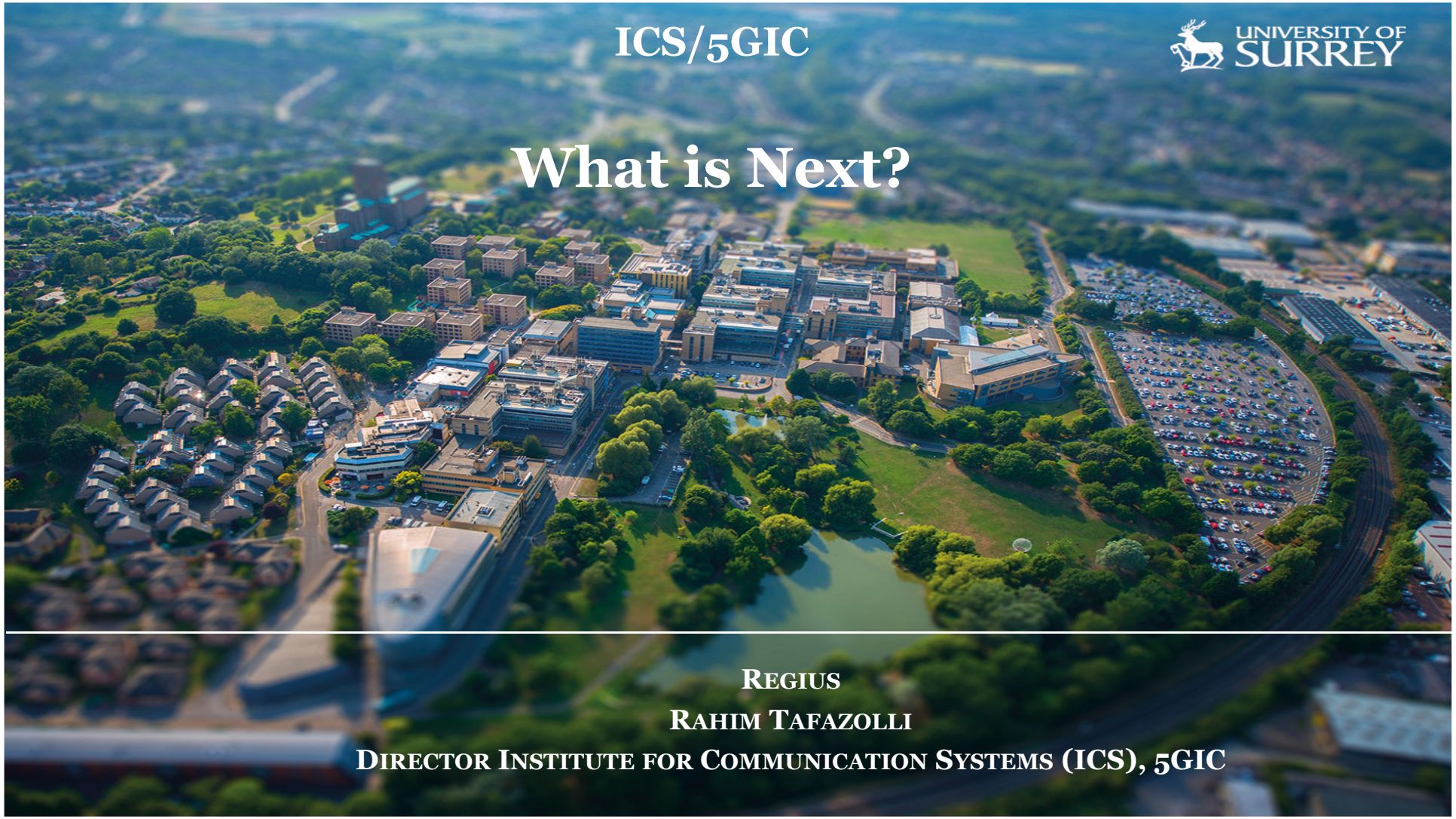


ICS/5GIC

UNIVERSITY OF SURREY

What is Next?

REGIUS

RAHIM TAFAZOLLI

DIRECTOR INSTITUTE FOR COMMUNICATION SYSTEMS (ICS), 5GIC

UNIVERSITY OF SURREY
5G INNOVATION CENTRE
LARGEST OPEN INNOVATION CENTRE ON 5G

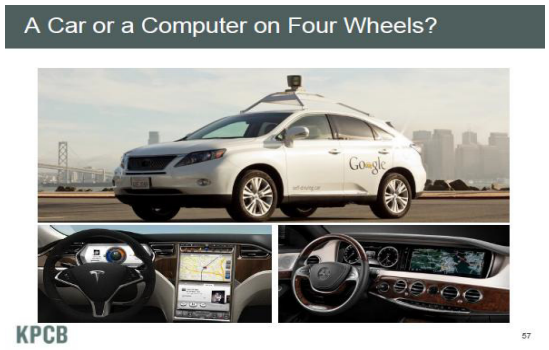
University of Surrey, 5GIC

NOT JUST MORE OF THE SAME

COMMUNICATIONS & AUTOMATION

Connectivity + Intelligence (AI and Machine Learning)

