BENCHMARK 5G USE CASES5G STRATEGY IN PA

December 2022

tic.gov.pt

ama AGÊNCIA PARA A MODERNIZAÇÃO ADMINISTRATIVA

PRR Plano de Recuperação e Resiliência

Index

01 INTRODUCTION

01 INTRODUÇÃO – OBJECTIVOS DESTE BENCHMARK

The objective of this benchmark for AMA is to identify trends, national and international practices, and use cases applicable to the national context of Public Administration, considering two perspectives: the impacts of adopting 5G on optimizing the public service delivery model, and the different policies and strategies to be adopted to minimize barriers to its implementation.

Phase	Deliverable
Benchmark	Benchmark document, including: • Use cases and best practices in the use of 5G technology • Applicability for government entities, public administration, and society • Systematized information by categories and conclusions organized by dimensions

01 INTRODUCTION – BENCHMARK APPROACH

1. Define and agree on the benchmark dimensions

Define and agree on the benchmark dimensions – Listing of dimensions for impact analysis on technical, financial, societal relevance, and Public Administration transformation aspects.

2. Conduct research and analyses using information sources

Identification of trends, practices, and use cases (national and international).

3. Identify best practices and use cases for adoption in Public Administration.

Identify best practices to describe the objective and functionality of each Use Case so that it can later be implemented in Public Administration.

4. Classify the use cases according to each dimension

Impact classification for each dimension: High, Medium, and Low (H, M, and L) – This classification will be carried out based on the references found and in a comparative manner between the different use cases.

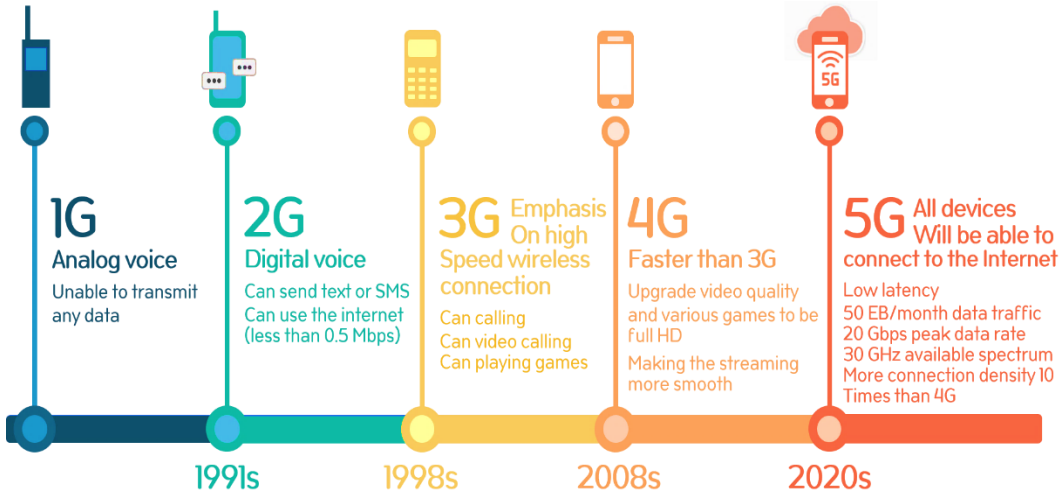
01 INTRODUCTION – BENCHMARK APPROACH | DIMENSIONS

DIMENSIONS	DESCRIPTION
Relevance for Society	Improvement in services for citizens and companies
Technical Feasibility	Technical complexity in implementation
Financial Sustainability	Level of investment and/or cost reduction in Public Administration
Replicability and Generalization	Replicability and generalization of use cases to other sectors of Public Administration
Transformation of the Sector/PA	Increased efficiency or quality in the Public Administration sector
Impact on the Economy	New sources of revenue and/or cost reduction for society
Impact on the Environment	Reduction of ecological footprint of Public Administration and Society
Impact on Emergency Response	Better response from emergency and Civil Protection services (Firefighters, Police, Hospitals)
Impact on Other Strategies	Data in Public Administration, Open Data, Smart Cities, Cloud, AI, and Emerging Technologies

CLASSIFICATION LEVELS

- High – Use Case with the highest impact
- Medium – Use Case with intermediate impact
- Low – Use Case with low impact

01 INTRODUCTION – CONTEXT | MOBILE COMMUNICATION: WHAT HAS CHANGED?



Source: https://techmodena.com/internet/internet-generation/

The first generation of technology (1G) was the gateway to wireless communication in the late 1970s. It provided voice, but with limited coverage, weak security, and low sound quality. This analog cellular communication system offered up to 14.4 kilobits per second (Kbps).

The second generation of technology (2G) arrived in 1990, offering CDMA (Code Division Multiple Access), GSM (Global System for Mobile Communications), and other mobile communication standards. Clearer voice calls, image messaging, and MMS were also introduced with this generation of mobile technology.

When the third generation of technology (3G) appeared in the early 2000s, internet speeds of 512 KB/s to 3.1 MB/s could be offered, enabling access to most social media services.
Until recently, the fourth generation of technology (4G) was the fastest mobile technology, with speeds between 100 and 300 MB/s. 4G opened broadband internet to mobile phones, introduced HD streaming, and Voice over Internet Protocol (called VoLTE), among other features.
5G technology enables higher data speeds (especially uplink), greater device capacity, improved quality of service in high-density areas, and much lower latency to support “Mission-Critical” or “Real-Time Safety” use cases.

01 INTRODUCTION – CONTEXT | OVERVIEW OF 5G

5G is a cellular technology which, like its predecessors, divides the network into small geographic areas called cells, where voice and data are transmitted by radio waves between antennas and mobile devices.

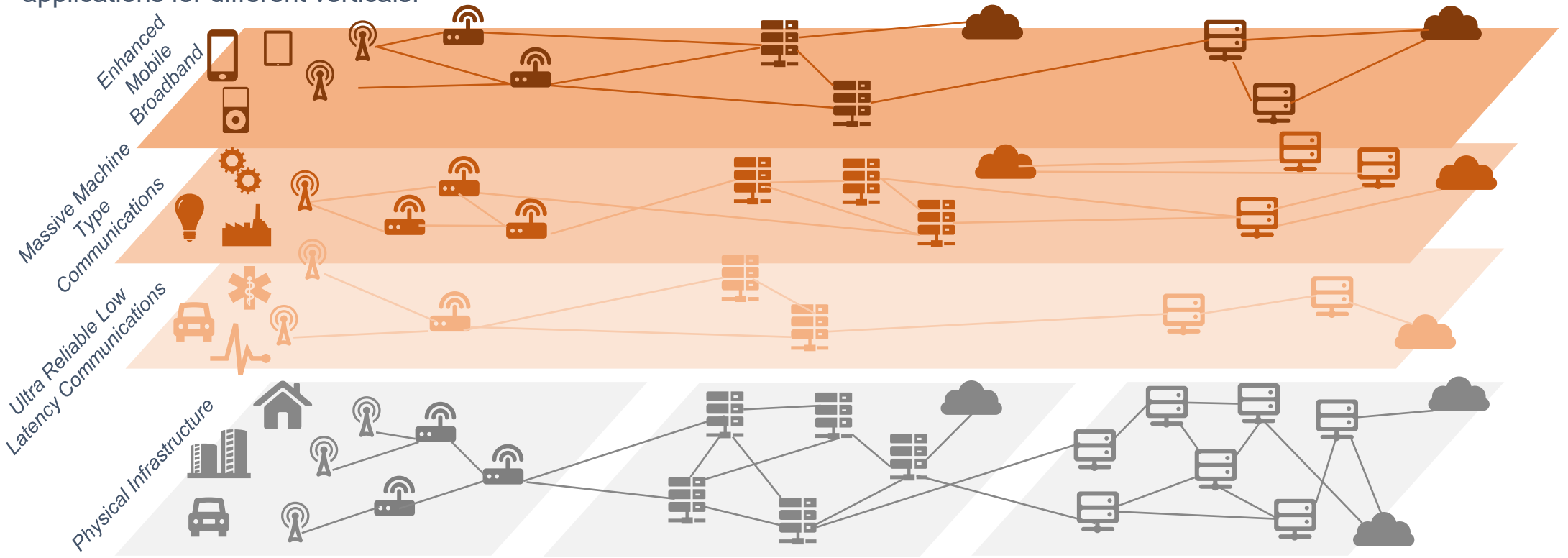
To overcome the saturation of current frequency spectrum bands, the solution to achieve higher transmission and processing speeds is to use wider bandwidths and higher transmission frequencies. For example, spectrum bands of millimeter waves with frequencies ranging from 2 GHz up to 300 GHz (mmWs, or Millimeter Waves).

The 5G architecture is also characterized by virtualization, cloudification, and automatic network orchestration. Greater flexibility, efficiency, and lower costs in this new technology are achieved through new functionalities such as “network slicing,” explained in the following slide.

The emergence of 5G technology enables the launch of new use cases, applications, processes, and broader, more efficient ecosystems across various sectors of Public Administration. 5G fosters innovation and the development of new solutions in the domains of the Internet of Things (IoT), Edge Computing, Smart Cities, Artificial Intelligence, Blockchain, Data Science, Open Data, and Virtual Realities.

01 INTRODUCTION – CONTEXT | 5G NETWORK SLICING

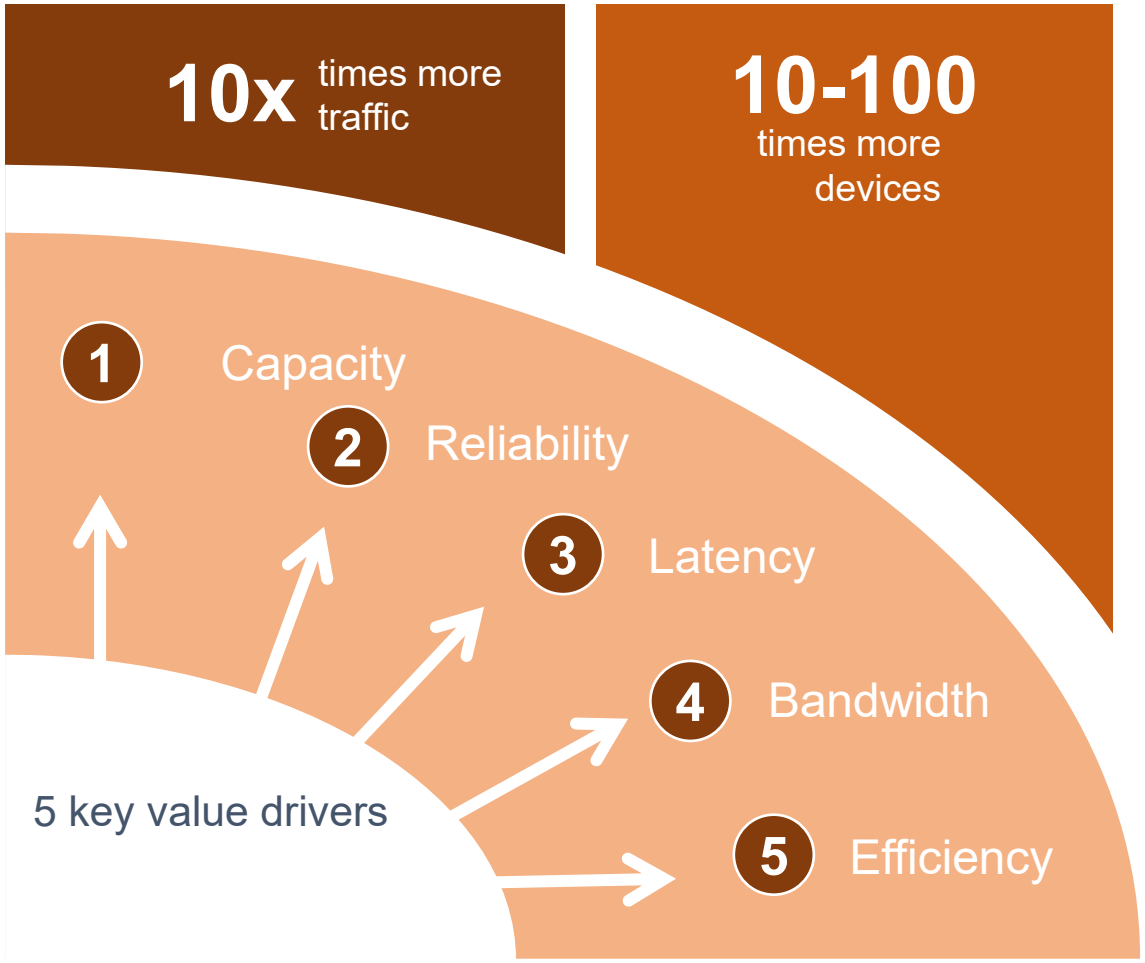
The partitioning of the 5G network enables the optimization of network resources through the logical separation of traffic and applications for different verticals.



Motivation: Sharing underutilized network resources, e.g., 50% of traffic is supported by 10% of the network; reducing CAPEX; ensuring SLAs by type of service; decreasing security risks; and increasing the volume of transmitted data and traffic.

01 INTRODUCTION – CONTEXT | CHARACTERISTICS OF 5G

The 5G architecture introduces significant advancements in network capacity (devices and data volume), energy efficiency, and latency, as described in the diagram below.



