

Introduction to 5G communication Systems evolution

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Development & Innovation



Orange Romania key figures

10+ million
mobile subscribers

> 3000
employees

#1 mobile telecom provider
in Romania for 11 consecutive years

over €2.5bn
CAPEX investments in networks
and telecom solutions

€987 m
revenues in 2016

#1 4G network
100% urban
coverage - fastest
network

top employer
4th year in a row

#4th place
in top 100 most valuable companies in
Romania

**most trusted
brand**
4 times in a row –
Readers' digest

Orange Innovation Ecosystem

Orange Educational Program 1997 - 2017

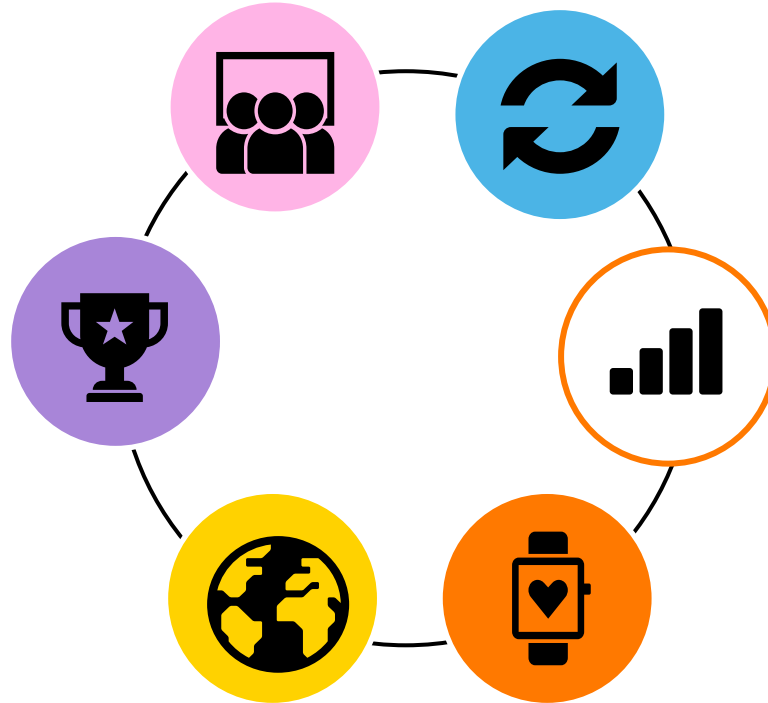
- +400K Euro scholarships
- +270K Euro Lab @ UPB
- 33% alumni became Orange employees

Pre-accelerator program

- 4 Years main partner at Innovation Labs
- 3 solutions integrated in Orange Portfolio

R&D

European founded projects on research and innovation: 5G, Smart Cities & IoT



1st Smart City

- Alba Iulia Smart City Pilot Project
- 14 integrated smart city solutions, 3 Innovation Labs projects integrated

New services on Romanian market

VoLTE, VoWi-Fi, 4G+, Gigabit mobile internet trials

New Products

- Smart Home
- Robots
- Latest flagship handsets
- Smart Stores

Orange Fab accelerator

Capitalize on the Romanian start-up ecosystem leadership

Orange Fab @



Smart Territories
Security
Future of Life

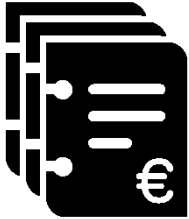
SiloMeter



5G Future



A European Commission study reveal that the benefits of 5G for automotive, healthcare, transport and utilities sector in Europe starting from 2025 are estimated at 113 billion euro per year*



Research Projects 5G Worldwide Service Revenue will Reach \$247 Billion in 2025 with North America, Asia-Pacific, and Western Europe being the top markets**

*Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe, A study prepared for the European Commission DG Communications Networks, Content & Technology

** www.abiresearch.com

5G Vision & Mission



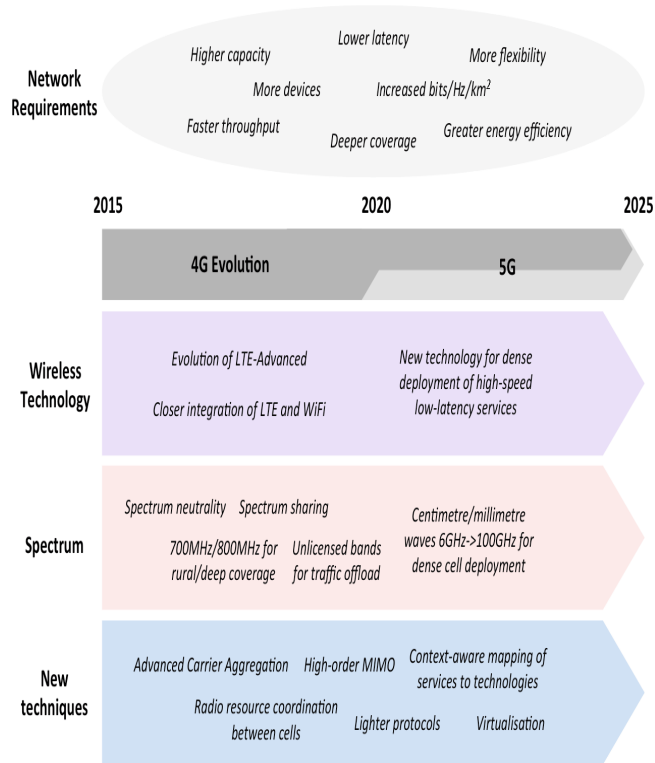
”5G is an end-to-end ecosystem to enable a fully mobile and connected society. It empowers value creation towards customers and partners, through existing and emerging use cases, delivered with consistent experience, and enabled by sustainable business models.”



5G is intended to deliver solutions, architectures and technologies for the next coming decades with huge potential of creating new markets, business models and innovation opportunities and actions in areas such as Smart Cities, e-Health, Intelligent Transport, Education, Agriculture, Media and Entertainment.

Evolution to 5G

Evolution to 5G

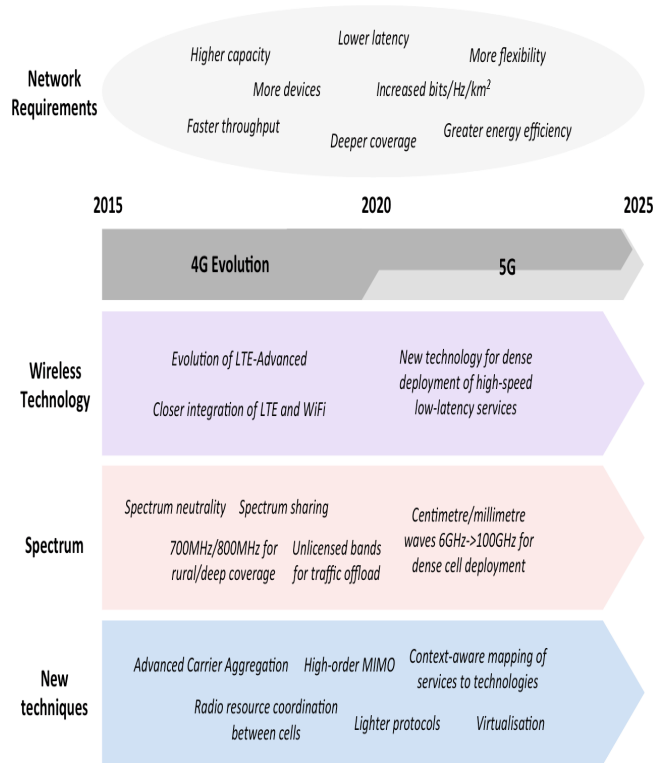


Evolution to 5G

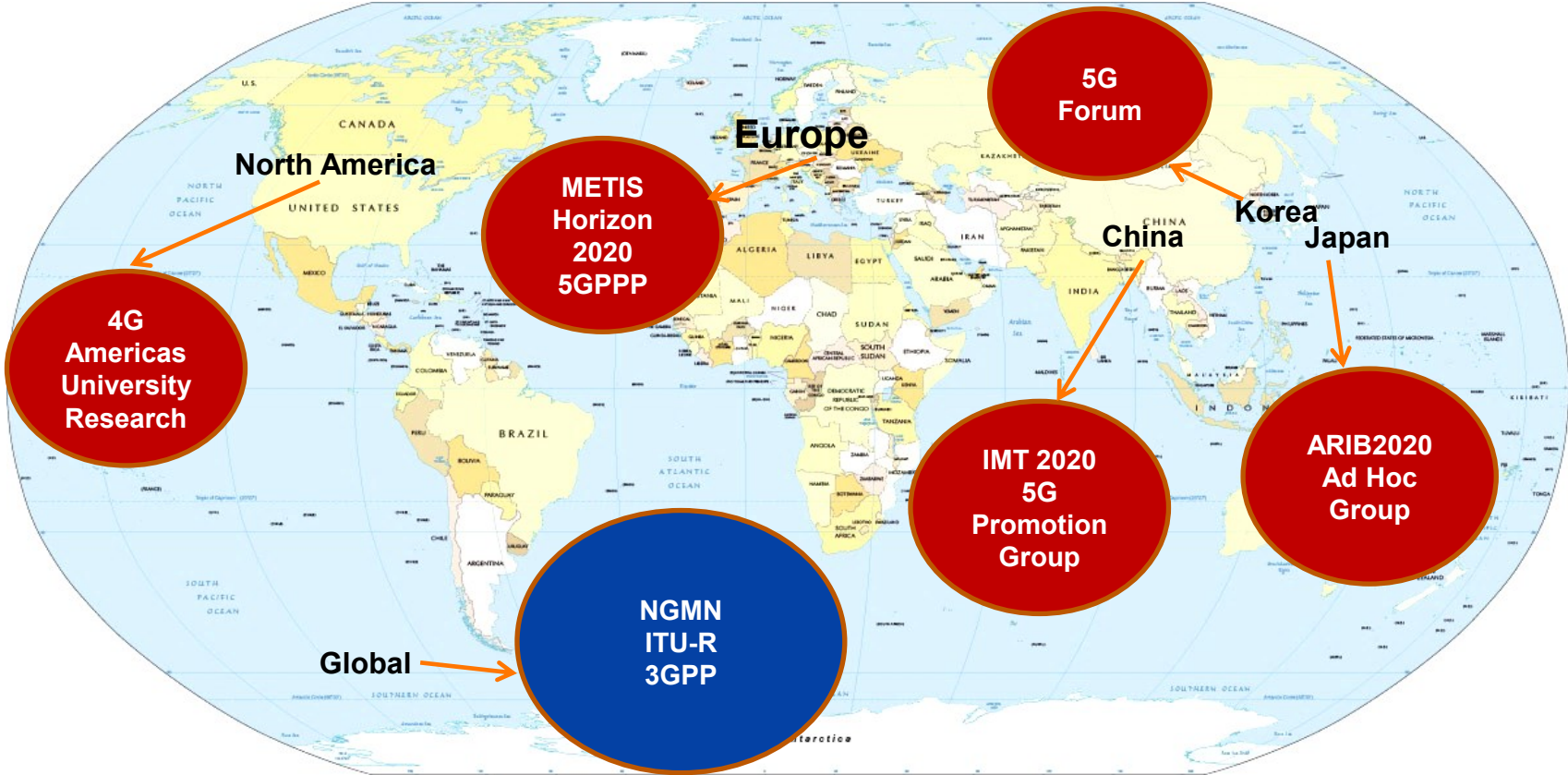
	1G	2G/2.5G	3G/3G+	4G/4G+	5G
Standards	NMT	GSM/GRPS/EDGE/CDMA	UMTS/CDMA2000/WCDMA/HSPA+	LTE/TD-LTE/LTE-A	?
Deployment	1970/1980	1980/2003	2000/2010	2010/2020	2020/2030
Technology	Analog cellular	Digital cellular	Broadbandwidth/CDMA/IP technology	Unified&Seamles combo of LAN/ WAN/WLAN/PAN	4G+?
Frequency bands	450MHz, 800-900 MHz	900MHz,1800 MHz	900MHz, 2100 MHz	800MHz, 1800 MHz, 2600 MHz, 3700 MHz	700 MHz, 3500MHz, 3700MHz, 6-10 GHz, >10 GHz
Services	voice	voice, SMS	voice, SMS, data	IP services	?
Multiplexing	FDMA	TDMA+FDMA / CDMA	CDMA	OFDMA, SC-FDMA	?
Switching	Circuit	Circuit/ Circuit for access network&air interface	Packet except for air interface	All packet	All packet
Core network	PSTN	PSTN	Packet Network	Internet	Internet
Bandwidth	20KHz, 25KHz	200 KHz	5 MHz	1,4MHz; 3MHz; 5MHz; 10MHz; 15MHz; 20 MHz	?
Latency	~	~0.5-1 s	~200 ms	~10ms RTT ; ~100 ms	1-10 ms
Peak data rate	N/A	<0.5 Mbps	3- 63+ Mbps	150-450 Mbps	1-10 Gbps
Spectral Efficiency	N/A	0.72 b/s/Hz	4.2 b/s/Hz	7.5 b/s/Hz	??

