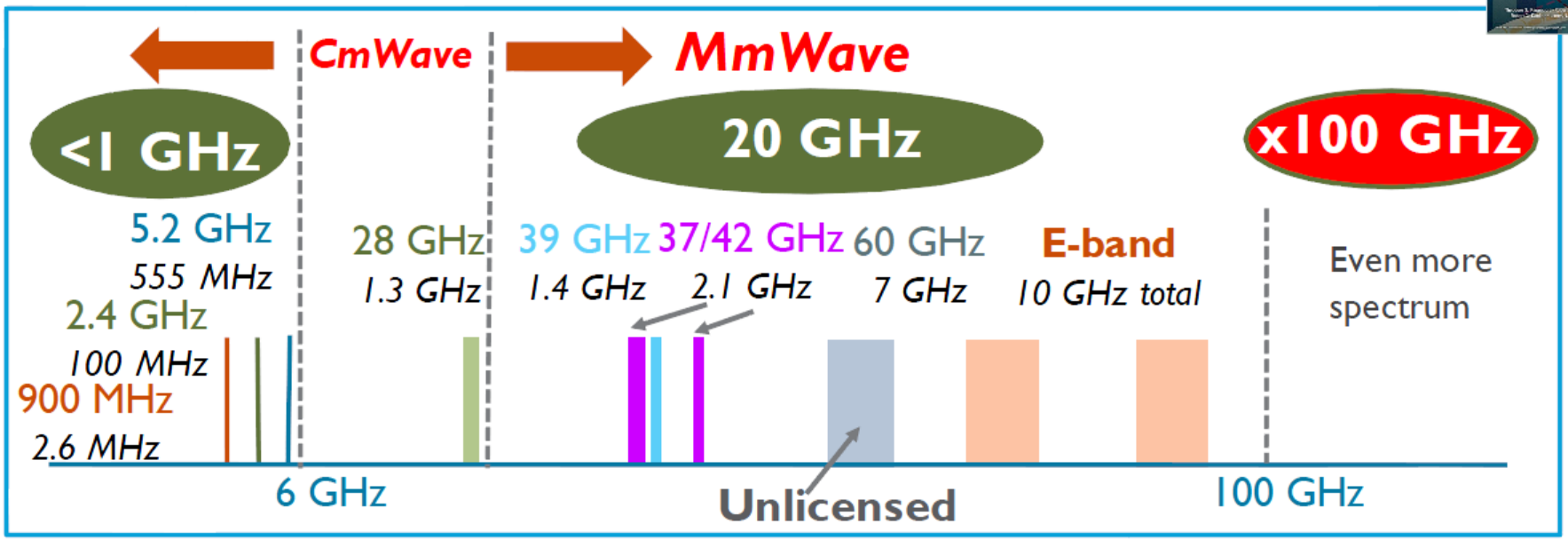


Massive MIMO (M-MIMO) Antenna Array Configurations





Millimeter wave spectrum for 5G



More spectrum, in bands not previously used for cellular

* T. Rappaport et al., "Millimeter wave mobile communications for 5G cellular: It will work!" IEEE Access, 2013.
** W. Roh et al., "Millimeter-wave beamforming as an enabling technology for 5G cellular communications: theoretical feasibility and prototype results,", IEEE *Commun. Mag.*,, 2014
*** A. Osseiran et al.,"Scenarios for 5G mobile and wireless communications: the vision of the METIS project," iIEEE Commun. Mag., May 2014