↓ 1 millisecond latency

10 years of M2M battery life

M2M ultra-low cost

↑ 10 Gbit/s peak data rate

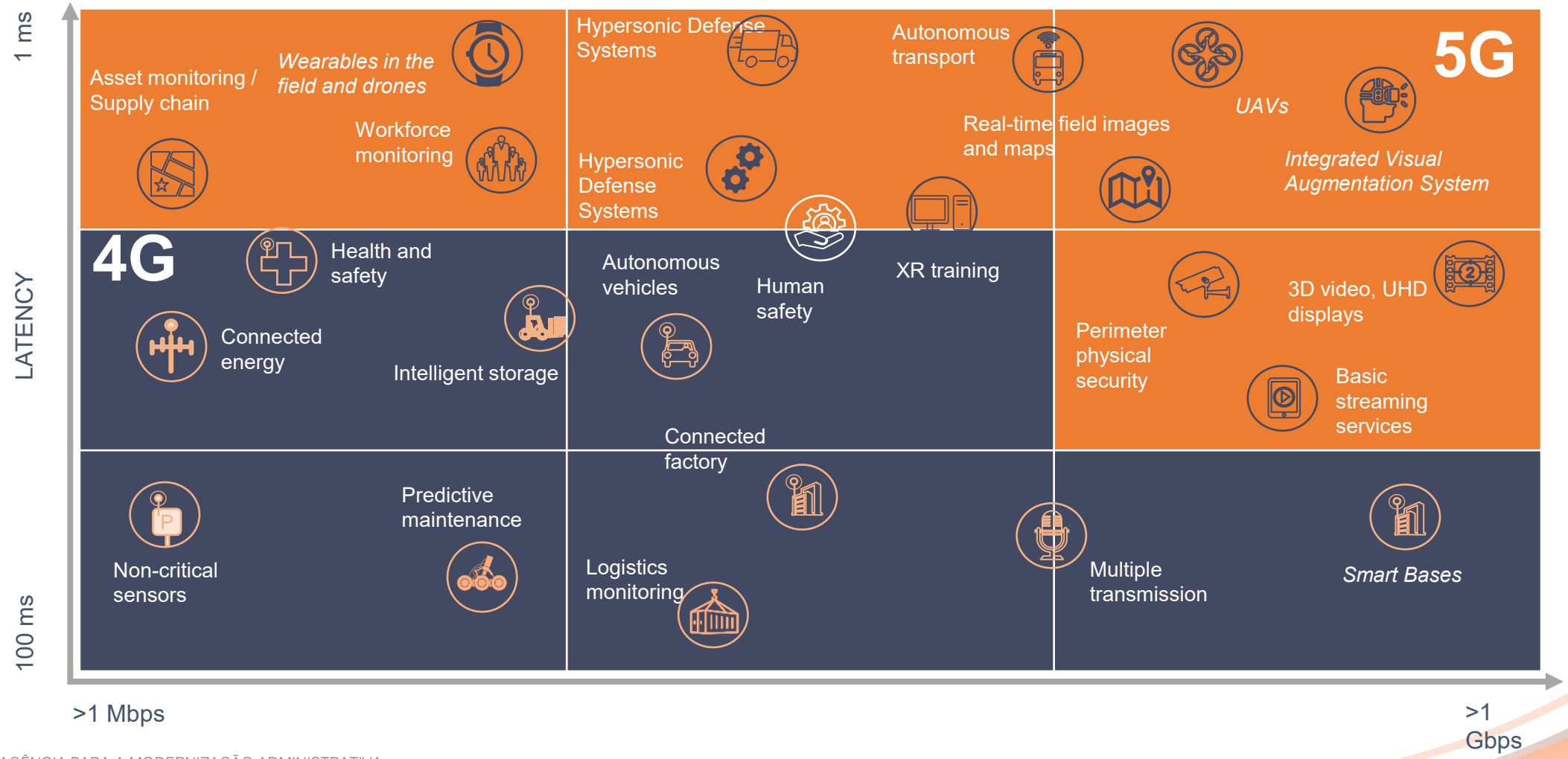
100 Mbit/s where needed

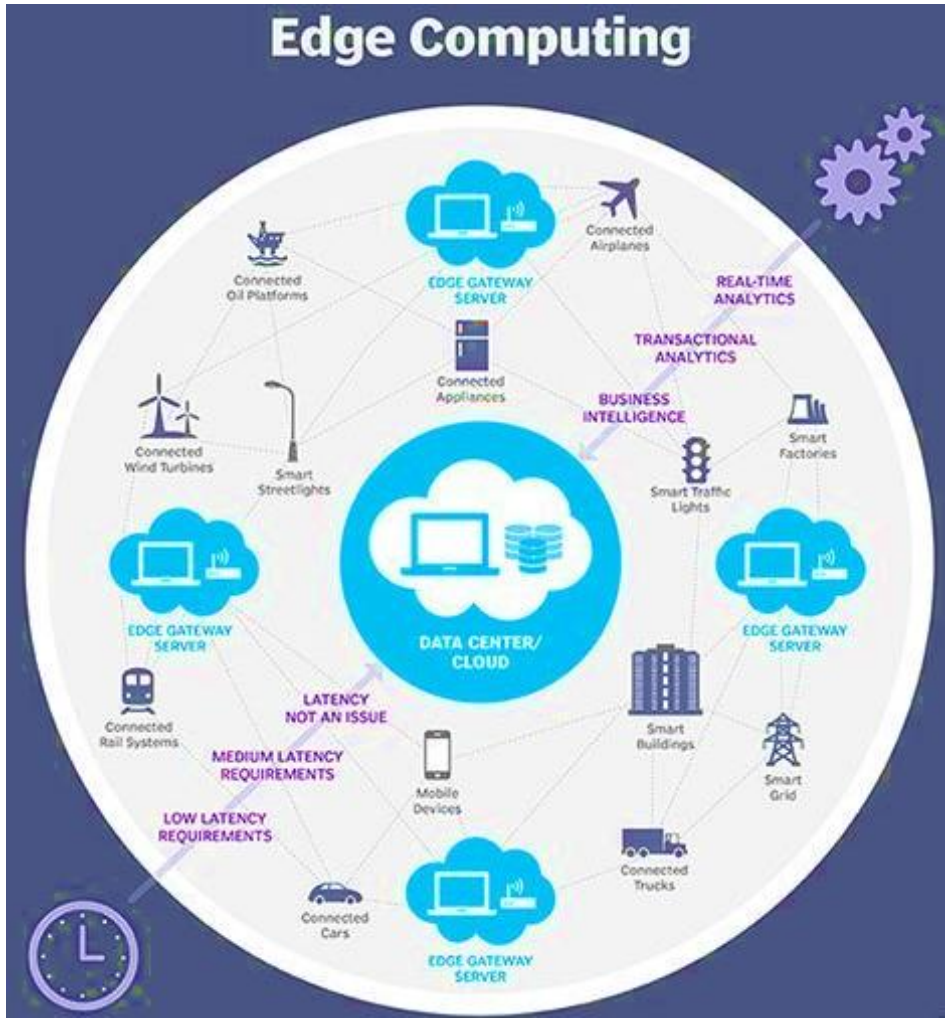
"The combination of speed, responsiveness, and reach can unlock the capabilities of other technology trends, giving a boost to autonomous cars, drones, virtual reality, and the Internet of Things." – Roger Cheng, c|net

https://www.cnet.com/news/notre-dame-cathedral-fire-slow-reconstruction-and-new-dangers-ahead-update/

01 INTRODUCTION – CONTEXT | SERVICES VS. 5G SPEEDS/LATENCIES

5G technology enables the launch of services with lower latency and higher speeds compared to 4G technology.

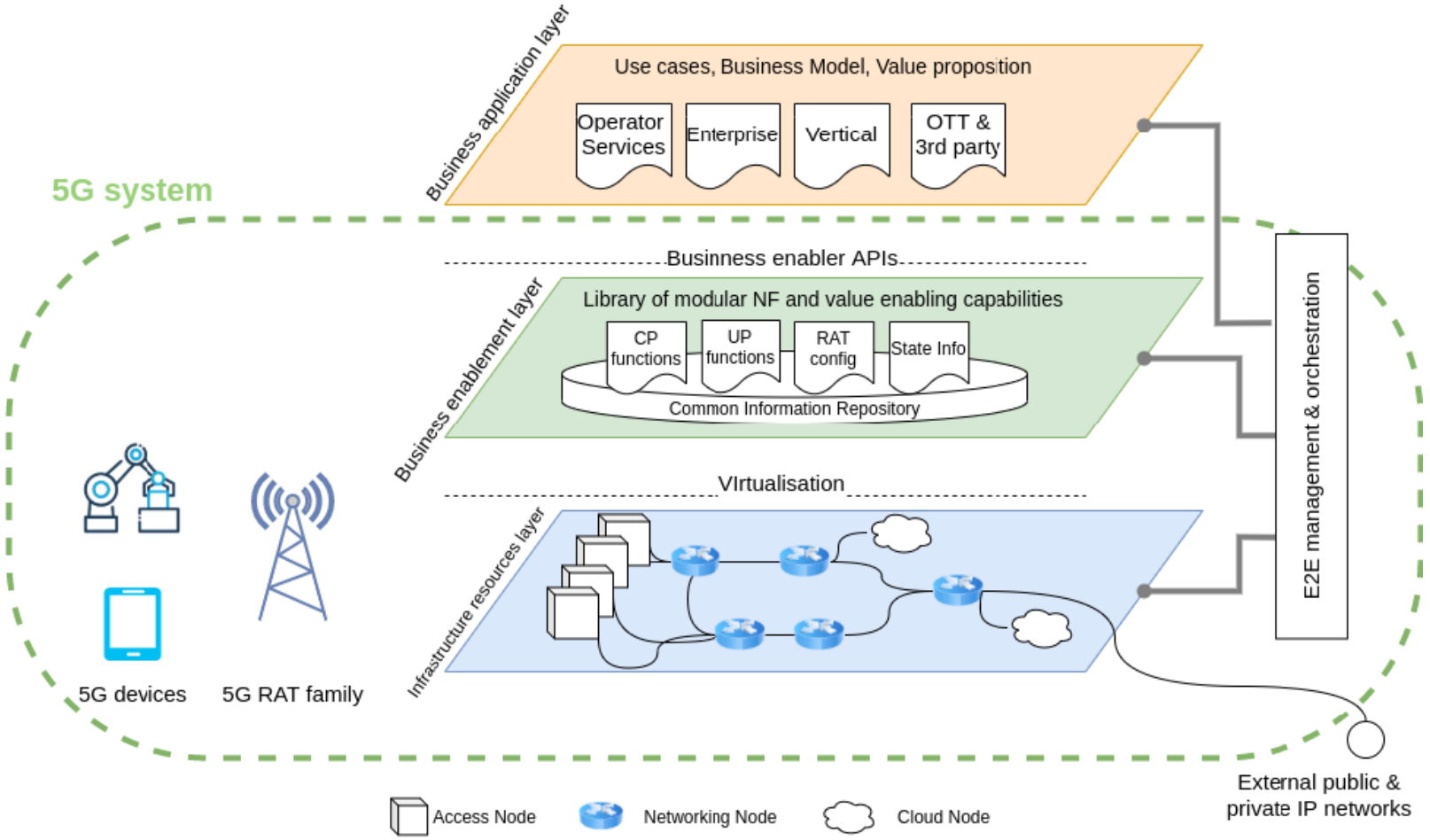




Source: What is multi-access edge computing, and how has it evolved? (techtarget.com)

MEC: Multi-Access Edge Computing

- MEC/Edge Computing refers to the ability to process data at the edge of the network, in order to prevent large volumes of traffic from traveling through most of the network.
- It helps save energy and infrastructure by reducing the traffic sent through the Central Network.
- Allows filtering and protecting data locally.
- Enables the launch of new applications, such as autonomous vehicles, virtual reality, and IoT in industry.
- In rural areas, the coverage provided by 5G and MEC allows many companies to develop specific software for local/edge processing instead of relying on the Cloud or Data Centers.



Source: N. Alliance, «5G white paper», Next generation mobile networks, white paper, vol. 1, 2015.

Virtualization

- The virtualization of telco functions in 5G networks allows them to be installed and managed on generic servers (in the cloud).

Orchestration

- Allows dynamic management and orchestration of virtualized resources. For example, the lifecycle of a network slice.
- Enables horizontal and vertical elasticity.

ARTIFICIAL INTELLIGENCE

- Application in areas such as planning, event prediction, autonomous repair, and automatic failure mitigation.
- Cost reduction, improved performance and network efficiency, and creation of new business opportunities.

CLOUD

- Base platform for the operation of 5G networks. The virtualization of 5G networks allows them to be installed on generic servers in the cloud.
- Enables increased network capacity, introduces the concept of elasticity, and allows greater hardware efficiency.

BIG DATA

- Big Data enables the processing of large volumes of 5G network data.
- Allows real-time analysis of 5G data and IoT applications (sensors, gateways, controllers), supporting predictive and autonomous decisions.

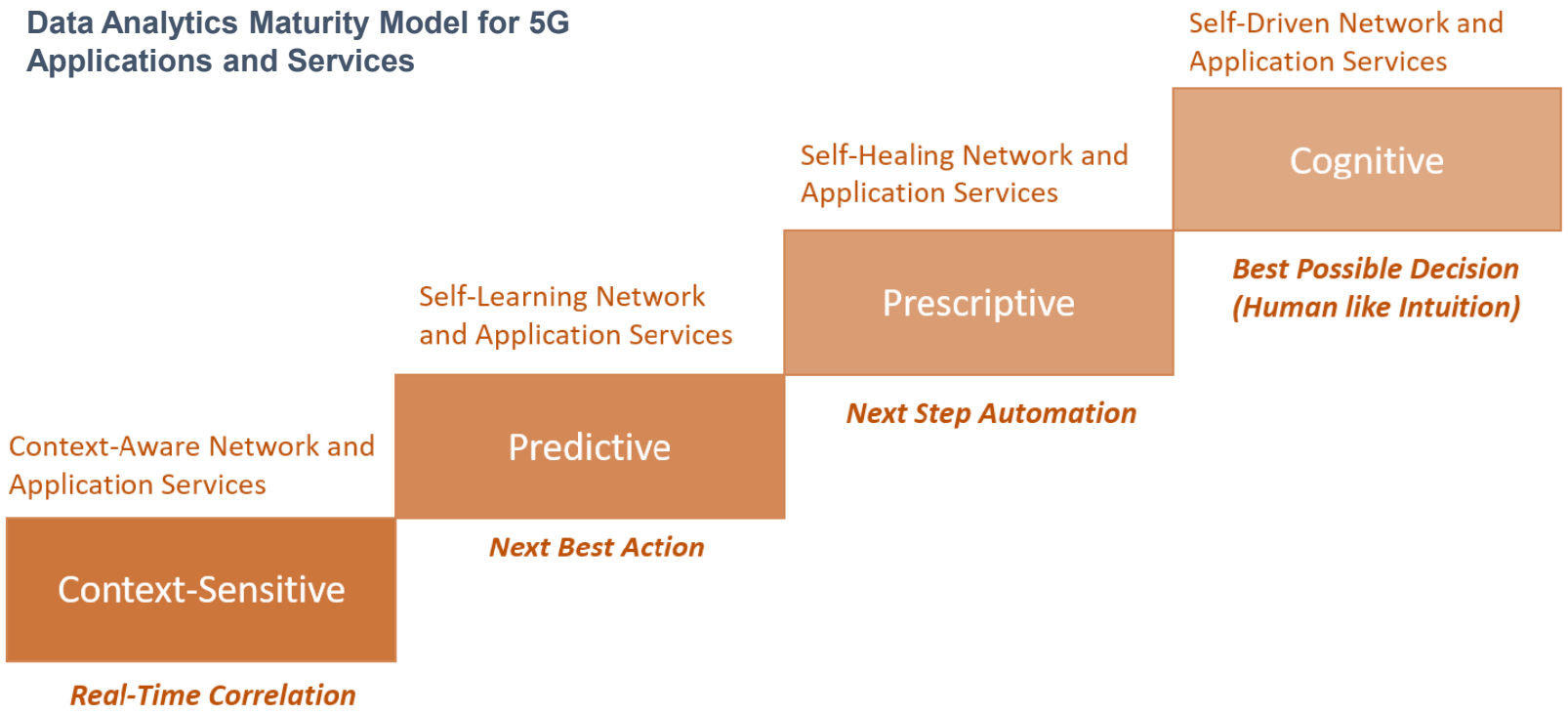
IOT SENSORS

- *Internet of Things* (IoT) and Industry 4.0 are the main drivers of networks and 5G use cases.
- *Context Aware Engine (CAE) will be part of 5G networks, introducing contextualization and cognitive intelligence to support decision-making.*

AR&VR

- 5G networks have specific characteristics for supporting AR & VR applications that require high speed, low latency, and many devices.
- Transmission of AR content for autonomous vehicles.
- Mobile VR solutions.

Data Analytics Maturity Model for 5G Applications and Services

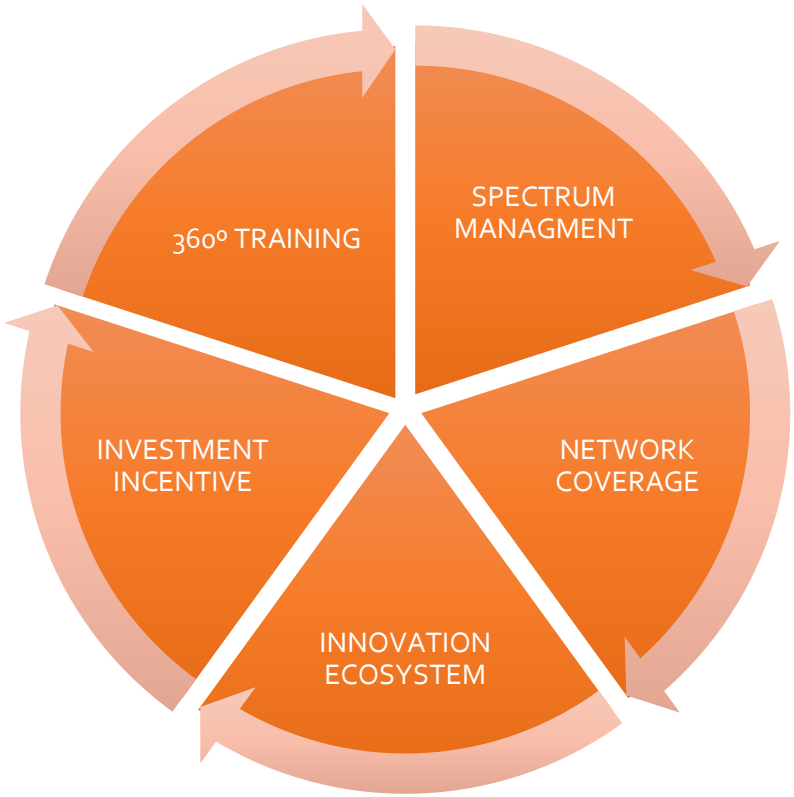


Source: Data-Analytics-in-5G-Applications030518.pdf (ieee.org)

- The data processing generated by IoT applications and 5G use cases will tend to evolve beyond basic reporting.
- It is expected that with the evolution of the network to 5G and 6G, applications will reach levels of full automation and autonomous remediation/decision-making.

