Telecommunication Infrastructures and Services for Smart Metropolitan and Urban Areas: The Opportunities Offered by 5G and Satellite Technologies

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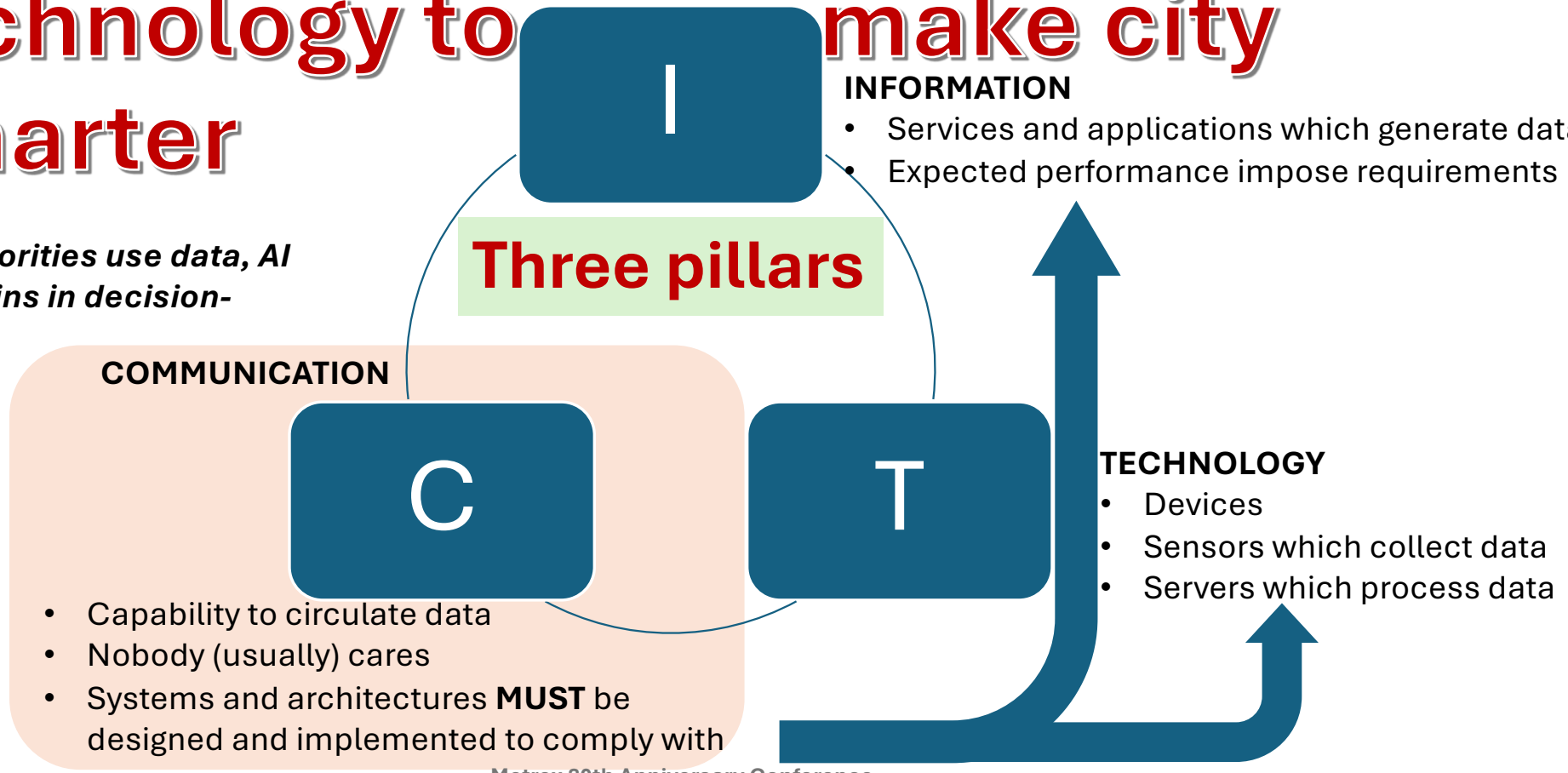
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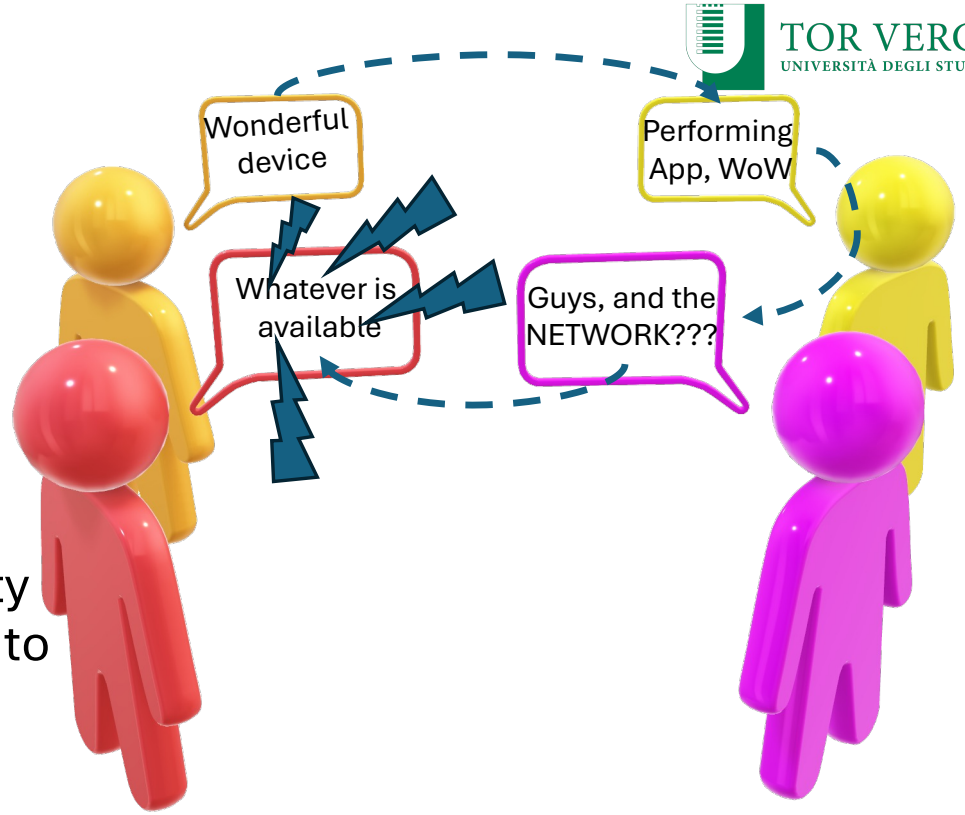
METREX 30
1996 — 2026