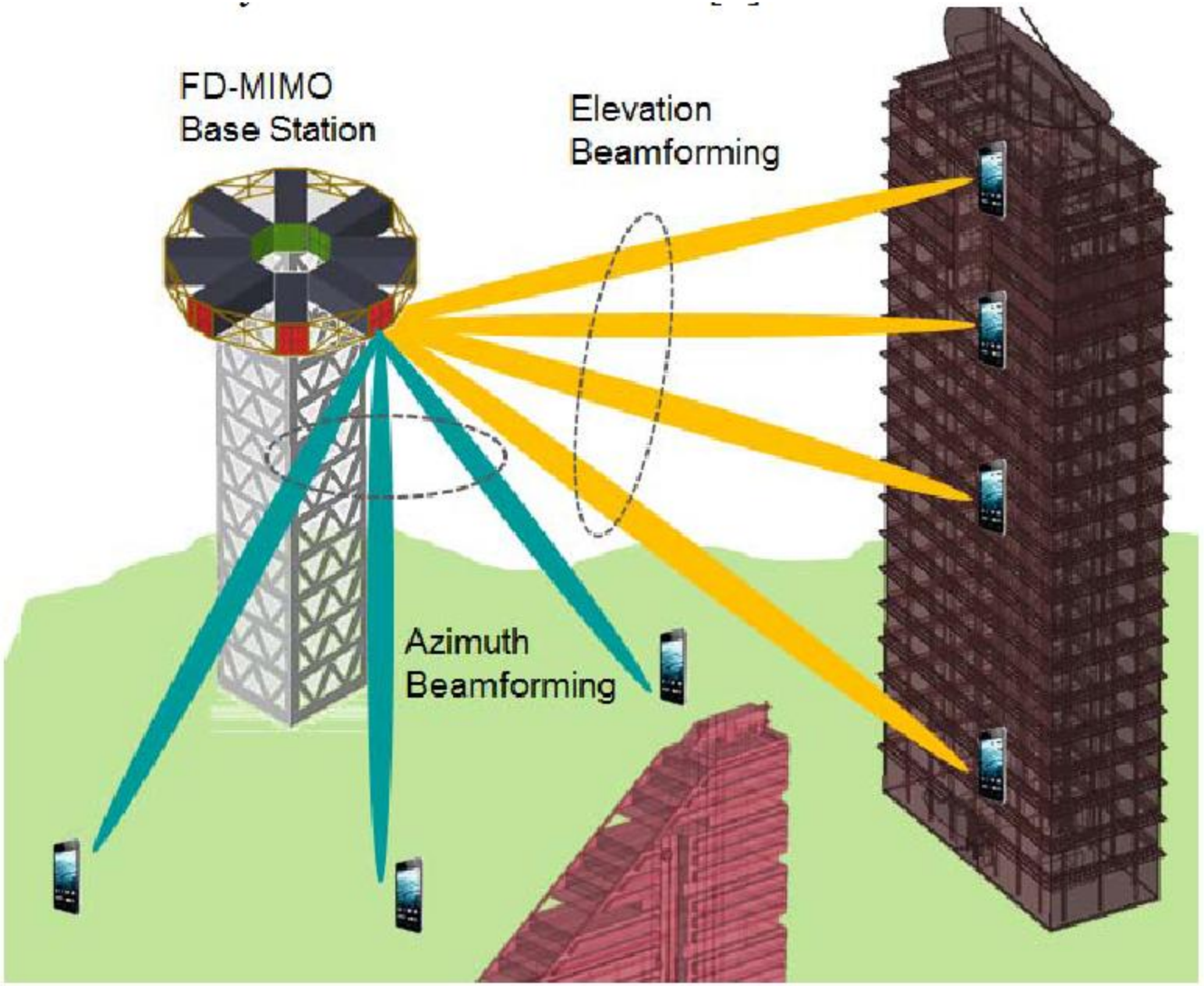
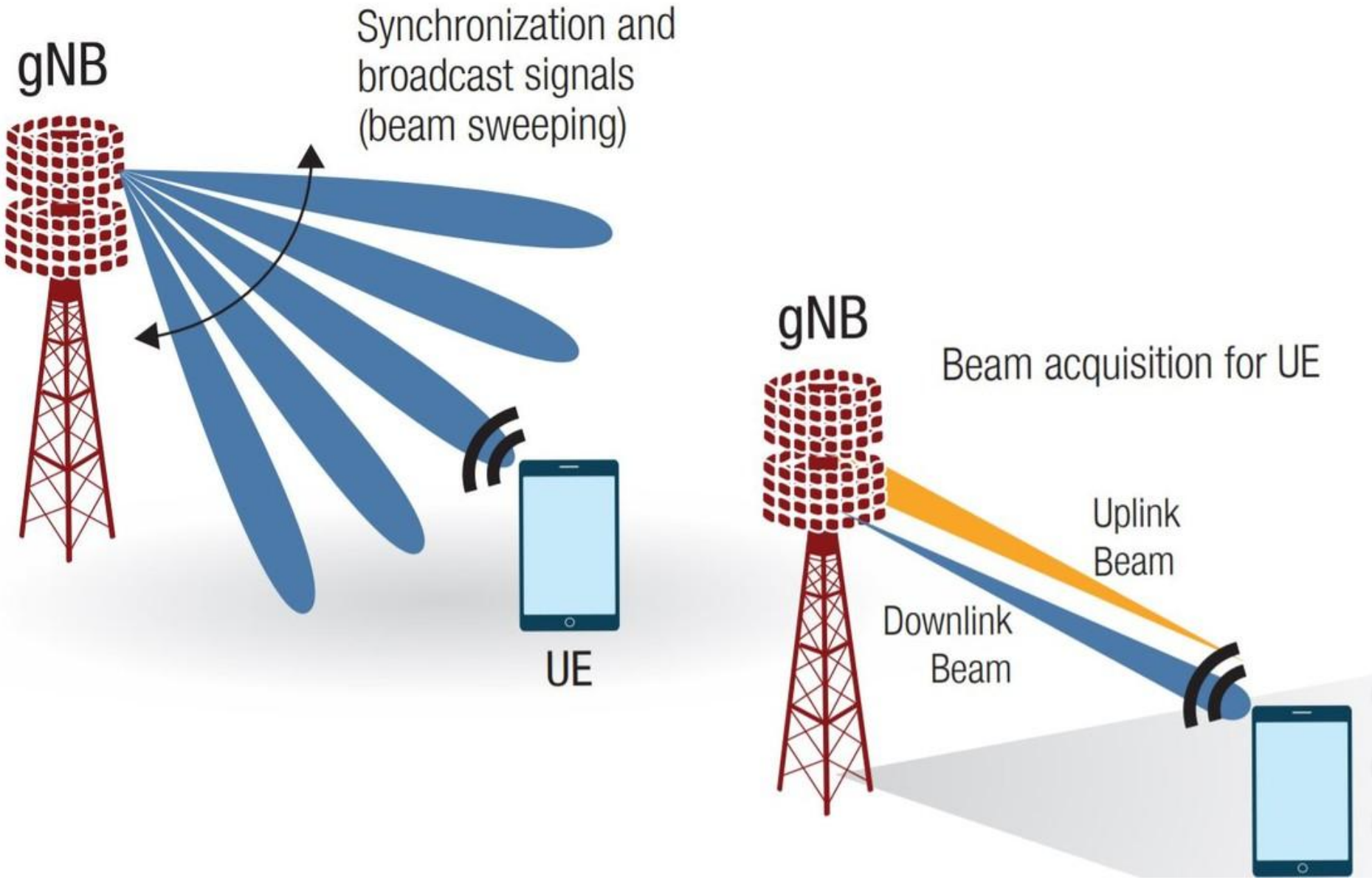
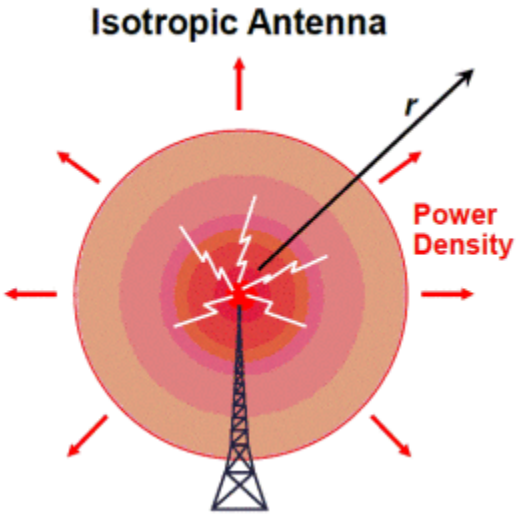
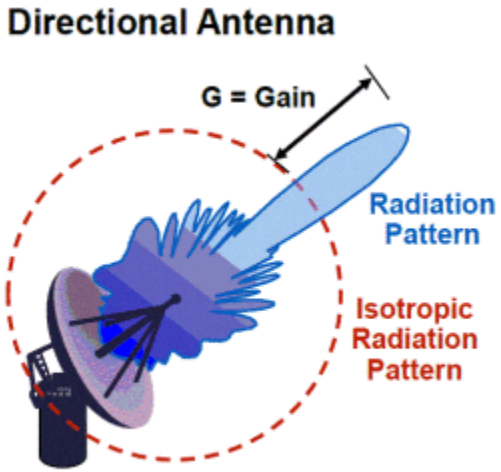