Automation



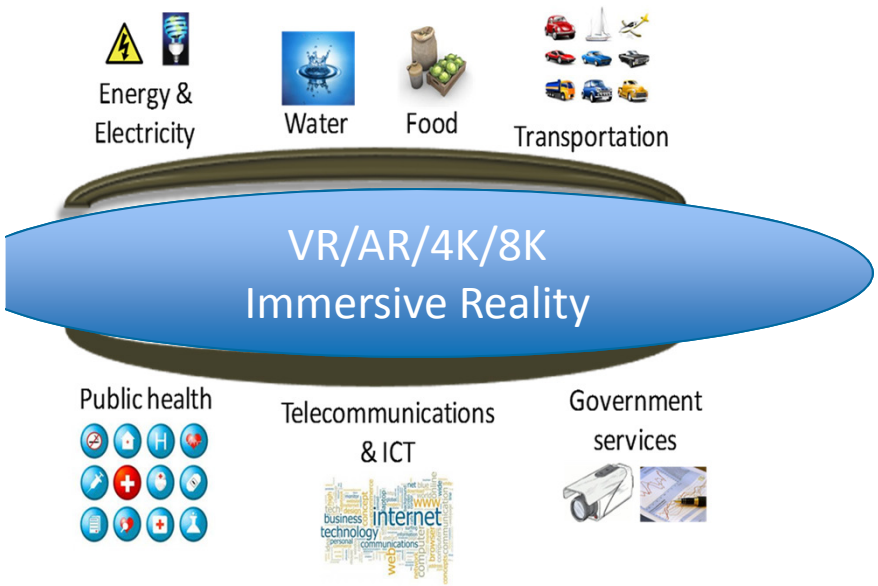
Data to information transformation

Blurring boundaries between real and cyber worlds

Connected Devices of small and large sizes and capabilities

(robots, cars, sensors, actuators, smart phones ……. driverless cars)

ONE NETWORK INFRASTRUCTURE SERVING ALL INDUSTRY SECTORS



- **Programmable**
- **Resilient**
- **Low delay, high reliability**
- **1000x more capacity than 4G**
- **One Million connections per km^2**

WHY 5G IS IMPORTANT?

5G Contribution to UK GDP by 2030 *

Mobile Broadband: +1.45%

Automation: +4.23%

* DCMS FCCG REPOORT

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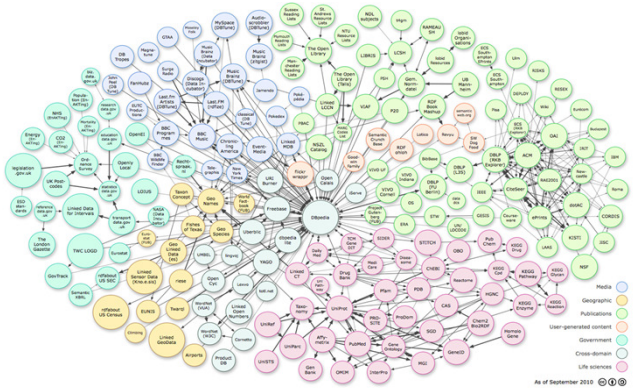
WHAT IS NEXT ?
IN 5 YEARS TIME



ARTIFICIAL INTELLIGENCE
&
ULTRA RELIABLE AND LOW LATENCY COMMUNICATION
&
MASS CONNECTIVITY

AUTOMATION: UK INDUSTRIAL STRATEGY

TRANSFORMING INDUSTRY 3.0 TO 4.0

- LOGISTICS/TRANSPORT
- MANUFACTURING
- GAMES/ENTERTAINMENT
- UTILITIES
- HEALTH

AUTOMATION

First

- ZERO-TOUCH NETWORK MANAGEMENT AND OPERATION
  - FUTURE NETWORKS WILL BE TOO COMPLEX FOR HUMAN OPERATOR
    - AI + CONNECTIVITY + DATA