Information and Communication Technology to make city smarter

How can authorities use data, AI and digital twins in decision-making?



Usual daily talks



- Services and applications
- Devices

…… but ……

- nobody cares that for full exploitation of such technologies and to get full capability of utilizing **DATA** they **MUST** circulate and to this aim we need (efficient) **telecommunication infrastructures**
- The important is the **peak data rate** ➡️ **NO**, it is important the **capability** of the network **to satisfy service requirements** that imply to guarantee also Quality of Service (**QoS**), other than **throughput**, **delay**, **security**, **flexibility**, **multiple connectivity**, etc.

NO (adequate) infrastructure ➡️ **NO services**

AI utilization and need for telecom infrastructure

	Today	2030
Smartphone users adopting and using Agentic AI	4%	38%
Daily use of AI	50%	67%
AI super users	10%	30% (generating 80% of AI derived activities). Each AI superuser may use AI for 5.5 h/day, 5+ applications, 60 activities/day, 15 uploads/day, interactions with 4 devices in three locations.
China, India, Indonesia and Thailand		40% of daily AI users (global average 30%)
Italian smartphone users using AI	38%	56%
Italian AI superusers	5%	19%
Italian agentic AI users	3%	25%

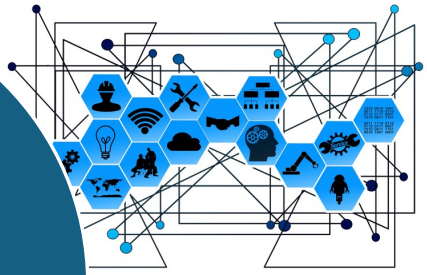
* Based on a study by Ericsson

Italian Ferrovie dello Stato Group generates 4.5 MBytes/s

Data circulation



Sensor networks, cellular devices





Data centers, Edge computers (processing and decision support)



Actions definition

Action Implementation



5G is now deployed

Generation	Technology
1	Analogue
2	Digital, circuit switching, narrow band (GSM)
3	Digital, circuit and IP packet switching, wide band (UMTS)
4	Larger bandwidth and data rate (LTE)
5	Larger bandwidth, SDN, NFV, lower power consumption, billions of connections