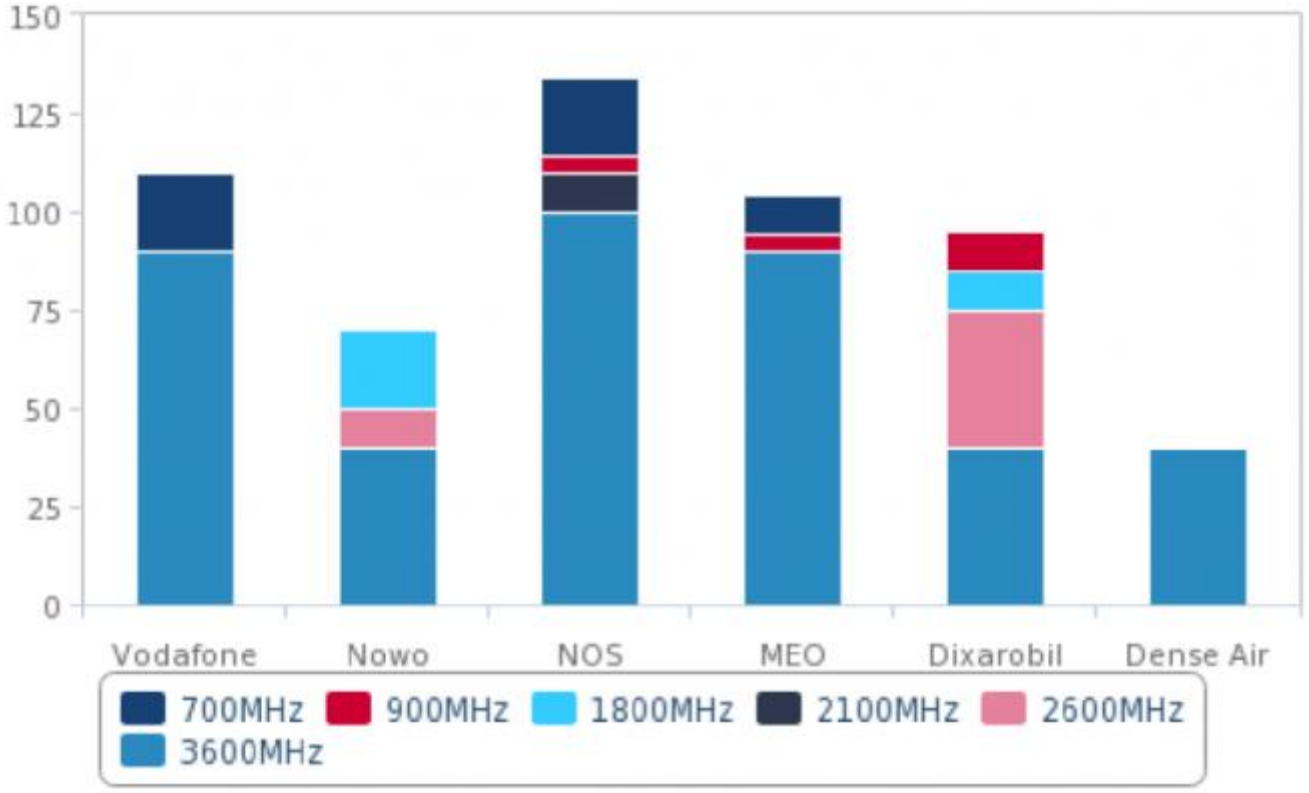
The table below shows the maturity level for the most well-known 5G use cases, which can be divided into four verticals.

	Smart Cities	E-Health	Autonomous Vehicles	Industry 4.0
Context	• Digital Shopping Experiences • Mobile Broadband • Public Transport	• Digital Medical Record	• Driver Behavior • On-board Diagnostics • Service Reminders• • Sensors	• Assets Management
Predictive	• Traffic Management • Waste Management • Banks/Insurance Companies	• Advanced Diagnostics • Predictive Alerts	• Predictive Alerts	• Maintenance • Revenue Forecasting
Prescriptiv	• Public Safety • Surveillance and Private Security	• Preventive Healthcare	• Fault Repair • Smart Routes • Fleet Management	• Energy Efficiency • Supply Chain Optimization
Cognitive	• Urban Infrastructure Planning • Emergency Response Systems	• Remote Trauma Care	• Intelligent Driving	• Control and Automation



- **Spectrum Management**
  Lower frequencies have the advantage of wider coverage, while higher frequencies allow higher speeds and better service experience. The harmonization and standardization of the spectrum are critical for the introduction of 5G technology.
- **Network Coverage**
  5G networks must consider mapping different traffic profiles by geographic area. The type of equipment and level of service (speed, latency) to be provided in each geography are important to ensure the satisfaction of different customer segments.
- **Innovation Ecosystem**
  Partnerships with the private sector, universities, operators, and other states facilitate brainstorming and accelerate the launch of new services with synergies.
- **Business/Investment Incentive**
  The launch of the 5G network should promote a favorable business climate to attract a higher number of investors. 5G pricing should convey the message that the increase in ARPU is offset by improved performance, lower latency, and new experiences in mobile device usage.
- **360º Training**
  Training programs encourage greater adoption and the creation of talent pools.

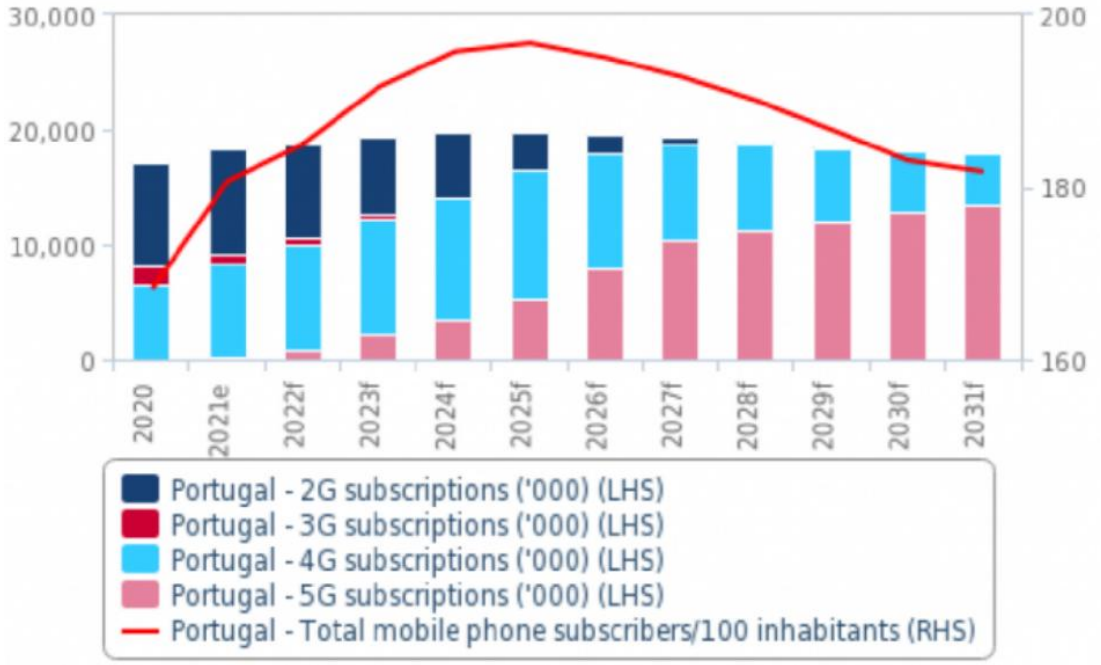
Alocação de Espectro 5G em Portugal [2021]



Source: ANACOM e Fitch Solutions

- The 700 MHz band is suitable for ensuring the transition to the 5G generation of mobile networks and for guaranteeing coverage in different areas.
- The 3.6 GHz band (3.4–3.8 GHz) is better suited for providing the necessary capacity for services supported by 5G systems.
- Other bands for mobile operation (900 MHz, 1800 MHz, 2.1 GHz, and 2.6 GHz) allow supporting new operations and/or complementing existing ones.

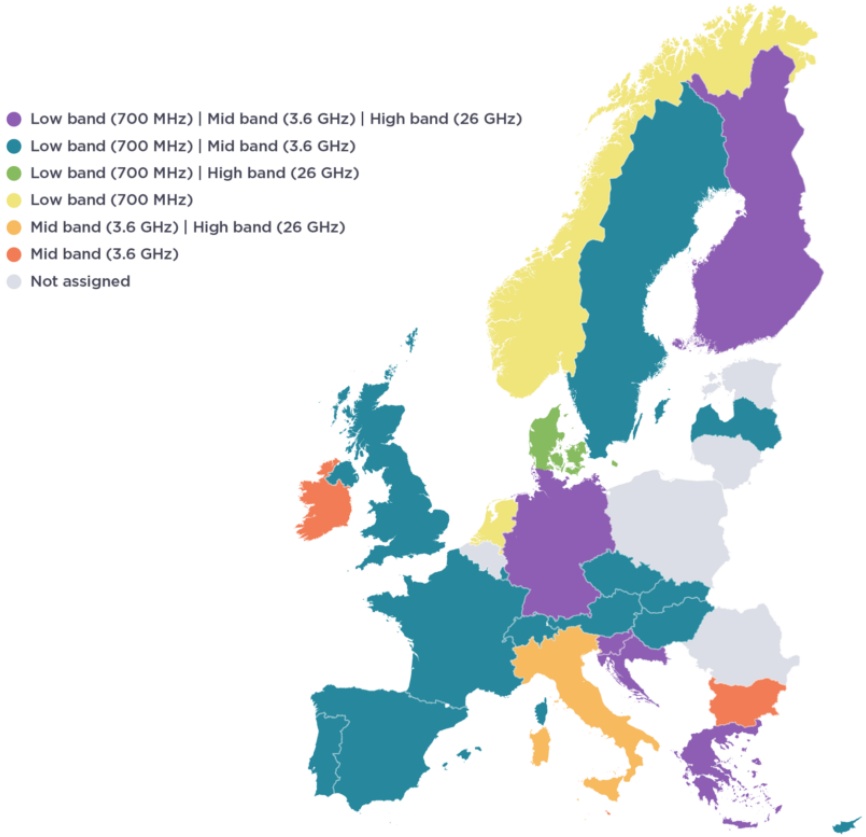
5G Adoption Forecast in Portugal [2020-2030]



Fonte: ANACOM e Fitch Solutions

The 5G network is available and covers half of the population in the national territory, from north to south, coastal and inland, and on the islands of the Azores and Madeira.

Cobertura em 2022 de 5G na EU



Source: https://www.ookla.com/articles/5g-europe-mapping-the-future-q1-2022

02 5G Use Cases

02 BENCHMARK – CATALOGUE OF USE CASES

The selection of the use cases below was based on the assumption of the need for 5G technology for their implementation.

SMART ECONOMY	SMART QUALITY OF LIFE	SMART GOVERNANCE	SMART MOBILITY	SMART SOCIETY	SMART ENVIRONMENT
• • Monitoring and Management of Public Infrastructure • 5G Neutral Hosts • Safety in Construction	• 5G Ambulances for Emergency Medical Services • Remote Surgeries in the National Health Service • 5G Hospitals in the National Health Service • Continuous Monitoring of Health and Sports Activities	• Migration of Emergency Networks to 5G • Monitoring and Firefighting Using 5G Drones • 5G Emergency Service Responses	• Management of Maritime Ports with 5G • Autonomous Vehicles • Real-Time Traffic Optimization in Cities	• Territorial Cohesion (e.g., Health, Education, Safety)	• Smart Agriculture – Sensing, Telemetry
Control or prevention of public buildings and restricted zones, as well as increased network resilience	Medical assistance, remote surgeries and optimization of logistics for resources and personnel in hospitals	Enhance the transmission of data from emergency services and firefighting using drones	Optimization of city traffic and management of port equipment	Personalized and remote education in rural and hard-to-access areas	Real-time monitoring of agricultural soils, humidity, etc.

02 BENCHMARK – Monitoring and Management of Public Infrastructure

The rollout of 5G will enable greater safety in public spaces and roads.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
MONITORING AND MANAGEMENT OF PUBLIC INFRASTRUCTURE

POTENTIAL PUBLIC SECTOR(S):
Central, Regional and Local Government; Ministry of Infrastructure and Housing

CATEGORY:
Public Infrastructure

REFERENCES:
- US
- Finland

SUMMARY:
This case study, through the implementation of video surveillance cameras using Private Wireless Networks (PWNs), will allow the creation of a secure environment in public buildings and areas with low mobility.

Functions	Advantages	Disadvantages	Risks/Challenge	Estimated Timeframe
• Control and prevention of public buildings and restricted areas	• Vehicle tracking and identification • Verification of access and exits	• GDPR – lack of regulatory framework for PWNs in Portugal	• Security failure • Compatibility of systems and equipment	• Medium term

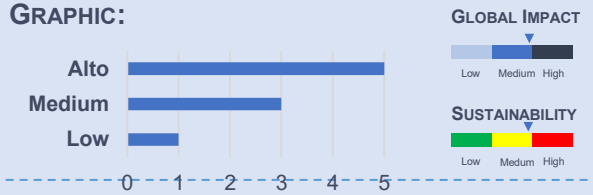
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ PWN
- ✓ IoT Sensors
- ✓ Cloud
- ✓ UHD & *Full* HD
- ✓ *Drones*
- ✓ MEC
- ✓ vCPEs

POTENTIAL PARTNERS:
- ✓ Beyond Vision
- ✓ Axiometek
- ✓ Government of Finland
- ✓ Telia
- ✓ Ericsson
- ✓ Bosch

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – High
- ✓ Technical Feasibility – High
- ✓ Sustainability – Medium
- ✓ Replicability and Generalization – High
- ✓ Sector/Public Administration Transformation – Medium
- ✓ Economic Impact – Medium
- ✓ Environmental Impact – Low
- ✓ Emergency Response Improvement – High
- ✓ Impact on Other Strategies – High

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and fixed costs (CAPEX) in this use case can be significant, depending on the number of cameras (4K/8K), sensors (motion and temperature) included in buildings, and the number and type of drones acquired.