AUTONOMOUS NETWORKING

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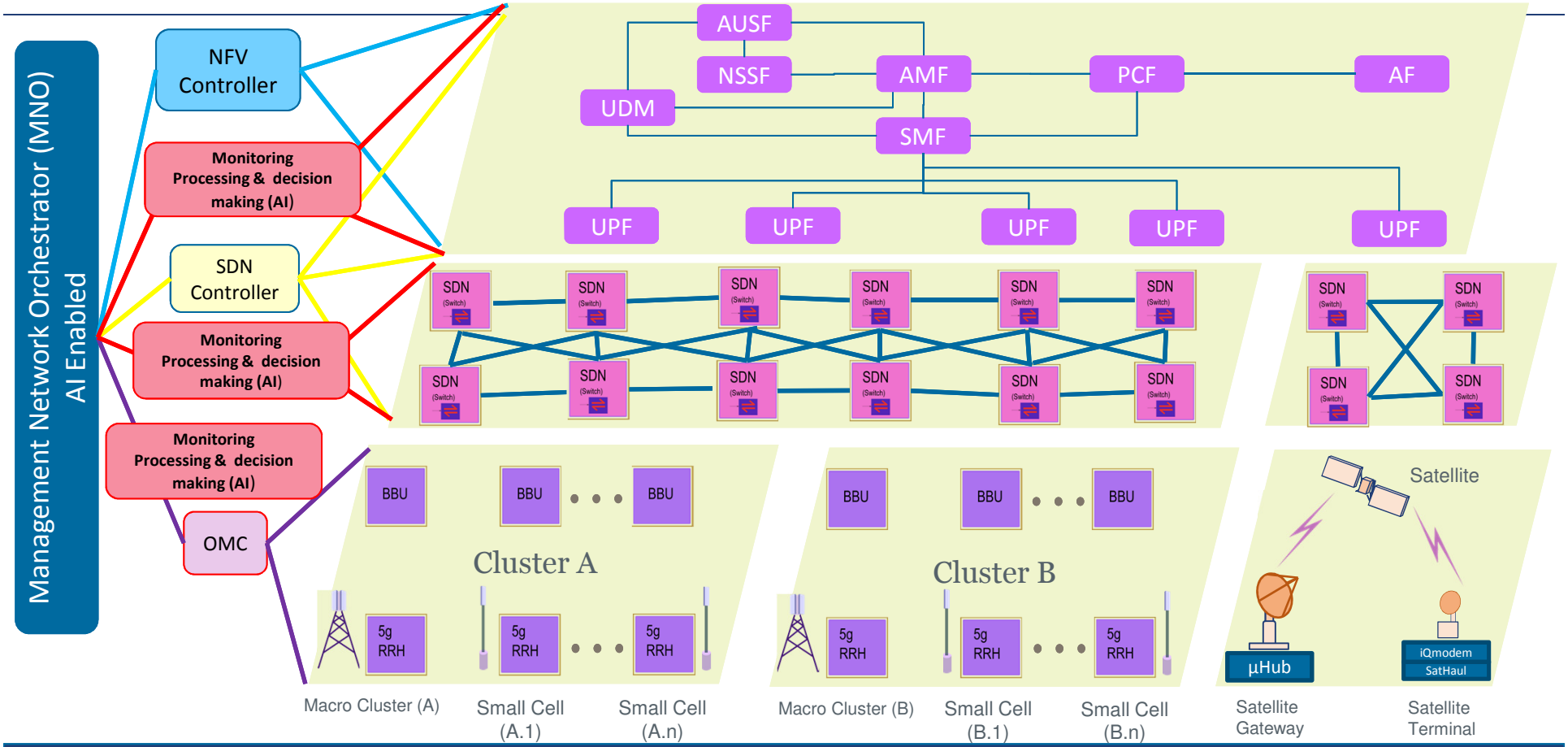


Which Vertical Industry First

5G Broadcast/Multicast services

Media & Entertainment (M&E)

- Hybrid broadcast services
- Virtual/Augmented reality broadcast
- Remote live production
- Object based broadcasting

Public Warning (PW)

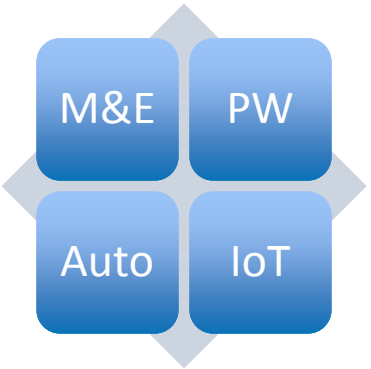
- Multimedia public warning alert

Automotive (Auto)

- V2X broadcast service

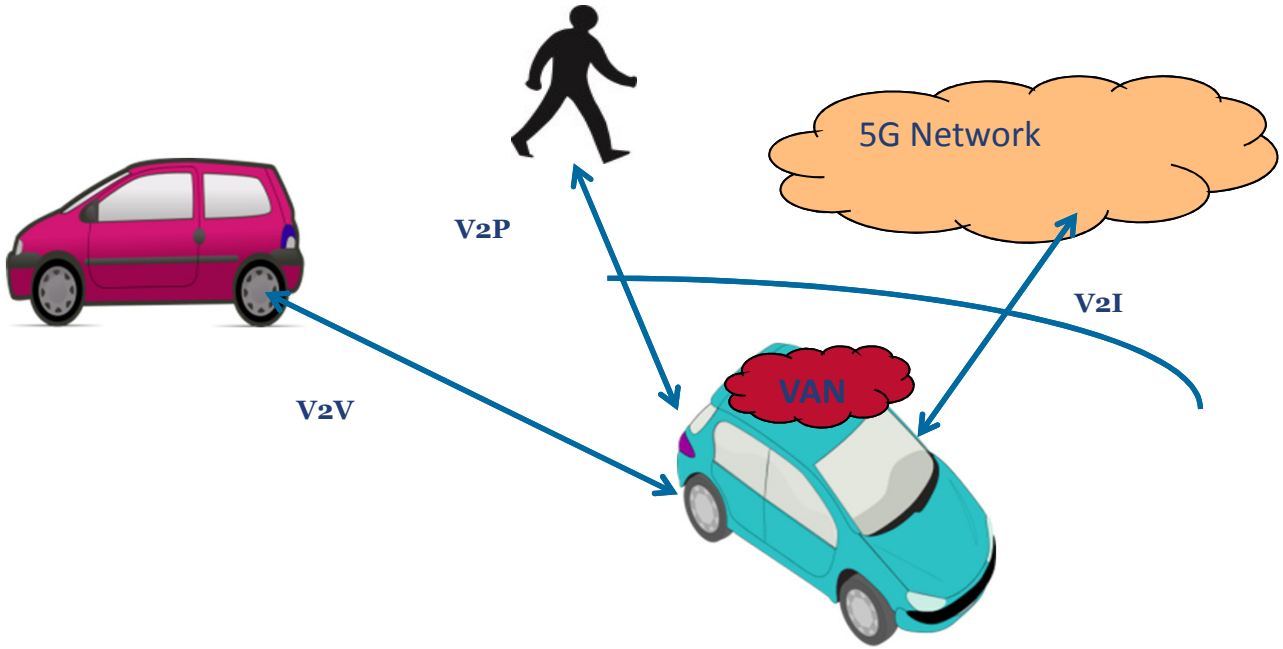
Internet of Things (IoT)