Changes

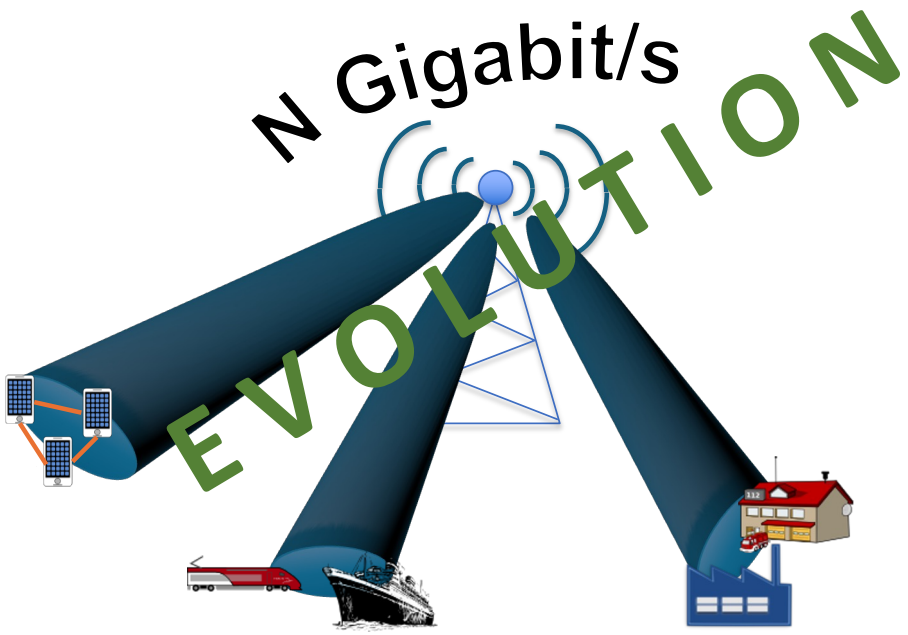
1. **Service based architectures**
   - distributed compute nodes, with network functions and applications dynamically created, moved, deleted
2. **explosion of IoT and M2M comms**
   - effective authentication, naming, addressing, routing and related functions for a vast number and kind of terminals
3. **vertical sectors (Automotive, Industry 4.0, Entertainment, Energy and E-health)**
   - transport and computing services as virtual distributed computers under complex SLAs

KPIs

- 1000 times higher mobile data volume per geographical area.
- 10 to 100 times more connected devices.
- 10 to 100 times higher typical user data rate.
- 10 times lower energy consumption.
- End-to-End latency of < 5ms.
- Location precision < 3m
- Mobile speed up to 500 km/h
- Ubiquitous 5G access including low density areas.

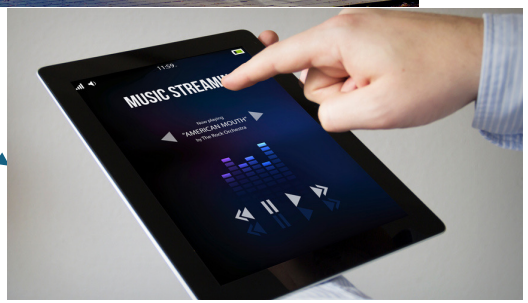
One of the most significant strategic opportunities

5G ultra-fast and global wireless access technology (RAN)







