Orchestrating the Performance of 5G

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InfoVista at a Glance

InfoVista provides cost-effective network performance orchestration solutions that help our customers provide top-quality user experience while increasing the capital efficiency of their network infrastructure.

Founded in 1995, Worldwide HQ in Paris, France.

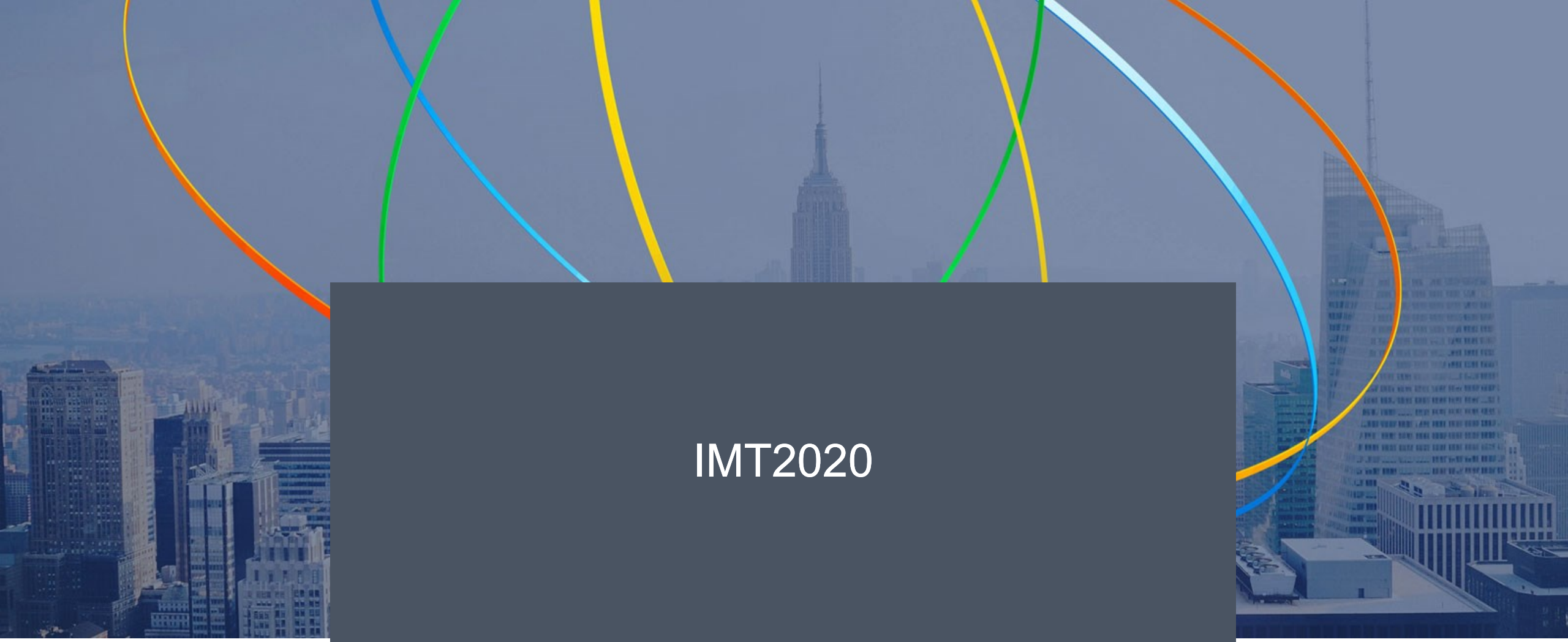
Worldwide
Customer support

Regional presence
24 local offices

R&D centers
France, Canada, Malaysia, Sweden, UK, USA

Over 1,500 customers
In more than 180 countries

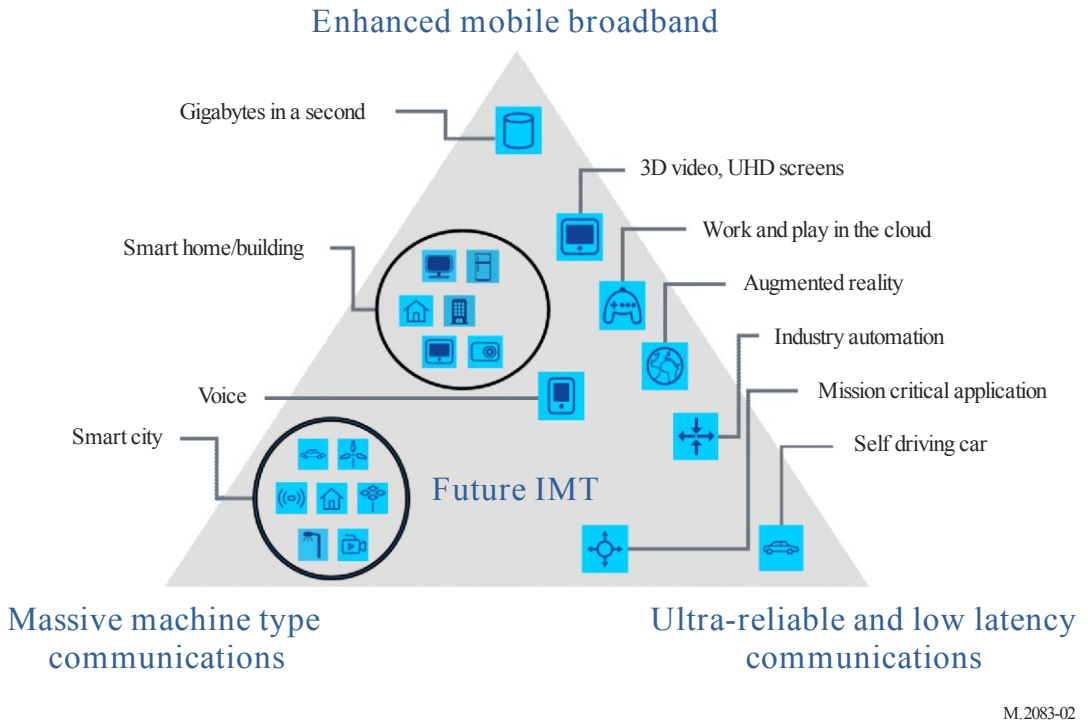
Acquisitions
Mentum, 2012 | Aexio, 2013 | Ipanema, 2015 | TEMS, 2016



IMT2020

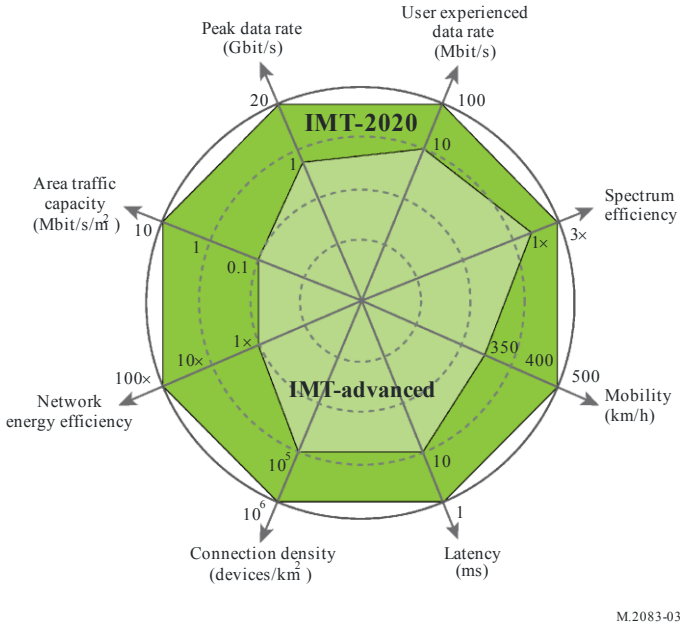
Usage scenarios of IMT for 2020 and beyond

- There are economic, political and technical needs for 5G
- Existing technologies are capable of satisfying today's requirements but not those of tomorrow
- Wide number of use cases with wide performance requirements
- More about connecting things
- No single technology will satisfy all requirements
- All requirements will not be met at the same time