- Massive software and firmware updates



CONNECTED AUTONOMOUS VEHICLES

Connectivity?



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WHAT IS NEXT ?
IN 10 YEARS TIME

Holoportation + Sensual Information = Teleportation

Cyber Space Networking

WHAT MAKES US US?

OUR PHYSICAL BODY OR OUR CONSCIOUS?

ANSWER: IT IS OUR CONSCIOUS

WE ARE OUR 5 SENSES

Ref [1] : Rahim Tafazolli, first presented in TEDx in 2015, Cyprus

Ref [2] : Rahim Tafazolli, Keynote NEAT Workshop, SIGCOMM 2018, Budapest

Ref [3] : Rahim Tafazolli, Keynote, ITU Network 2030, 18th Feb 2019, London

TELEPORTATION

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DO NOT NEED TO TRANSMIT OUR PHYSICAL BODIES

ALL NEEDED IS TO HAVE MULTI-SENSORY INFORMATION TRANSMITTED FROM:

PLACE B TO PLACE A (CONTRARY TO CURRENT THINKING)

SIMPLEST FORM OF TELEPORTATION

RXer TXer

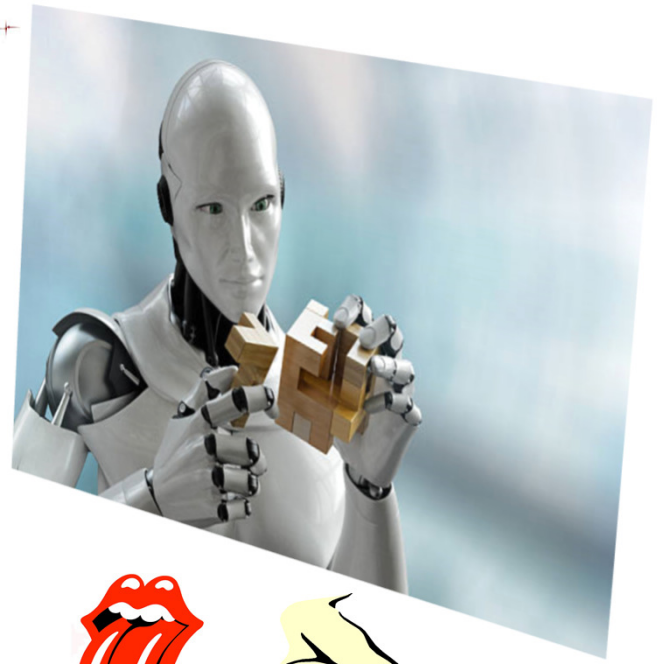
Sensual Info

TELE-INTERACTIONS

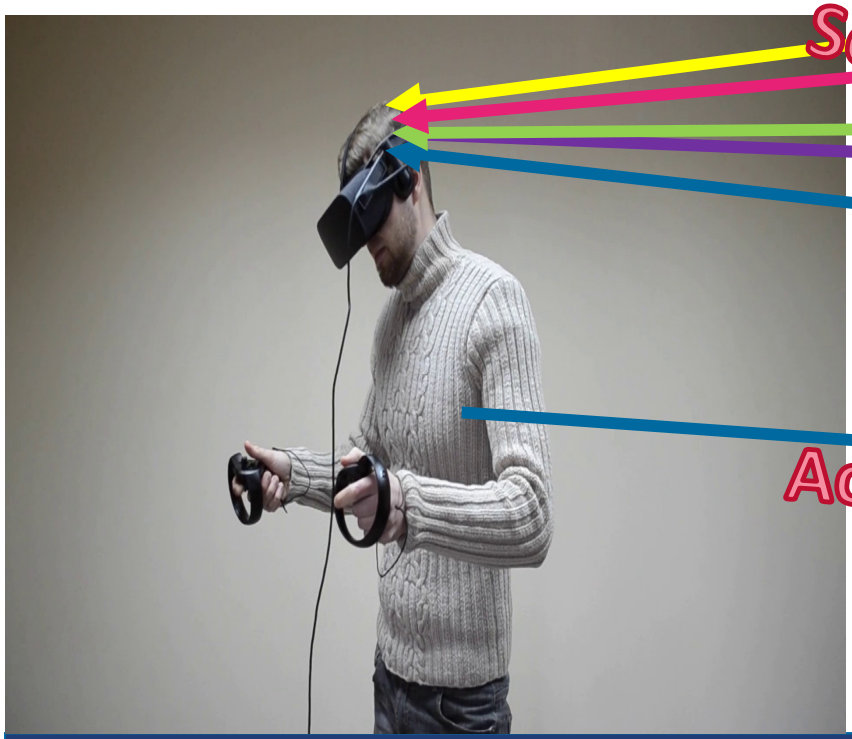
RXer

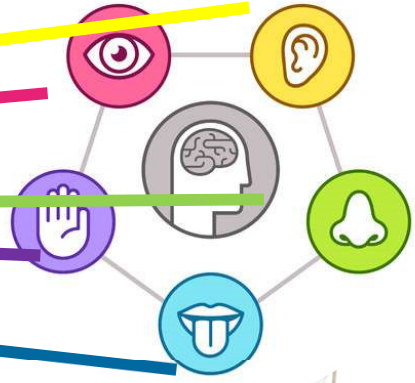
TXer

Sensual Info



REAL-TIME TELE-INTERACTIONS





Sensual Info

Actuation Info

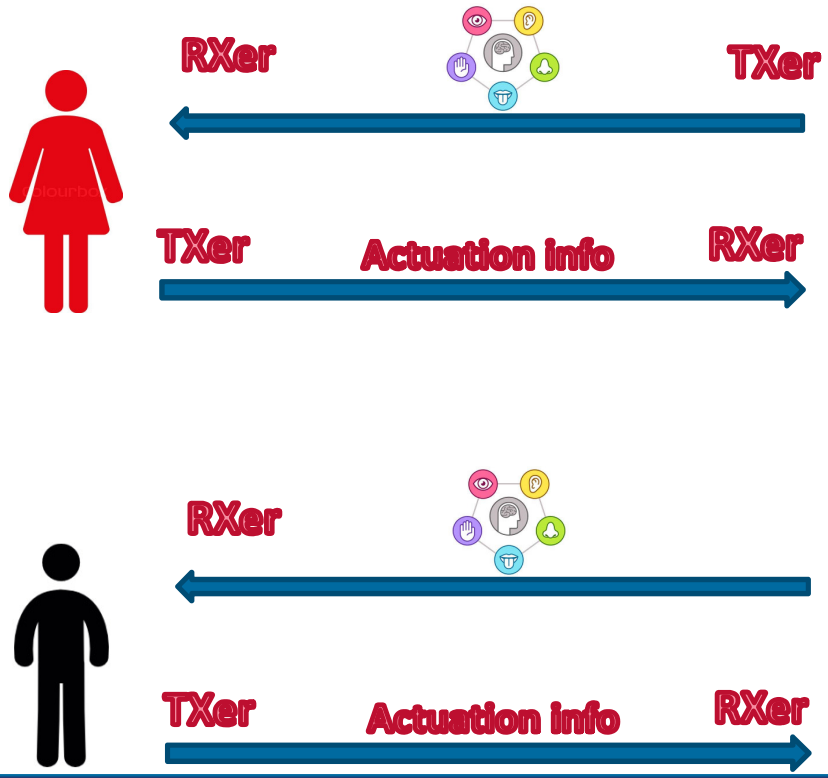
REAL-TIME INTERACTIONS VIA HOLOPORTATION

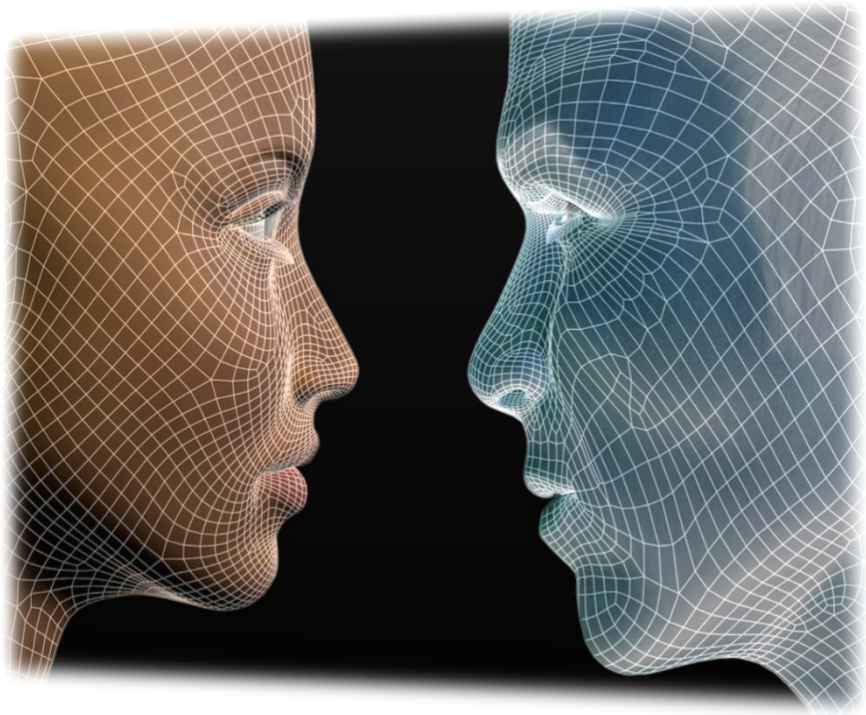
RXer TXer

TXer RXer

Holoportation

REAL-TIME INTERACTIONS IN CYBER SPACE





HIGH QUALITY HOLOPORTATION REQUIREMENTS

	Dimension	Bit Rate
Tile	4x4 inches	30 Gbps
Human	77x20 inches	4.62 Tbps

Colour, FP (full parallax), 30fps