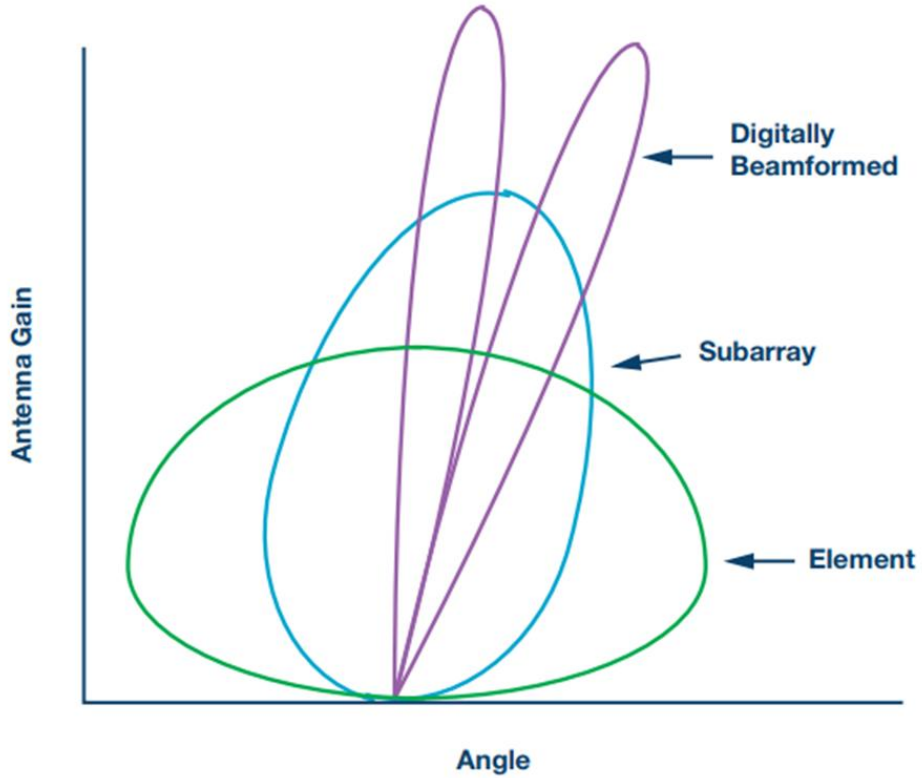
Fig. 1. Application example of FD-MIMO system in 5G network

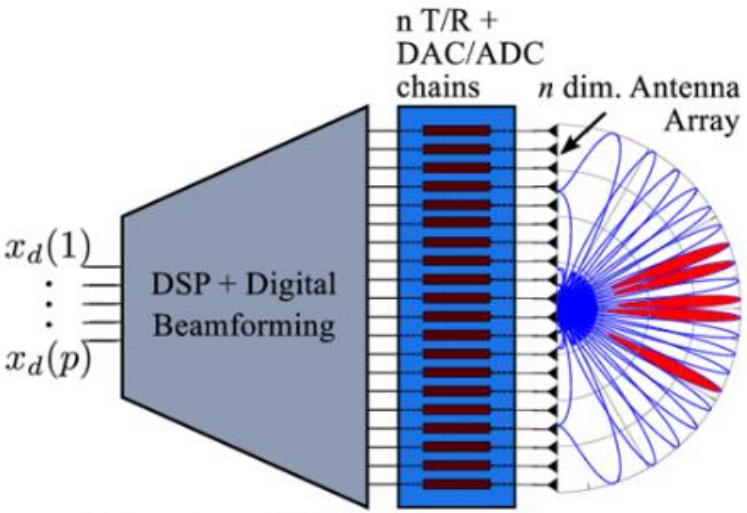

gNB
Synchronization and
broadcast signals
(beam sweeping)
UE
gNB
Beam acquisition for UE
Uplink
Beam
Downlink
Beam



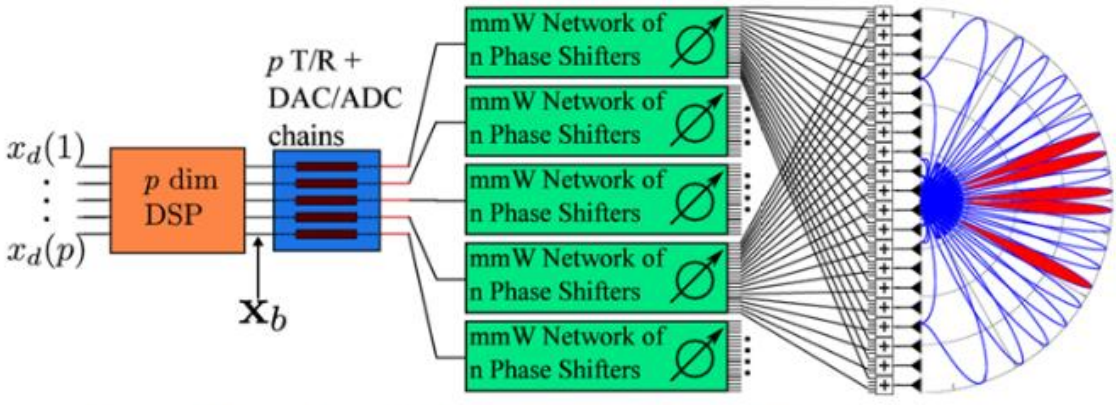


Κεραίες:
Κατευθυντικές – Ισότροπες.