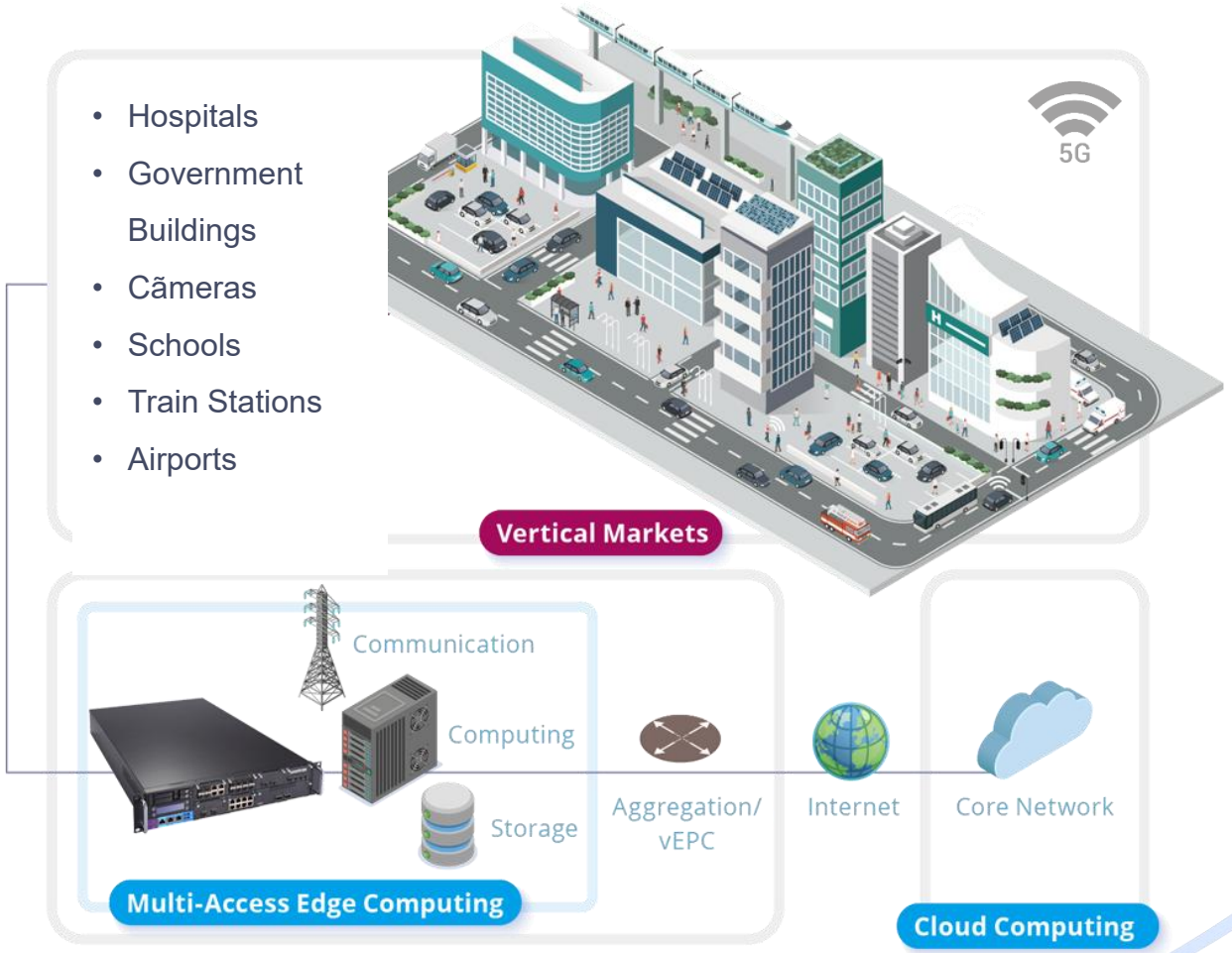
02 BENCHMARK – Monitoring and Management of Public Infrastructure

TECHNICAL ANALYSIS

- Type of Buildings: Government Buildings, Cameras, Train Stations, Metro, Schools, Universities
- Communication Network: Directorate-General of the Public Security Police, PWNs (Private Wireless Networks)
- Type of Data Transmitted: Cloud ⇢ (infrastructure management applications), Location, Temperature, Video, Facial Recognition
- Caraterísticas: Characteristics: 4K Resolution, Motion, Sound, and Temperature Sensors
- Accessories: Security cameras, sensors, drones

MAIN REGULATION

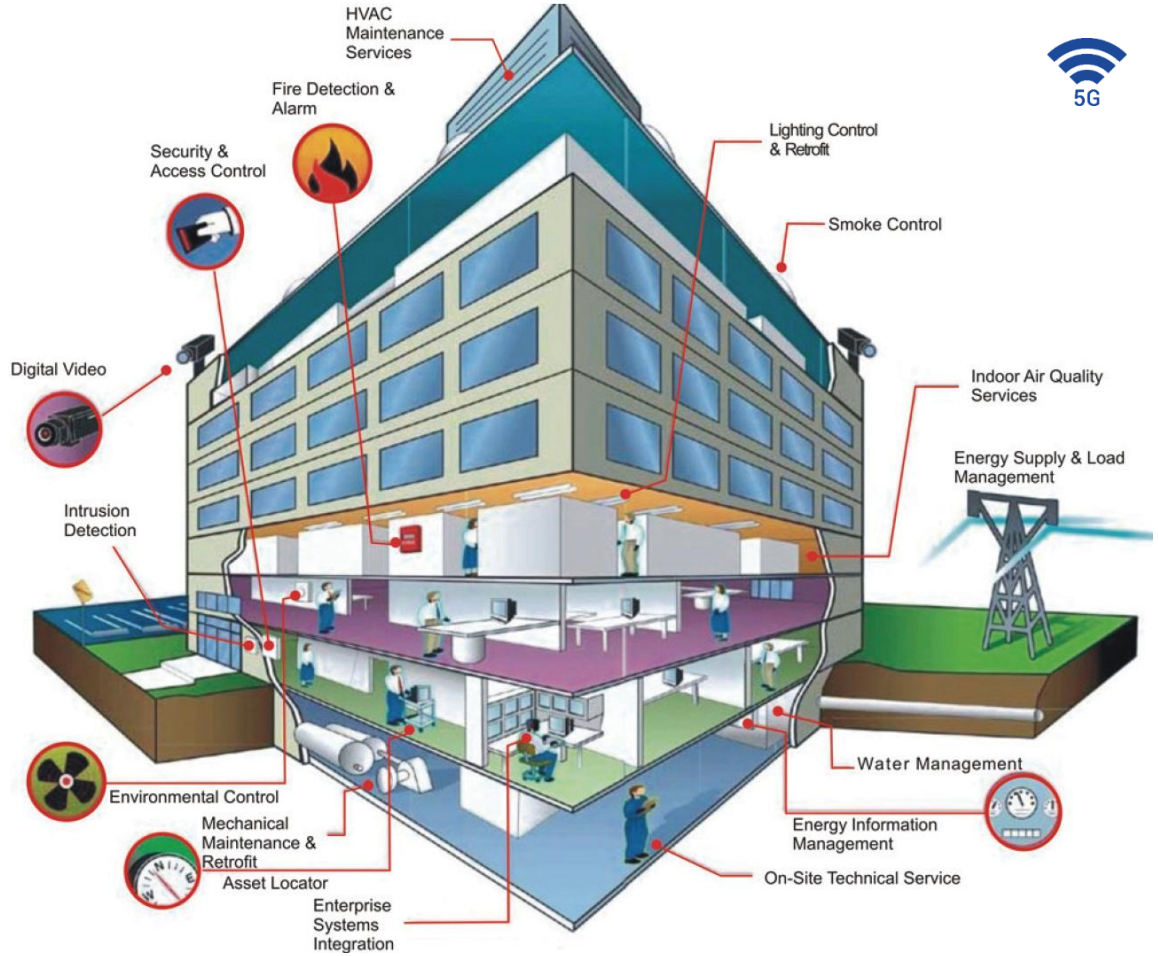
- https://dre.pt/dre/detalhe/lei/95-2021-176714548
- https://www.pgdlisboa.pt/leis/lei_mostra_articulado.php?nid=1924&tabela=leis
- https://www.gestlegis.com/lei-n-o-95-2021-sistemas-de-videovigilancia-para-captacao/



Source: Network Server for 5G Edge Applications (axiomtek.com)

02 BENCHMARK – Monitoring and Management of Public Infrastructure

ILLUSTRATIVE FIGURE AND CHARACTERISTICS



Source: http://www.mdpi.com/journal/sustainability

- Centralized management at regional or national level of all public infrastructure
- Autonomous control and optimization systems
- Video surveillance using 4K/8K video and drones
- Secure and independent 5G Network Slicing or Private/Dedicated 5G Network (PWN)
- Sensors for detecting movement and temperature
- Remote management of building water and sewage systems
- Monitoring of fires and interconnection with other national emergency systems
- *Handover between WiFi 6 and 5G devices*
- Facial recognition for critical areas
- Air conditioning control
- Automation of manual processes
- Use of Cloud and Big Data computing for storage and processing of large data volumes
- Centralized management of humidity, temperature, and air quality

02 BENCHMARK – 5G "Neutral Host"

The rollout of 5G will increase the need to build and implement new network-sharing solutions inside buildings.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
NEUTRAL HOST

POTENTIAL PUBLIC SECTOR(S):
Central Government, ANACOM, Ministry of Internal Administration

CATEGORY:
Governamental

REFERENCESS:
- US
- Italy

SUMMARY:
This use case allows private entities to create 5G networks, generally inside buildings, which they then lease to other providers. It also enables cost optimization, as each operator shares the same network infrastructure.

Functions	Advantages	Disavantages	Risks/Challenge	Estimated Timeframe
Increase network resilience	Launch of new applications	Network management and maintenance complexity	Higher risk of signal exposure and interference	Medium to Long Term

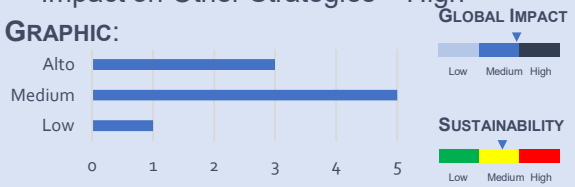
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ 5G slicing
- ✓ Cloud
- ✓ AR & VR
- ✓ MEC

POTENTIAL PARTNERS:
- ✓ NOKIA
- ✓ Lucca-IT
- ✓ Bristol-UK
- ✓ Cellnex
- ✓ ATIS-US
- ✓ Ericsson

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – High
- ✓ Technical Feasibility – High
- ✓ Sustainability – Medium
- ✓ Replicability and Generalization – Medium
- ✓ Sector/Public Administration Transformation – High
- ✓ Economic Impact – High
- ✓ Environmental Impact – Medium
- ✓ Emergency Response Improvement – Low
- ✓ Impact on Other Strategies – High

GRAPHIC:



OBSERVATIONS:
Operating (OPEX) and capital (CAPEX) costs are reduced due to network sharing among multiple operators, while also enabling faster installation of private 5G networks by new entities.

02 BENCHMARK - 5G “Neutral Host”

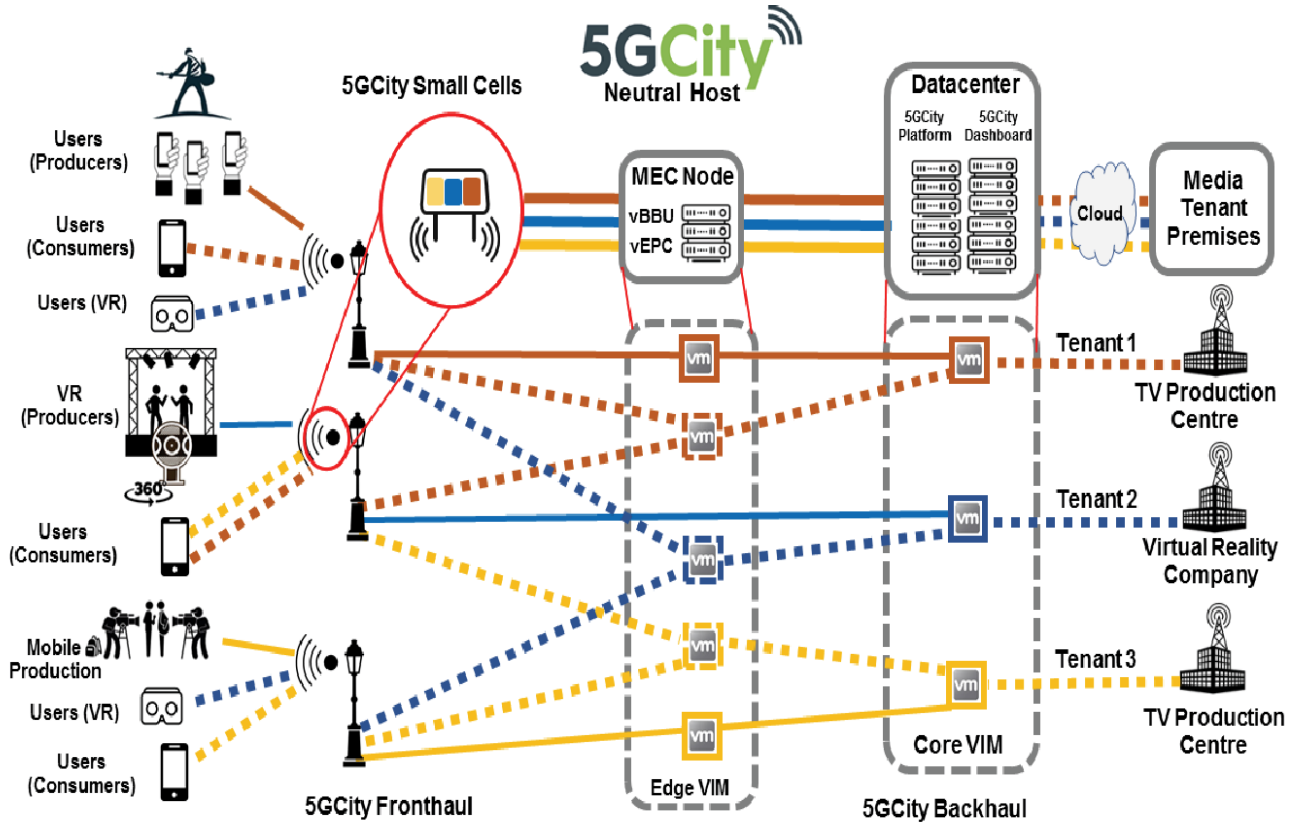
TECHNICAL ANALYSIS

•Type of Data Transmitted: voice, video, and text in real time, highest priority; “Massive IoT” and “device-to-device”

•Characteristics: Network slicing ensures much higher speeds and very low latencies

MAIN REGULATION

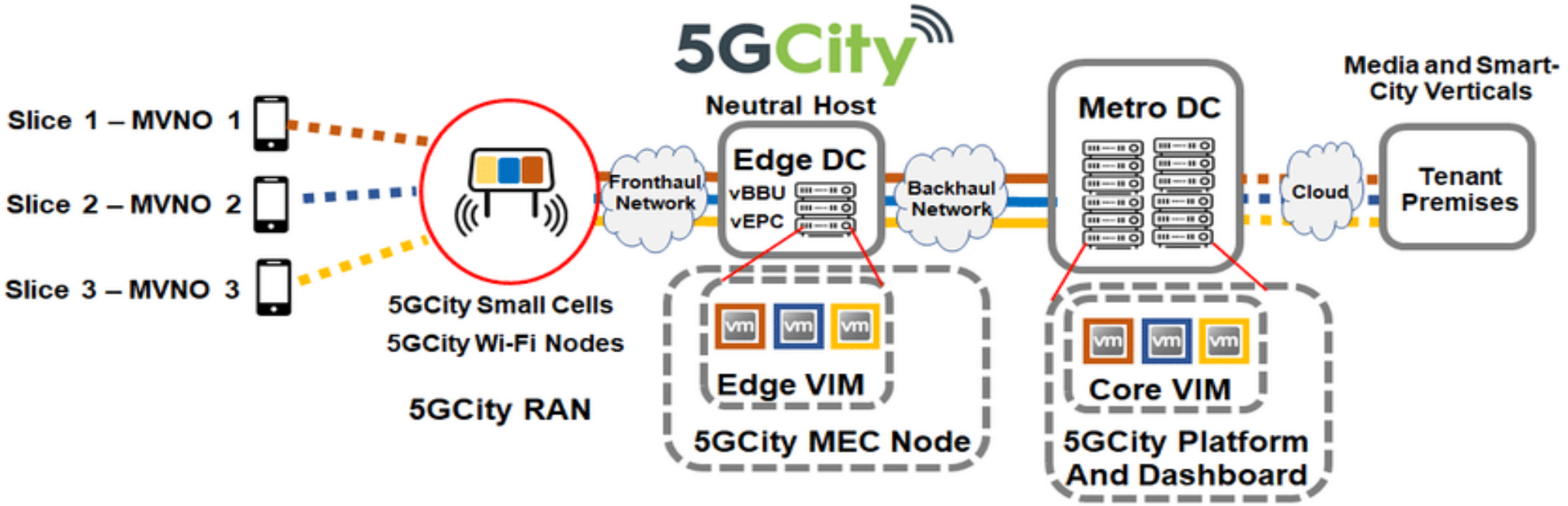
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8659788/
- ANACOM - Portaria n.º 554-A/2022, de 21 de junho
- ANACOM - Regulamento n.º 183/2022, publicado a 21 de fevereiro
- ANACOM - Decreto-Lei n.º 20/2022, de 28 de janeiro



Source: https://www.semanticscholar.org/paper/5G-City%3A-A-Novel-5G-Enabled-Architecture-for-and-on-Meixner-Diogo/4f50d42270c9c904608fe8fa42fc07c5dc00fadb/figure/7

02 BENCHMARK - 5G “Neutral Host”

ILLUSTRATIVE DIAGRAM AND CHARACTERISTICS



Source: https://www.researchgate.net/figure/5GCity-neutral-host-Vision-with-multiple-MVNOs-sharing-virtualized-functions-at-the-edge_fig2_336742096

- The investment in MEC by the Neutral Host will enable lower latencies.
- A centralized control and management system will ensure more efficient network operation.
- Through network virtualization, it is possible to increase flexibility and reduce network implementation and operation costs.