Evolution to 5G

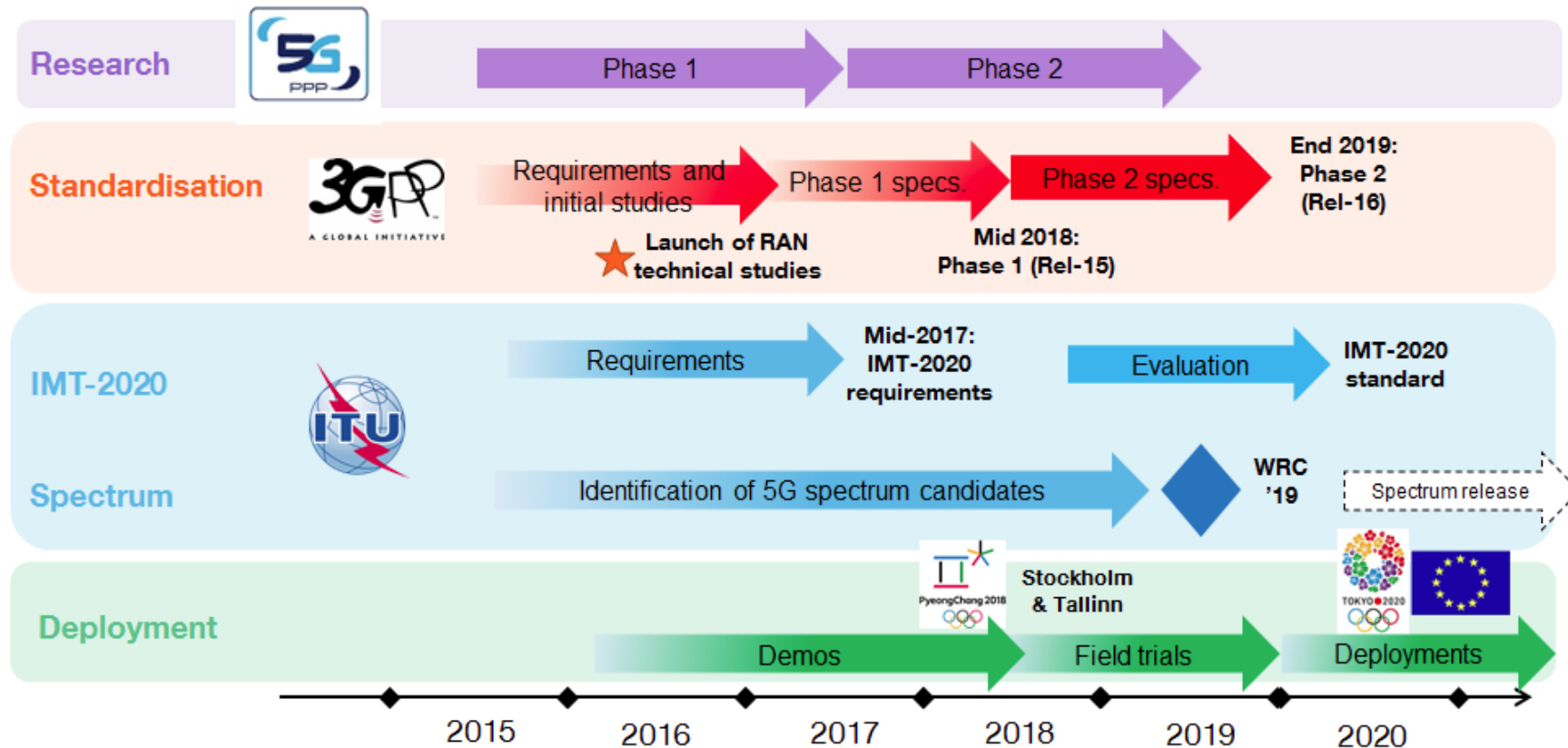
Evolution to 5G



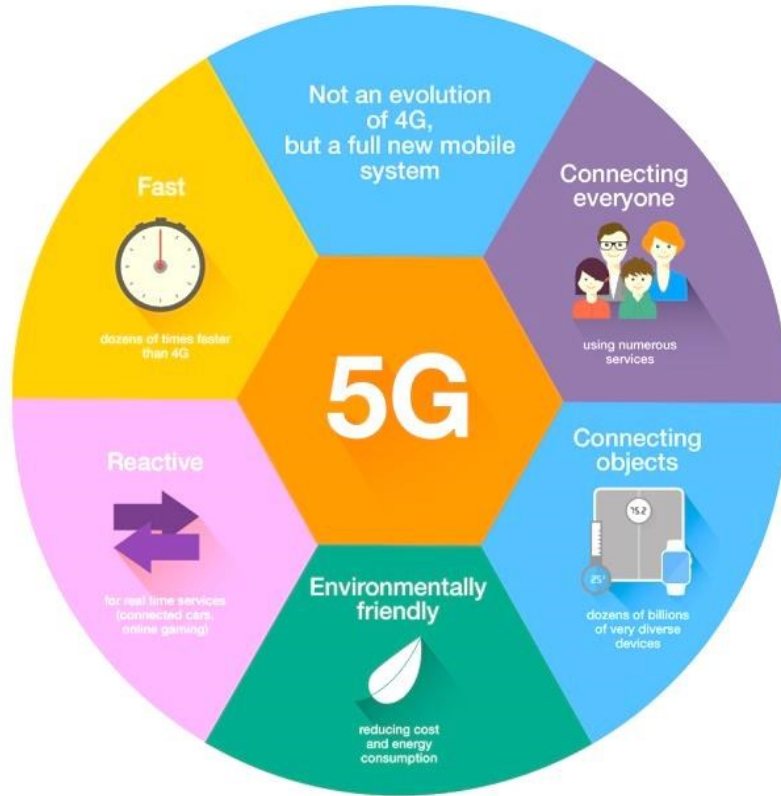
Global initiatives towards 5G



5G overall roadmap



5G key requirements

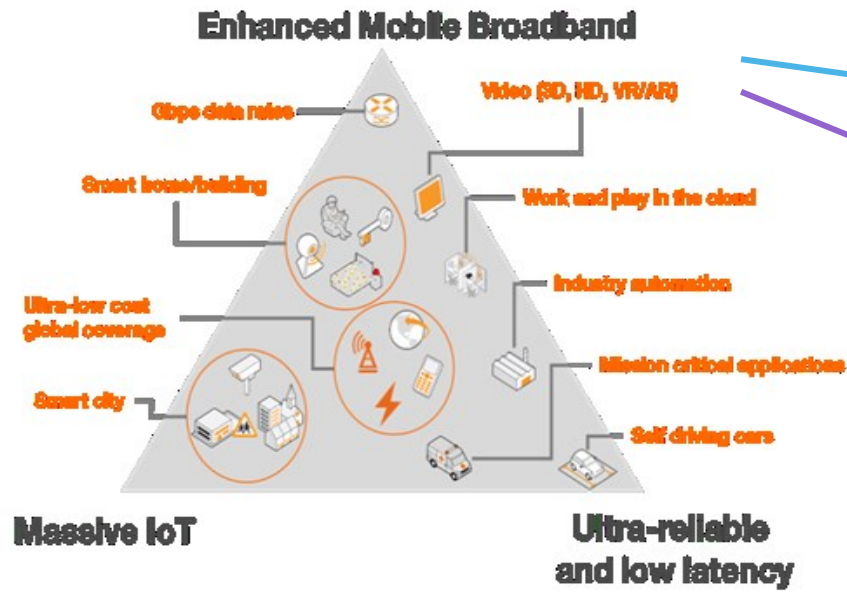


- Low power consumption
- Homogenous user experience
- Support ultra-low cost networks
- Cost efficiency with variable cost model
- Security and privacy
- Flexibility for future evolutions
- Fixed-mobile convergence
- New radio and new architecture/core

Orange 5G

- ❑ new standard => new spectrum, new radio, new features
- ❑ new way of thinking about mobile network design => virtualisation, slicing

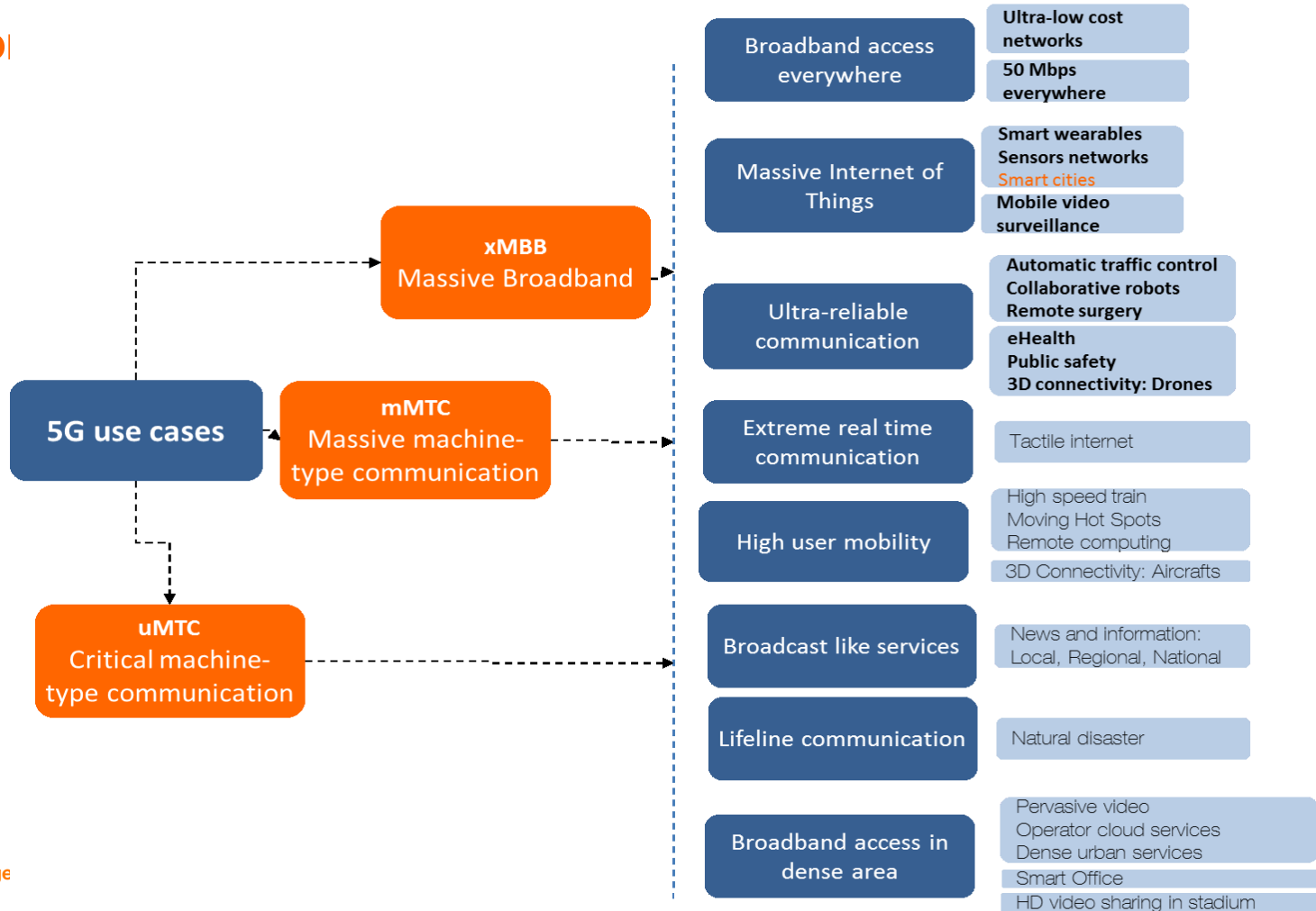
- 5G means :**
- ❑ have more capacity
 - ❑ deploy with more flexibility
 - ❑ Opportunities to launch new services



- eMBB : enhanced Mobile BroadBand**
- ❑ New spectrum / new features
 - ❑ Better coverage, more capacity and speed

- Fixed Wireless Access**
- ❑ New spectrum / new features

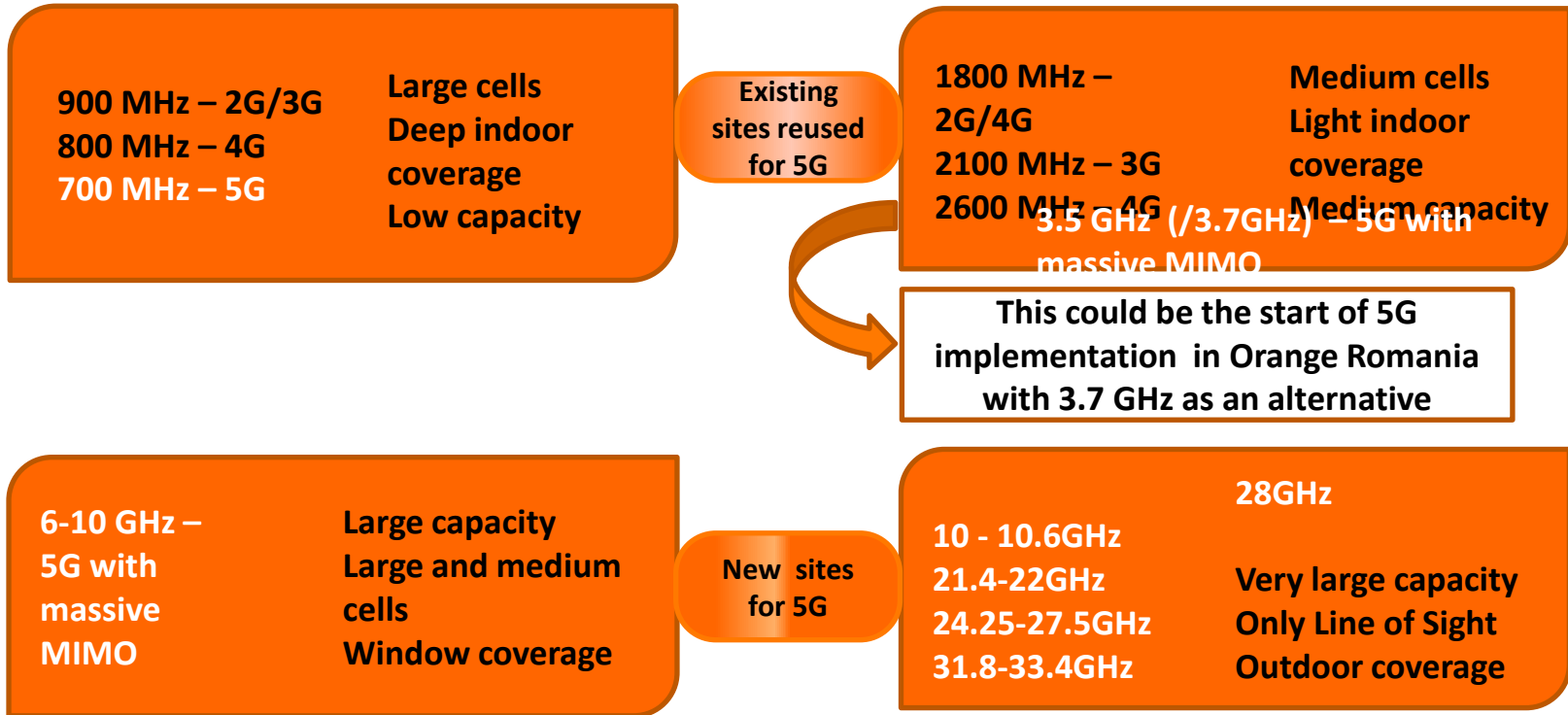
- Specialised Services : V2X , Robotic , ...**
- ❑ New feature URLLC : Ultra Reliable & Low Latency Communication
 - ❑ Better latency, better reliability