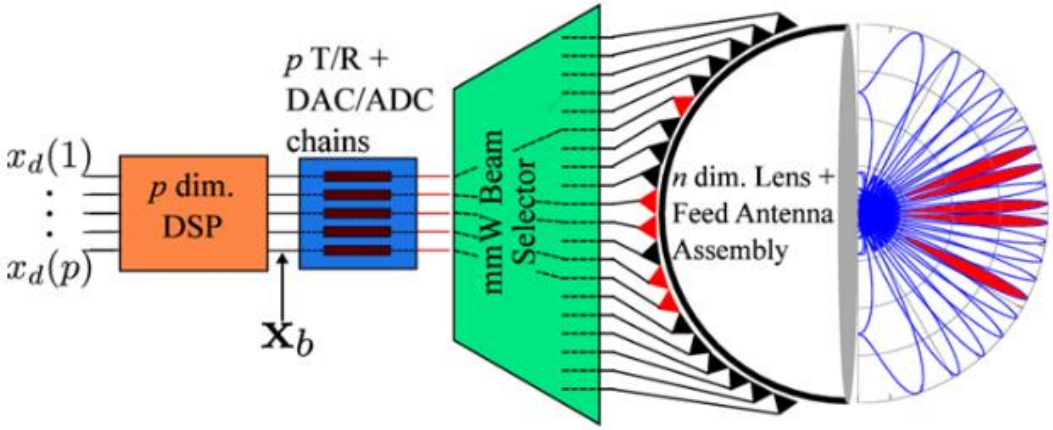




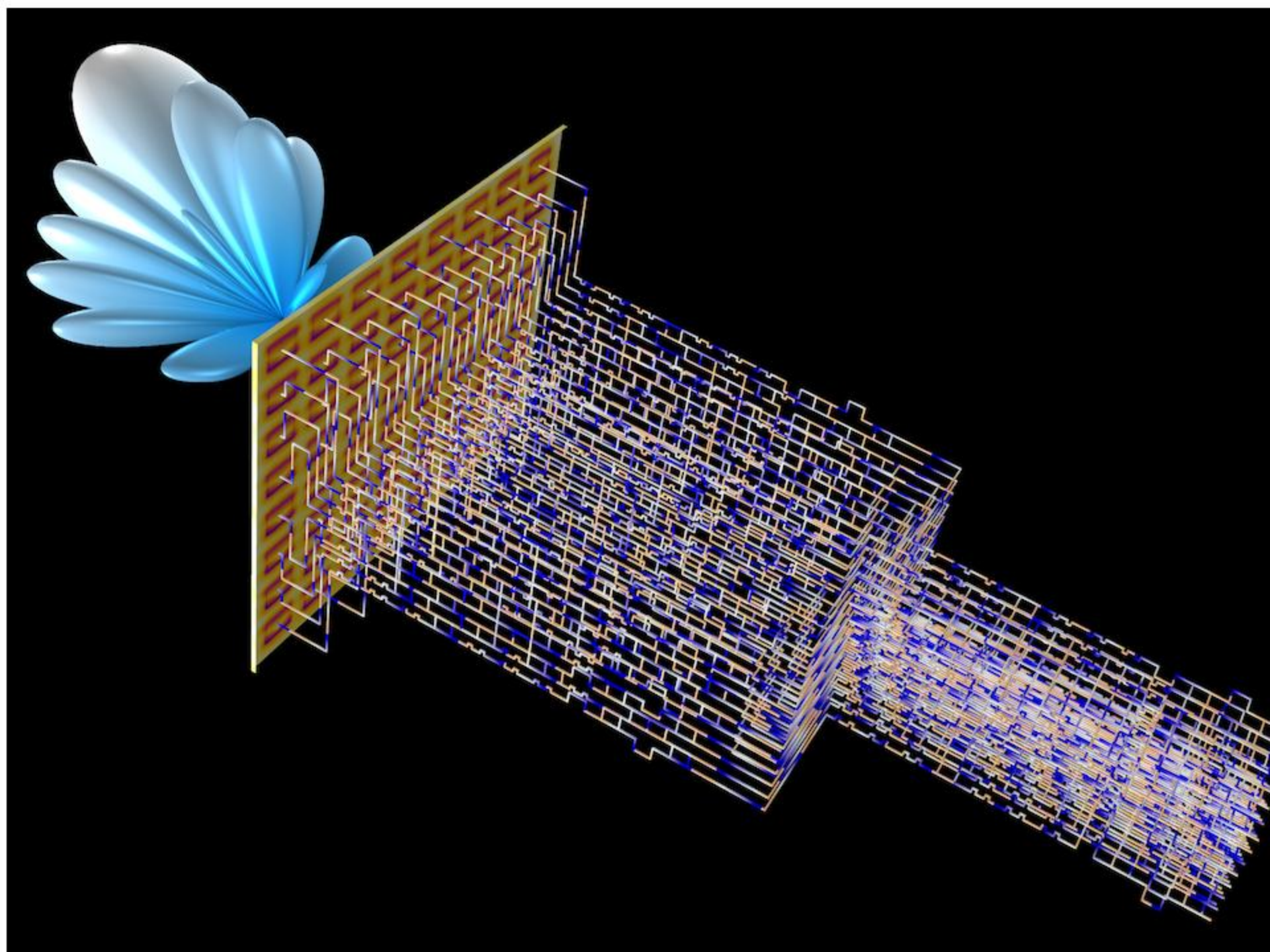
Conventional MIMO: Digital Beamforming



Phased Array-Based MIMO: Hybrid Analog-Digital Beamforming



Lens Array-Based CAP-MIMO: Hybrid Analog-Digital Beamforming



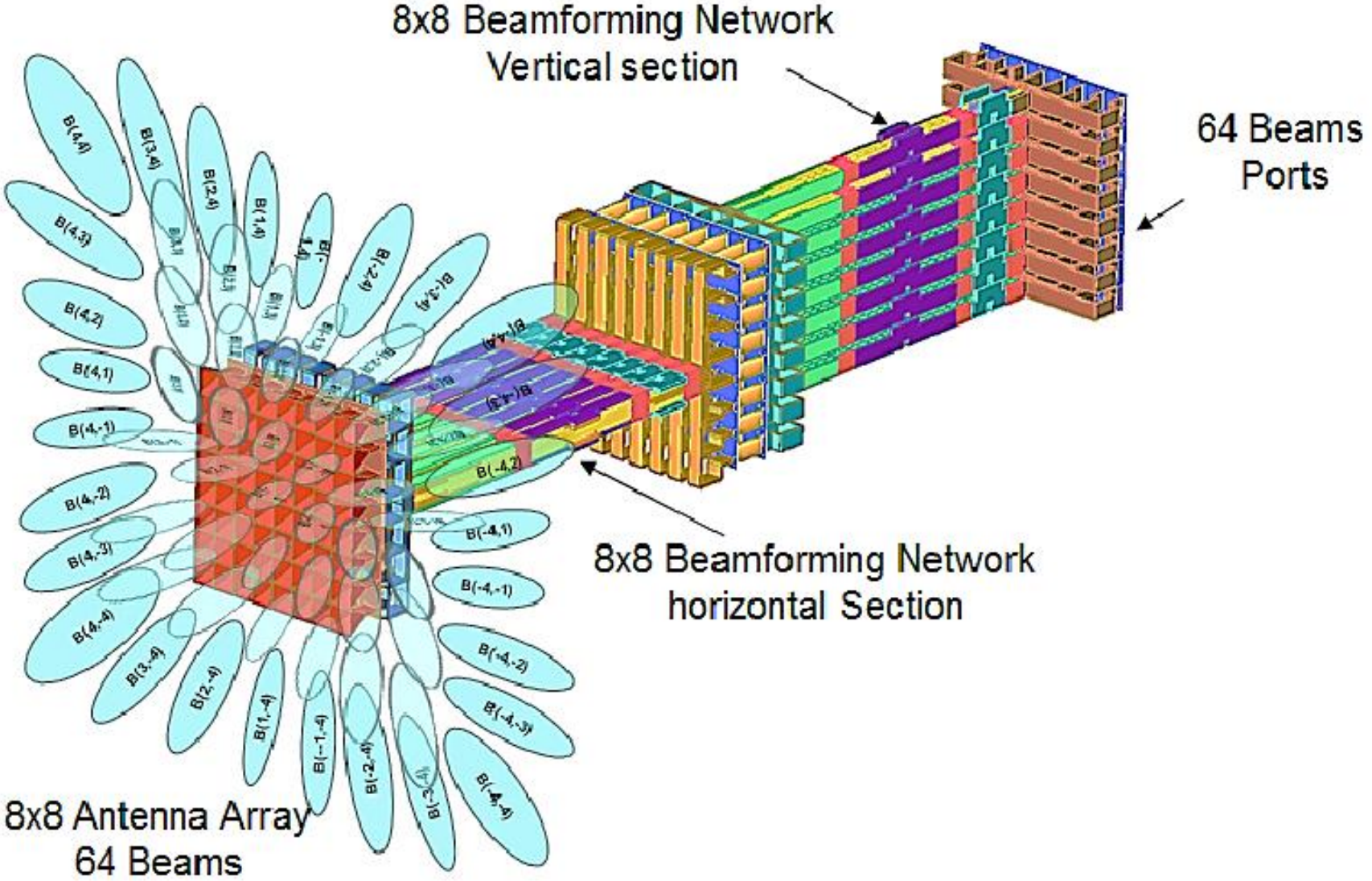
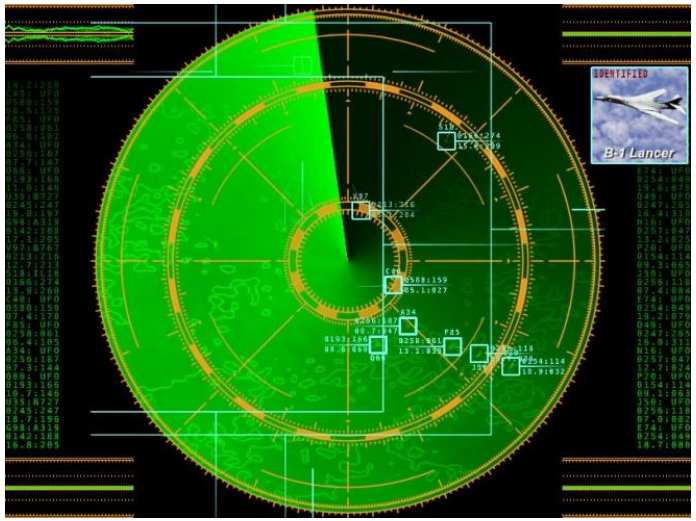