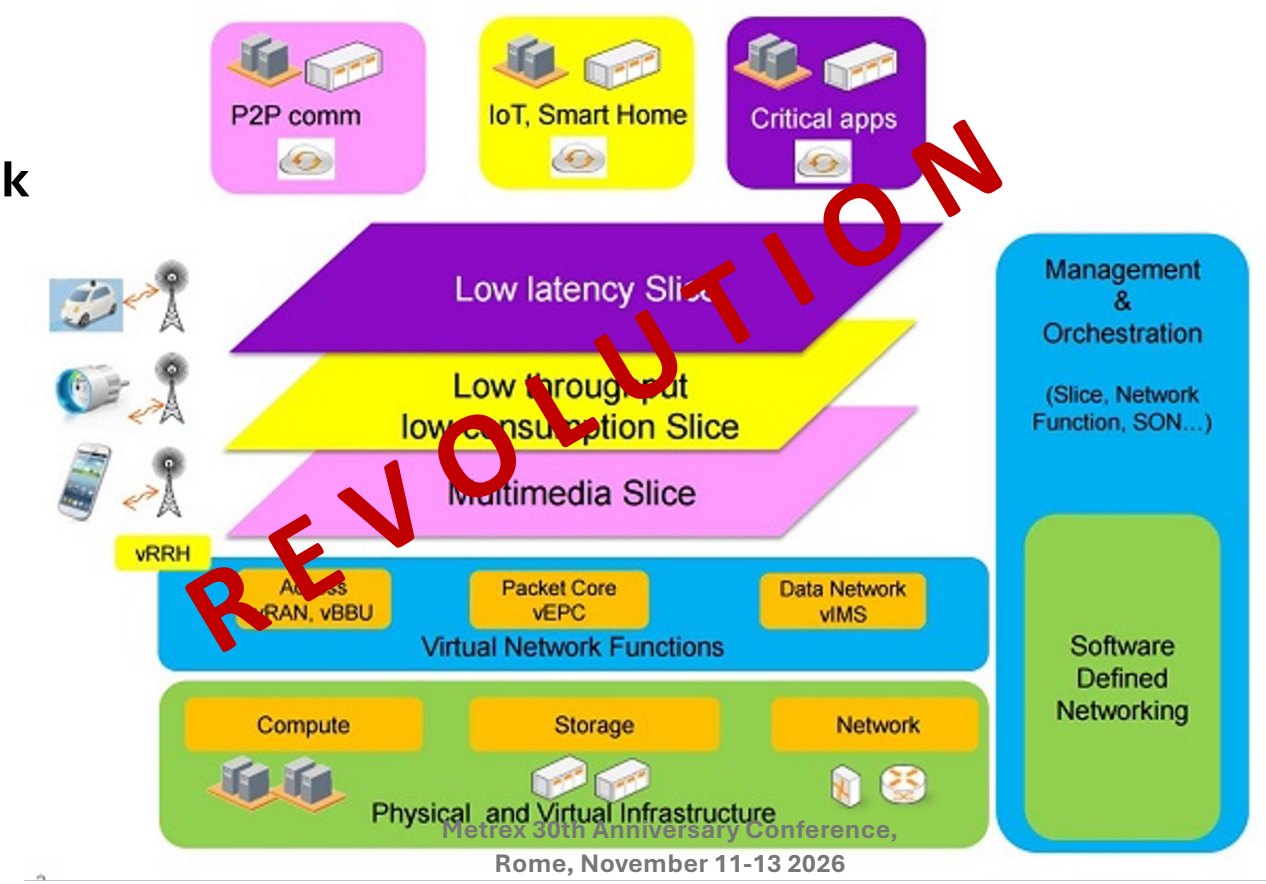


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5G target architecture (System and Core Network)