User Experience KPI's

	Use case category	User Experience Data Rate	E2E Latency	Mobility	Connection Density	Traffic Density
Broadband access in dense area	Broadband access in dense areas	DL: 300 Mbps UL: 50 Mbps	10 ms	0-100 km/h	200-2500 /km2	DL: 750 Gbps / km2 UL: 125 Gbps / km2
	Indoor ultra-high broadband access	DL: 1 Gbps UL: 500 Mbps	10 ms	Pedestrian	75,000 / km2	DL: 15 Tbps/ km2 UL: 2 Tbps / km2
	Broadband access in a crowd	DL: 25 Mbps UL: 50 Mbps	10 ms	Pedestrian	150,000 / km2	DL: 3.75 Tbps/ km2 UL: 7.5 Tbps / km2
Broadband access everywhere	50+ Mbps everywhere	DL: 50 Mbps UL: 25 Mbps	10 ms	0-120 km/h	400 /km2 in suburban 100 / km2 in rural	DL: 20 Gbps / km2 in suburban UL: 10 Gbps / km2 in suburban DL: 5 Gbps / km2 in rural UL: 2.5 Gbps / km2 in rural
	Ultra-low cost broadband access	DL: 10 Mbps UL: 10 Mbps	50 ms	0-50 km/h	16 / km2	16 Mbps / km2
High user mobility	Mobile broadband in vehicles (cars, trains)	DL: 50 Mbps UL: 25 Mbps	10 ms	up to 500 km/h	2000 / km2 (500 active users per train x 4 trains, or 1 active user per car x 2000 cars)	DL: 100 Gbps / km2 (25 Gbps per train, 50 Mbps per car) UL: 50 Gbps / km2 (12.5 Gbps per train, 25 Mbps per car)
	Airplanes connectivity	DL: 15 Mbps/ user UL: 7.5 Mbps/ user	10 ms	up to 1000 km/h	60 airplanes per 18,000 km2	DL: 1.2 Gbps / plane UL: 600 Mbps / plane
Massive Internet of Things	Massive low-cost/long-range/low-power MTC	Low: 1-100 kbps	seconds to hours	0-500 km/h	Up to 200,000 / km2	Non critical
	Broadband MTC	See the requirements for the Broadband access in dense areas and 50+Mbps everywhere categories				
Extreme real time communication	Ultra-low latency	DL: 50 Mbps UL: 25 Mbps	<1 ms	Pedestrian	Not critical	Potentially high
Lifeline communication	Resilience and traffic surge	DL: 0.1-1 Mbps UL: 0.1-1 Mbps	not critical	0-120 km/h	10,000 / km2	Potentially high
Ultra-reliable communication	Ultra-high reliability & Ultra-low latency	DL: 50 kbps - 10 Mbps UL: few bps - 10 Mbps	1 ms	0-500 km/h	Not critical	Potentially high
	Ultra-high availability & reliability	DL: 10 Mbps UL: 10 Mbps	10 ms	0-500 km/h	Not critical	Potentially high
Broadcast like services	Broadcast like services	DL: Up to 200 Mbps UL: 500 kbps	<100 ms	0-500 km/h	Not relevant	Not relevant

Radio spectrum aspects (frequency recommendation and regulations)



Highlights

5G will bring

- **new standard => new spectrum, new radio, new features**
- **new way of thinking about mobile network design => virtualization, slicing**
- **more capacity**
- **flexibility in deployment**
- **more opportunities to launch new services**
- **ultra low latency**
- **connect things to super-networks**
- **higher number of connected devices**
- **low power consumption**

5G Use Cases family

Broadband Access in Dense Areas
service availability in densely-populated areas

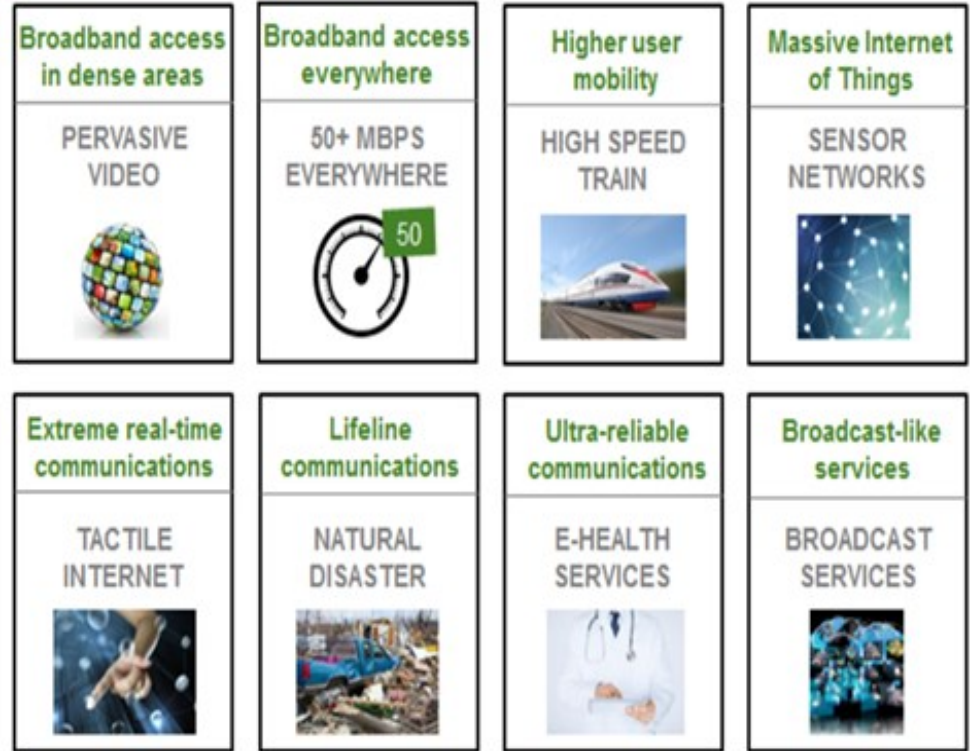
Broadband Access Everywhere
50+ Mbps everywhere at ultra-low cost

Higher User Mobility
services at speeds greater than 500km/h

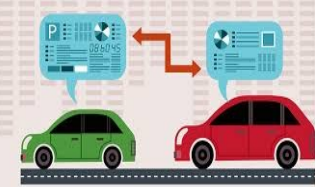
Massive Internet of Things
huge number of devices
@low-cost/long-range/low-power

Extreme Real-Time Communications
autonomous driving & natural disasters


Ultra-reliable Communications
robots control
e-Health



5G Requirements




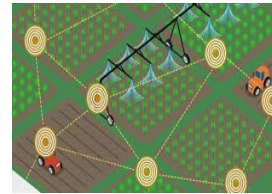
5ms
99.999%




1ms
99.999%



DL: 100Gbps/km²
UL: 50Gbps/km²
500km/h



DL: 300Mbps
UL: 60Mbps
200.000 devices/km²



200.000 devices/km²
0.3-20 Mbps
0.1-10 Mbps/m²

5G Design Principles

Radio

- Leverage spectrum
- Dense deployments, mMIMO, CA
- Dynamic Radio topology
- New Radio Interface

Network

- Common Core
- Network Slicing
- Facilitate XaaS, NGCN
- Exposed Network APIs

O&M

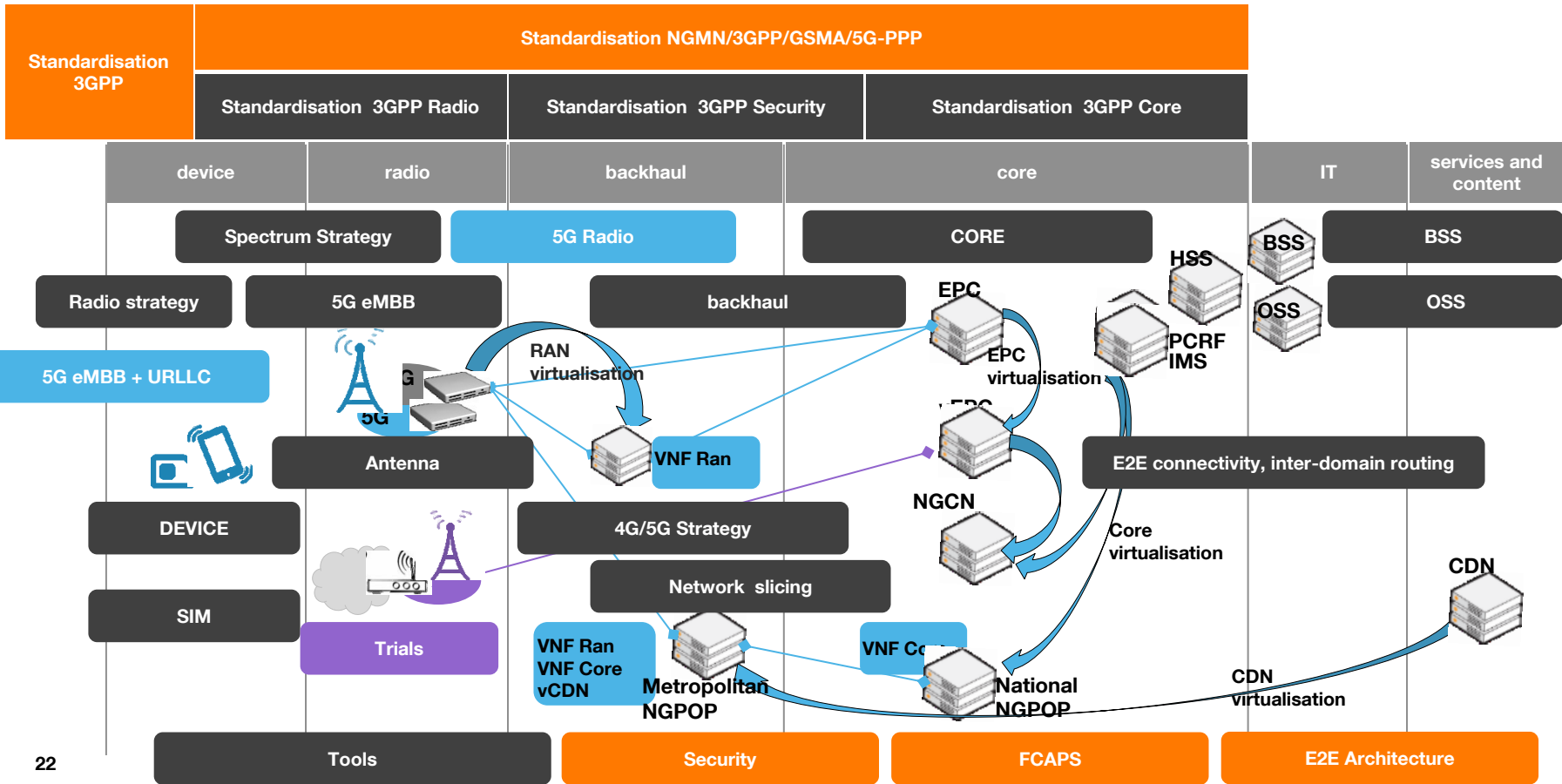
- Simplified O&M
- Programmability
- Security & Privacy
- Service Based Architecture
- FCAPS

Cloud

- Native Environment
- Radio Cloud, Edge
- D-RAN, C-RAN, MEC
- MEC
- IoT platforms

Efficiency: Power, Latency, Resiliency, Secured ICT, Costs

5G Technical Transformation



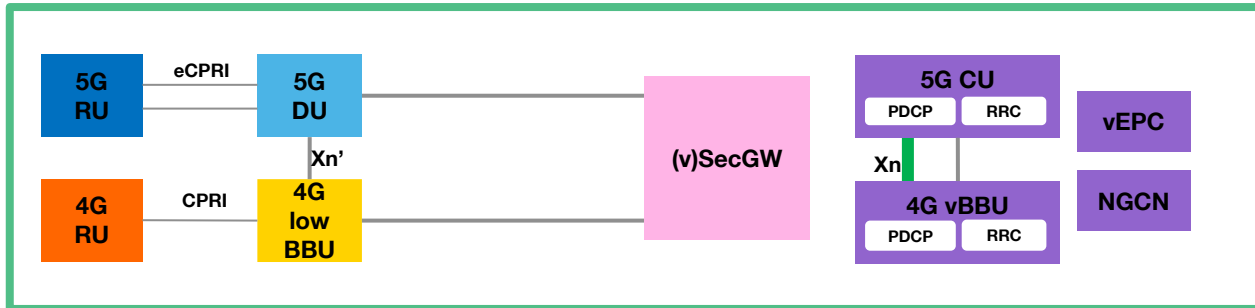
RAN Transformation

Frequency Bands

- Sub 1GHz: 700 MHz (FDD)
- Between 1-6 GHz: 3.4-3.8 GHz (TDD)
- Above 6GHz: 26 GHz (TDD)
- Others LTE bands

Hardware baseband

- Distributed Unit
- Central Unit

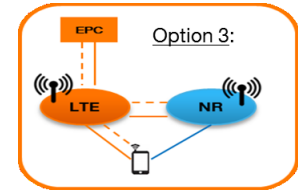


RAN virtualization

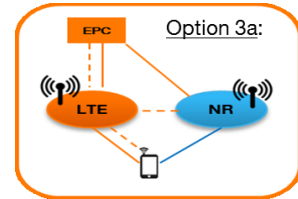
- 5G RAN virtualization
- 4G legacy RAN
- 4G virtualized RAN
- VNF integration in NGPoP
- Slicing