Fig. 2. The proposed 3-D waveguide beamforming phased array system

Radar

- Έλεγχος Εναέριας Κυκλοφορίας & Ναυσιπλοΐας
- Συστήματα Αυτόματης Προσγείωσης Αεροσκαφών (**ILS – MLS**).
- Ραντάρ Ανίχνευσης Υπεδάφους
- Ραντάρ Ηλεκτρονικής Σάρωσης της Δέσμης – Συστοιχίες Φάσης



5G Key Enabling Technologies (1/2)

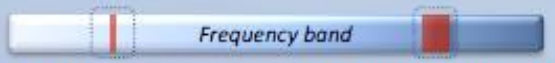
SAMSUNG

Disruptive Technologies for Significant Performance Enhancement

- Peak Data Rate
- Cell Edge Data Rate
- Cell Spectral Efficiency
- Mobility
- Energy & Cost Efficiency
- Simultaneous Connection
- Latency

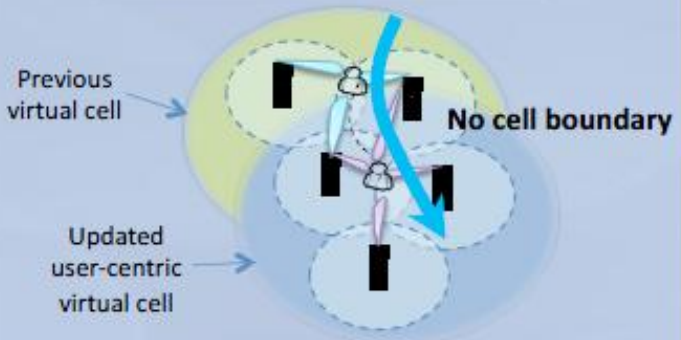
mmWave System Tech.

Peak Rate 1 Gbps → Peak Rate 50 Gbps

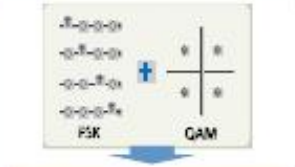


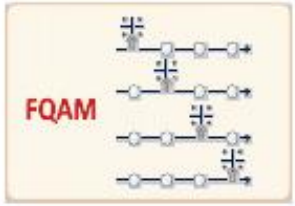
4G frequencies — New higher frequencies

Adv. Small Cell

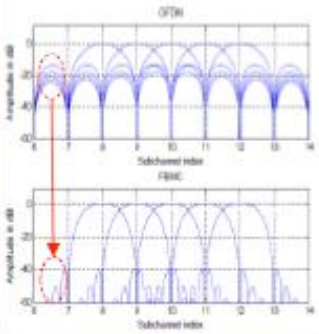


Adv. Coding & Modulation

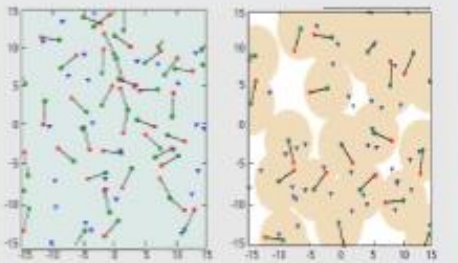




Filter-Bank Multi-Carrier



Device-to-Device (D2D)



Enhancing areal spectral efficiency

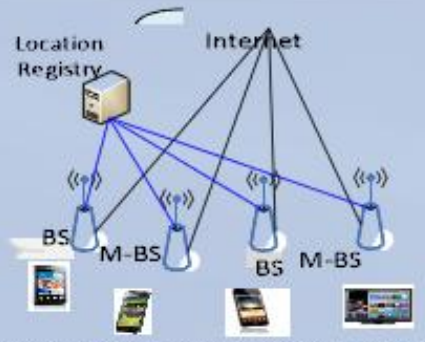
5G Key Enabling Technologies (2/2)

SAMSUNG

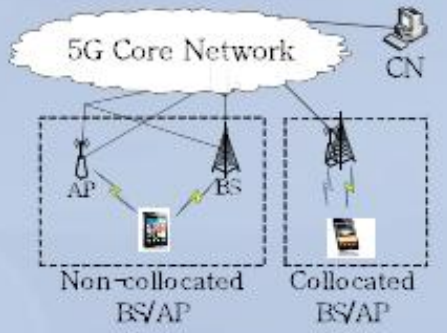
- Disruptive Technologies for Significant Performance Enhancement

Peak Data Rate
Cell Edge Data Rate
Cell Spectral Efficiency
Mobility
Energy & Cost Efficiency
Simultaneous Connection
Latency