Ref: N.Peyghambarian, University of Arizona

Other Senses

Touch

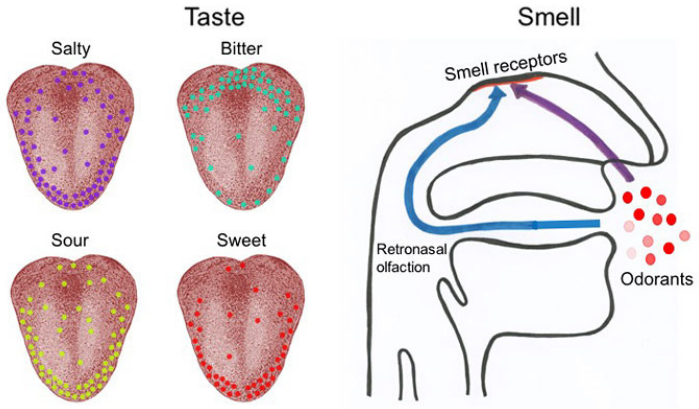
- Per inch^2 ~ 20 to 50 Mbps → For one average size Hand: ~ 1Gbps
- Latency <100 ms,
  - for natural delay with the brain touch function

Taste

- Chemical Reactions
- Bit rate and Latency ?

Smell

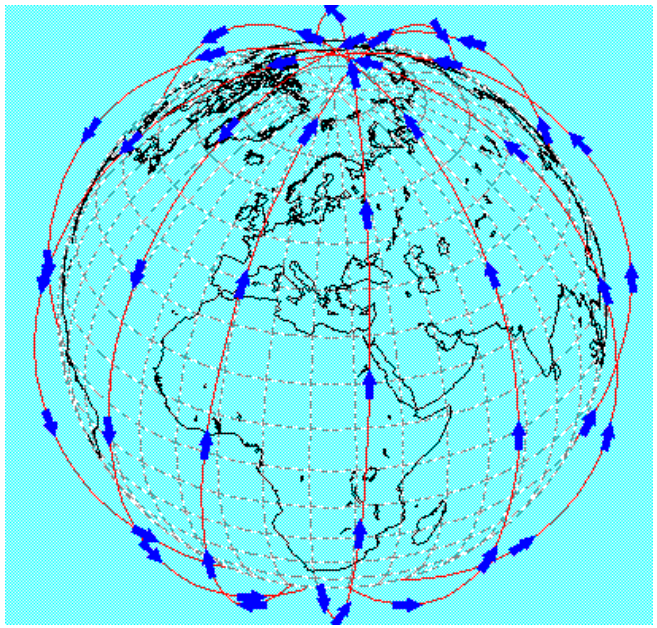
- Smell and Taste are inter-related

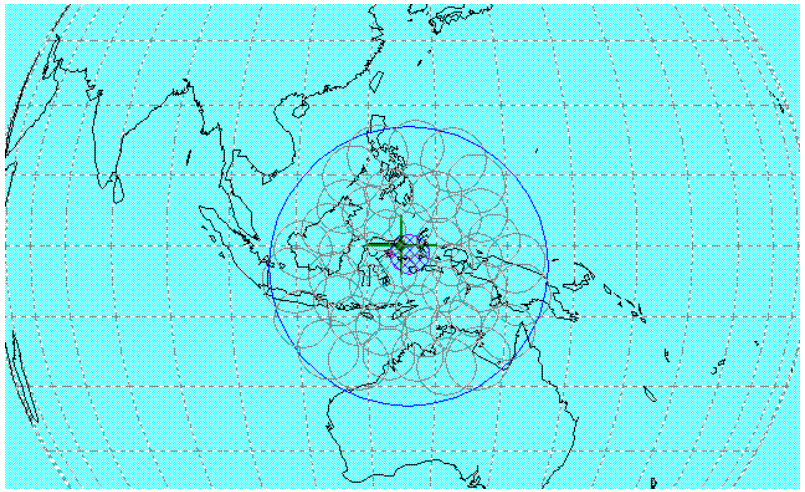


NEW INFRASTRUCTURE

FIXED/MOBILE/INTERNET/DRONES/SATELLITE

NON-TERRESTRIAL NETWORKS





OPPORTUNITY:
ECONOMY OF SPACE COMMUNICATIONS NOW COMPARABLE TO TERRESTRIAL

CHALLENGE:
DIRECT COMMUNICATIONS BETWEEN UE TO SATELLITE AND/OR TERRESTRIAL

CYBER SPACE NETWORKING 2030+ (TELEPORTATION)