Carrier Aggregation

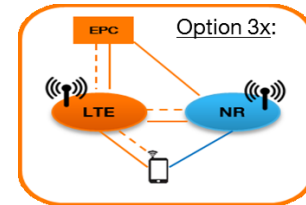
- Scenarios as CA and DC
- LTE-NR coexistence



managed by the LTE
EPC has no view of the 5G RAN



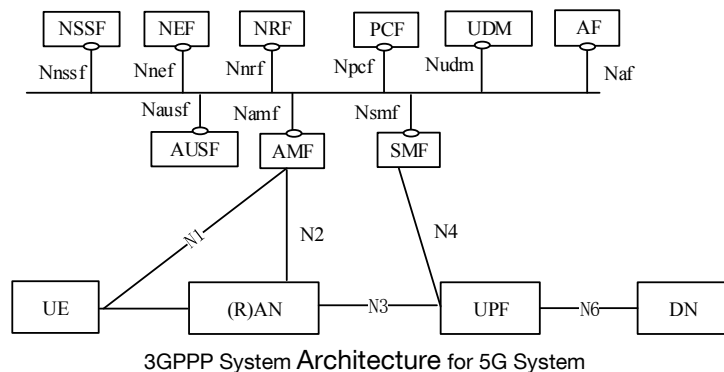
CP managed by tLTE
EPC connected to 5G RAN



CP managed by LTE
EPC connected to t 5G RAN for UP.
LTE manages the 5G traffic in mobility

Core Transformation

NG CN Control Plane



5G Control Plane Network Functions

AUSF	Authentication Server Function
AMF	Core Access and Mobility Management Function
DN	Data network
NEF	Network Exposure Function
NRF	NF Repository Function
NSSF	Network Slice Selection Function
PCF	Policy Control function
SMF	Session Management Function
UDM	Unified Data Management

Main Requirements

- Service Based Architecture
- Interfaces and Protocol stacks
- Slicing and Virtualization
- PCF functions and procedures
- 5G QoS Model based on flows
- QoS Flow Indicator
- Flexibility adaptability, fast deployment
- Services discovery, on demand networks
- Interoperability
- Green solutions

Key principles

- Network Control Functions
- Network Control Entities
- API & Interfaces

Architectural Options

E2E Vision

○ Phase 1

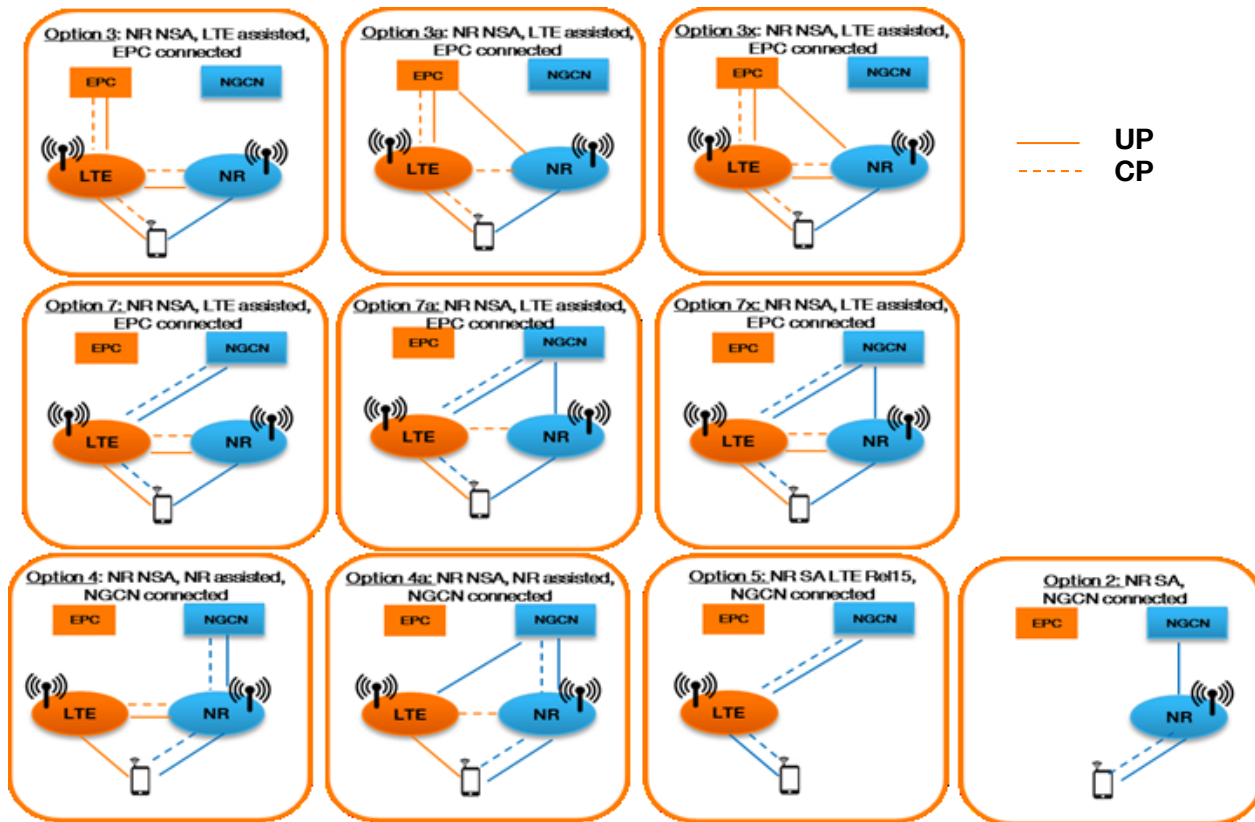
- Non-Standalone Architecture(NSA)

○ Phase 2

- Dependency of terminals
- Dependency of NGCN

○ Phase 1 to phase 2 transition

- Starting NSA Option 3
- Migrate to SA architecture



Automation and Programmability

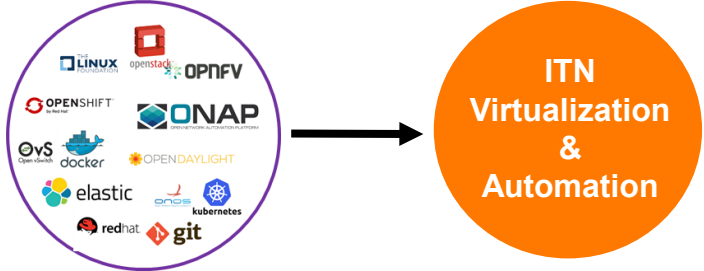
From dedicated network functions

to Software network functions

service configuration



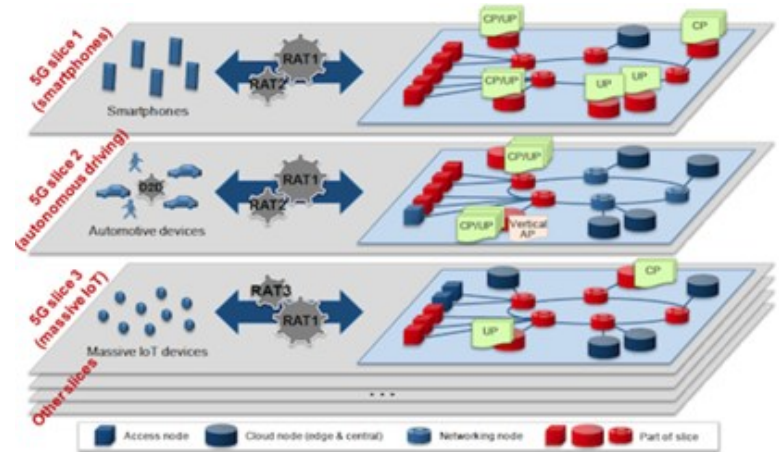
Business Model	<p>Online Self Services</p> <p>Real time customer journey</p> <p>Transformation through automation</p>
Network	<p>Fast deployment</p> <p>Reduce Time-to-Market</p> <p>Savings-> reducing costs of operations</p>



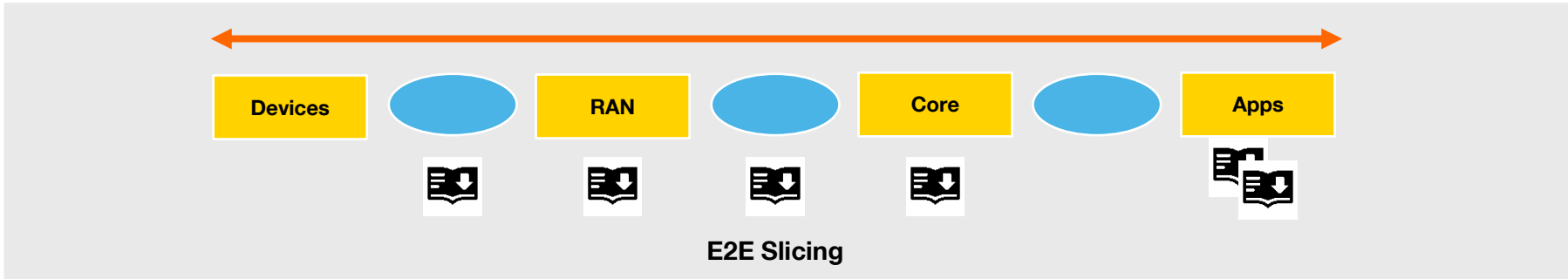
5G Network Slicing

Economic context for deploying

- One big network for all services types
- Separate dedicated core networks per service type
- Network slice per service type (Service n slice)
- E2E network resources to fulfil the connectivity requirements for service categories (eMBB, mIoT, URLLC)
- Network slice at Core Network Control Plane and User Plane Network Functions
- 5G Radio Access Network

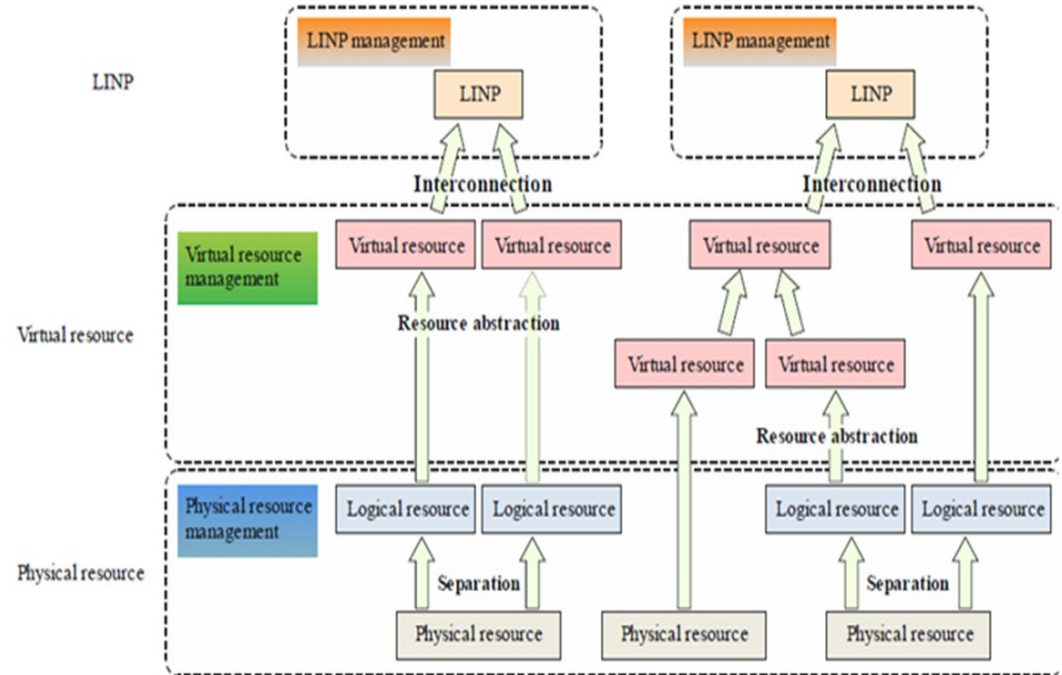


NGMN



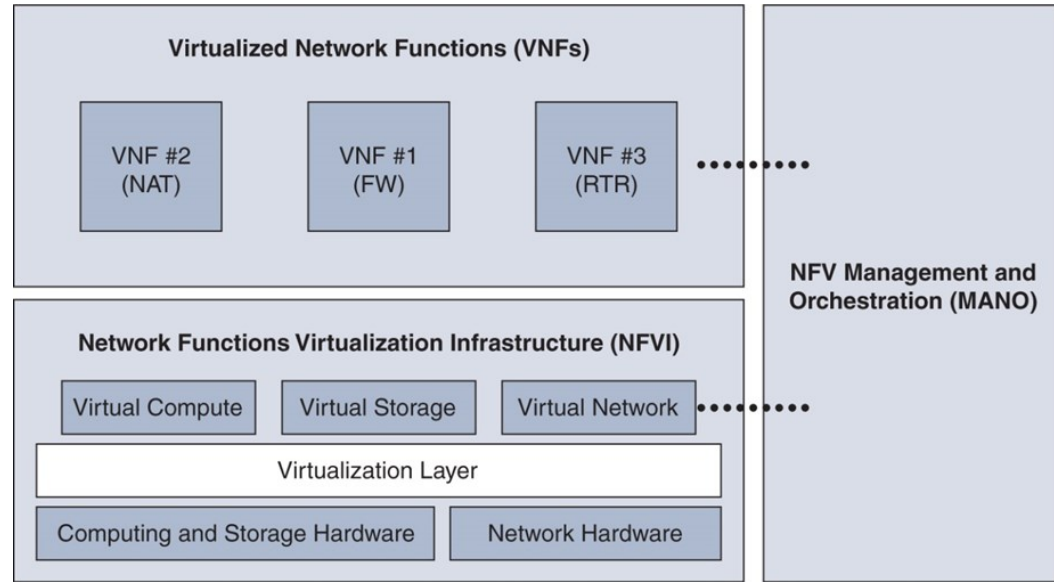
Standards references

- 5G networks requires specific network virtualization functions and implementations
 - Resources and resource management
 - Physical
 - Virtual
 - Security and isolation of network partitions
 - Management of logically isolated network partition
 - Service management
 - FCAPS capabilities
- Multiple virtual networks, logically isolated, to be deployed over single physical network
- Computing resources
 - Processing CPU
 - Memory
 - Storage