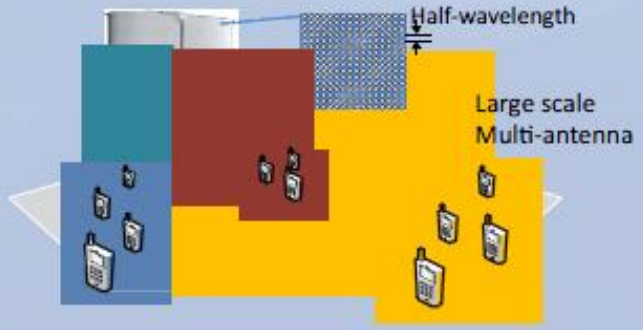
Enhanced Flat NW



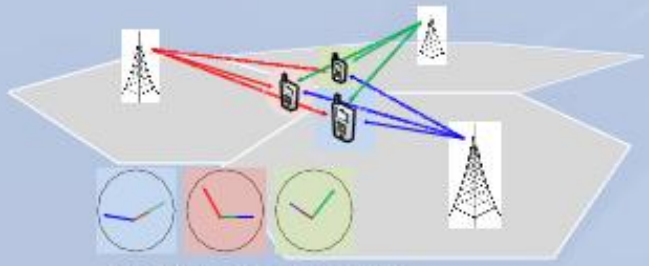
IWK/Integration w/ Wi-Fi



Adv. MIMO/BF



Interference Management



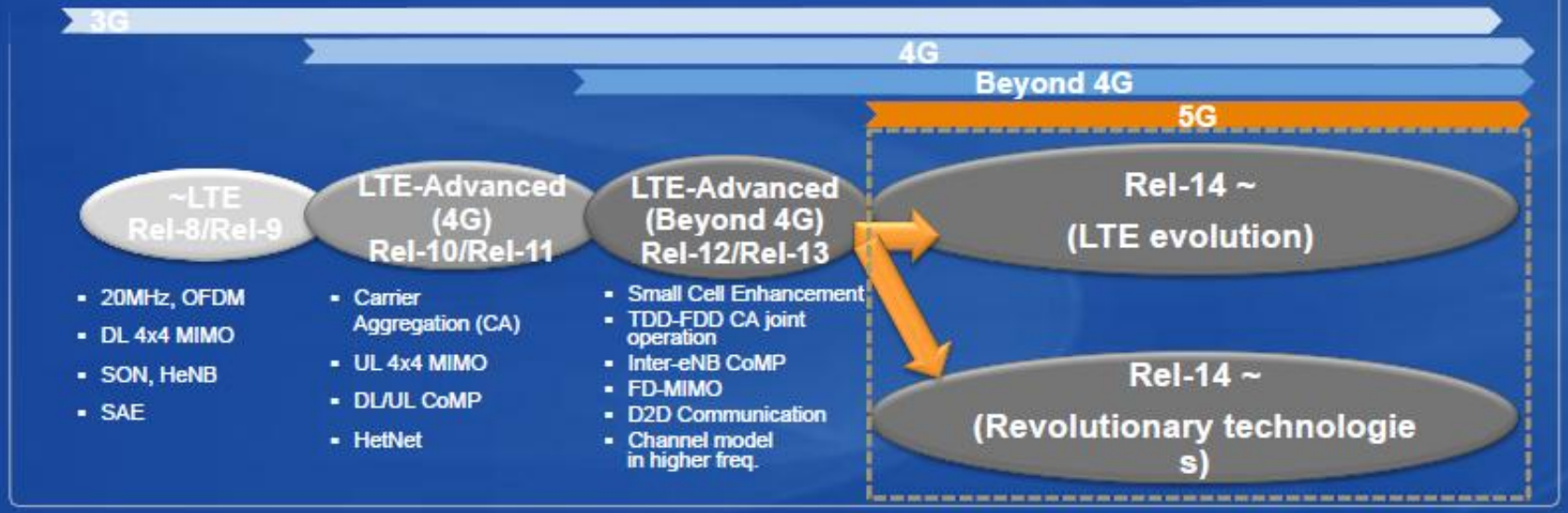
Interference alignment

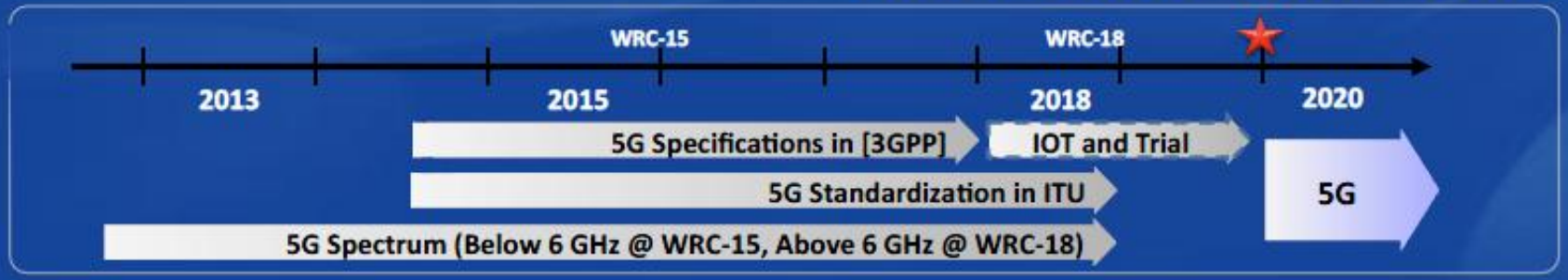
5G Timelines

SAMSUNG

5G Commercialization around 2020

— First release of 5G standard should be available by EOY 2017 or 1H 2018