5G Access and 4G core Network

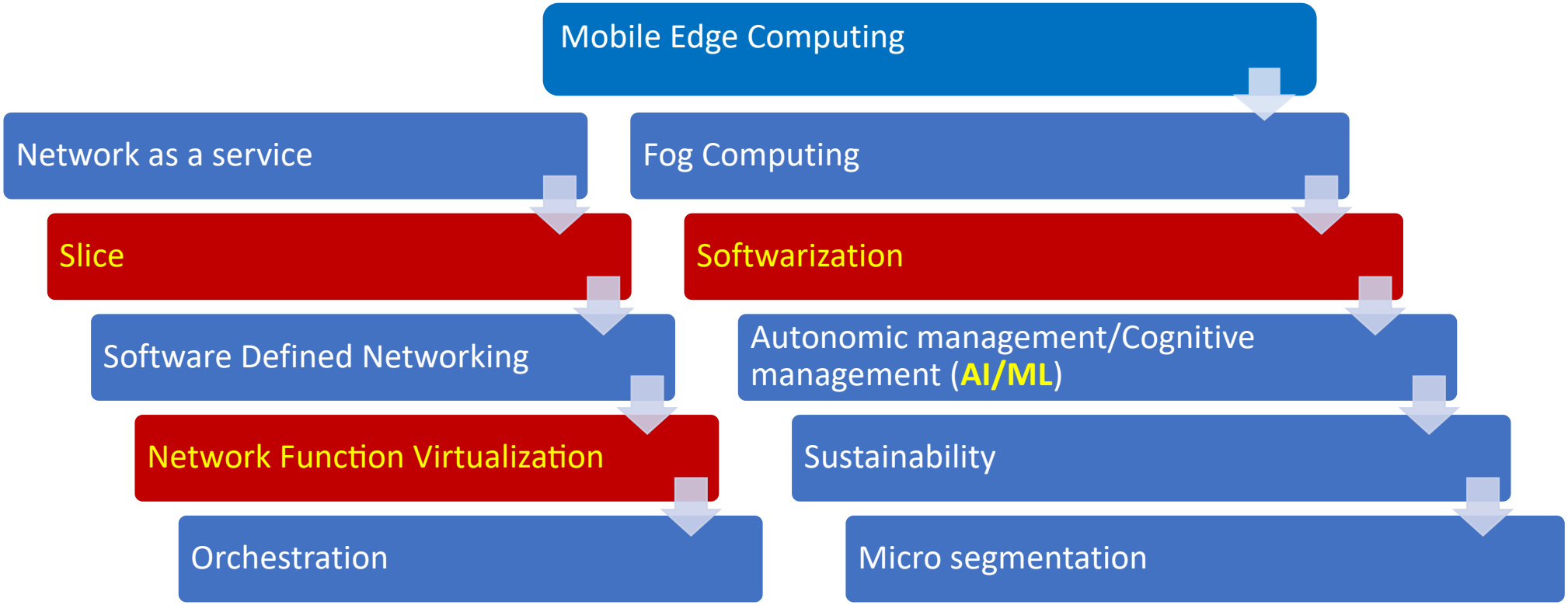
5G NO Standalone



5G Access and 5G core Network

5G Standalone

5G development: Key Concepts



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Internet & 5G





Telecommunications

Infrastructure

that travel over the

over which we run

Signals

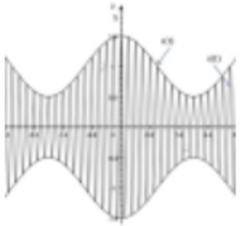
Applications

which are transferred through

generate that

Information

Computer science





LinkedIn

skype

facebook



Use case categories

- Enhanced Mobile Broadband (eMBB)
- Massive Machine Type Communications (mMTC)
- Ultra Reliable and Low Latency Communications (URLLC)

Requirement	Required value
Latency, user plane	1 ms for URLLC
Latency, control plane	20 ms
Connection density	1 000 000 devices / km^2
Reliability	99.999% success rate within 1 ms
Mobility interruption time	0 ms
Throughput (peak)	20 Gbit/s (DL) - 10 Gbit/s (UL)
Mobility	500 km/h (0.45 bit/s/Hz)
Latency, user plane	4 ms for eMBB

URLLC requirement
mMTC requirement
eMBB requirement

Myths and realities

Not only mobile but also fixed network is addressed

Not only physical layer but also network management

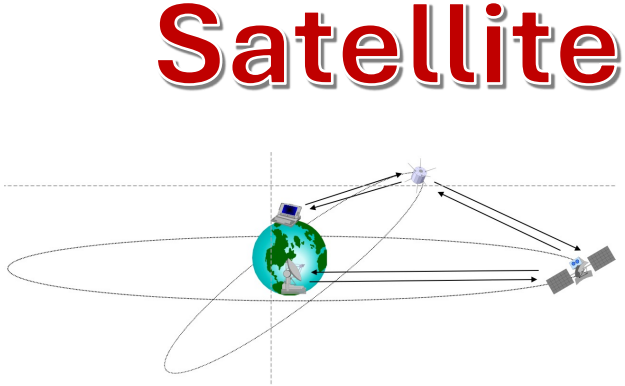
So far, the roll out concerns the physical layer and marginally the core network. Non standalone and standalone networks

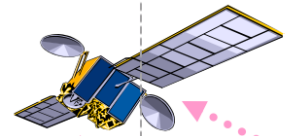
Zero latency: physics was not revolutionized