TECHNICAL CHALLENGES

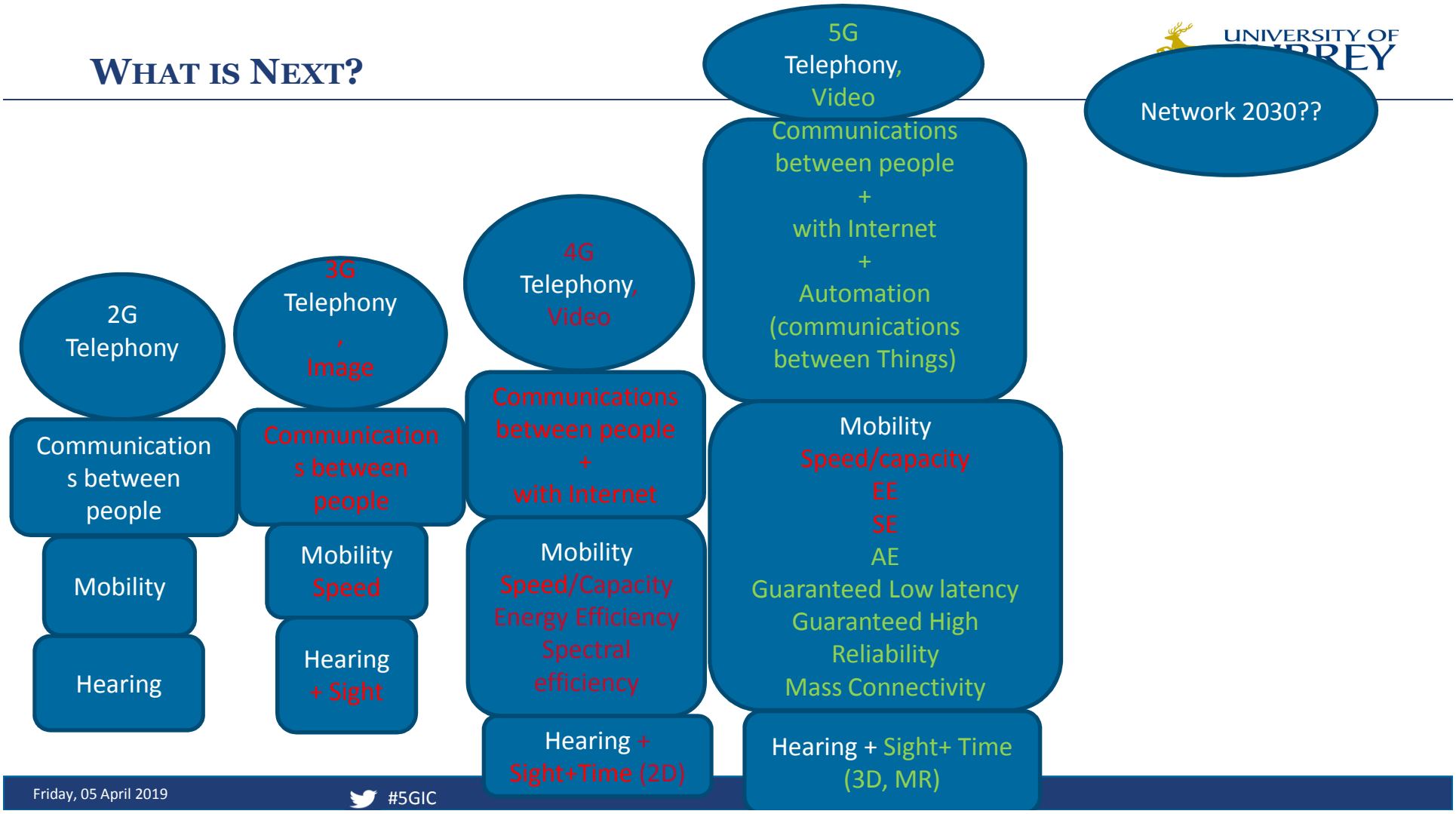
- BIT RATES AL LEAST SEVERAL TBPS/PERSON
- LATENCY <1MS (GUARANTEED) BETWEEN SENSING AND ACTUATION
- GEO-LOCATION ACCURACY BETTER THAN 1CM AND UPDATE RATE < 1MS
- SYNCHRONISATION WITHIN 10MS, FOR NATURAL FEEL