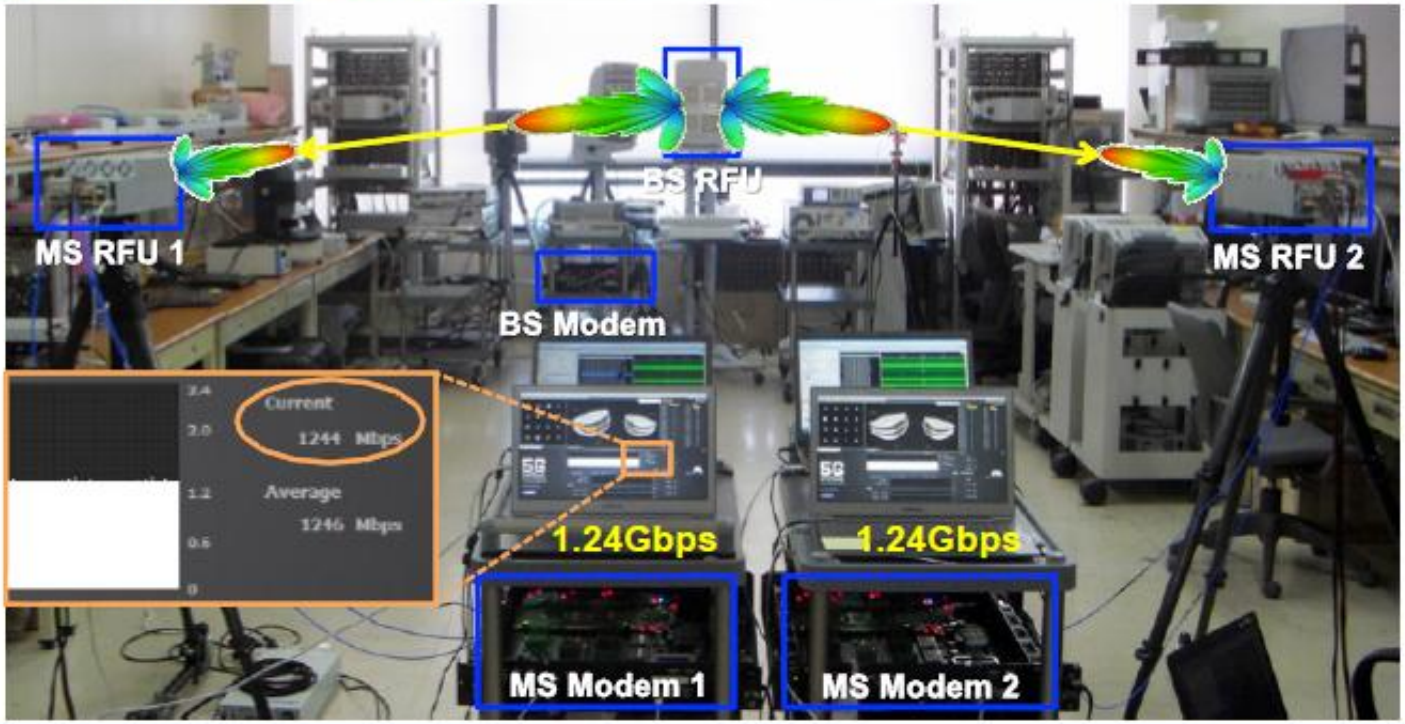
Test Results – Multi-User Support

SAMSUNG

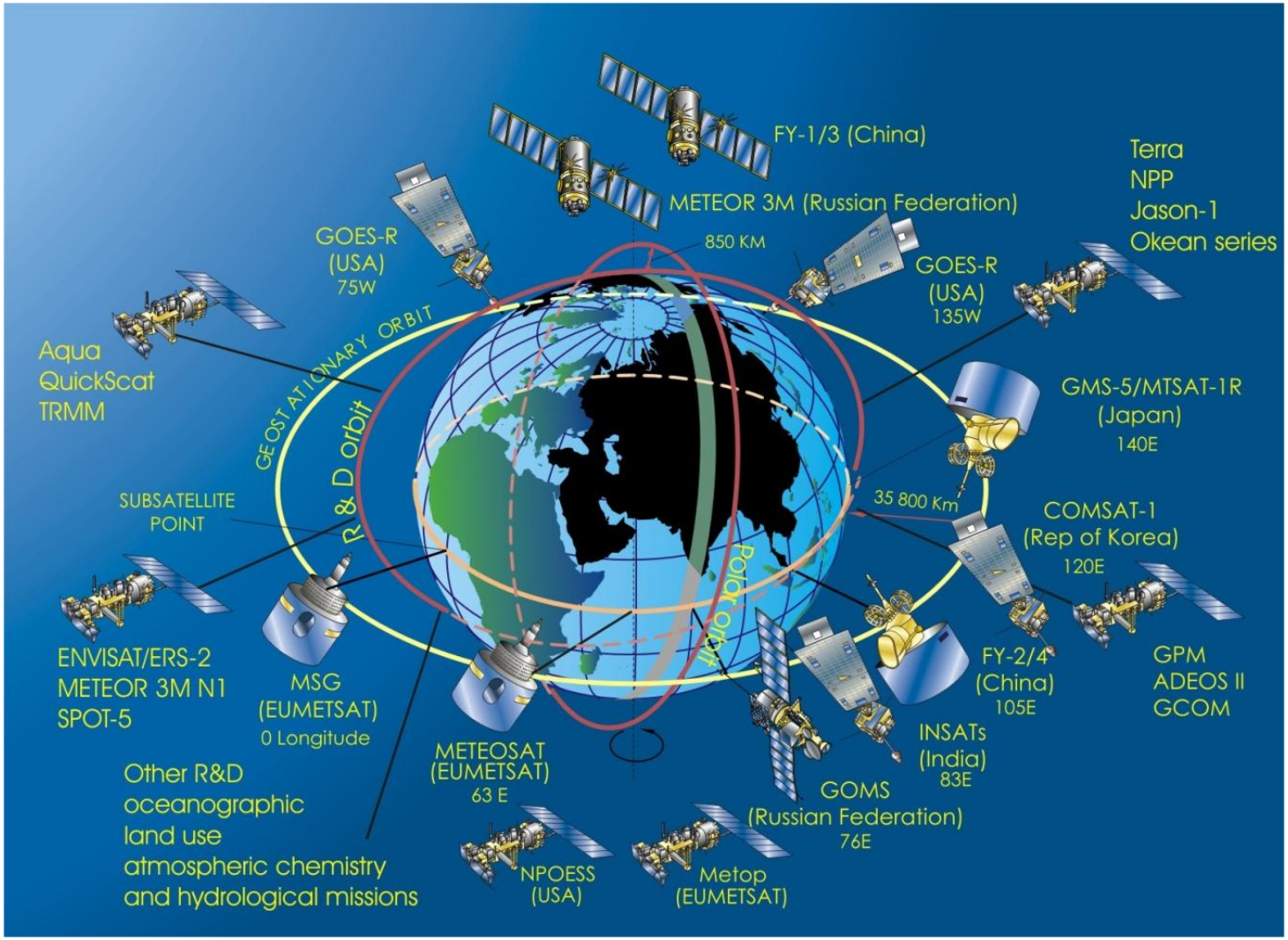
- **Multi-User Communication Tests**
  - 2.48 Gbps aggregate throughput in MU-MIMO mode

PARAMETER	VALUE
Carrier Frequency	27.925 GHz
Bandwidth	800 MHz
Max. Tx Power	37 dBm
Beam-width (Half Power)	10°
Multiple Antenna	2x2 MIMO