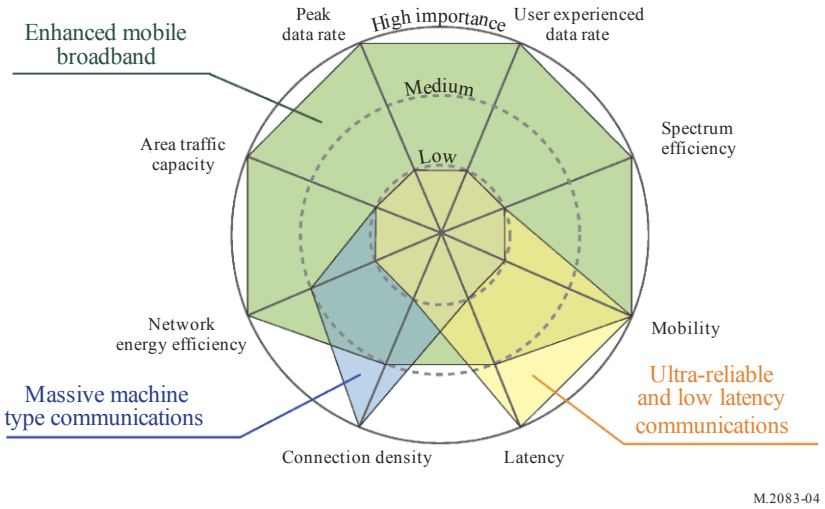


Usage scenarios of IMT for 2020 and beyond

Enhancements and Importance for Different Usage Scenarios



Enhancement of key capabilities from IMT-Advanced to IMT-2020



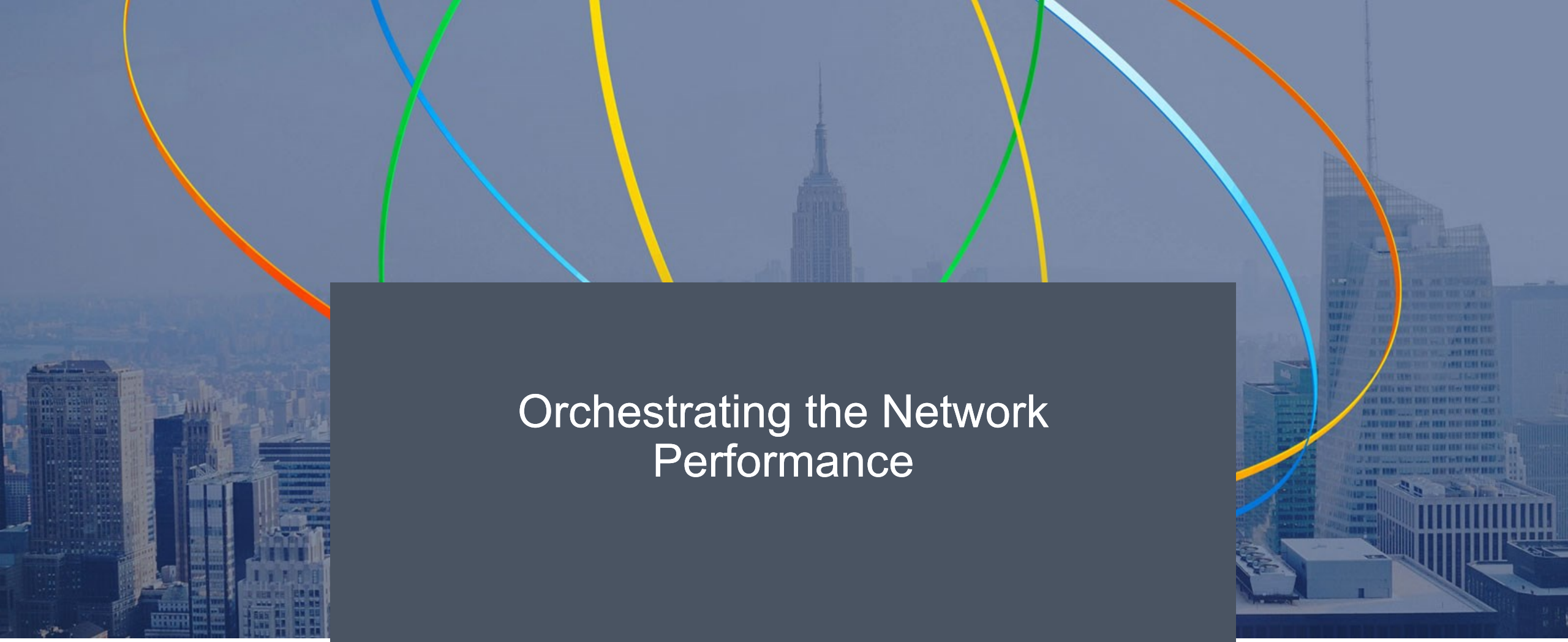
The importance of key capabilities in different usage scenarios

To meet Requirements, 3GPP needs to define:

- New Radio Interface (NR)
- Evolved LTE Radio Interface
- New Core Network (NextGen)
- Evolved LTE Core Network (EPC)

Usage Case Priority

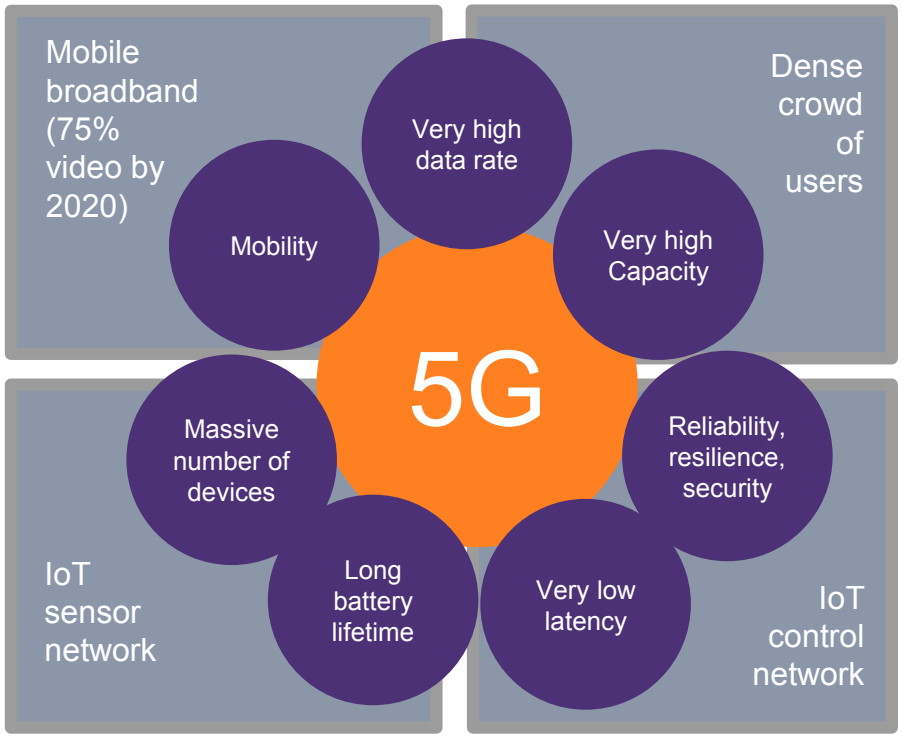
- Enahnced mobile broadband
- Some ultra-reliable and low latency communications
- Massive machine type communications and more comprehensive ultra reliable/low latency functionality