02 BENCHMARK – Construction Safety

The rollout of 5G will enable construction automation, leading to increased productivity and monitoring capacity.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
CONSTRUCTION SAFETY

POTENTIAL PUBLIC SECTOR(S):
Central Government, Ministry of Infrastructure and Housing

CATEGORY:
Civil Construction

REFERENCES:
- UK
- Singapore

SUMMARY:
In this case study, detailed and updated digital models of construction sites in public works are created, monitoring progress and verifying work quality in real time.

Functions	Advantages	Disadvantages	Risks/Challenge	Estimated Timeframe
• Reduction of delays, promoting faster real-time decision-making	• Improved workplace safety; Greater precision in construction monitoring	• Need for worker training • Higher investment costs	• Cyberattacks • Equipment failure	• Medium to Long term

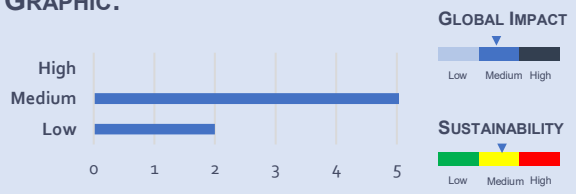
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ UHD
- ✓ IoT Sensors
- ✓ IA
- ✓ *Robots*
- ✓ *Cloud*
- ✓ *Drones*

POTENTIAL PARTNERS:
- ✓ 5Gradar
- ✓ UK
- ✓ KT Enterprise
- ✓ Ericsson
- ✓ GSMA
- ✓ Qualcomm
- ✓ Singapore

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – M
- ✓ Technical Feasibility – M
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – M
- ✓ Economic Impact – M
- ✓ Environmental Impact – B
- ✓ Emergency Response Improvement – B
- ✓ Impact on Other Strategies – M

GRAPHIC:



OBSERVATIONS:
Operating (OPEX) and infrastructure (CAPEX) costs are variable depending on the number of cameras and other equipment acquired.

02 BENCHMARK – Construction Safety

TECHNICAL ANALYSIS

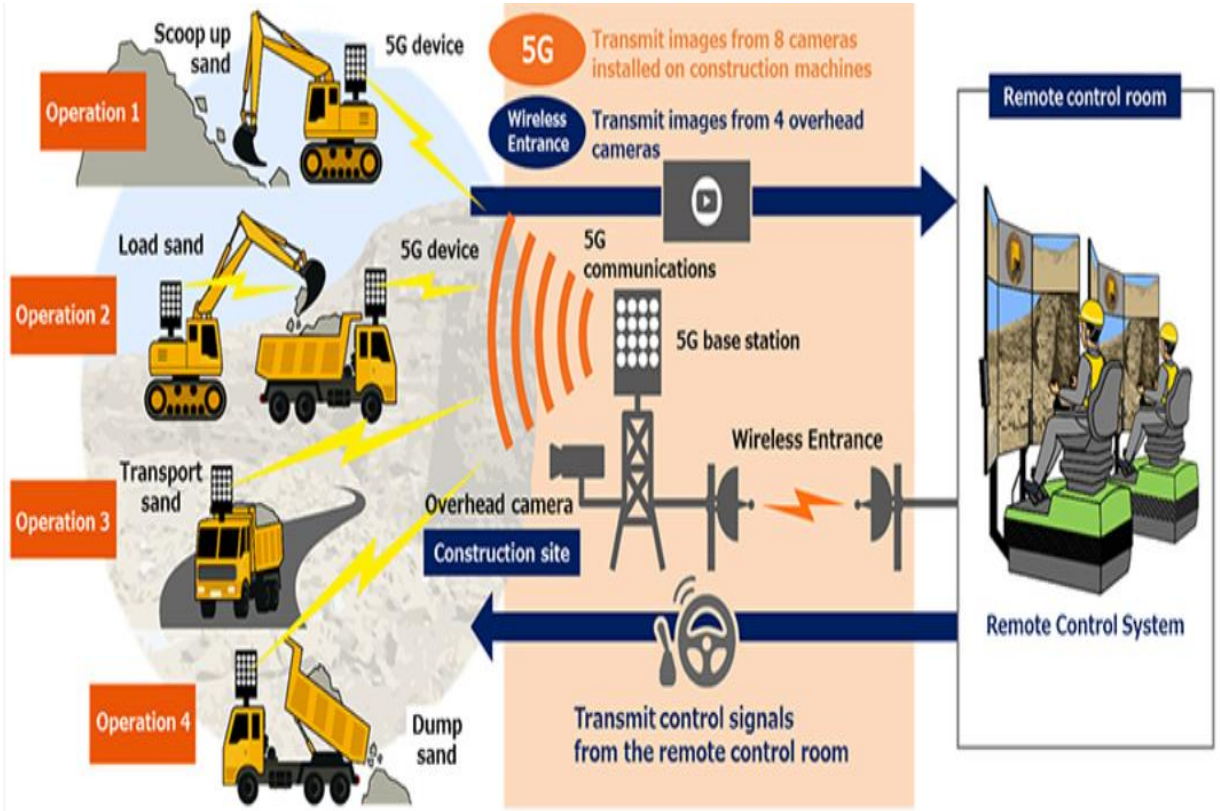
• Type of Data Transmitted: Video captured by high-definition 4K cameras mounted on construction machinery is transmitted to the remote controller via a 5G system. The operator in the remote-control room operates the equipment while watching the high-resolution video on the monitors in real time.

• Characteristics: Ultra-fast data transmission speeds

• Accessories: 4K Cameras, IoT Sensors

MAIN REGULATION

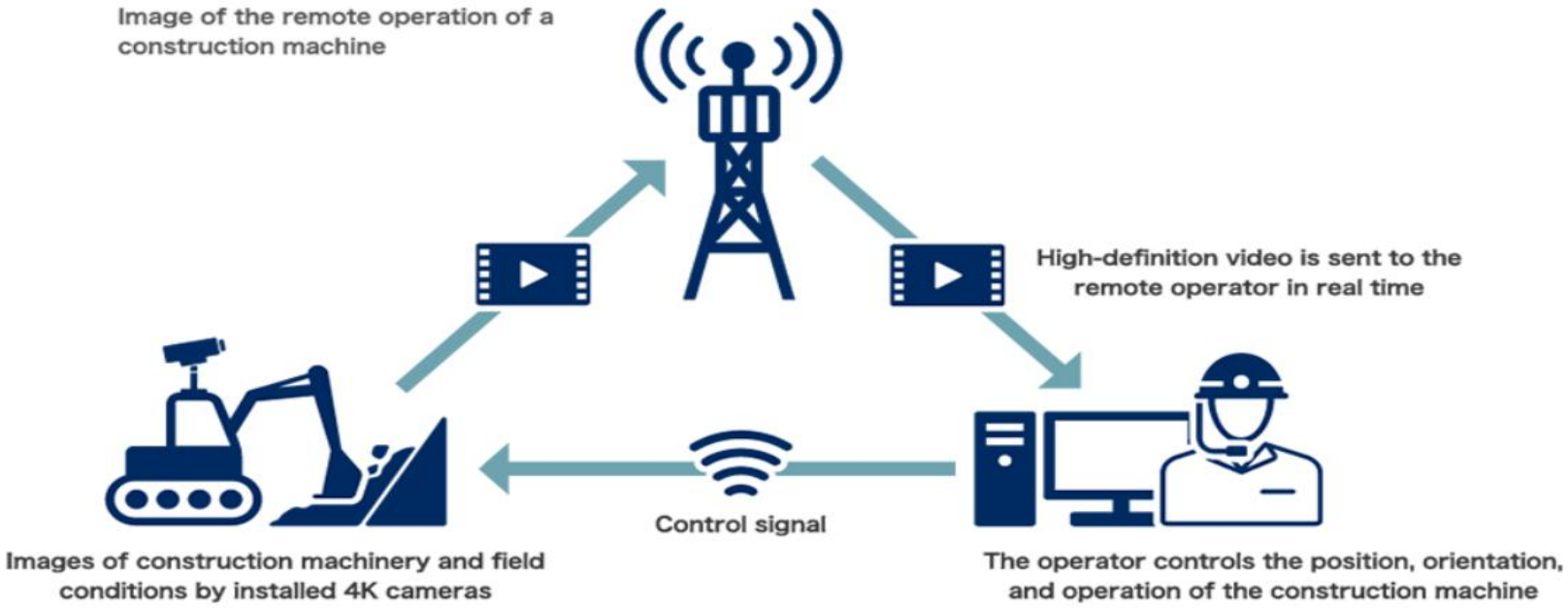
- https://www.anac.pt/vPT/Generico/drones/enquadramento_regras_procedimentos/enquadramento_uas/Paginas/Enquadramento_uas.aspx
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1166
- Site rules and induction - Construction health & safety (hse.gov.uk)



Source: KDDI, Obayashi, NEC use 5G to successfully remotely control construction machinery - Japan Today

02 BENCHMARK – Construction Safety

ILLUSTRATIVE DIAGRAM AND CHARACTERISTICS



Source: 5G boosts unmanned remote construction KDDI Corporation, Obayashi Corporation, and NEC conduct field experiment

- Build a remote construction control room, which can potentially improve efficiency and reduce the costs of public works projects.
- Increase work efficiency to enable effective and streamlined execution, while simultaneously improving work quality.

02 BENCHMARK – 5G Ambulances for Emergency Medical Services

The rollout of 5G in EMS will enable remote and real-time medical assistance for patients at the scene of an accident and during transport.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
5G AMBULANCES FOR EMERGENCY MEDICAL SERVICES

POTENTIAL PUBLIC SECTOR(S):
Central Government, Ministry of Health, State Secretariat for Civil Protection

CATEGORY:
Health, Emergency Transport

REFERENCE:
- UK
- Barcelona

SUMMARY:
In this case study, the use of emergency transport vehicles constantly connected to the internet allows real-time exchange of clinical information between hospitals and ambulances, providing remote medical assistance directly to the patient.

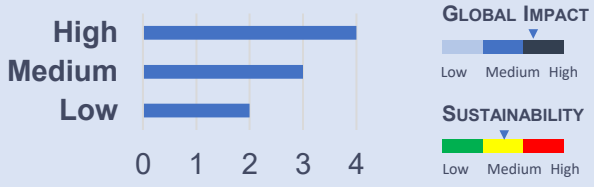
Functions	Advantages	Disadvantages	Risks/Challenges	Estimated Timeframe
• Use of IoT in real time between ambulances and hospitals • Remote medical assistance	• Increased efficiency in emergency response • Personalized treatment	• Requires significant investment and staff training	• Network failure	• Medium term

DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ *5G Emergency Networks*
- ✓ AR&VR
- ✓ *Cloud*
- ✓ AI
- ✓ GPS
- ✓ IoT Sensors

POTENTIAL PARTNERS:
- ✓ Mobile Operators
- ✓ Government of Catalonia
- ✓ Government of Thailand
- ✓ University Hospitals Birmingham
- ✓ Fibocom

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – A
- ✓ Technical Feasibility – A
- ✓ Financial Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – M
- ✓ Economic Impact – B
- ✓ Environmental Improvement – B
- ✓ Emergency Response Improvement – A
- ✓ Impact on Other Strategies – A



OBSERVATIONS:
Operating (OPEX) and capital/setup (CAPEX) costs in this use case may be significant depending on the number of ambulances to be equipped, the number of IoT devices and sensors to be included in 5G ambulances: 4K/8K cameras, VR/AR headsets, 5G medical devices, and V2X communications.

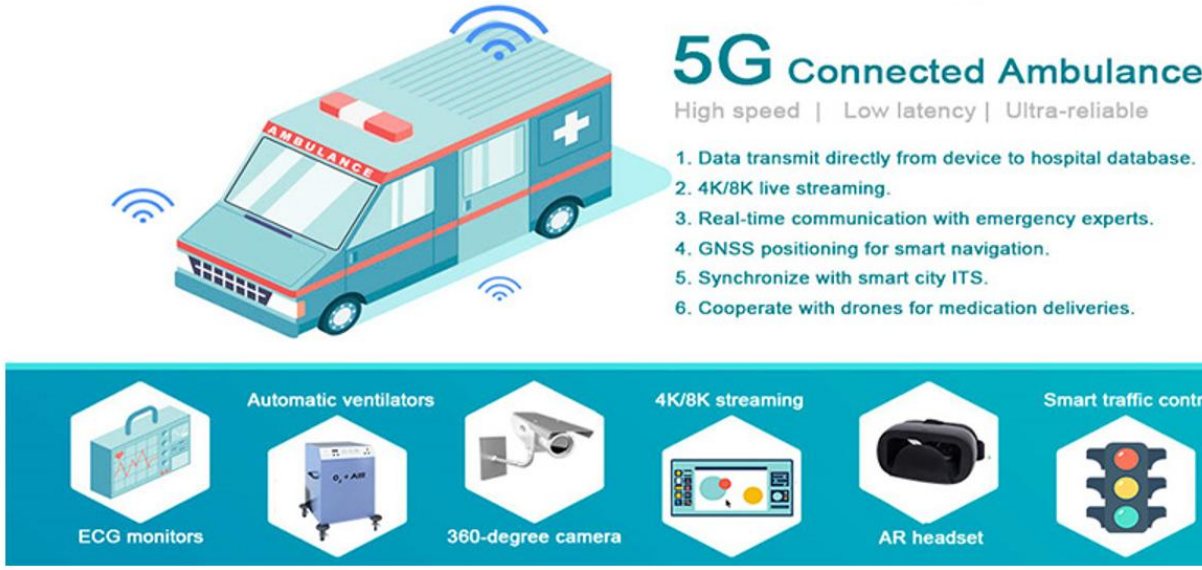
02 BENCHMARK – 5G Ambulances for Emergency Medical Services

TECHNICAL ANALYSIS

- Type of Ambulances: Ambulances at Emergency Medical Posts (PEM) and Emergency Medical Ambulances (AEM)
- Communication Network: National Institute of Medical Emergency
- Type of Data Transmitted (Cloud <> Ambulance): Vehicle geolocation, personal and medical information of the patient
- Accessories: Joystick connected to a robotic ("haptic") glove, 4K/8K camera, VR headset