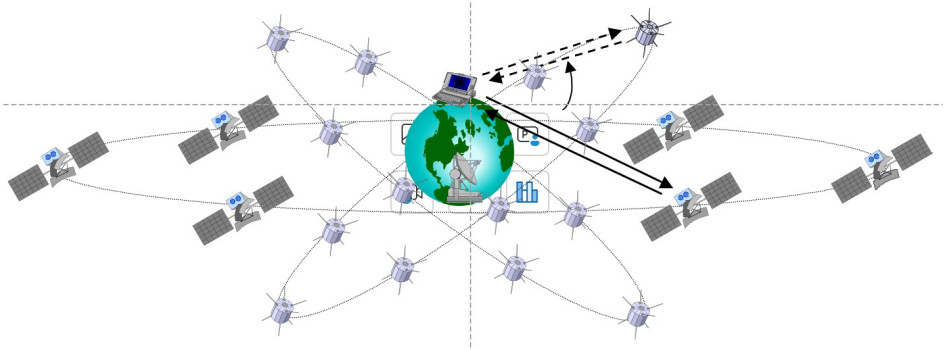
$s = v \bullet t$

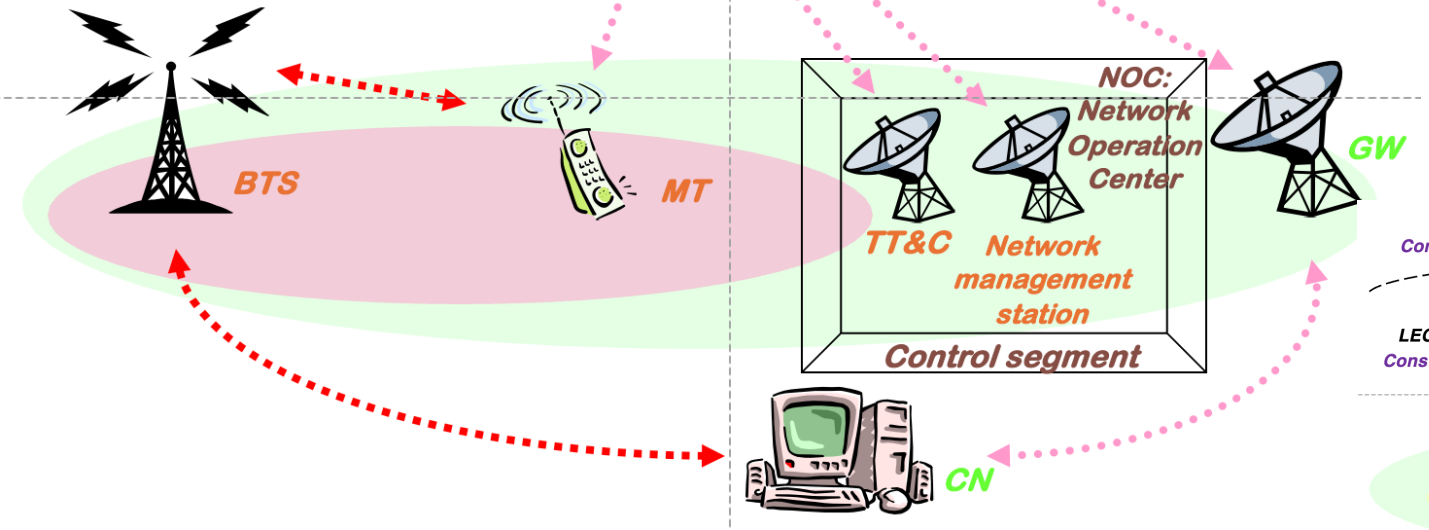
Change of the perspective: the starting point is the service and not the infrastructure

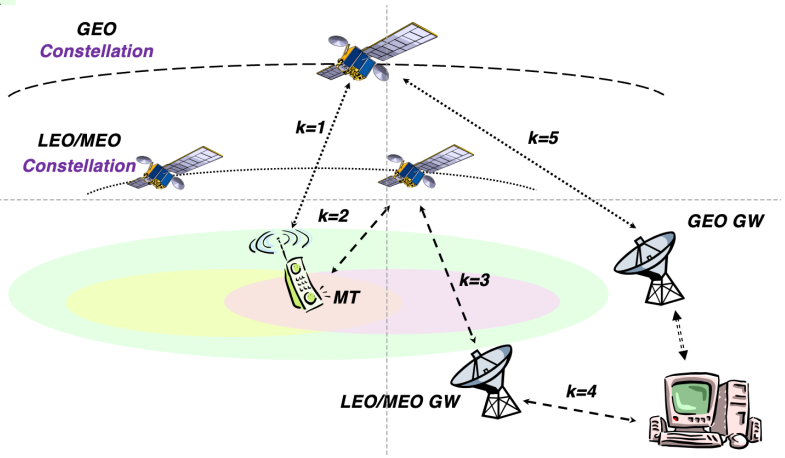
Satellite systems











Why to use satellites?

- Costs independent on distance (within one satellite coverage)
- Collecting and **broadcasting characteristics**
- Particularly suitable and **cost effective for multicasting**
- Irreplaceable in areas with scarce or no infrastructures (**gap filler**)
- Irreplaceable in case of **disaster**
- Suitable for large coverage areas and **long range mobility**
- Relatively short deployment time
- Flexible architecture
- Bypass very crowded terrestrial networks
- With the same infrastructure both fixed and mobile services

- Disruptive to feed CDN nodes
- Efficient to distribute security keys

From being a problem due to delay

to being the element that can meaningfully contribute to achieve the “zero latency” and to efficiently face the multi-domain issue

Integration may arrive from the sky

In USA, in addition to the bandwidth around 2GHz (5+60MHz from Echostar for 17B$) already utilized, Starlink acquired (for 8B$) the bandwidth around 800MHz (14 MHz) to significantly improve the capability to provide D2D (D2C) connectivity from satellite (the lower band is even better also from propagation point of view and most of terrestrial terminals already support it).

Terrestrial operators have always been skeptical about pursuing integration with satellite networks and now are skeptical that Starlink will be capable to offer the same quality of service of terrestrial networks (they don't have at present adequate network) ..... but we will see ..... the market will decide also as a function of killer applications.

5G full utilization

To fully satisfy target performance all the technological aspects included in specifications of 5G and satellite systems MUST be implemented

To reach promised bit rate (3-5 Gbit/s)	• Full bandwidth use up to Ka band • Allowing electromagnetic constraints to be compliant with international standards (61 V/m)
To guarantee efficient deployment of innovative services	• Full access to 5G core network (5G standalone)
To guarantee “zero latency”	• Edge computing
To guarantee satisfaction of peculiar (for Metrex30 community) service requirements: full control of resource management and target performance	• Slice implementation
To take advantage of cost/effectiveness for broadcast and multicast-based services and to fill coverage gaps	• Inclusion of satellite segment in the architecture

User point of view

Everything **transparent** for the user

It doesn’t decide the network configuration but just ***experiences a service using an application***