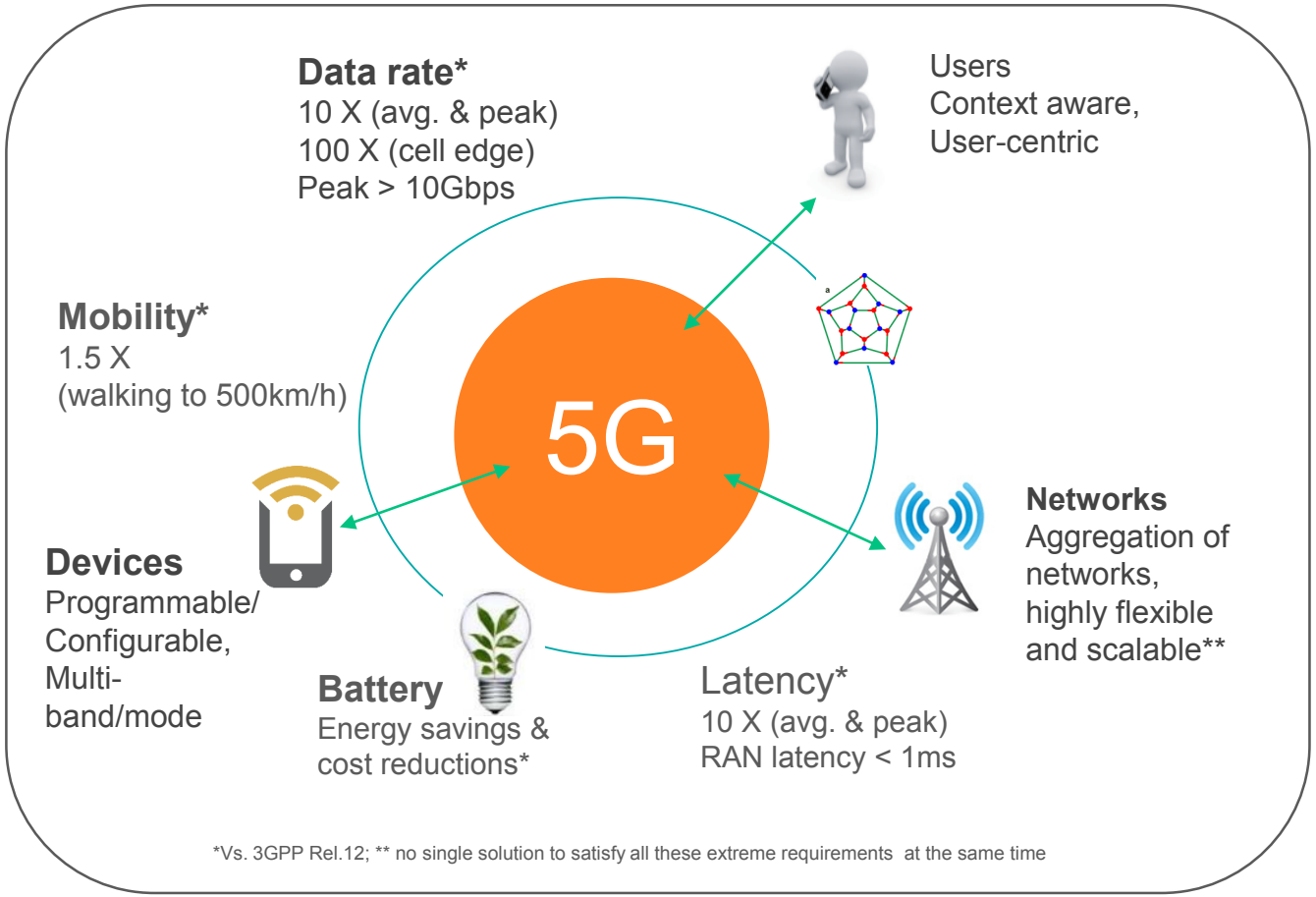
Orchestrating the Network Performance

5G at a glance: use cases and requirements

Use Cases



Requirements



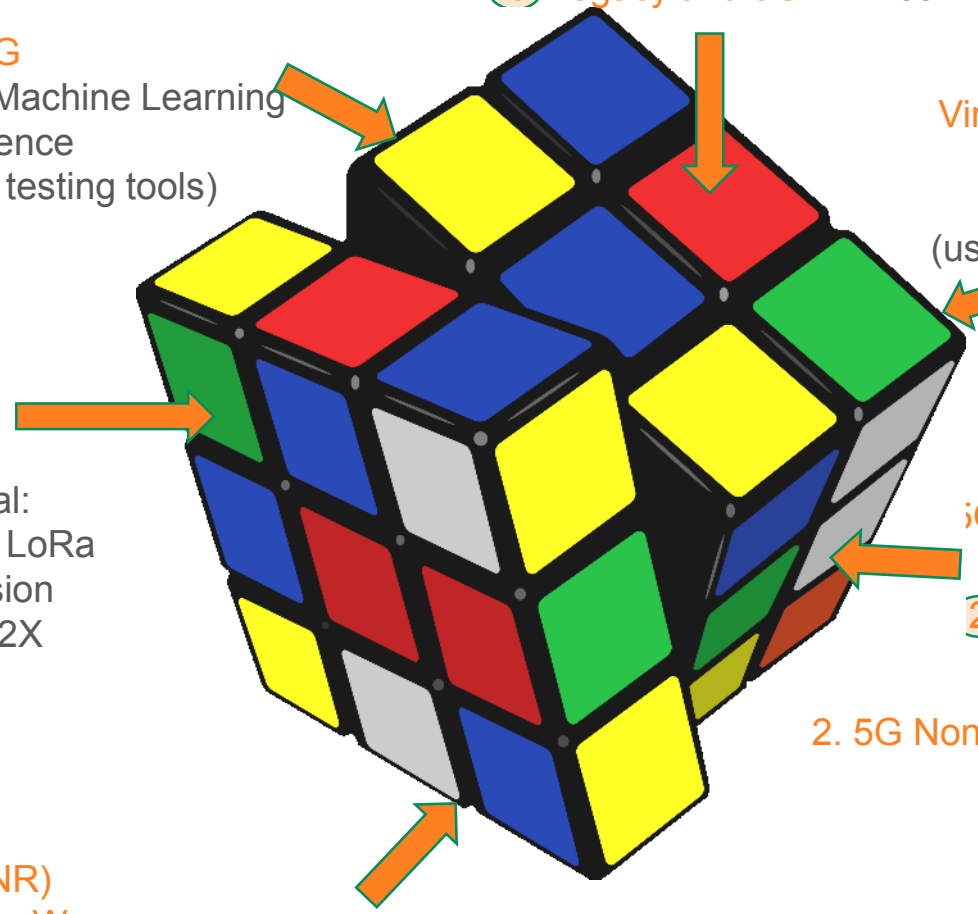
The 5G Rubik Cube

6. 5G context aware QoE

6. Legacy and 5G D2D communications

4. Legacy and 5G
Big Data Analytics; Automation, Machine Learning and Artificial Intelligence
(used in networks as well as testing tools)

3. Legacy and 5G
Virtualization; SDN/NFV requiring Mobile edge computing and distributed cloudification
(used in networks as well as testing tools)



5. Legacy and 5G
Network Slicing
per 5G type of use case and/or verical:
eMBB, Massive connectivity IoT (legacy: LoRa NB-IoT, LTE-M based, EC-GSM), Mission critical IoT (legacy: connected cars, V2X communications)

5G New Core (NC) – Rel 2018+

2. 5G Standalone (NR, NC)

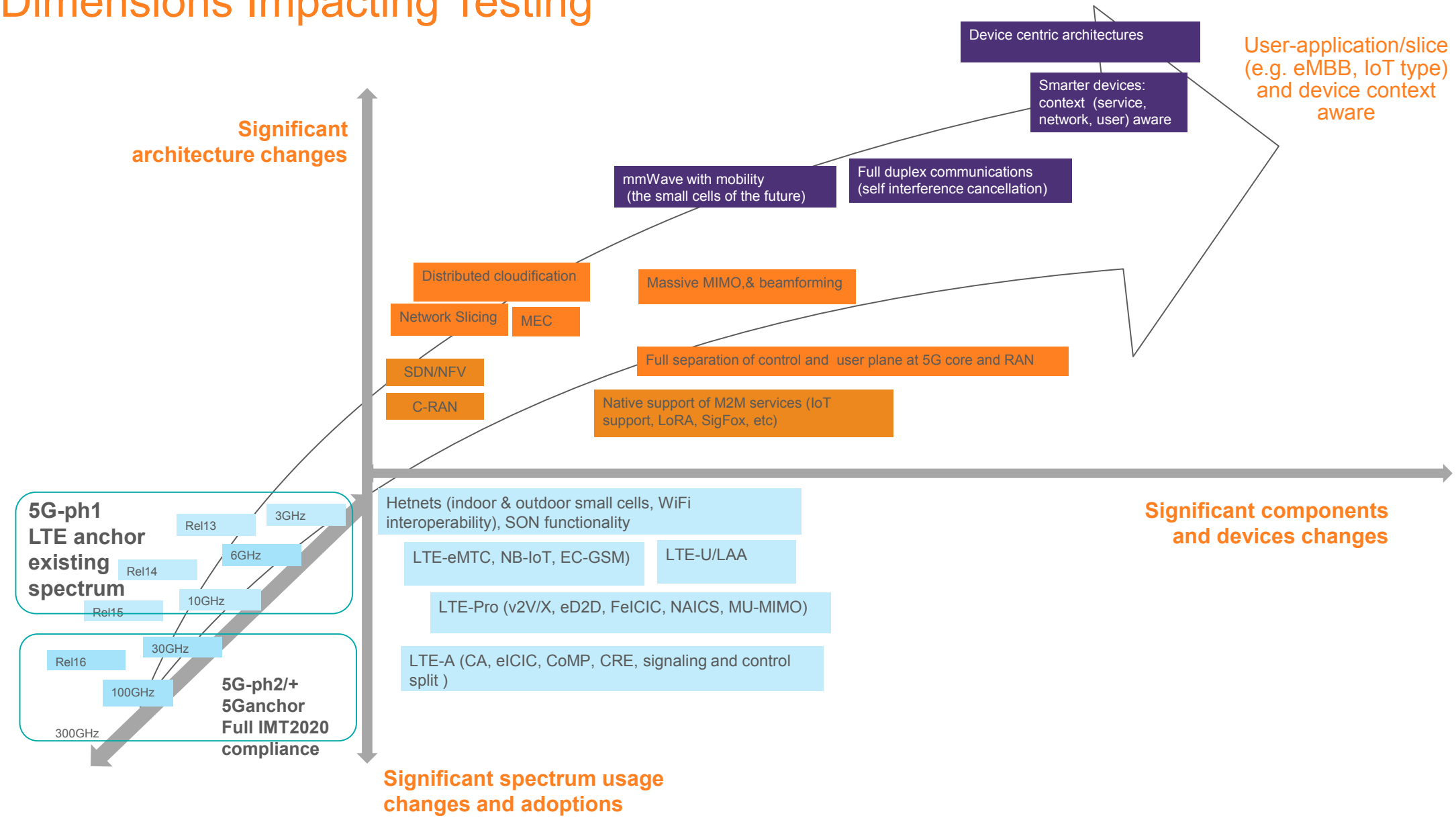
2. 5G Non Standalone (5G NR, LTE core) with mutliconnectivity