MAIN REGULATION

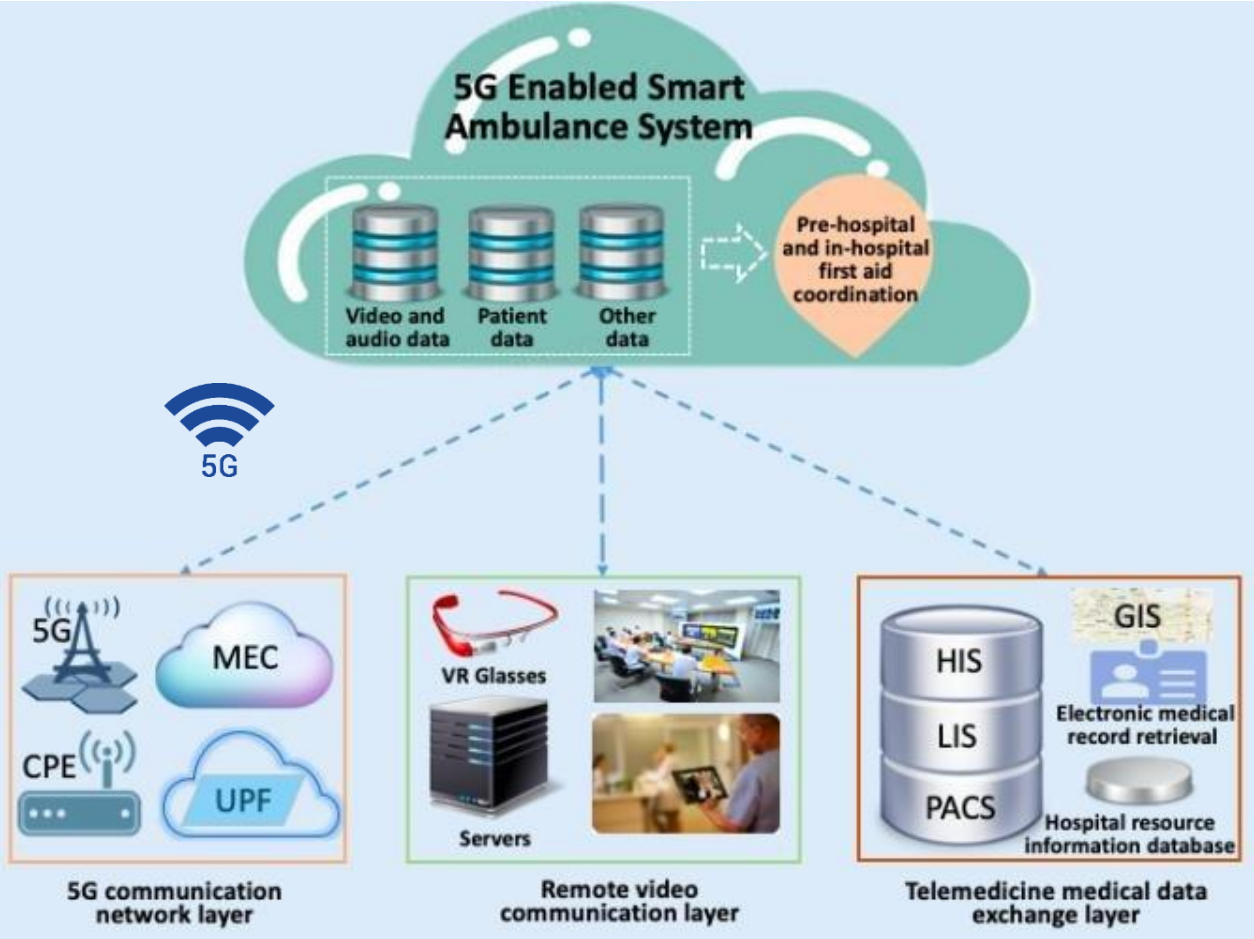
- Regulation for ambulance identification: https://dre.pt/dre/detalhe/deliberacao/705-2019-122605190
- EU Regulations for ambulances: https://health.ec.europa.eu/medical-devices-sector/new-regulations_en



Source: https://iotbusinessnews.com/2020/10/21/10541-fibocom-5g-modules-empower-connected-ambulances-for-modern-telehealth/

02 BENCHMARK - Ambulâncias 5G para o Serviço de Emergência Médica

EXEMPLARY DIAGRAM AND CHARACTERISTICS



- High-definition video to receive remote specialized support during patient care inside the ambulance
- Independent and secure 5G Network Slice
- Massive connection for IoT devices – Communication with various sensors and intelligent devices in the region, near the ambulance, and inside the ambulance itself
- 360° camera for communication between hospital and ambulance
- V2X communications between ambulance and infrastructure, ambulance and other vehicles, ambulance and pedestrians, ambulance and aircraft
- Use of Cloud and Big Data computing for storage and processing of large amounts of data

02 BENCHMARK – Remote Surgeries in the National Health Service

The rollout of 5G in the NHS will allow doctors to perform surgical procedures together from different locations.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
REMOTE SURGERIES IN THE NATIONAL HEALTH SERVICE

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Health, Directorate-General of Health

CATEGORY:
Health

REFERENCES:
- Portugal (Fund. Champalimaud)
- Strasbourg

SUMMARY:
In this case study, the use of augmented and virtual reality enables the acceleration of training processes for new doctors, as well as the possibility of performing surgical operations on patients in remote locations.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Surgical interventions in remote locations	• Increased training capabilities and faster treatment for patients	• Intensive training required	• Network failure	• Long term

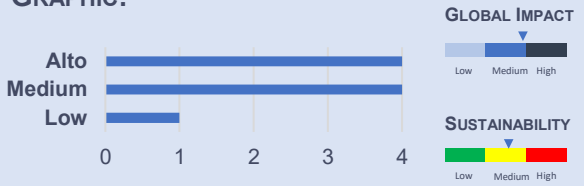
DESCRIÇÃO

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR & VR
- ✓ UHD
- ✓ IA
- ✓ IoT Sensors
- ✓ *Tactile Robots*
- ✓ Wifi6/7 (*backup*)

POTENTIAL PARTNERS:
- ✓ Fundação Champalimaud
- ✓ King's College London
- ✓ Medtronic – RAS System
- ✓ Johnson & Johnson MedTech
- ✓ Huawei; Ericsson

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Transformation of the Sector/PA – H
- ✓ Economic Impact – M
- ✓ Environmental Improvement – H
- ✓ Improvement in Emergency Response – H
- ✓ Impact on Other Strategies – M

GRAPHIC:



OBSERVATIONS:
Operational (OPEX) and capital (CAPEX) costs of this use case may be significant, depending on the number of IoT devices in hospitals, the implementation of robots in operating rooms, and the inclusion of AR & VR equipment.

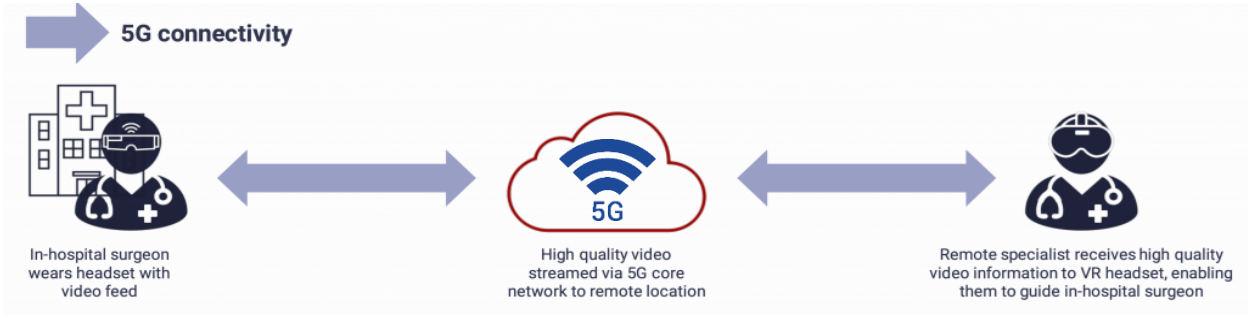
02 BENCHMARK – Remote Surgeries in the National Health Service

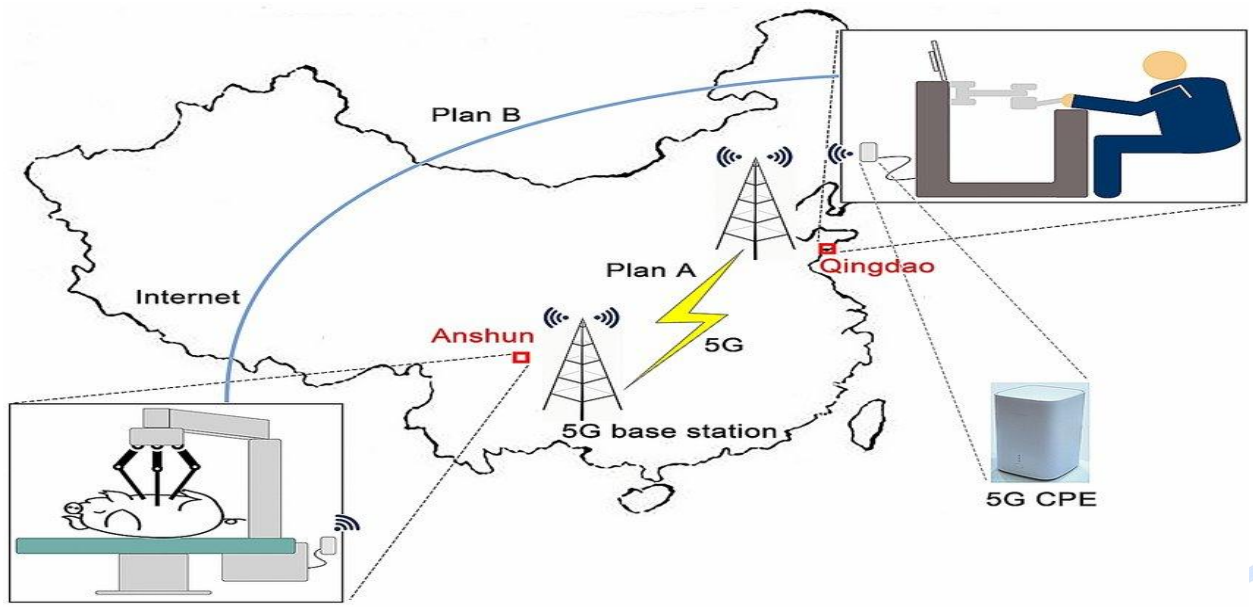
TECHNICAL ANALYSIS

- Communication Network: National Institute of Medical Emergency
- Type of Data Transmitted: 4k/8k Streaming
- Characteristics: Surgeries performed between 900 and 3000 km apart
- Accessories: VR Headset, Tablet, Robot, Cameras

MAIN REGULATION

- Regulation of medical equipment: https://single-market-economy.ec.europa.eu/single-market/european-standards/harmonised-standards/medical-devices_en
- Clinical Trials Regulation: https://www.ema.europa.eu/en/human-regulatory/research-development/clinical-trials/clinical-trials-regulation

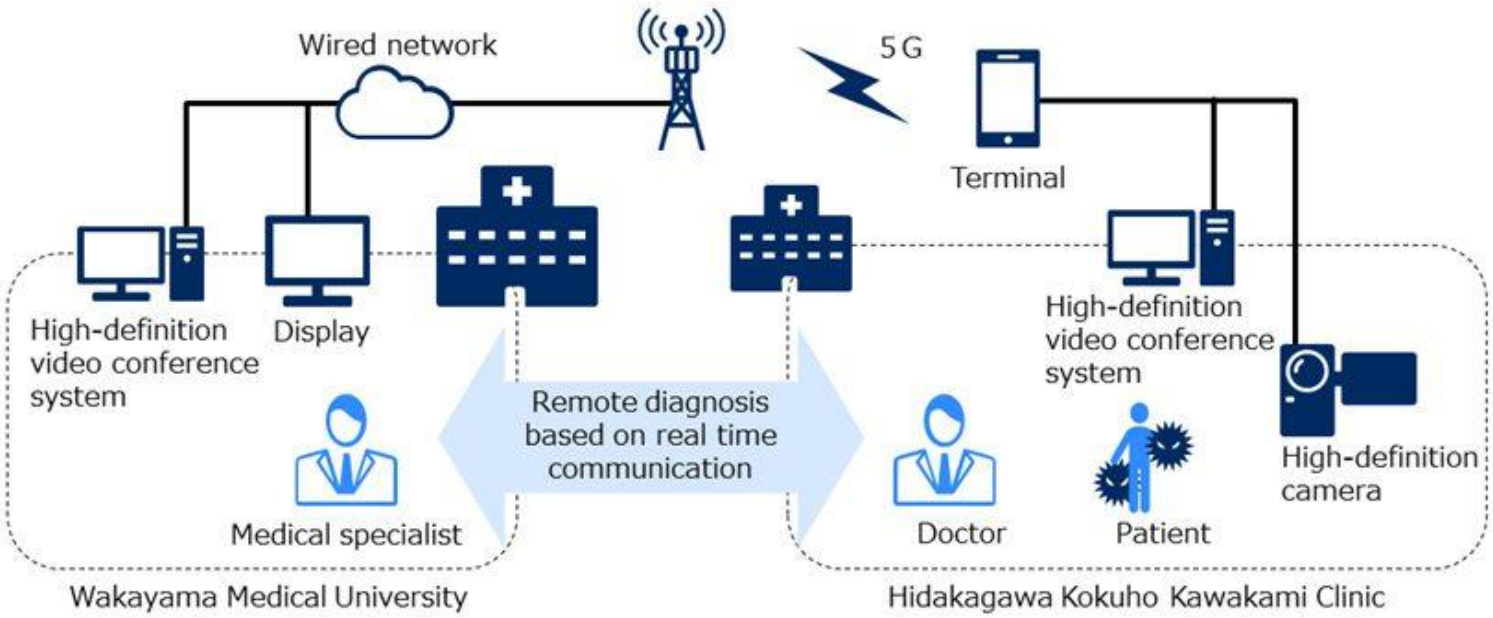




Source: https://www.researchgate.net/figure/Network-connection-plan-for-telesurgery-Plan-A-Both-sides-the-surgeon-console-and-the_fig2_343146995

02 BENCHMARK – Remote Surgeries in the National Health Service

EXEMPLARY DIAGRAM AND CHARACTERISTICS



- 4K high-definition video connection between two healthcare professionals connected remotely, using AR & VR, allowing real-time access to the patient
- Surgeries performed by top professionals in remote areas or regions with low population density
- AI to increase efficiency, speed, and precision during surgery
- Centralized management of logistics and resources (operating rooms, specialized equipment) and personnel (doctors, nurses, assistants)

Source: https://www.nec.co.nz/market-leadership/news/nec-uses-5g-to-contribute-to-remote-medical-examination-trials/

Backup of communications through multiple operators (hybrid e-SIM) and other technologies (WiFi6)

02 BENCHMARK – 5G Hospital in the National Health Service

The rollout of 5G in hospitals will enable a transformation in healthcare services, improving process and resource optimization.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
5G HOSPITAL IN THE NATIONAL HEALTH SERVICE

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Health, Directorate-General of Health

CATEGORY:
Health

REFERENCES:
- Thailand
- Portugal-Fundação Champalimaud

SUMMARY:
This case study enables new technologies in healthcare, improving process visibility and efficiency, streamlining operational and technical performance, and enhancing the service provided.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Improve hospital operations	• Advancement in healthcare quality	• Training hours required	• Network failure	• Long term

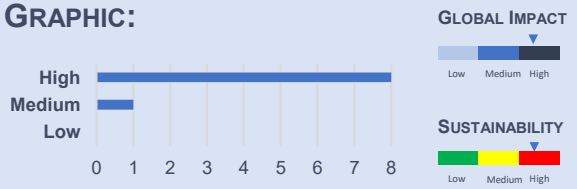
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR&VR
- ✓ IoT Sensors
- ✓ IA
- ✓ WiFi
- ✓ *Cloud*
- ✓ *Big Data*

POTENTIAL PARTNERS:
- ✓ Hospital da Luz
- ✓ NOS operator
- ✓ Huawei
- ✓ AT&T
- ✓ Thailand's Siriraj Hospital
- ✓ Ericsson

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – A
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Improvement – H
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – H

GRAPHIC:



OBSERVATIONS:
Operating (OPEX) and capital (CAPEX) costs of this use case may be significant, depending on the number of new equipment/applications adopted in hospital processes. However, these costs are expected to be offset in the medium/long term by process efficiency gains.