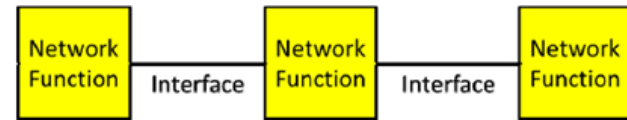
- **NFVI architecture, based on**

- compute domain
- hypervisor domain
- OSS/BSS

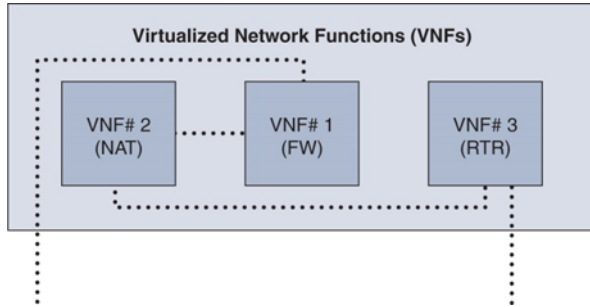


- **Functional blocks**

- Input interface
- Internal state
- Output interface
- Transfer function: tuple: input and current state -> output and next state



Transit to virtualization



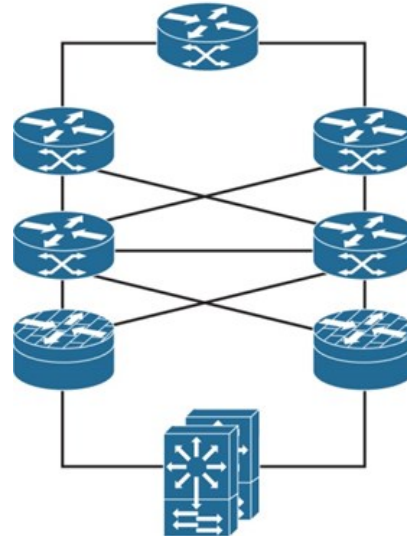
Separate Appliance for each Function

Proprietary Software:
Designed to Run on Custom Hardware

Proprietary Hardware:
Custom FPGA/ASIC/Optics/CPU ...

Fixed Network Function

Limited Scalability:
Physical Space and Power Limitations



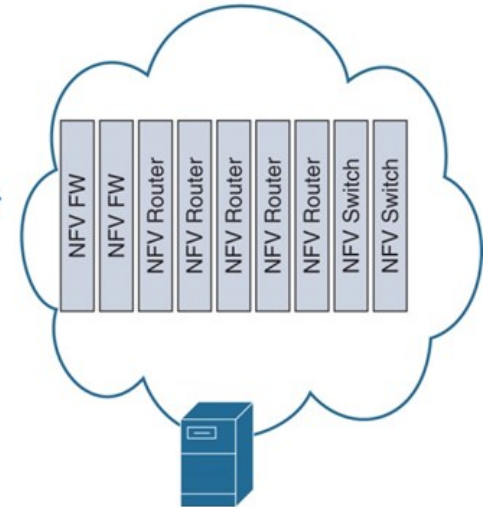
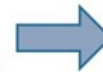
Virtualized Function on High Capacity Device

Software with Open APIs
Designed to Run on **Generic** Hardware

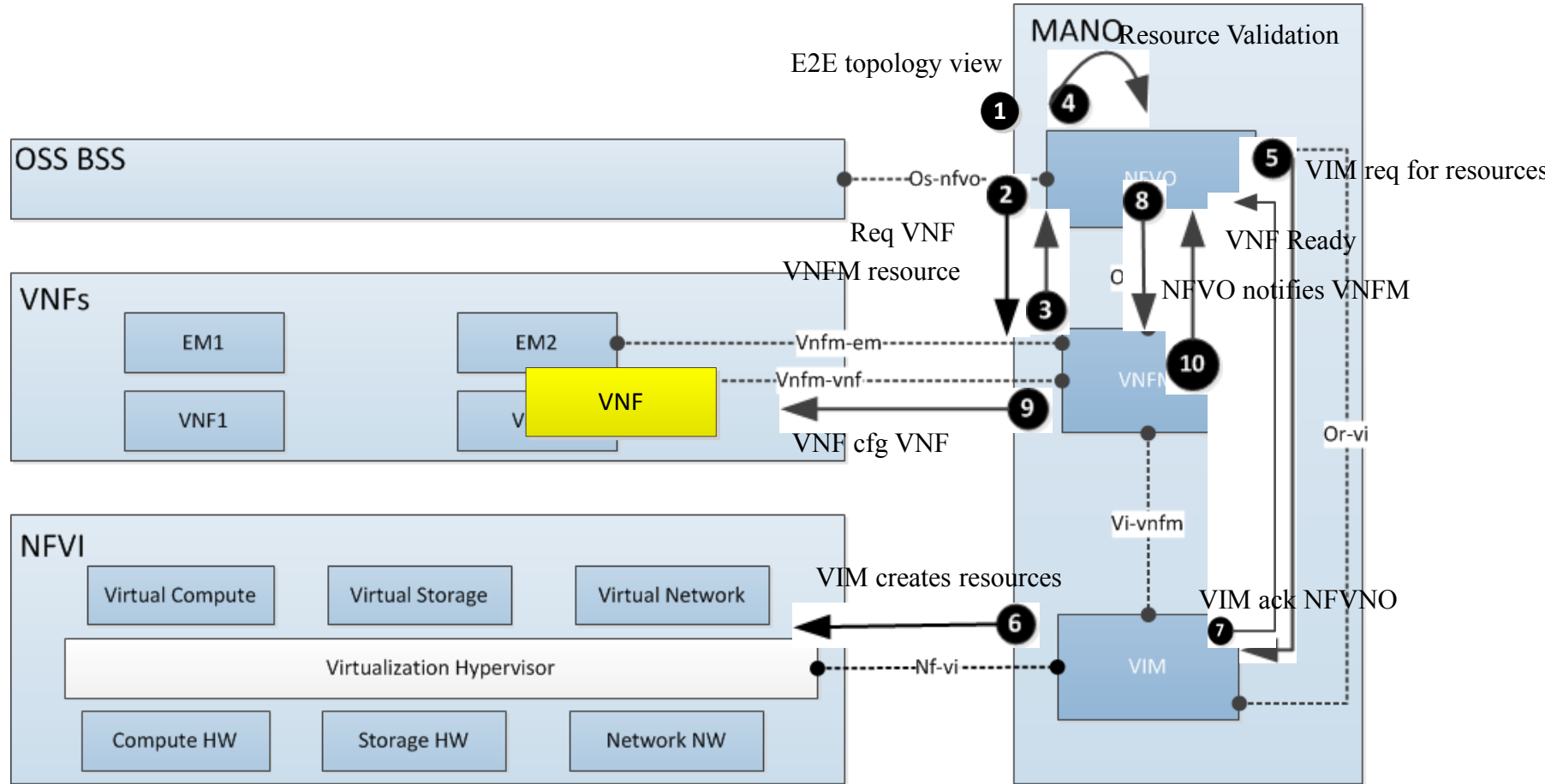
Generic (COTS) Hardware:
Standard FPGA/ASIC/Optics/CPU ...

Flexible Network Function

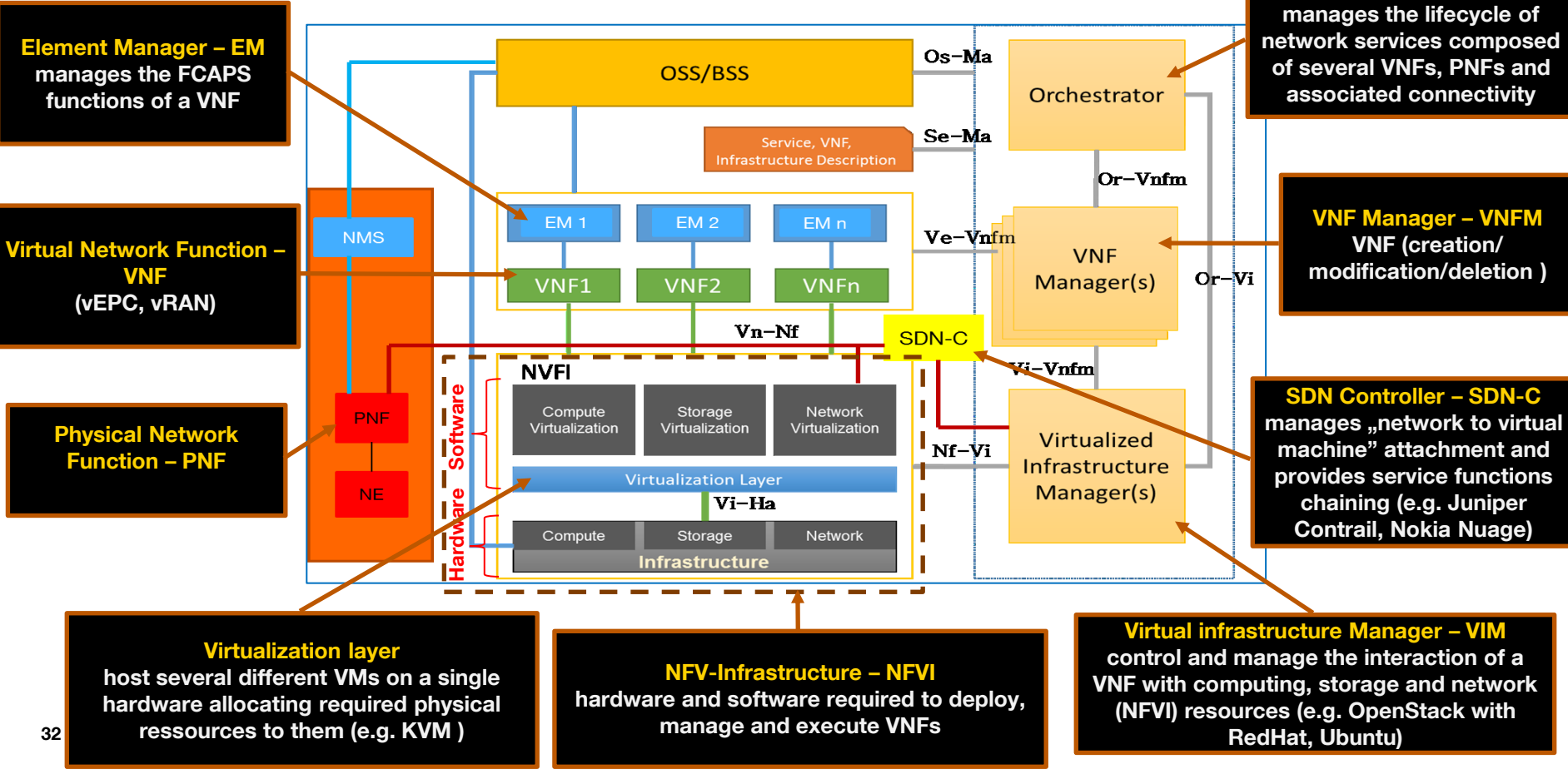
Cloud Scale:
Span Across Multiple Locations



MANO Architecture & Interfaces



ETSI NFV/VNF Architecture



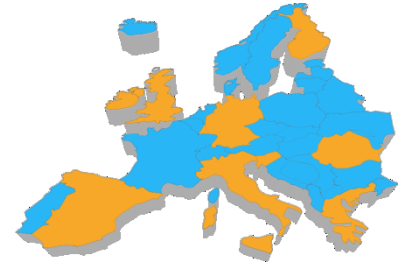
5G PPP Research Activities

H2020



MATILDA

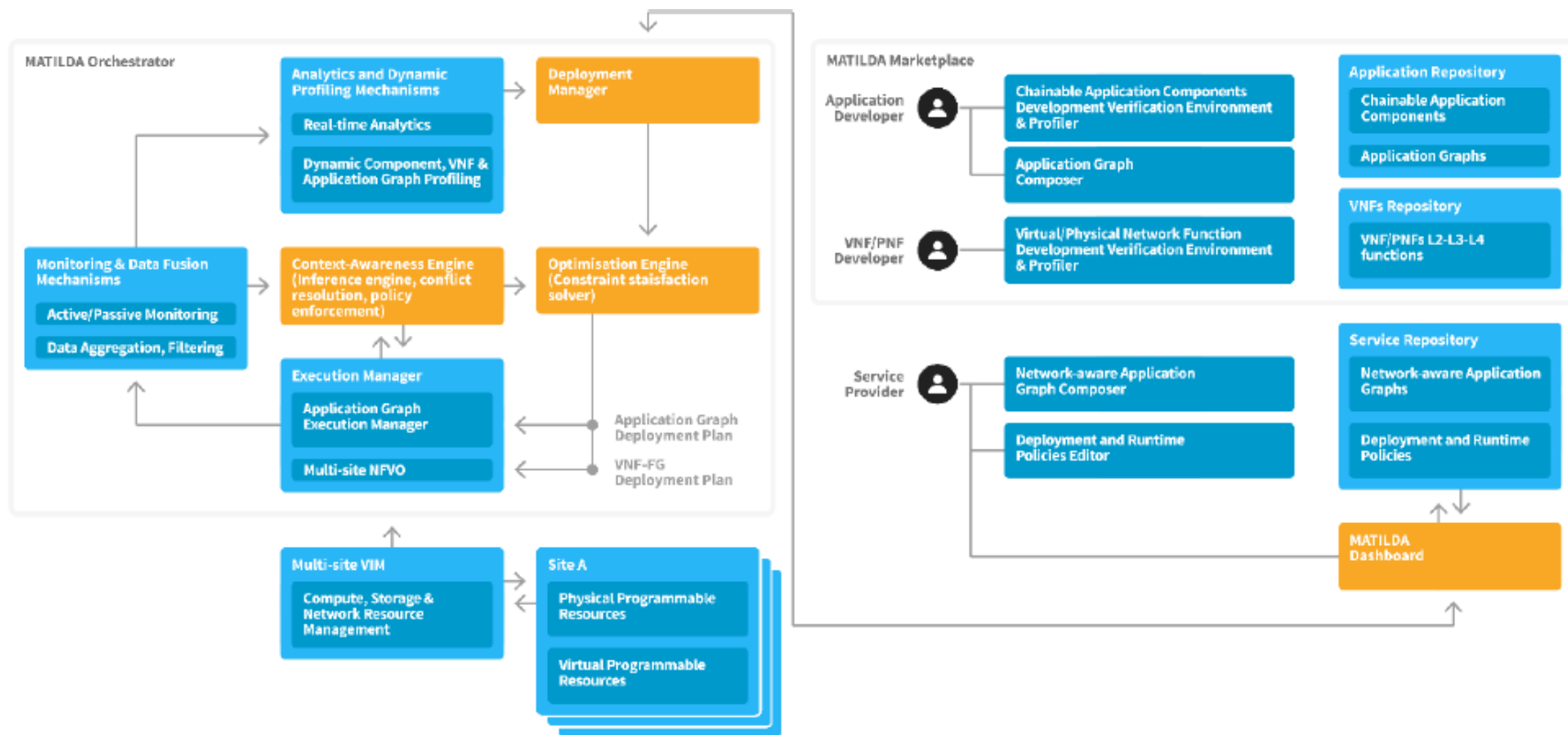
A holistic, innovative framework for the design, development and orchestration of 5G-ready applications and network services over sliced programmable infrastructure.