1. 5G New RAN (NR)
above 6HGz and mmW
(new air interface including some LTE-Pro concepts e.g. Cell Range Expansion, control /user plane split, Coordinated Multipoint CoMP, reduced L2 signaling)

1. 5G capabilities (latency and throughput) with Licensed and Unlicensed spectrum (LTE-U/eLAA; LTE-WiFi interoperability, dual connectivity)

1. 5G capabilities (latency and throughput) with LTE-Pro RAN technology features (e.g. massive MIMO, beamforming, higher order coding, DL/UL CA) (sub 6GHz)

Dimensions Impacting Testing



Behind the use cases

Enhanced Mobile Broadband

Wider bandwidths; higher frequencies
mmWave : hot spots vs. mobility
Shared Spectrum; licensed and unlicensed
Device-centric mobility
Dynamic, low-latency TDD/FDD
Massive MIMO and beamforming (incl. high mobility channels)
Advanced higher order channel coding
Multicast support

Massive IoT

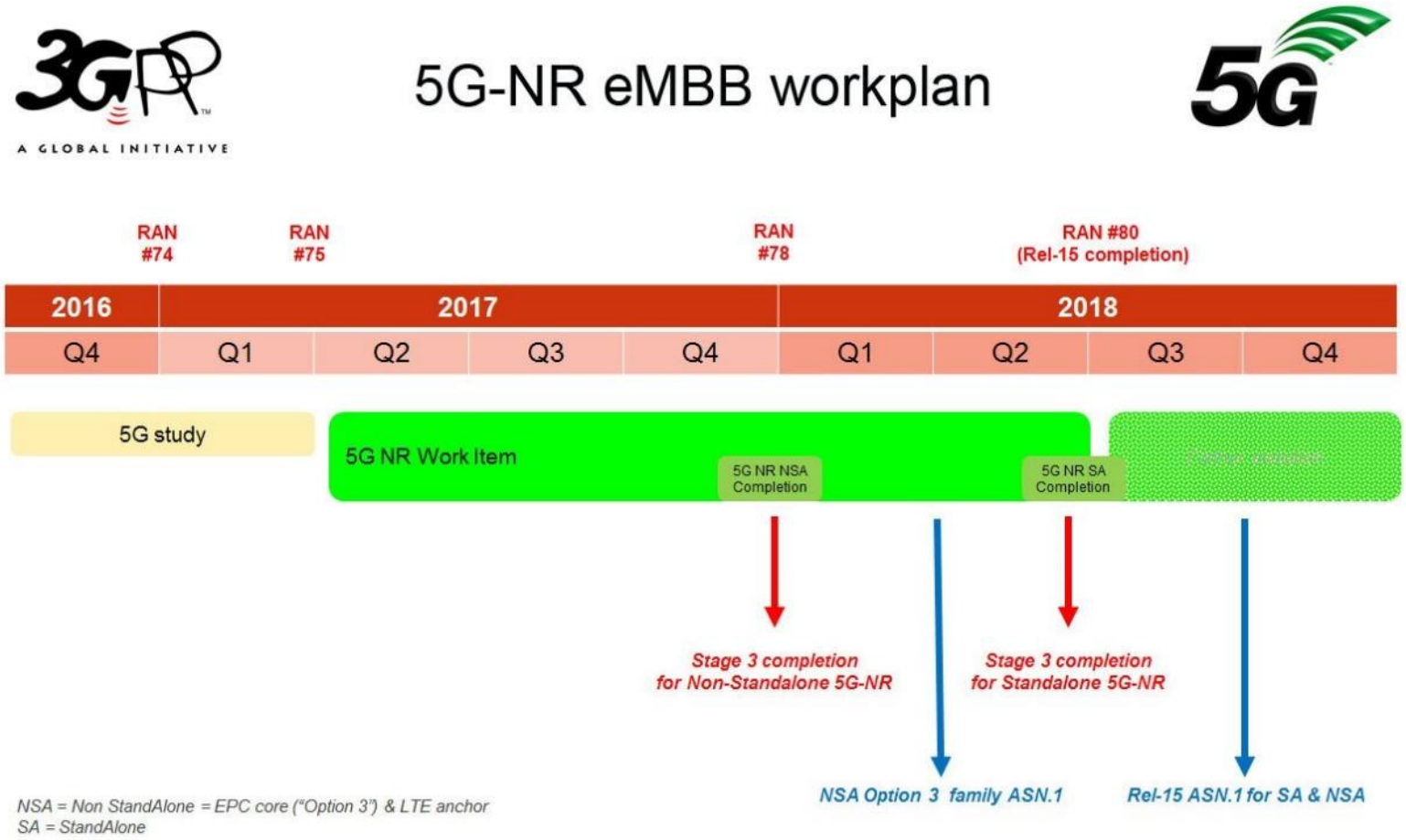
- Low complexity narrowband
- Low power modes for deep sleep
- Efficient signaling
- Grant-free uplink transmission
- Optimized link budget
- Multi-hop mesh

Mission Critical Control

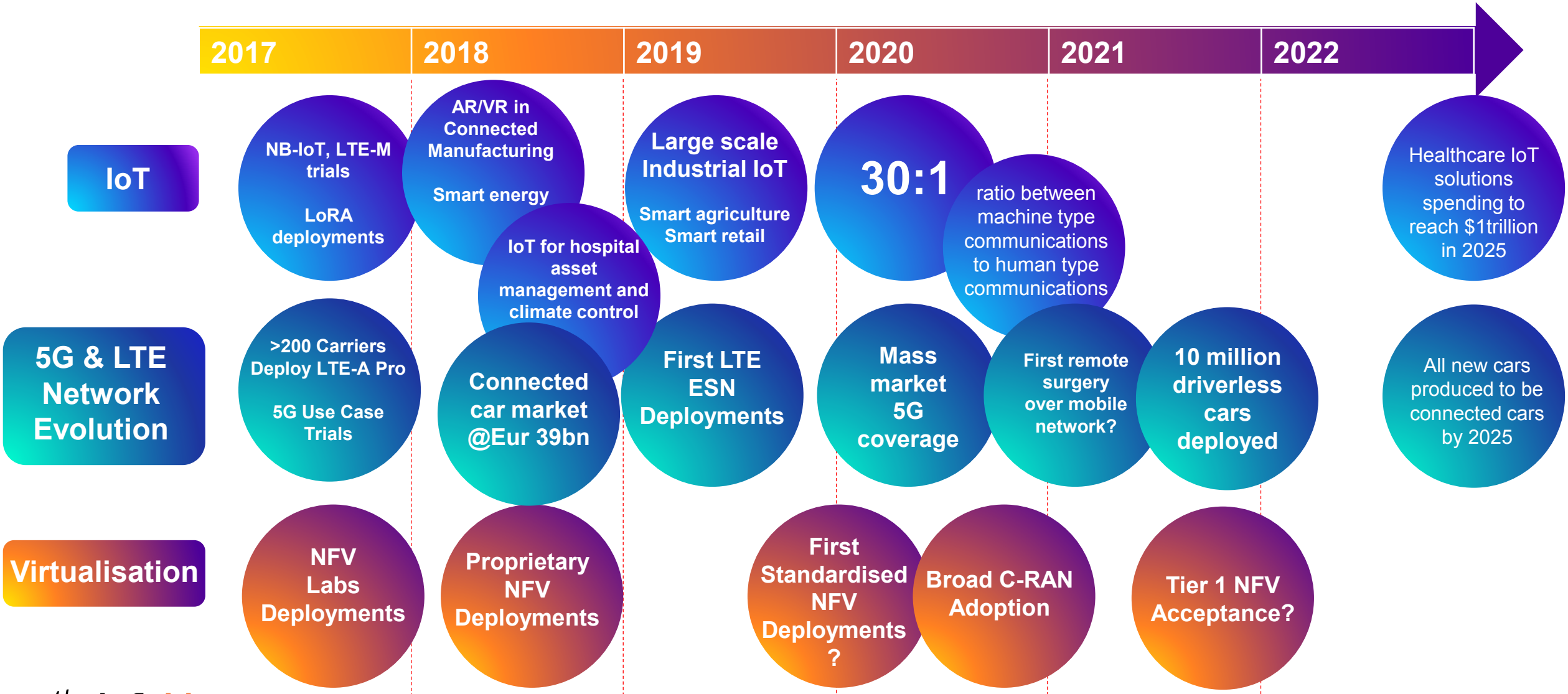
- Low-latency with bounded delay
- Efficient multiplexing with nominal traffic
- Grant-free Uplink Tx
- Simultaneous redundant links
- Reliable device-to-device links
- Optimized PHY/pilot/HARQ

- Spectrum: 300MHz-100GHz
- Massive/MU/FD MIMO and Beamforming,
- Multi-connectivity,
- User and control plane split, Cell Range Expansion (CRE; reuqired sync between macro and pico layer)
- Flexible and scalable L1: OFDMA (FB-OFDMA) with flexible numerology, multiplexing of WB and NB devices on same resources, filtering and shapig by digital processing, support for various spectrum allocation schemes
- Distributed architecture