Single User unaware of the infrastructure (also because it is not skilled in telecommunications)

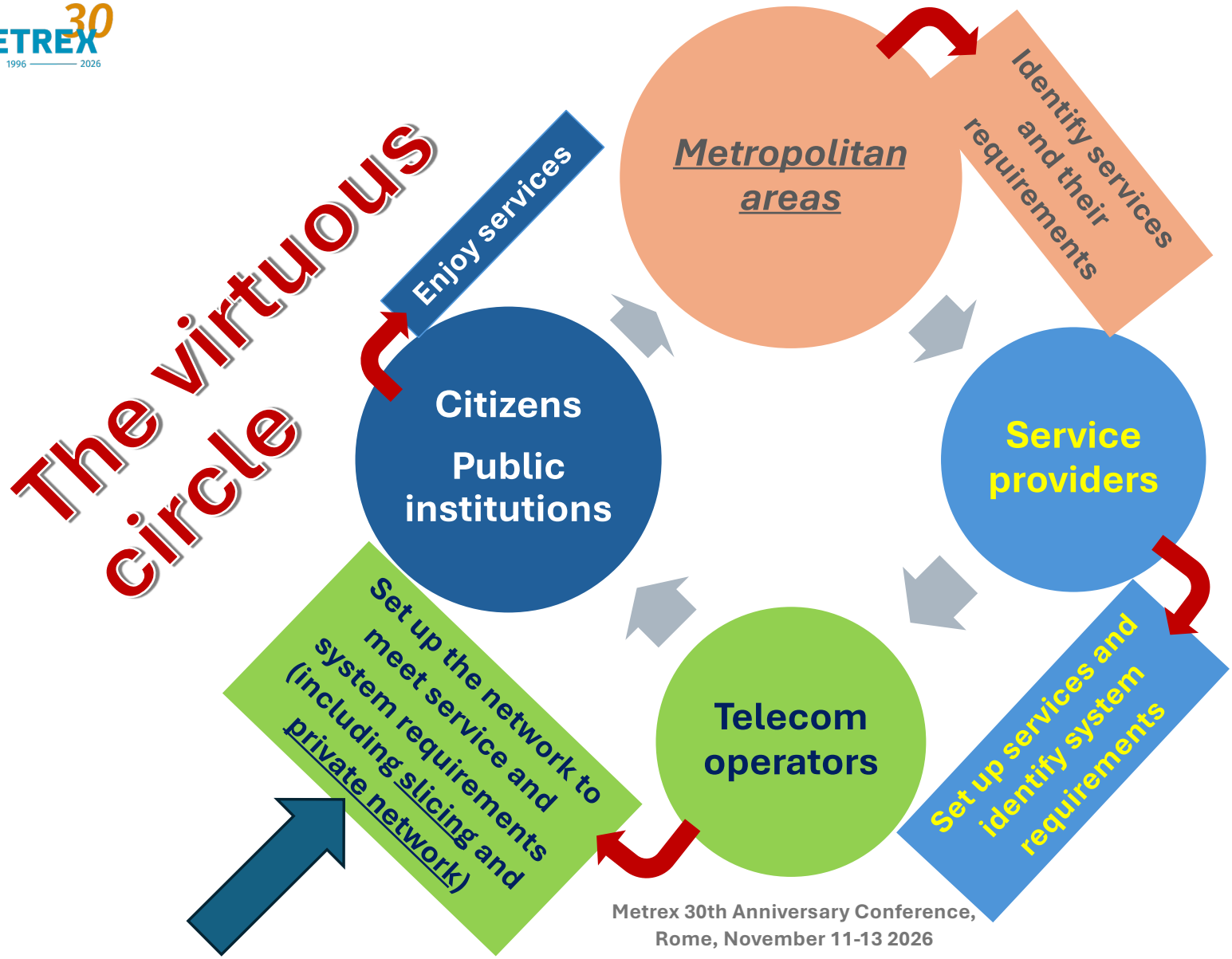
Institutional User: (1) require 5G operators to deploy also the core network so that (2) really advanced services can be agreed to be provided.