The vision of MATILDA is to design and implement a holistic 5G end-to-end services operational framework tackling the lifecycle of design, development and orchestration of 5G-ready applications and 5G network services over programmable infrastructure, following a unified programmability model and a set of control abstractions.

H2020 Project, Grant no: 761898, with 18 partners from 11 countries, the total project budget being at 6.6M Euros and ORO effort is evaluated is 60PMs (<http://www.matilda-5g.eu/>)

Vision & high level architecture



ORO role

- **One of the 2 telecom providers (the other one is Cosmote Greece)**
- **Leverages its knowledge on smart city vertical**
- **Brings technological resources: Core EPC infrastructure, 4G RAN eNodeBs, Wi-Fi GW, IP/MPLS network, vEPC, vFirewalls, vLoadBalancer**
- **Involved in 6 WPs out of 8**
- **Leading 3 tasks**
- **Task 6.1 Demonstrators Planning and Validation Scenarios**
- **Task 6.6 Smart City Intelligent Lighting System Vertical**
- **Task 7.4 IPR Handling and Innovation Management (ORO, M1-M30)**
- **Responsible for 1 deliverable - Smart City Intelligent Lighting System Implementation Report**
- **Involved in dissemination**
- **Contribution & Commitment to 5 GPP**
- **Assures the role of Innovation Manager**

SLICENET

End-to-End Cognitive Network Slicing and Slice Management Framework in Virtualised Multi-Domain, Multi-Tenant 5G Networks.

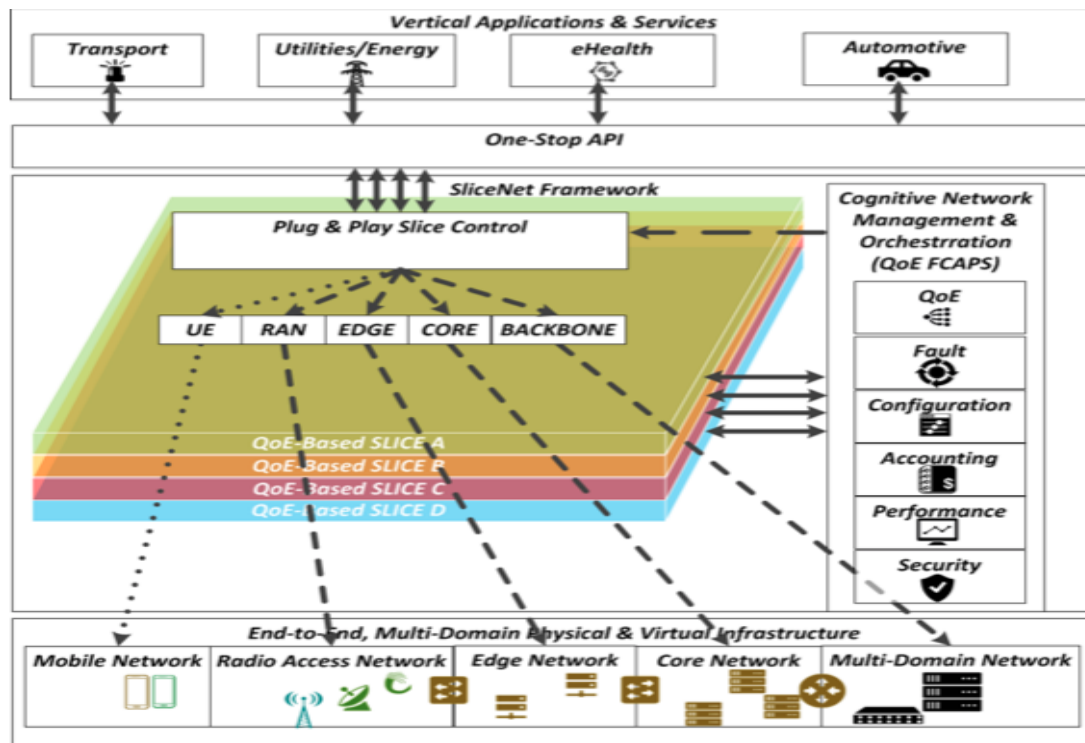


Design, prototype and demonstrate an innovative, verticals-oriented, QoE-driven 5G network slicing framework focusing on cognitive network management and control for end-to-end slicing operation and slice-based/enabled services across multiple operator domains in SDN/NFV-enabled 5G networks.

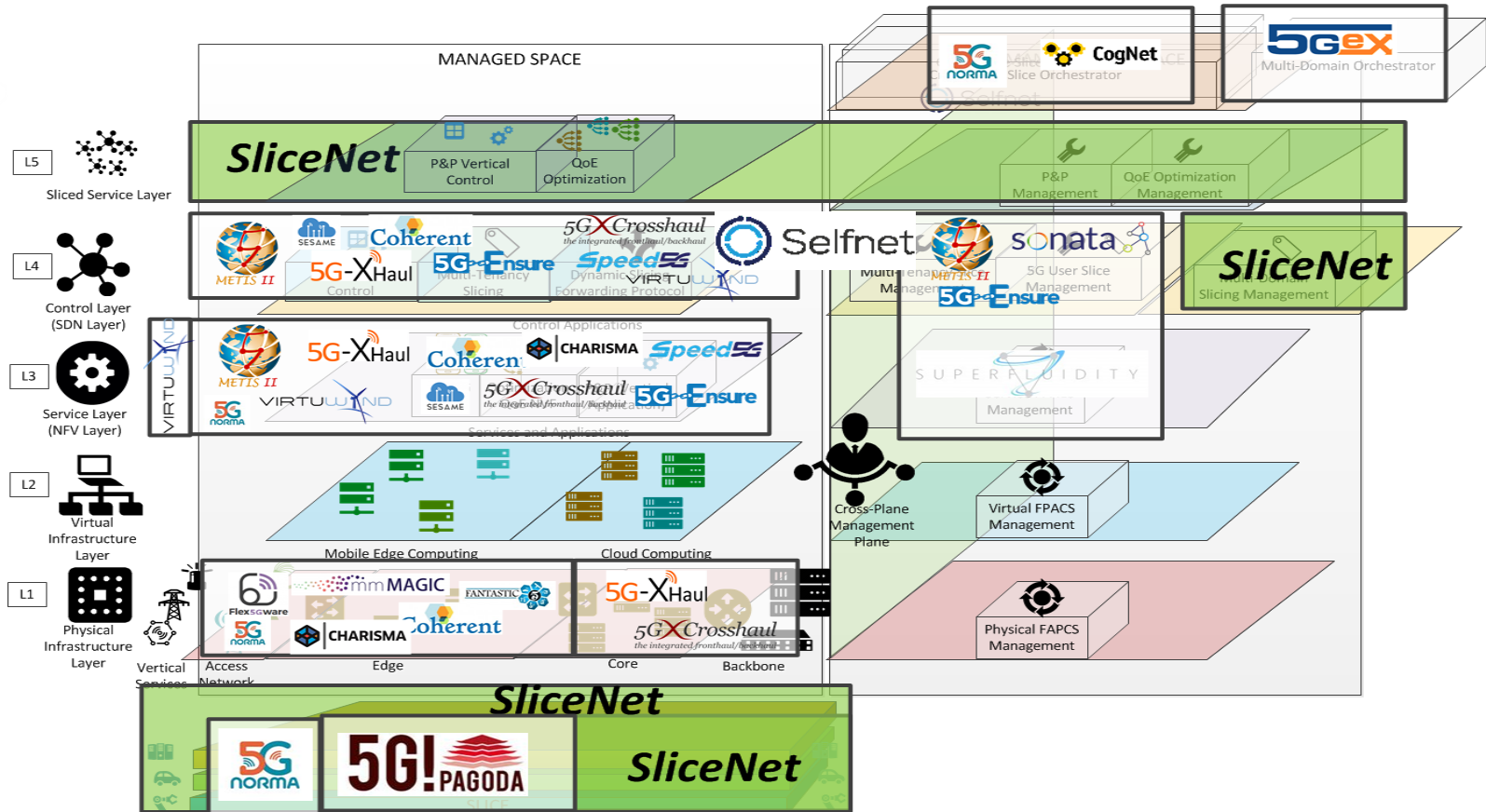
H2020 Project, Grant no: 761913, with 15 partners from 11 countries, the total project budget is 8M Euros and ORO total effort through 36 months of project work is 83PMs (<https://slicenet.eu/>)

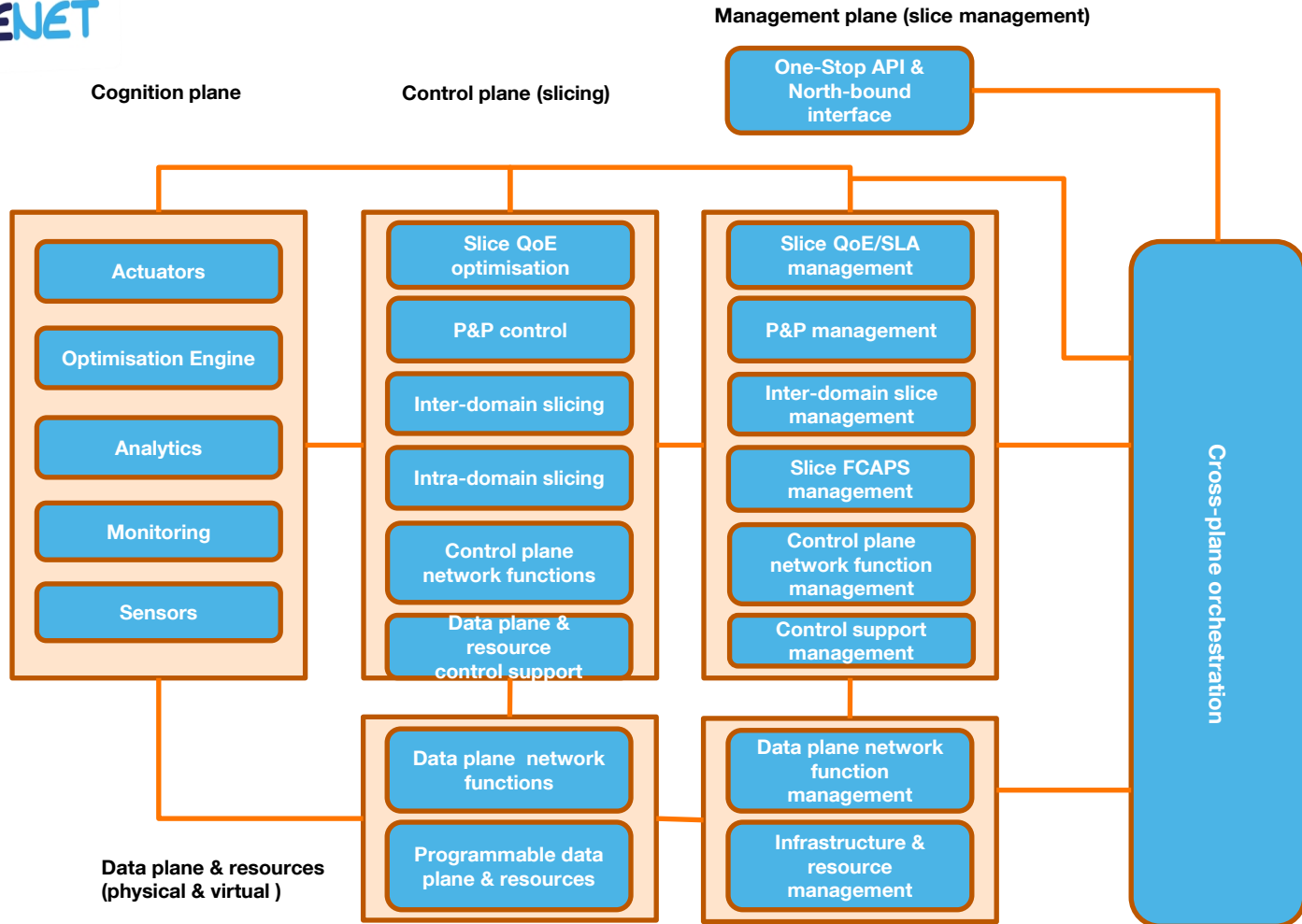
SLICENET Architecture

1. Achieve an innovative, cognitive, integrated **'one-stop shop' 5G slice management framework** for **vertical businesses** and co-designed by vertical sectors
2. Enable extensible, **end-to-end slice FCAPS management** across multiple planes and operator domains
3. Establish **cognitive, agile QoE management of slices** for service assurance of vertical businesses
4. Empower **orchestration** for cross-plane coordination of management, control, service and data planes to achieve **system-level slicing** control and slice operation