A reality check: 3GPP Standards 5G Radio Timeline Overview

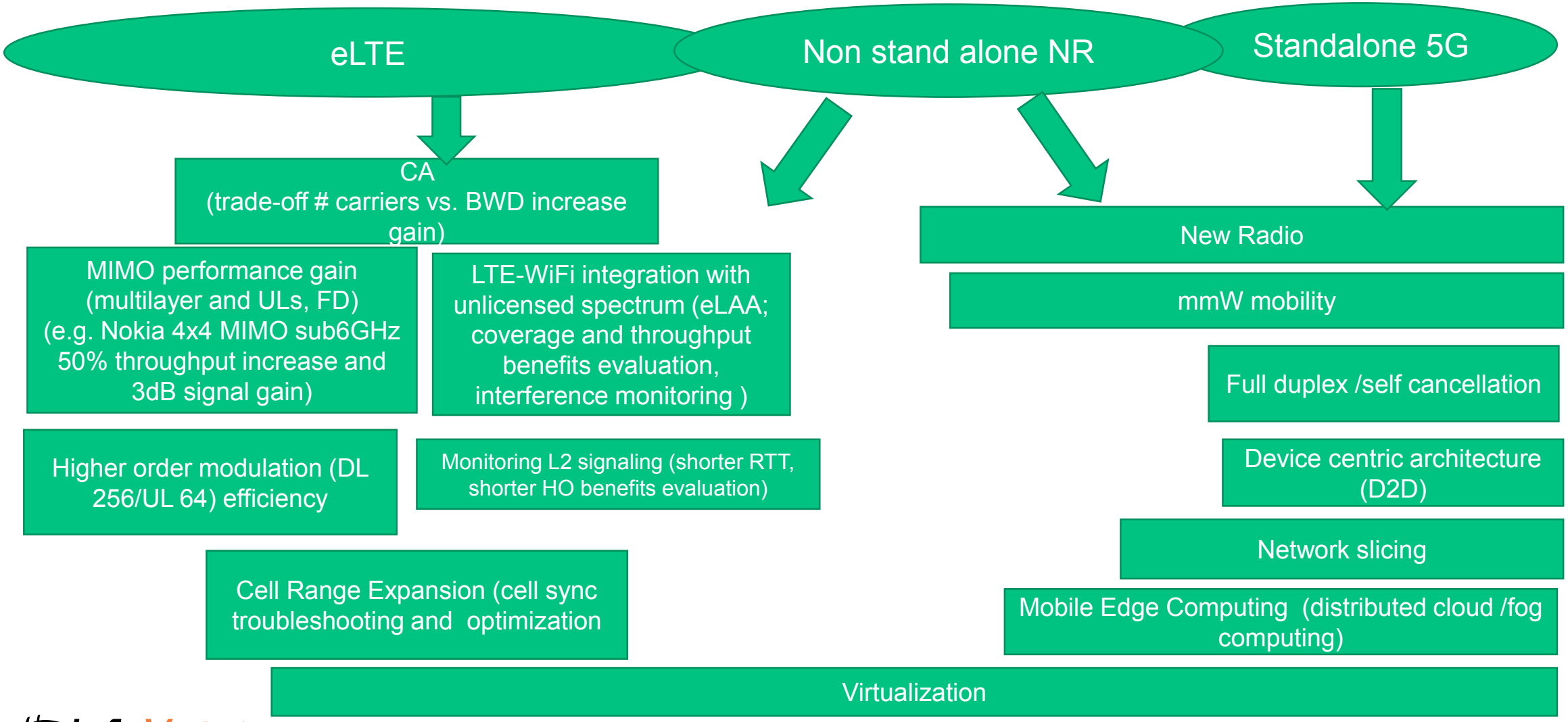


Market trends



Therefore until then ….from eLTE (LTE-A/Proto) to 5G NR – transparent to 5G use cases

5G World trend expressed by Nokia, Telefonica, DT, SK



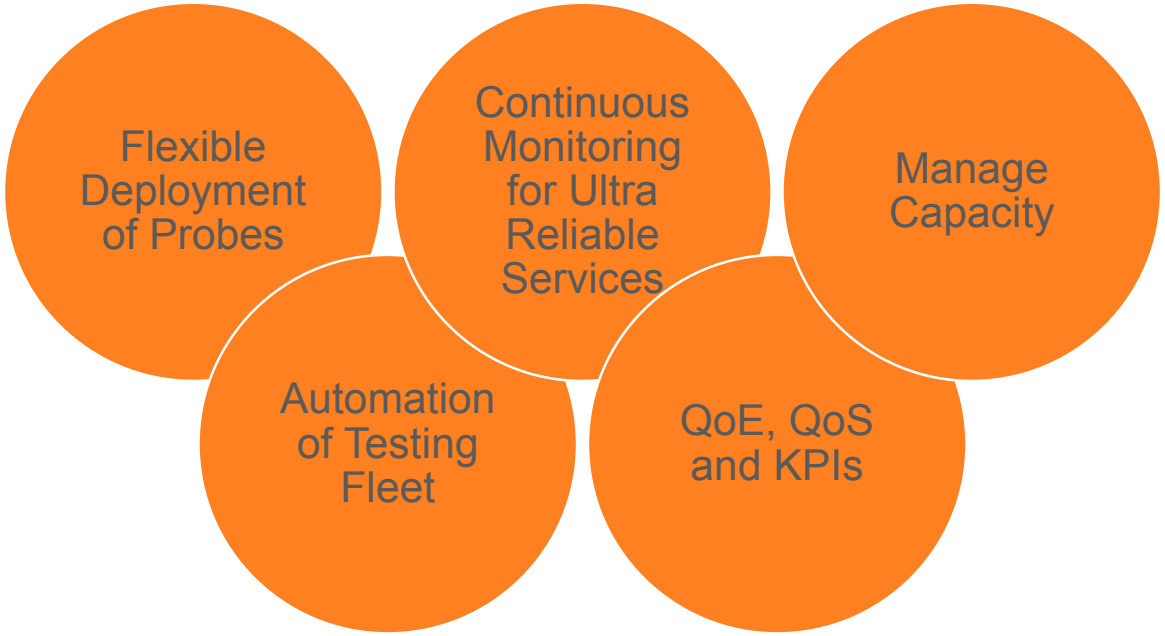
Testing Challenges

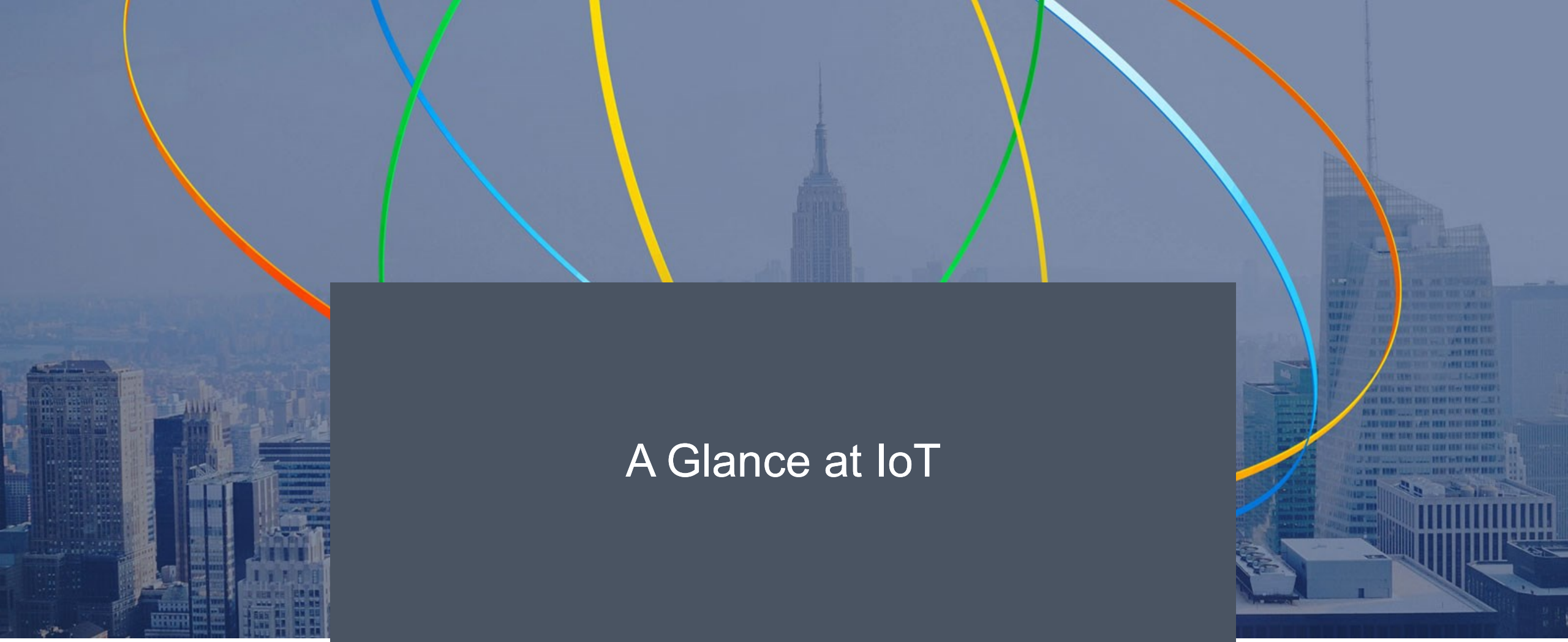
Evolving the Ecosystem – Challenges

Enhanced Mobile Broadband	Peak of **10-20 Gbit/s** **1 Gbit/s** (Indoor) User Experience **100Mbit/s** (Urban, Suburban)
Area Traffic Capacity	**10Mbit/s/m^2**
Over the Air Latency	Capable of supporting services of very low latency, **1ms**
Connection Density	Expected to support a connection density of **10^6/km^2**, for example in massive machine type communications
High Mobility	Expected to enable high mobility up to **500 km/h** with **acceptable QoS**

Evolving the Ecosystem – What is Needed?