Advantages of 5G core network

- Cloud-native, **Service-Based Architecture** that communicates via modular software functions and modern HTTP/2 RESTful APIs
- Decouples control functions (like SMF and AMF) from user-plane forwarding (UPF)
- Enables end-to-end network slicing (even **multi-tenant**), creating **multiple** virtual networks on the same physical infrastructure tailored for specific needs
- Core functions designed as Cloud-Native Network Functions (CNFs) that run on Commercial Off-The-Shelf (COTS) hardware
- Delivers ultra-low latency dropping down to **1 millisecond** (versus 10–50 ms in 4G)
- Dramatically higher peak data throughput

Who should do what in smart city ecosystem

Technology	Target performance	In charge to
Full bandwidth use up to Ka band	Adequate bit rate	Telecom Operators, Governments
Electromagnetic constraints compliant with international standards (61 V/m)	Adequate bit rate	Governments
Full access to 5G core network (5G standalone)	Efficient deployment of innovative services	Telecom Operators
Edge computing	“zero latency”	Telecom Operators
Slice implementation	Satisfaction of peculiar (for members of Metrex30 community in this case) service requirements	Customers (each member of Metrex30 community in this case) **to identify requirements**, Telecom operators or Telecom service providers or IT companies or, why not, customers **to implement and manage the network**.
Inclusion of satellite segment in the architecture	To take advantage of the intrinsic advantages offered for broadcast and multicast-based services and to fill coverage gaps	Telecom operators or Telecom service providers or IT companies or, why not, customers
5G Private networks	To efficiently manage institutional services	Technology providers and integrators


The virtuous circle
Metropolitan areas
Identify services and their requirements
Service providers
Set up services and identify system requirements
Telecom operators
Set up the network to meet service and system requirements (including slicing and private network)
Citizens
Public institutions
Enjoy services

Infrastructure – Services correlation matrix

Infrastructures

- Slice
- Edge computing
- 5G Private Networks
- Satellite

Very short <u>not comprehensive</u> list of services

- Services for citizens
  - Tourist information
  - Pharmacies
  - Hospitals
  - Schools
  - Public Transportation
  - Safety Alerts
  - Maps update distribution
  - Autonomous driving
- Institutional services
  - Security
  - Cultural heritage control
  - Traffic management
  - Pollution measurements
  - Public transportation management
  - Maintenance of roads and other infrastructures

Infrastructure – Services correlation matrix

Infrastructures \ list of services	Tourist information	Pharmacies	Schools	Hospitals	Public Transportation	Safety	Alerts	Maps update distribution	Autonomous driving	Security	Cultural heritage control	Traffic management	Pollution measurements	Maintenance of roads and other infrastructures	Public transportation management
	Services for citizens									**Institutional services**					
Slice	X									X	X	X	X	X	X
Edge computing					X			X	X	X	X	X	X	X	X
5G Private Networks				X						X	X	X	X	X	X
Satellite					X			X							

5G 4 V2X

- Automated vehicles on public roads and campuses require stable heart-beat signals to the control center and differentiated connectivity for advanced driver assistance systems (ADAS) and autonomous driving (AD). The integration of ADAS with differentiated connectivity significantly improves safety, efficiency, and resource management beyond local sensors.
- Connectivity requirements
  - Periodic heartbeat signals including vehicle status and position in congested scenarios, ~100 kbps every 1s
  - Indirect or direct remote control depends on video quality and if direct control allowed
  - 1-15 Mbps High/ultra-high-quality video stream
- Technology enablers
  - 5G Advanced RAN Differentiated Connectivity with Rate Control Scheduling to guarantee seamless transmissions also in congested scenarios
  - 5G Advanced Critical-IoT with Low-latency Mobility & L4S (Low Latency, Low Loss and Scalable Throughput)
- Ericsson 5G Advanced subscriptions
  - Critical IoT
  - RAN Differentiated Connectivity
  - Mission Critical Services

- C-ITS (Connected ITS), CCAM (cooperative connected automated mobility), ADAS (Advanced Driver Assistance Systems)

Best practices and worst problems

- Milan: Autonomous driving, test for three years with Niulinx. Objective robo-taxi from 2029 and 60 European cities.
  - Problem: ICT infrastructure, 5G and GPS/Galileo coverage, capability of the vehicle to make decisions even without external connectivity.
- Rome: Last August a public call was issued for experimental services of autonomous driving
- Turin: Living Lab ToMove managed by GTT, Ohmio and 5T. Route: A loop of approximately 3 km in the Vanchiglia district, starting and ending at the University of Turin's Luigi Einaudi Campus, with stops along Corso Tortona, Corso Regina Margherita, and Lungo Dora Siena (5 stops in total)
- Robotaxi
  - USA, China, Emirates (fully autonomous but in limited areas)
    - Waymo (Alphabet) and Zoox (Amazon) in USA - Baidu, Pony.ai, AutoX e WeRide in China
  - Ryad, Zagabria, London (supervised on board)
- To fully implement autonomous driving V2X (family) standard MUST be implemented but instead of realizing its own infrastructure (at present very very limited) it can be much more efficiently based on 5G one (already largely deployed) but STANDALONE implying to use 5G core instead of previous versions. Leverage 5G coverage.

Summary messages

Identify services

↓

Care telecommunications

↓

Set up infrastructure (slice, private networks)

↓

Provide services

↓

Your city will be much smarter