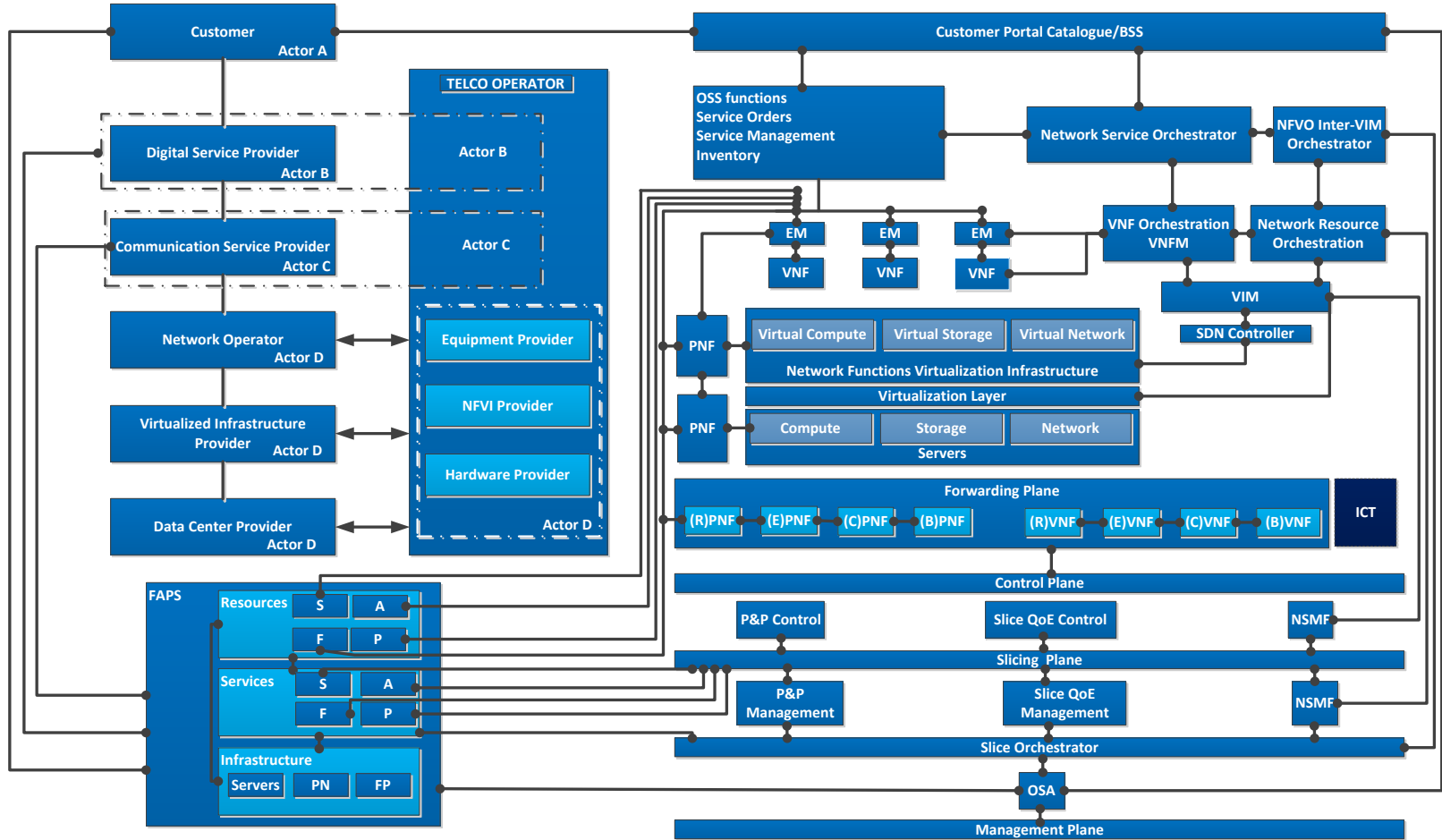


SLICENET 5G-PPP working group

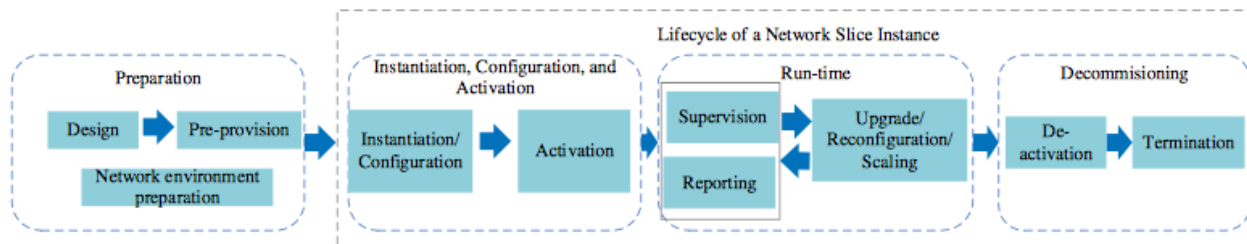
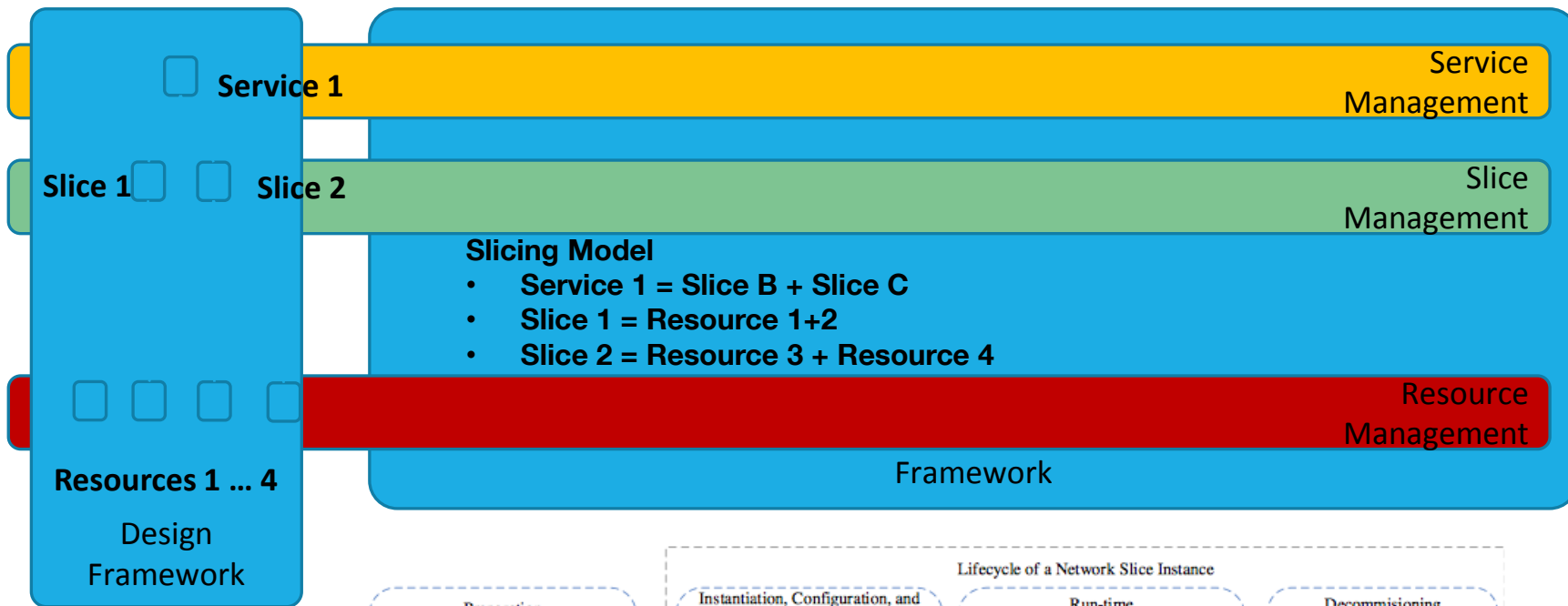




SLICENET Architecture



5G Slicing model



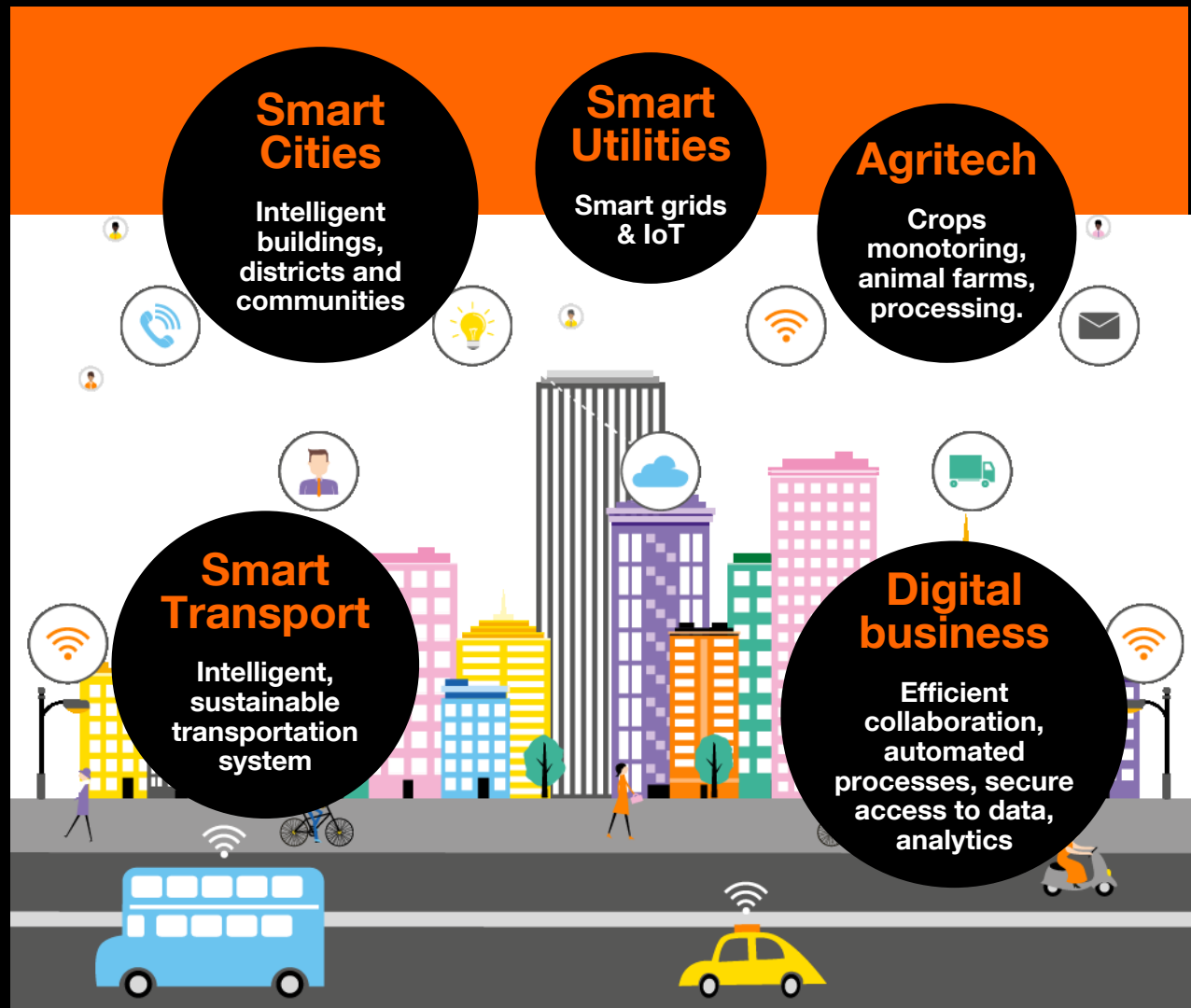
3GPP TR 28.801

Alba Iulia Smart City



Orange combines the strength of an **operator** and the expertise of a specialized **digital services company** to ensure the **successful** design, development, implementation and operation of your **Smart Territories program**.

Our services cover intelligent businesses, communities and cities.



open framework architecture for co-innovation and urban collaboration.