- Enhanced Mobile Broadband
- Area Traffic Capacity
- Over the Air Latency
- Connection Density
- High Mobility





A Glance at IoT

IoT at a glance

A range of technologies for a range of applications within mission critical and massive communications context

USE CASES

Surveillance

Connected cars, connected homes

Smart meters, agriculture, transportation, environnent, health care, industry

REQUIREMENTS & CONSTRAINTS

THROUGHPUT

LATENCY

COST

BATTERY

TECHNOLOGY

LTE Cat-1

LTE Cat-M

LoRa

LTE NB-IoT

sigfox

	2015	2021	CAGR 2015-2021
Cellular IoT	0.4	1.5	27%
Non-cellular IoT	4.2	14.2	22%
PC/Laptop/Tablet	1.7	1.8	1%
Mobile Phones	7.1	8.6	3%
Fixed Phones	1.3	1.4	0%
	15 billion	28 billion	

Connected devices forecast from Ericsson Mobility Report, June 2016

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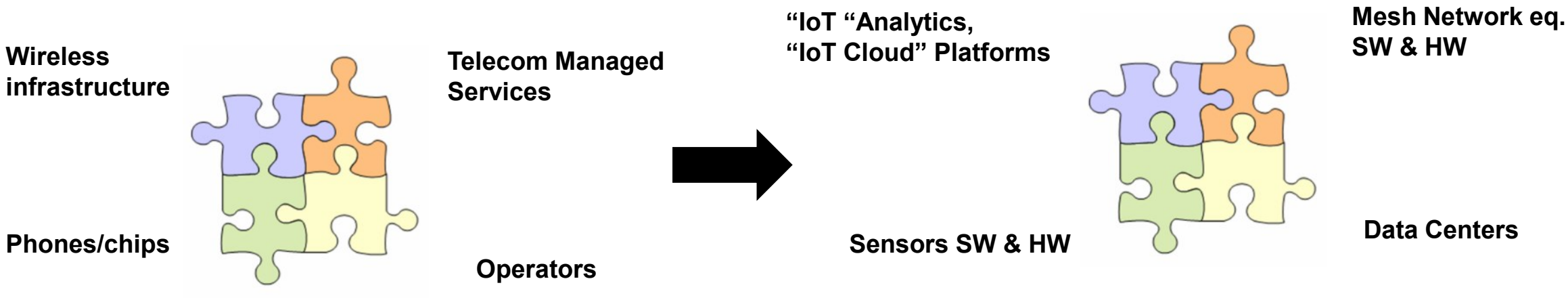
IoT Changing the landscape….



Besides service assurance, troubleshooting and optimization…

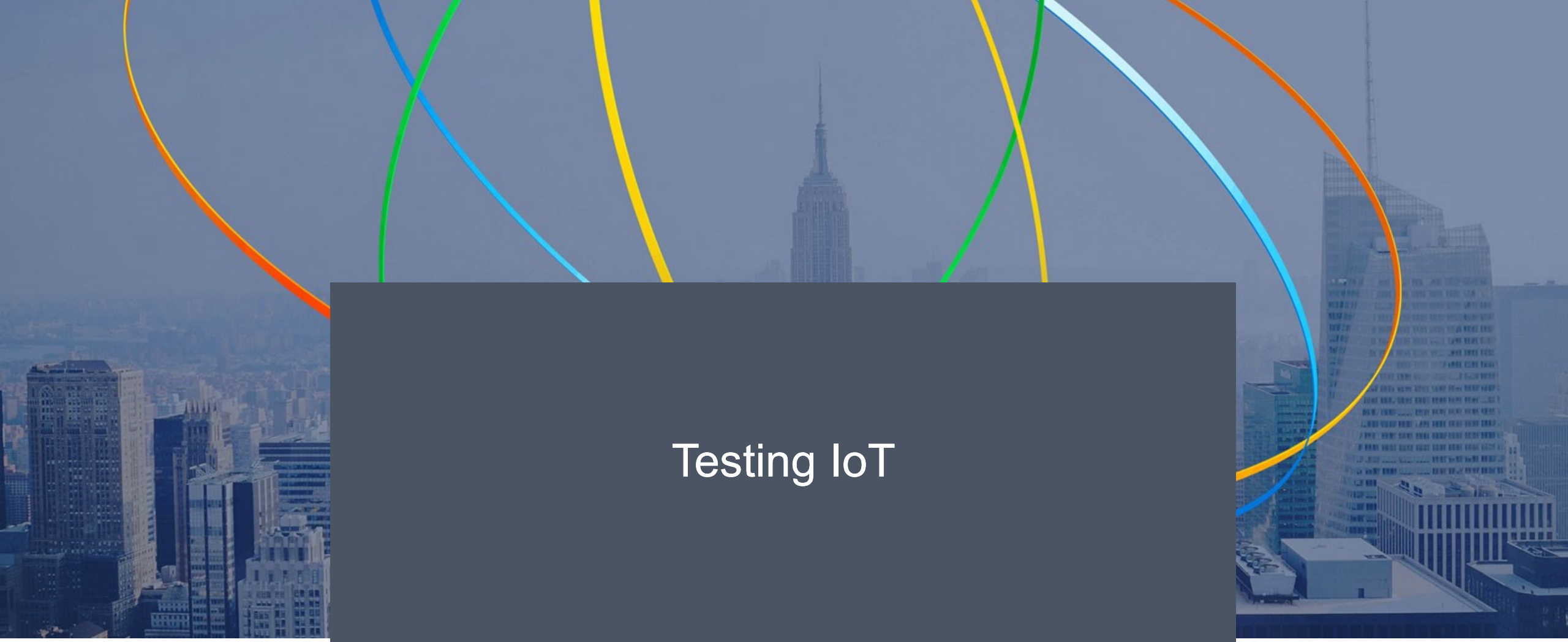
- How do I ensure that my IoT services work seamlessly, reliably and securely on my network?
- How can I differentiate my network/services without sacrificing profitability or quality?
- How do I ensure that the SLAs towards IoT partners are being met?

Telcos need to also provide provisioning and device management services, systems integration, data analytics, together with flexible platforms and middleware.

…Raw connectivity will only generate a small fraction of overall IoT revenues for carriers… (according to analysts)

IoT technologies
NB-IoT vs LoRA vs Sigfox vs LTE-M

NB-IoT / LTE Cat-NB	LoRAWAN	Sigfox	LTE-M / LTE Cat-M1
• Modulation: QPSK / BPSK • **Coverage: <15 Km** • Frequency spectrum: LTE In-band, Guard Band, Standalone • Signal Bandwidth: 180 KHz • Data Rate: 200 Kbps • Battery life : 10 years	• Modulation: LoRA • Coverage: < 10 Km • Frequency spectrum: Unlicensed Band • Signal Bandwidth: 125 KHz • Data Rate:10 Kbps • Battery life : 10 years	• Modulation: BPSK • Coverage: < 12 Km • Frequency spectrum: Unlicensed Band • Signal Bandwidth: 0.1 KHz • Data Rate: 0.1 Kbps • Battery life : 10 years	• Modulation: DL OFDMA 15kHz tone spacing Turbo Code, 16QAM 1 Rx; UL SC-FDMA 15kHz tone spacing Turbo Code, 16QAM • Coverage: < 10 Km • Frequency spectrum: part of 1.4 MHz block of the LTE channel • Signal Bandwidth: 1.08 MHz • **Data Rate: 100 Kbps (peak 1Mbps UL/DL)** • Battery life : 10 years
Cellular but not part of LTE, hence needs to operate in a side band using different software	Not Cellular	Not Cellular	Cellular, part of LTE 1.4 MHz block
Favoured by China carriers. Target: Simple devices that need to connect to an operator's network via licensed spectrum	Uses unlicensed spectrum, proprietary modulation system sold by Semtech – the only manufacturer/license holder. LoRA Alliance. Can be used by non-operators to implement solutions. LoRaWAN networks interfere when more than one is operated in an area. Best suited for: Electric grid monitoring	Lowest cost radio modules, UL only (though limited downlink possible) Sigfox was originator of LPWAN concept Best suited for Alarms, meters (small infrequent bursts of data)	Favoured by US Carriers Best suited for: Low density sensors; Automated Meter Reading; Asset Tracking