MU-MIMO Configuration



Δορυφορικές Επικοινωνίες

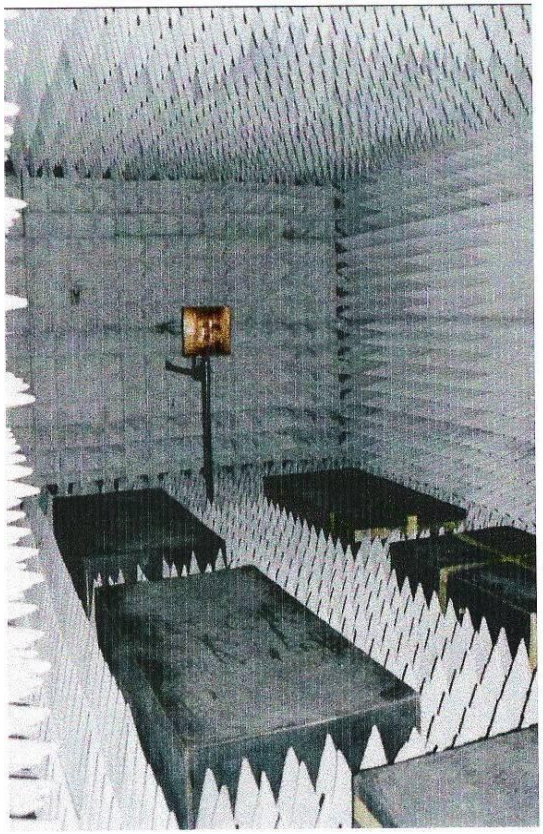


Παρουσίαση του Τομέα Τηλεπικοινωνιών και Διαστημικής

Εργαστήριο Μικροκυμάτων
Ερευνητικός Εξοπλισμός

Αναλυτής Κυκλωμάτων

Αναλυτής Φάσματος



Ανηχωικός Θάλαμος

Ερευνητικός Εξοπλισμός Εργαστηρίου Μικροκυμάτων

Κινητή Μονάδα Μετρήσεων Ασφάλειας Η/Μ Ακτινοβολίας

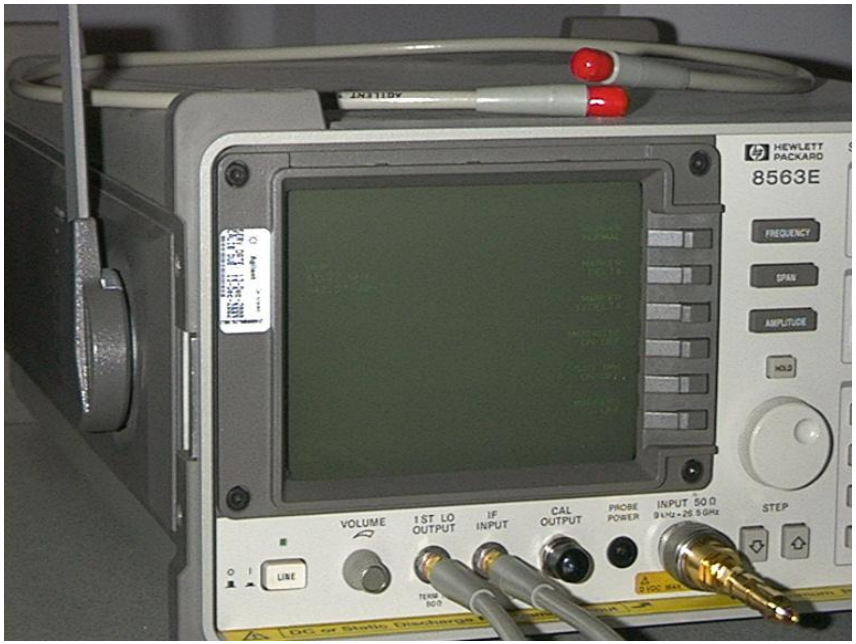
MWL DUTH – Microwave Measurements Instrumentation
HP8510c Vector Network Analyzer System

- Frequency range up to 50GHz using two frequency synthesizers (26.5GHz & 50GHz)
- Measurement of the linear characteristics (S-parameters) of antennas, filters, amplifiers, oscillators, etc.
- Measurement of non-linear characteristics
  - 1dB compression point
  - gain
- Measurement of 3-port and 4-port devices such as mixers and circulators with two test set units (3.5mm up to 26.5GHz, 2.4mm up to 50GHz)

MWL DUTH – Microwave Measurements Instrumentation
HP8593E Spectrum Analyzer

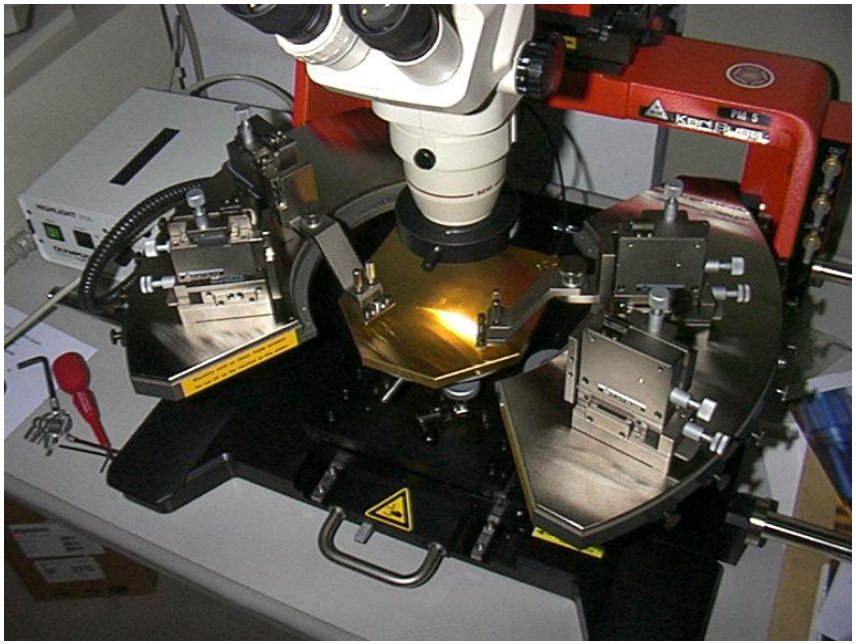
- Frequency range up to 50GHz using the Agilent 11907A and 11907Q Harmonic mixers.
- Measurement of non-linear characteristics:
  - 1dB Compression Point
  - 2nd and 3rd order intercept points
- Harmonic distortion measurements using options R01 (fast time-domain sweeps retrofit kit) and R15 (time-gated spectrum analyzer retrofit).
- **Noise figure** measurements.
- Measurement of CDMA terminals with the Agilent 85725C CDMA measurement personality.

MWL DUTH – Microwave Measurements Instrumentation
HP8563E Spectrum Analyzer



- Digital spectrum analyzer with a frequency range up to 26.5GHz.
- Measurement of non-linear characteristics
  - 1dB Compression Point
  - 2nd and 3rd order intercept points
- **Phase Noise** measurements due to the 1Hz resolution bandwidth adjustment.

MWL DUTH – Microwave Measurements Instrumentation
Karl-Suss MIC/MMIC Probe Station



- Compatible with all the above measurement equipment.
- Measurement of MICs and MMICs up to 50GHz.
- Calibration kit Substrate containing all the necessary components to support SOLT, TRL, LRM / LRRM calibration techniques.
- Calibration software.