MEGA-CONSTELLATIONS CHALLENGES

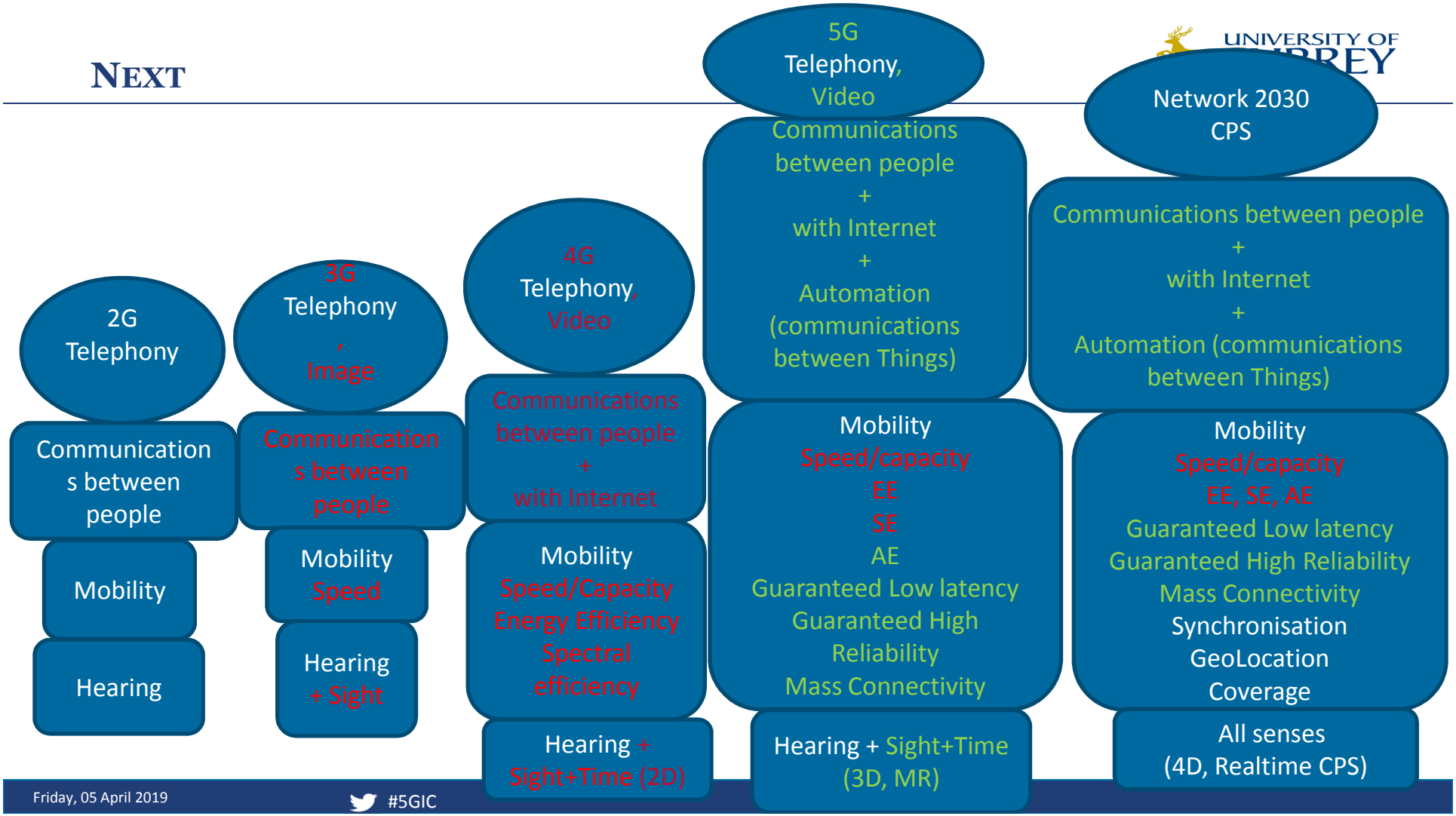
- OVERALL COST HAS TO BE SAME AS TERRESTRIAL FOR SAME (COVERAGE AND CAPACITY)

- DIRECT COMMUNICATIONS BETWEEN USER TERMINAL TO SATELLITE AND/OR TERRESTRIAL

WHAT IS NEXT?


2G
Telephony
Communication
s between
people
Mobility
Hearing
3G
Telephony
,
Image
Communication
s between
people
Mobility
Speed
Hearing
+ Sight
4G
Telephony,
Video
Communications
between people
+
with Internet
Mobility
Speed/Capacity
Energy Efficiency
Spectral
efficiency
Hearing +
Sight+Time (2D)
5G
Telephony,
Video
Communications
between people
+
with Internet
+
Automation
(communications
between Things)
Mobility
Speed/capacity
EE
SE
AE
Guaranteed Low latency
Guaranteed High
Reliability
Mass Connectivity
Hearing + Sight+ Time
(3D, MR)
Network 2030??

NEXT


2G
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Communications between people
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Hearing
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,
Image
Communications between people
Mobility
Speed
Hearing
+ Sight
4G
Telephony,
Video
Communications between people
+
with Internet
Mobility
Speed/Capacity
Energy Efficiency
Spectral efficiency
Hearing + Sight+Time (2D)
5G
Telephony,
Video
Communications between people
+
with Internet
+
Automation (communications between Things)
Mobility
Speed/capacity
EE
SE
AE
Guaranteed Low latency
Guaranteed High Reliability
Mass Connectivity
Hearing + Sight+Time (3D, MR)
Network 2030
CPS
Communications between people
+
with Internet
+
Automation (communications between Things)
Mobility
Speed/capacity
EE, SE, AE
Guaranteed Low latency
Guaranteed High Reliability
Mass Connectivity
Synchronisation
GeoLocation
Coverage
All senses
(4D, Realtime CPS)

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THANK YOU