Testing IoT

NB-IoT and LTE-M QoS/QoE testing

NB-IoT

LTE-M

Connectivity (indoor, outdoor) based on L3 decoding of NB-IoT/LTE-M signaling

Coverage validation and performance (indoor, outdoor)

Mobility performance (indoor, outdoor)

Latency, UL/DL peak rate

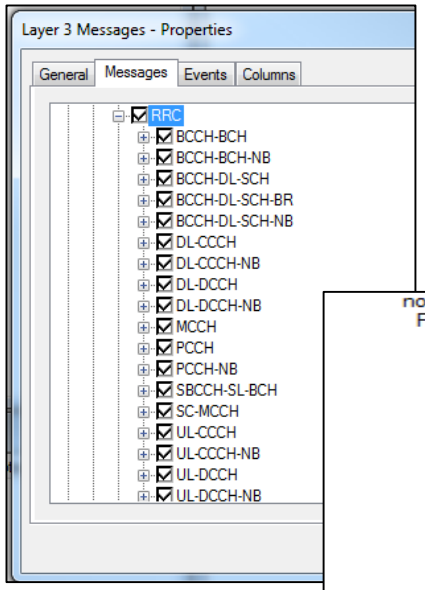
Battery life (PowerSavingMode, eDRX activity %)

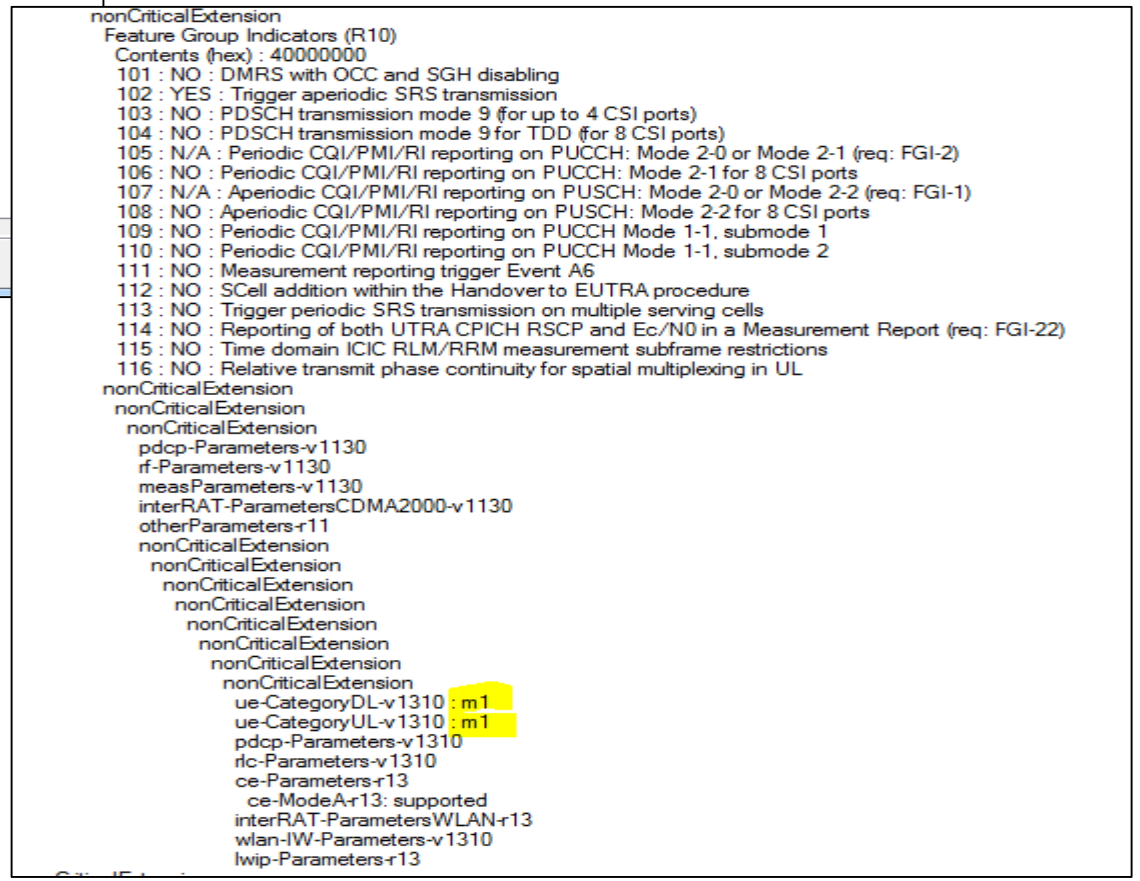
LTE-M voice service support (call control and performance MOS)

Unique QoE model (under research)

IoT
NB IoT and LTE-M (device availability dependent)

The L3 decoding of LTE and WCDMA has been updated to support 3GPP release 13, this includes:
LTE RRC
LTE NAS
UTRAN RRC
UTRAN NAS
The L3 LTE RRC decoder enables thus decoding of NB IoT signalling.





LTE UE category has been extended to support M1.
A number of Qualcomm specific reports has also been updated to support LTE 3GPP release 13 signalling and some NB IoT specific reports handling:
-PSS search
-NPDSCH decoded data

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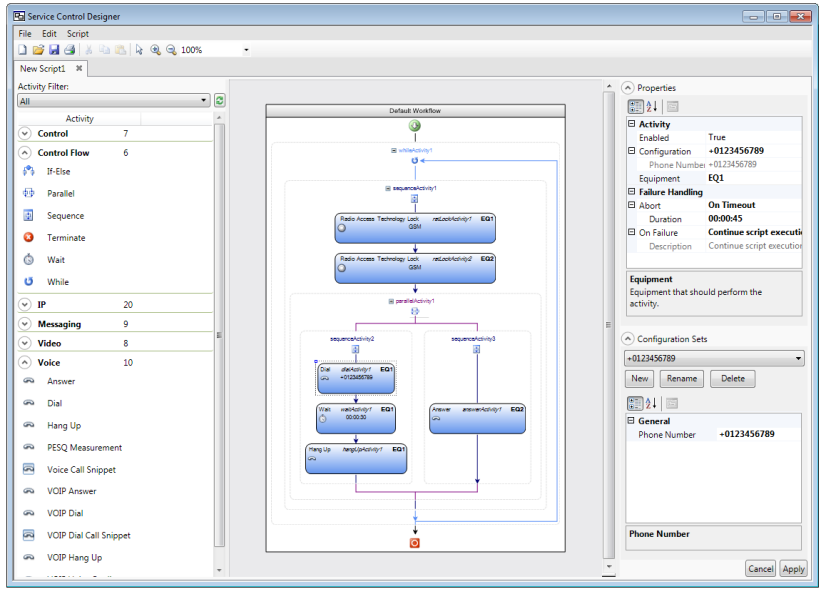
IoT
NB IoT and LTE-M (device availability dependent)

NB-IoT KPIs – under further developments

UBLOX and Quectel both using QualComm chipset, operated via AT commands- no Layer 3 or no LTE information
Signal power: <power>
Total power: <tot_power>
TX power: <tx_power>
TX time: <tx_time>
RX time: <rx_time>
Cell ID: <cell_ID>
DL MCS: <dl_mcs>
UL MCS: <ul_mcs>
DCI MCS: <dci_mcs>
Last ECL value: <ECL>

Script Design tool – User Defined Activity



Testing LoRaWAN QoS

Control functions

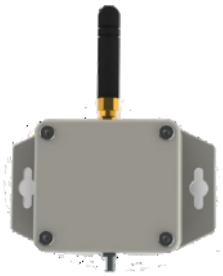
- Tx Power
- Spreading factor
- Tx Interval settings
- Ack/ No ack handling
- Retransmission/No retransmissions
- Channel mask
- Tx lock

Monitoring capability

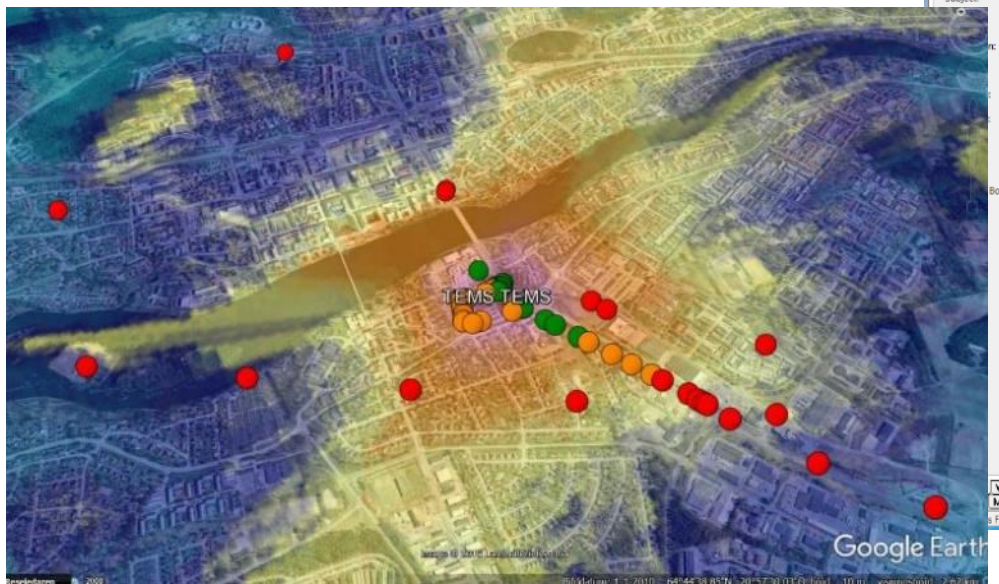
- RSSI
- SNR
- Spreading factor DL
- Spreading factor UL
- TxPower