Smart Territories Dashboard (based on co-developed vertical applications)



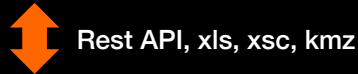
Live Objects IoT middleware

storage

security

processing

visualization



public data sets
data.gov.ro

IoT access for data collection
using 2G/3G/4G, Wi-Fi, Bluetooth, LoRa, LTE-M

sensor

sensor

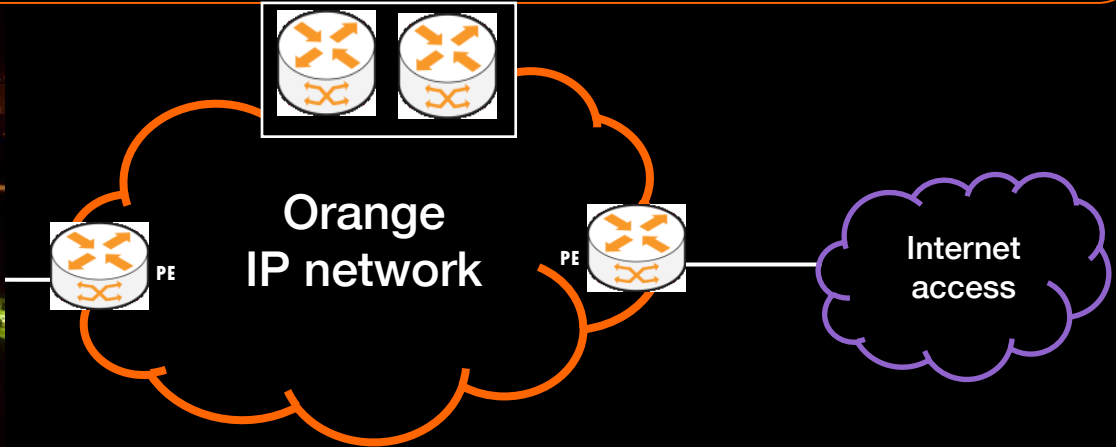
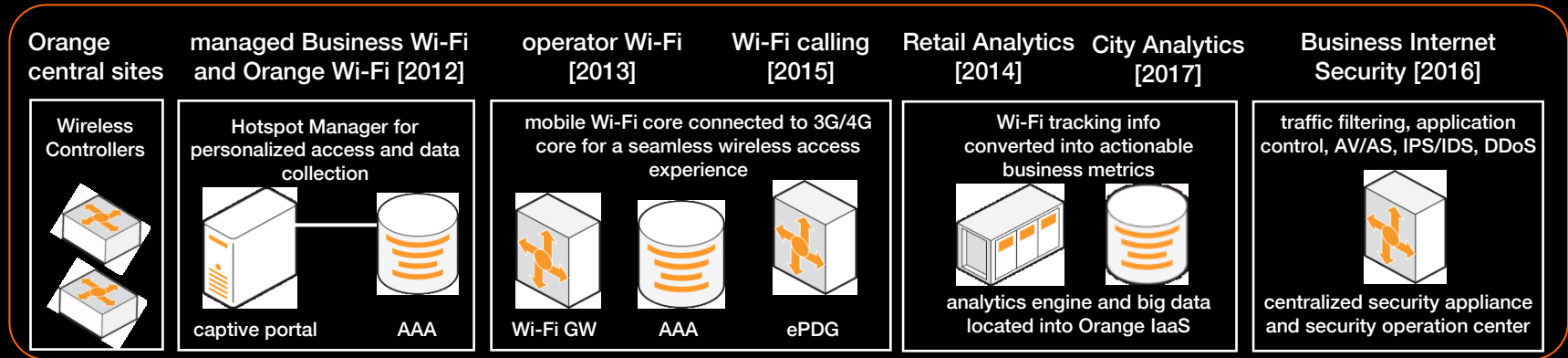
sensor

sensor

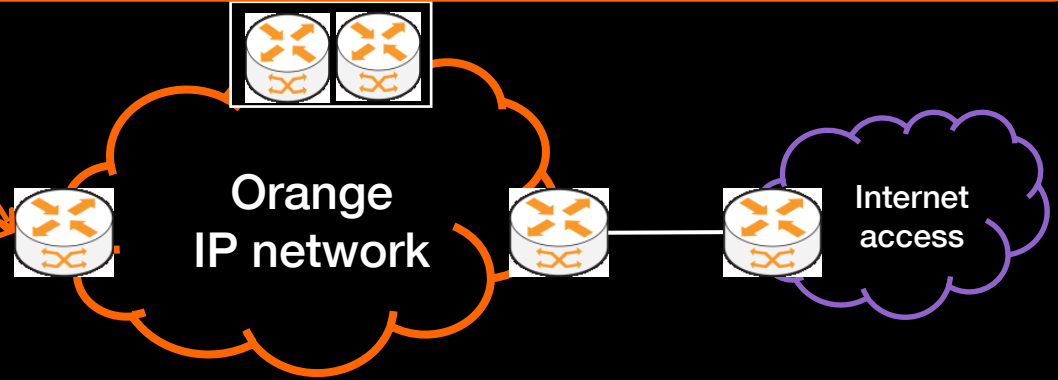
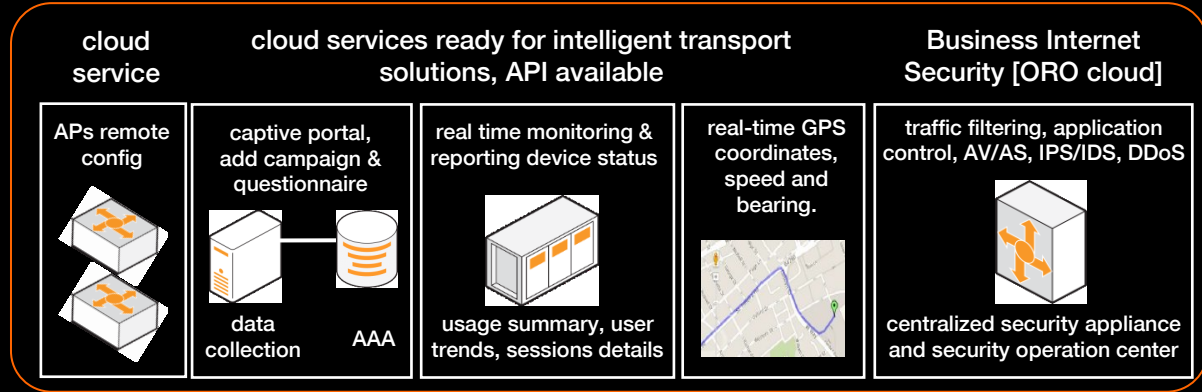
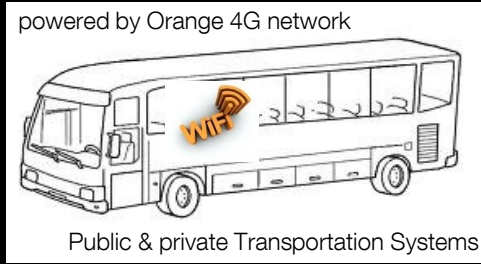
sensor

sensor

observe, anticipate, simplify and build for future needs



integrated, security by design to cross-sell other services



from connectivity to data collection for customer engagement citizen polling through public Wi-Fi

1 Wi-Fi AP per bus with Orange 4G backhaul, 15 buses

enhanced users experience during bus travel

opening the door for a new set of on-board value added services

public interest information dissemination, collection and analytics based on on-line questionnaire

real time analyzes with bus dispatch, occupancy and location

safe internet surfing, secured access to digital content and public services, as well as to the preferred applications on smartphone, tablet or laptop

unlimited connexion (time or traffic)



Civic Alert – a crowd information platform for reporting & tracking the problems in the city

reported alerts are processed by the operators and sent to the right public institutions

requires civic participation and follow-up from public institutions



26,127 all cases

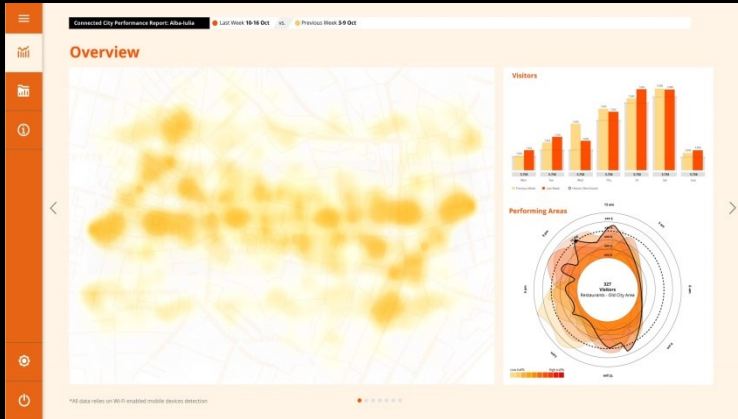
18,414 all cases in handling

10,164 authorities responses

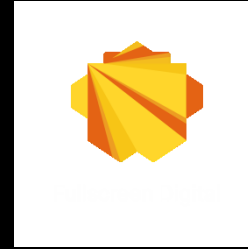
996 solved cases

<http://www.civicalert.ro>

from networks to big data analysis for public service optimization connected City Analytics



we use **Wi-Fi tracking technology, triangulation,** and **device detection** to create **real-time analytics** around visitors patterns and match these with other public services specific information to **improve Alba Iulia brand awareness** and boost citizens & visitors interactions with local authorities



Innovation partner
Innovation Labs 2014 winner



> **55%** of citizens & visitors will be anonymously monitored

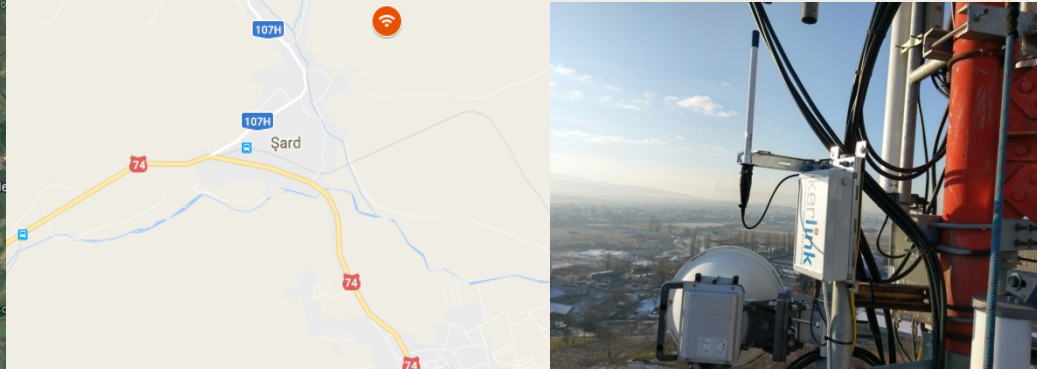
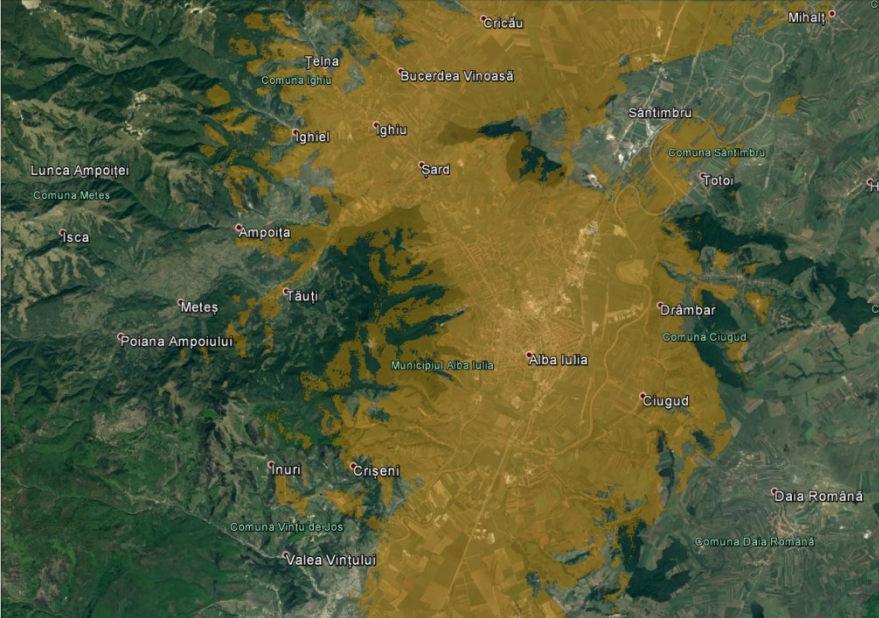
LoRaWAN infrastructure to address short term opportunities considering also the available applications and modules ecosystem



testing lighting control, energy sub-metering and water metering for optimizing energy and water consumption + air quality

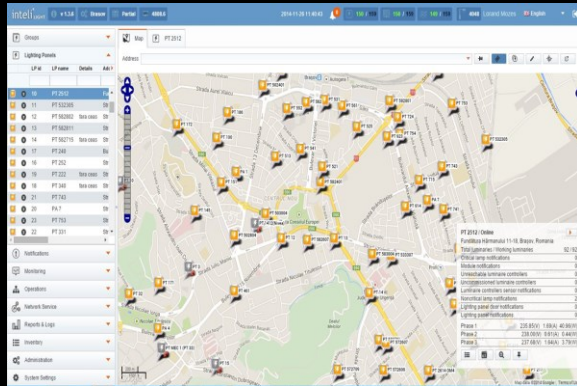
LTE-M to address most of IoT use cases while its roll-out expected starting with 2018 will have little impact on the network





from sensors to operational data for efficient resource planning

LoRaWAN for IoT applications and devices



from offline to online for e-Governance & Electronic Direct Democracy

iBeacons for augmented real life experiences

225 strategic
tourist spots
and other
places in Alba
Iulia are
promoted with
beacons

visit the most beautiful Vauban-style
citadel in Romania



Alba Iulia
becomes a
national
example and
a landmark in
tourism
innovation

digital class room

a complete solution for education



Innovation Labs 2017

Dedicated Internet Access



Business Internet Security



Business Wi-Fi



Smart Board



Laptop, tablet, smartphone



Smart Printing



Video surveillance



e-learning apps
training virtual class



Videoconferencing
Collaboration



Alba Iulia:
Universitatea "1 Decembrie 1918"
Grupul Scolar "Horea, Closca si Crisan"
Colegiul Economic "Dionisie Pop Martian"

Smart City enablers




Internet gratuit în mișcare
în **Orange Wi-Fi Zone**



Air Quality Monitoring



CIVICALERT



**Azi la Innovation Labs,
măine în Silicon Valley**

Tehnologie

Mentorat și workshopuri

Dezvoltare și testare de prototipuri

Înscrie-ți proiectul până pe 3 martie
www.innovationlabs.ro

orange® It's all about what matters to you

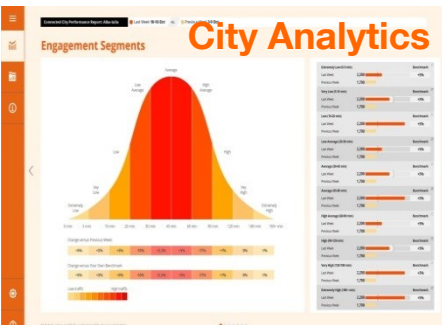
Orange Joins LoRa Alliance™



SEMTECH

A World of Solutions™

Engagement Segments **City Analytics**



City Analytics dashboard showing engagement segments and various data points.

Beacons for Smart Cities



Effective public services & interactive experiences for citizens
by using micro-location, presence detection



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Business Internet Security

- Identifying threats
- Blocking attacks
- Safe web

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Thank You!

And remember:

be faster than competition!