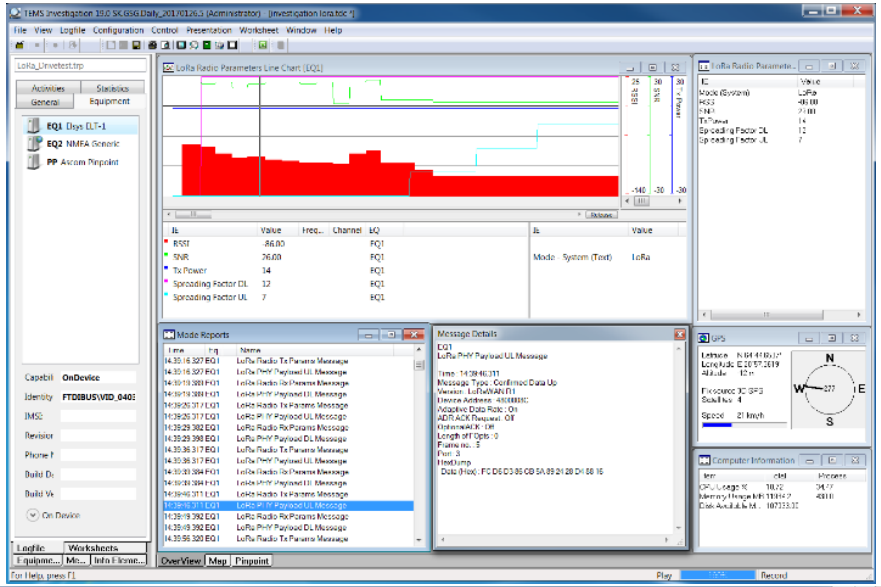
Use cases

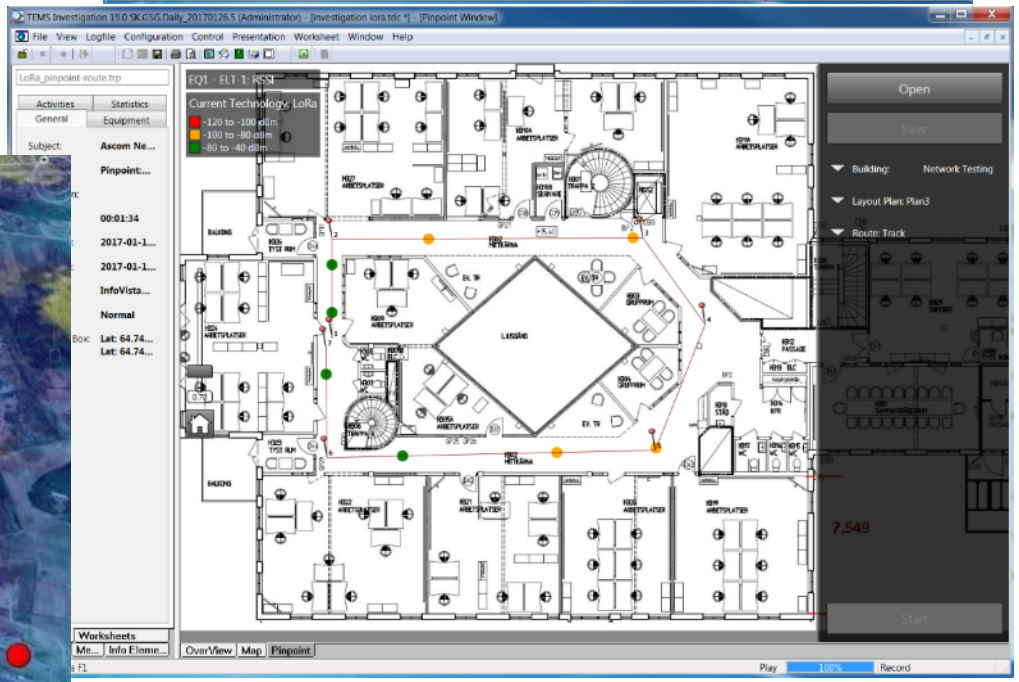
- Outdoor & indoor
- coverage/troubleshooting
- Validate coverage
- plots (possibility to
- change Tx intervals for
- more freq. RSSI
- update



ELSYS ELT-1 LoRa sensor







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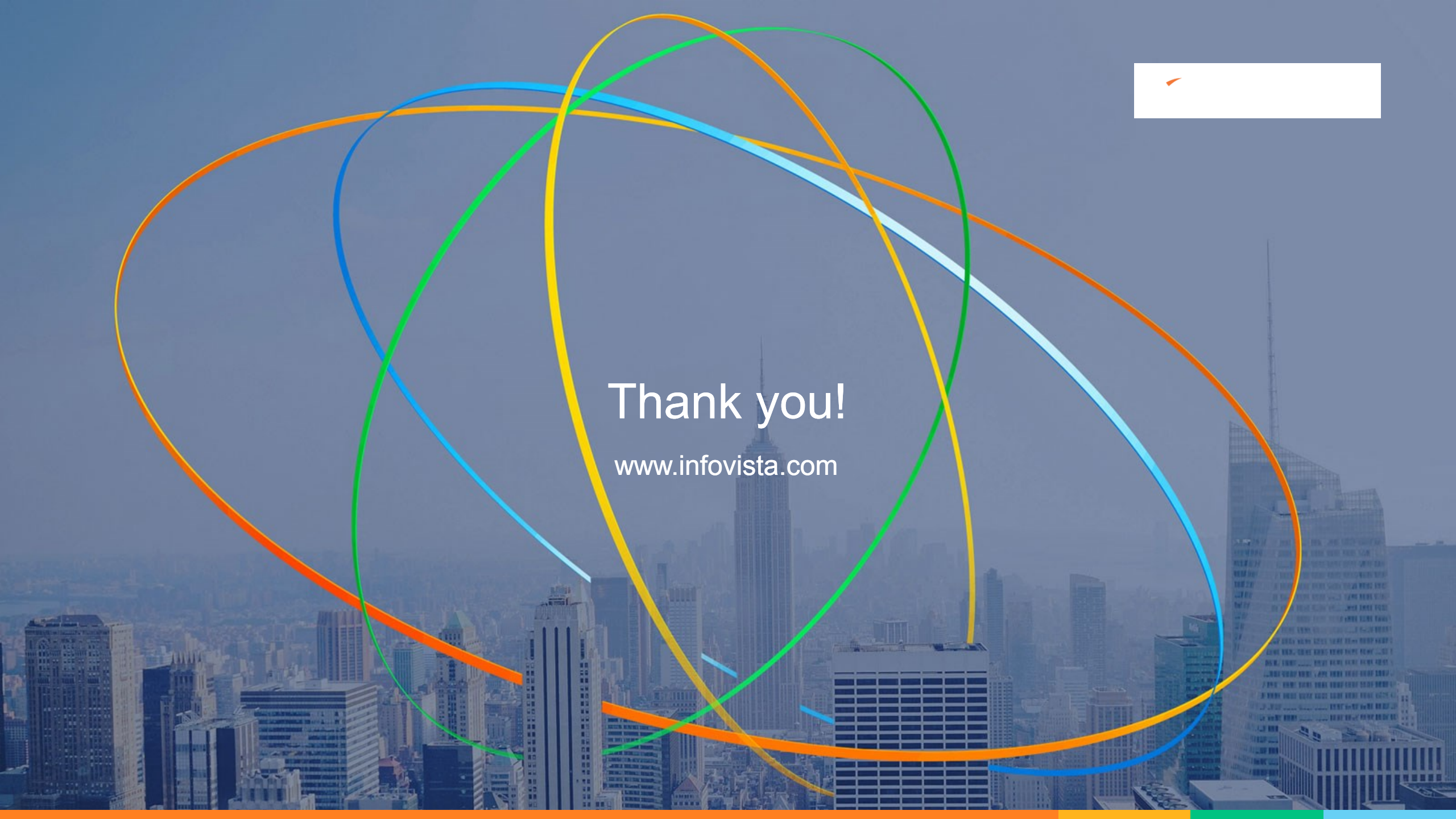
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