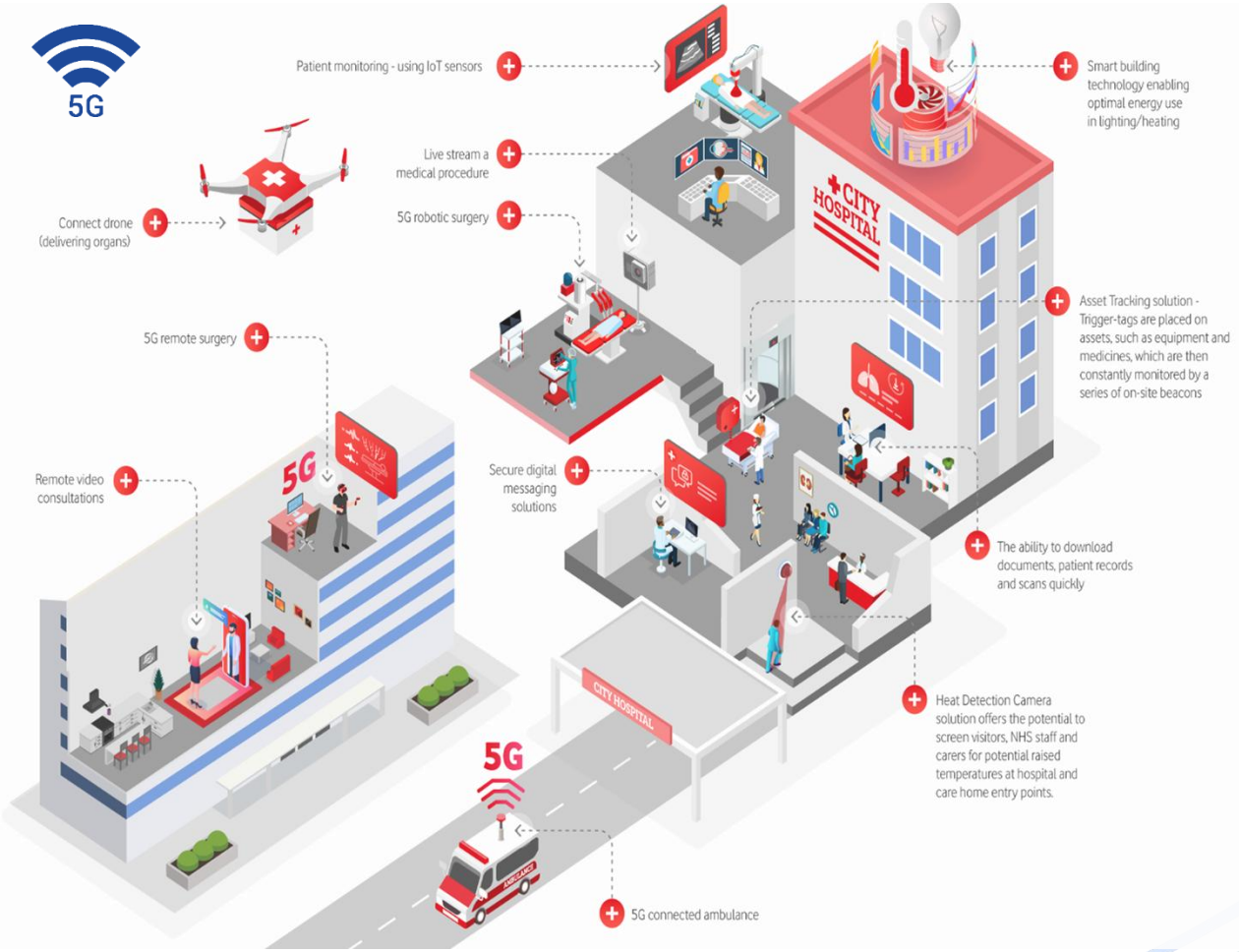
02 BENCHMARK – 5G Hospital in the National Health Service

TECHNICAL ANALYSIS

- Communication Network: National Health Service
- Type of Data Transmitted: Information transmitted between patient sensors and the doctor
- Characteristics: Smart medical devices, doctor location tracking, monitoring of infrastructures and critical equipment, home hospitalization

MAIN REGULATION

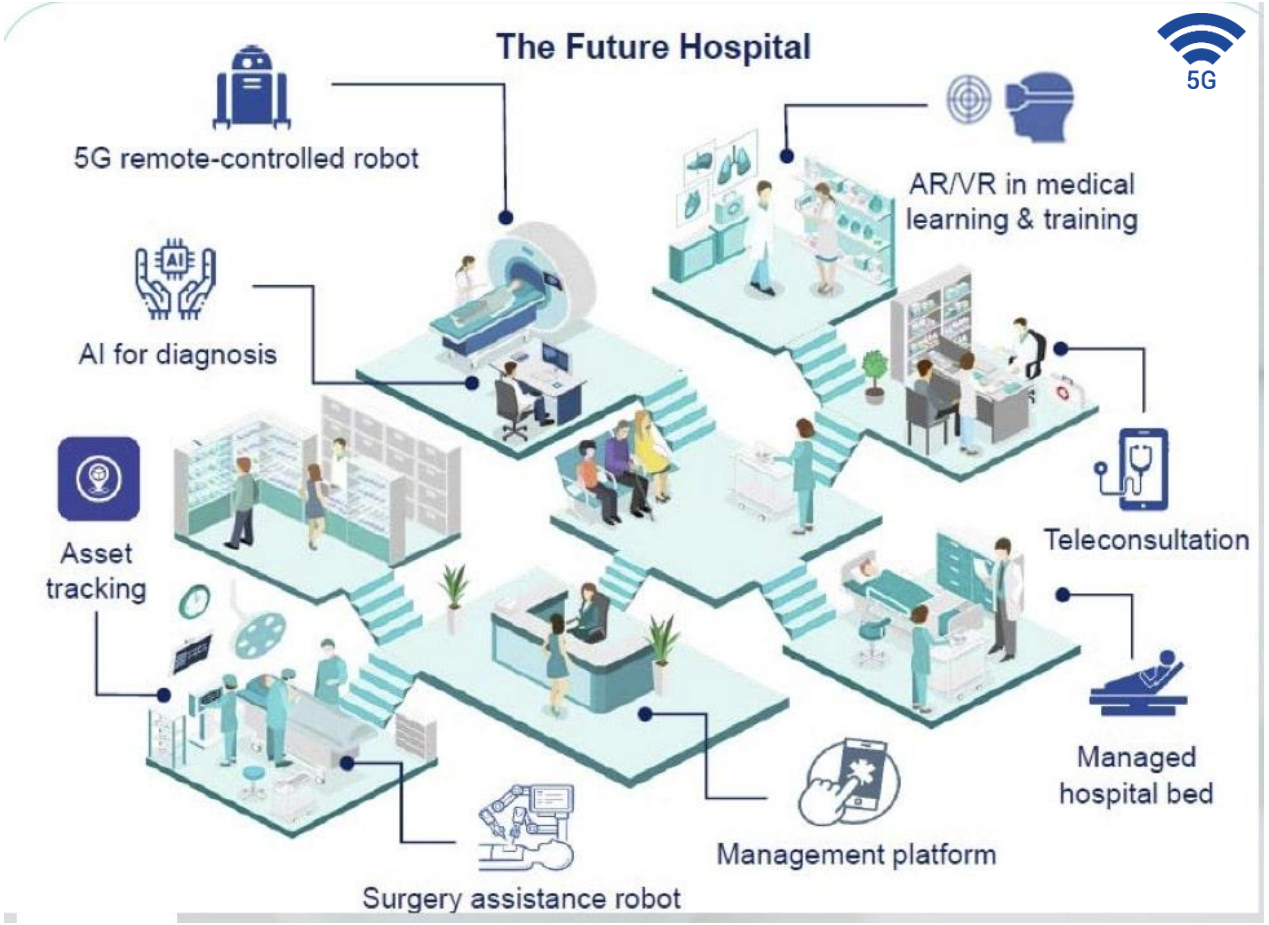
- Legislation on 5G in Portugal – 5G Portal
- EUR-Lex - 32020D0590 - EN - EUR-Lex (europa.eu)



Source: https://wond.co.uk/project/vodafone-5g-health-infographic/

02 BENCHMARK – 5G Hospital in the National Health Service

EXEMPLARY DIAGRAM AND CHARACTERISTICS



Siriraj 5G Smart Hospital aims to be the future of healthcare in Thailand (disruptive.asia)

- Artificial Intelligence enabling the analysis of large amounts of medical data with greater accuracy
- 4K audiovisual systems for calls and remote consultations
- Use of Cloud and Big Data computing for storing and processing larger volumes of data• AI to increase efficiency, speed, and accuracy in image editing and diagnostics
- Real-time connection between patients, medical professionals, ambulances, aircraft, and other emergency services
- Optimization of logistics and resources (medications, operating rooms, waiting queues) and personnel (doctors, nurses, assistants)

02 BENCHMARK – Continuous Health and Physical Activity Monitoring

The rollout of 5G in the NHS will allow doctors to remotely monitor patients.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
CONTINUOUS HEALTH AND PHYSICAL ACTIVITY MONITORING

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Health, Directorate-General of Health, IPDJ

CATEGORY:
Health, Sports

REFERENCES
- FIA *Biometric Gloves*
- Austria
- Portugal – IPDJ SUAVA

SUMMARY:
This case study aims to improve the monitoring of patients' clinical conditions and vital signs, as well as athletes, through remote monitoring and cross-referencing of health data.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Anticipation of severe health situations • Personalized recommendations	• Better patient clinical monitoring • Reduction of waiting lists in health centers	• Battery issues • Equipment maintenance	• Cyberattacks • Network coverage	• Short/Medium Term

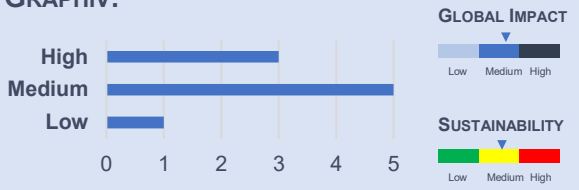
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR & VR
- ✓ WiFi6/7
- ✓ Video Cameras
- ✓ AI
- ✓ Sensores IoT
- ✓ *Cloud*
- ✓ *Big Data*

POTENTIAL PARTNERS:
- ✓ FIA
- ✓ Honeywell
- ✓ Diceus
- ✓ CNTS – National Telehealth Center
- ✓ Agency for Healthcare Research and Quality

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance to Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – M
- ✓ Environmental Improvement – H
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – M

GRAPHIV:



OBSERVATIONS:
Infrastructure (CAPEX) and operational (OPEX) costs should be relatively low if sensors are acquired by users themselves, with the state only responsible for launching the monitoring application and creating the support and follow-up teams.

02 BENCHMARK – Continuous Health and Physical Activity Monitoring

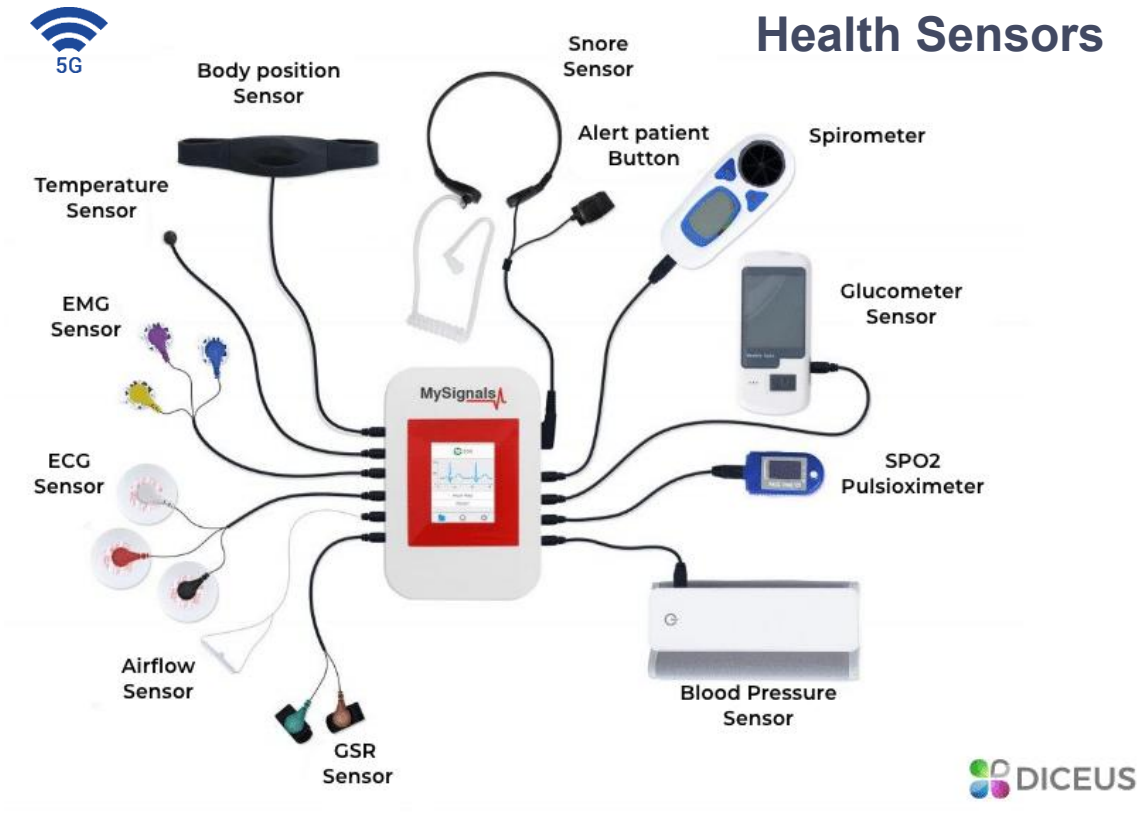
TECHNICAL ANALYSIS

- Application Areas: Telemonitoring, Cardiology, Telerehabilitation, General Practice, Physical Activity Monitoring
- Communication Network: CNTS (National Telehealth Center), Health Regulatory Authority
- Type of Data Transmitted: UHD Video, Telemetry
- Accessories: Computer, Mobile Phone, Tablet, Wearables, Sensors

MAIN REGULATION

- Telehealth Services:

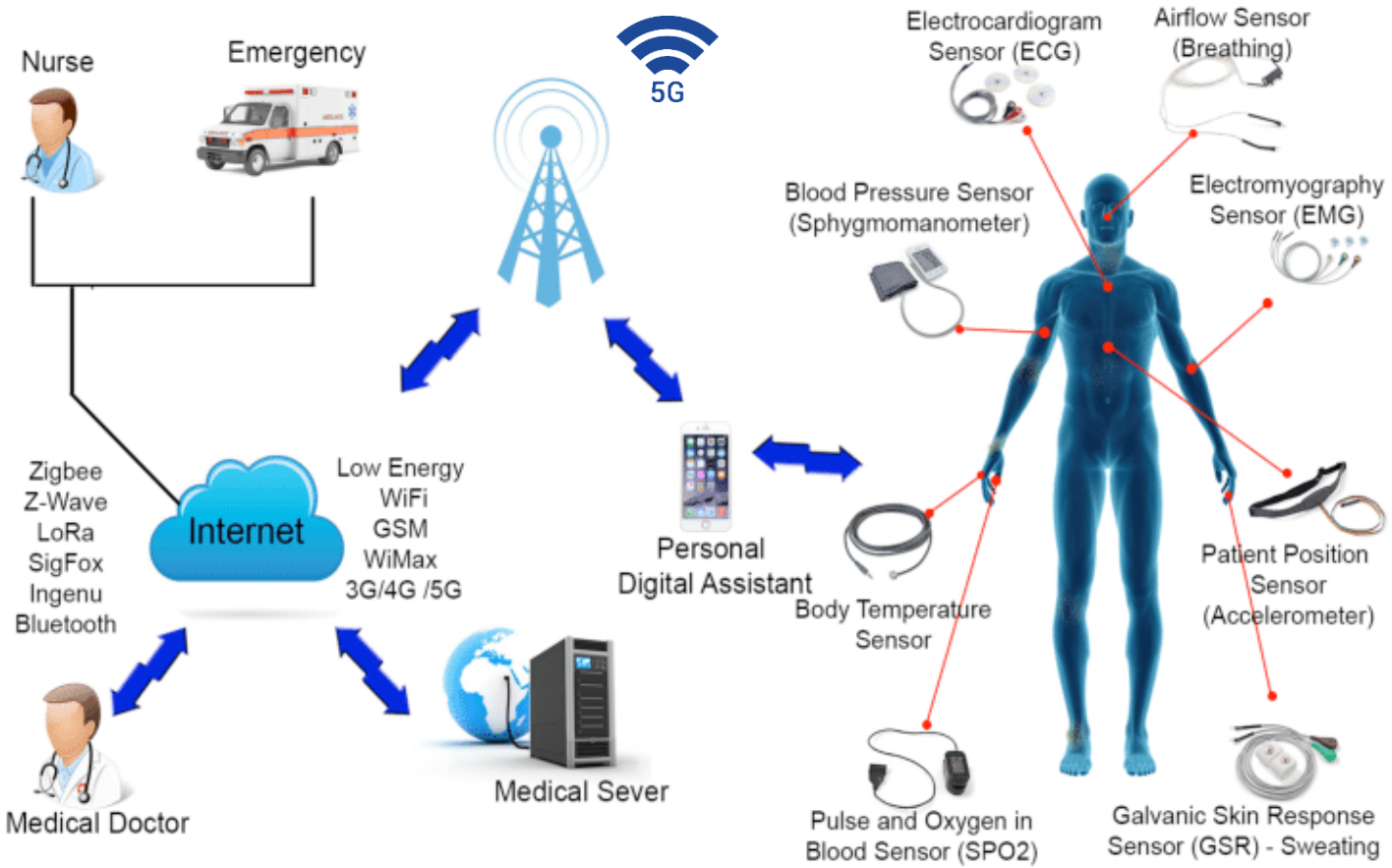
https://files.dre.pt/1s/2016/10/20600/0382403825.pdf
https://www.cnts.min-saude.pt/wp-content/uploads/2017/03/Desp8445_2014.pdf



Source: Custom Healthcare Software Development DICEUS

02 BENCHMARK – Continuous Health and Physical Activity Monitoring

EXEMPLARY DIAGRAM AND CHARACTERISTICS



- High-definition video connection between the patient/athlete and health/sports professionals• Capacity to connect many health/sports sensors
- Access to top professionals in remote or low-population-density areas
- Transmission of large volumes of data for intensive data applications
- Use of Cloud and Big Data computing for storing and processing large quantities of data• Integration with other systems of the National Health Service/IPDJ
- Anticipation of severe health situations with automatic prescription of medication, recommendations, and automated communication (calls, messages) to family members or emergency services

Source: (PDF) Enabling Technologies for the Internet of Health Things (researchgate.net)

02 BENCHMARK – Migration of Emergency Networks to 5G

The migration of Tetra emergency networks to 5G technology will enable the use of new applications and services to support the population.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME

MIGRATION OF THE EMERGENCY NETWORK TO 5G (DEDICATED 5G NET SLICE)

POTENTIAL PUBLIC SECTOR(S):

Central Government, State Secretariat for Civil Protection, ANACOM, Ministry of Internal Administration

CATEGORY

- Governments (Norway – Defense)
- Private sector, Universities

REFERENCE

- Belgium

SUMMARY:

This case study aims to migrate national emergency networks (Hospitals, Police, Fire Departments) to 5G in order to promote new data services.

Current Tetra emergency networks only support voice services.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Enhance data transmission for national emergency services (+PTT/TR)	• Launch of new support applications for emergency services	• CAPEX required	• Cyberattacks • Greater surface of exposure to attacks	• Medium Term

DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:

- ✓ *MEC*
- ✓ *Cloud*
- ✓ Tetra Network (backup)
- ✓ Satellites (Backup)
- ✓ Wifi6/7

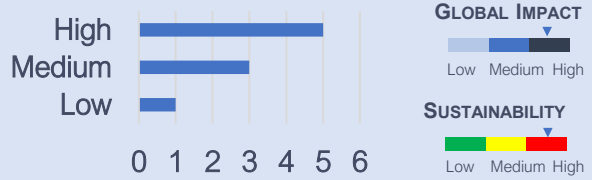
POTENTIAL PARTNERS:

- ✓ Ericsson
- ✓ Mobile Operators
- ✓ Airbus
- ✓ Government of Belgium
- ✓ Government of Norway (Defense)

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):

- ✓ Relevance to Society – H
- ✓ Technical Feasibility – M
- ✓ Financial Sustainability – M
- ✓ Replicability and Generalization – H
- ✓ Sector Transformation – H
- ✓ Economic Impact – M
- ✓ Environmental Improvement – M
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – H

GRAPHIC:



OBSERVATIONS

Migration costs from Tetra to 5G will be high due to the need for new devices, applications, and processes. However, 5G flexibility through network slices will allow a cost reduction through the introduction of new services, while ensuring a high level of redundancy and additional security.

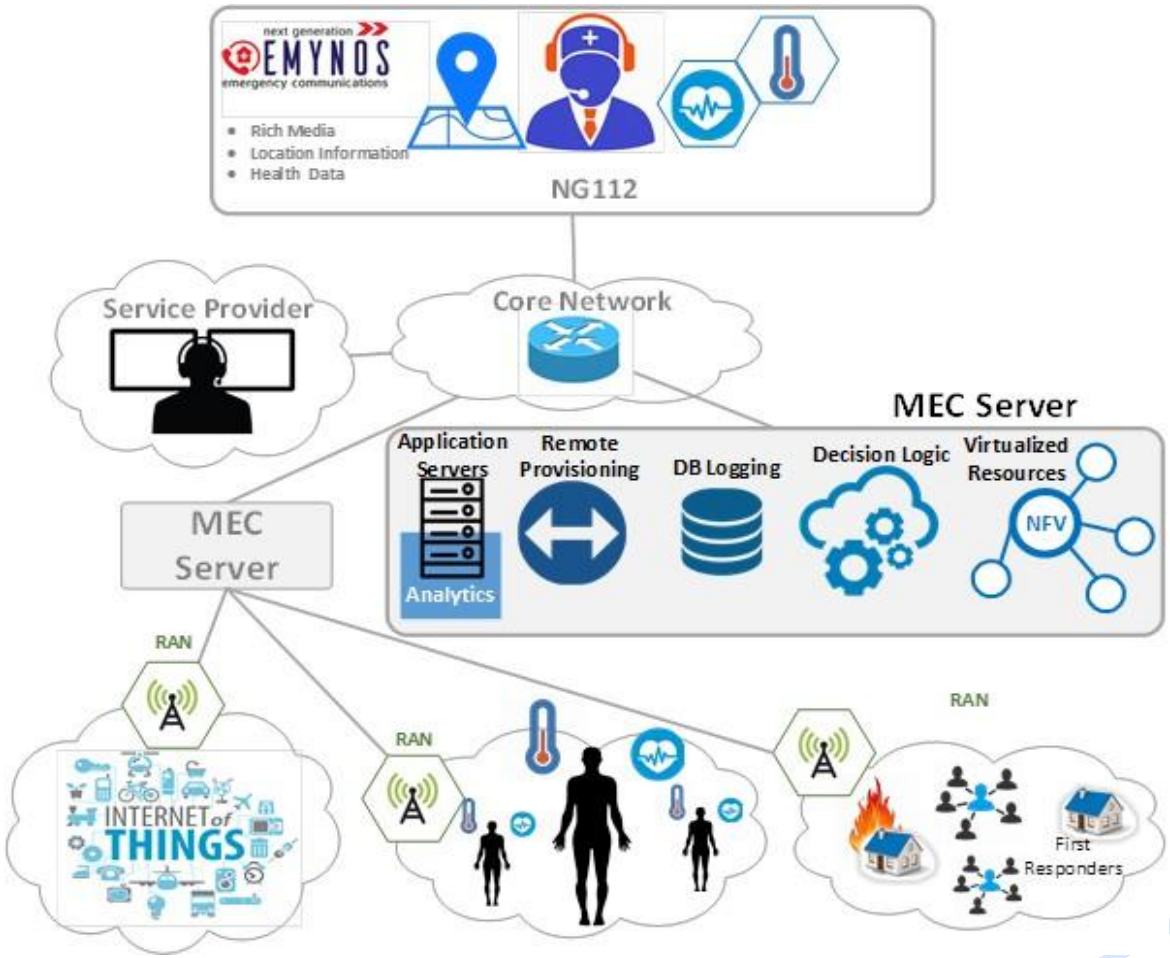
02 BENCHMARK – Migration of Emergency Networks to 5G

TECHNICAL ANALYSIS

- Communication Network: 5G Emergency (TETRA or Satellite as backup).
- Type of Data Transmitted: voice, video, and text in real time, with maximum priority: “Massive IoT” and “device-to-device”.
- Increase in data from health sensors, accident/patient location, health records, insurance data, etc.
- Characteristics: “Network slicing” ensures much higher speeds and much lower latencies in communications compared to TETRA. The flexibility of orchestrating “network slices” is made possible through SDN/NFV programming and the management of RAN and Backhauling resources within the MEC infrastructure.

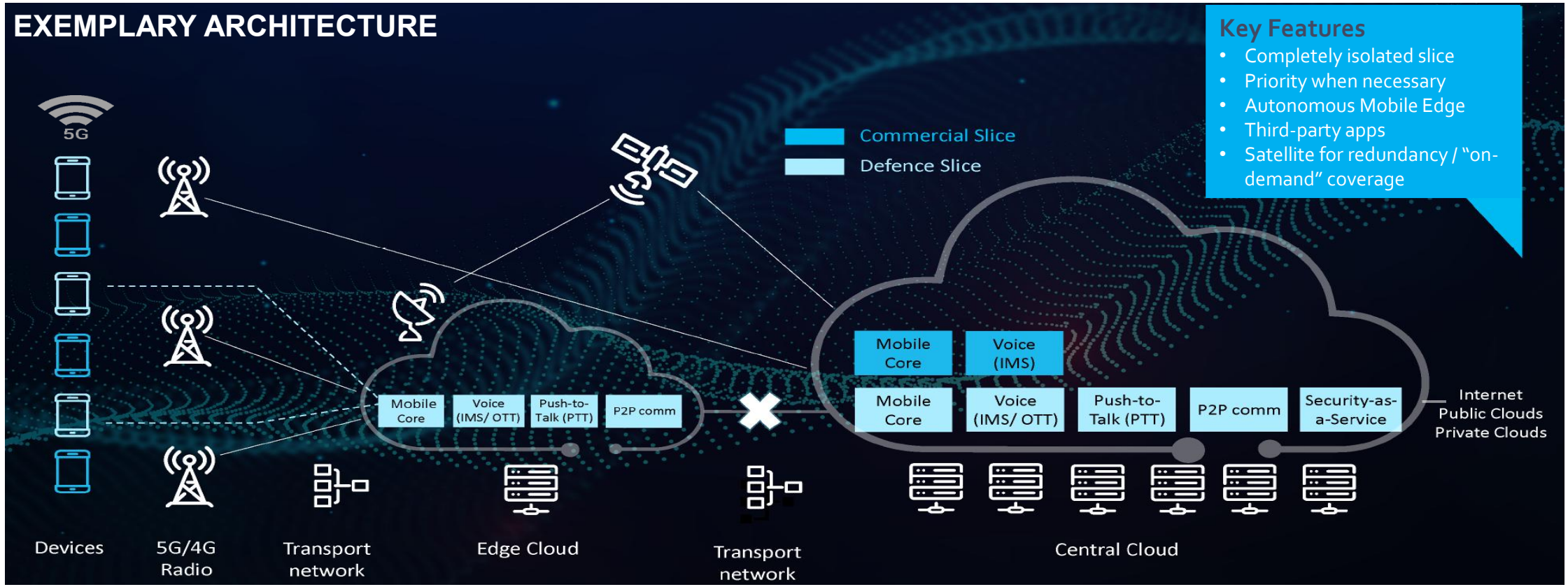
MAIN REGULATION

- ANACOM - Portaria n.º 554-A/2022, de 21 de junho
- ANACOM - Regulamento n.º 183/2022, publicado a 21 de fevereiro
- ANACOM - Decreto-Lei n.º 20/2022, de 28 de janeiro



Source: 5G for emergency services: Slicing through the complexity | TMForum - Inform Emergency-Communications030518.pdf (ieee.org)

02 BENCHMARK – Migration of Emergency Networks to 5G



Source: 5G is a game changer for the military - Data Respons

- 5G Network Slices enable the required independence and security for national emergency services.
- Satellite or TETRA communication can serve as backup.
- MEC ensures lower latency.
- Supports all current emergency services (e.g., PTT – Push-to-Talk).
- Launch of new data-based emergency services

02 BENCHMARK – Monitoring and Fighting Fires with 5G Drones

The rollout of 5G will enable UHD video transmission and more efficient control of drones/UAVs in remote or hard-to-access areas.

5G Use Case in Public Administration

NAME:
MONITORING AND FIGHTING FIRES WITH DRONES

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Internal Administration, Civil Protection Secretariat

CATEGORY:
Forests

REFERENCES
- Netherlands; Canada
- ESA

SUMMARY:
This case study would allow the detection of a fire outbreak at an early stage, accelerating the response of emergency teams and preventing rapid spread.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Monitor and proactively support firefighting operations • Search operations	• Prevention • Quick response • Reduced helicopter costs	• Privacy • Batteries	• Network failure • Unauthorized drones • Night operations • Resistance to implementation	Short/Medium Term

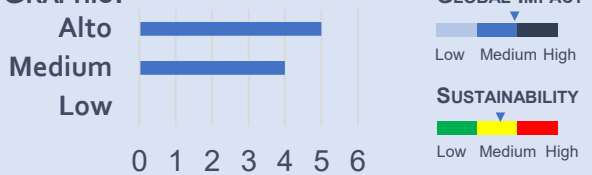
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES
- ✓ 5G Emergency Network
- ✓ *Drones/UAV*
- ✓ AR & VR
- ✓ AI
- ✓ *Cloud*

POTENCIAL PARTNERS:
- ✓ Unmanned Life
- ✓ Portuguese Armed Forces; ESA; Avy BV; British Columbia; Dronecloud,DroneStream;
- ✓ Netherlands, Germany

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance to Society – H
- ✓ Technical Feasibility – H
- ✓ Financial Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – M
- ✓ Economic Impact – M
- ✓ Environmental Improvement – H
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – H

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and fire monitoring through drones are expected to be significantly lower compared to helicopters (by a factor of x10). Fixed and initial costs (CAPEX) are variable and depend on the number and type of drones acquired. For this reason, we classified the overall Sustainability as Medium.

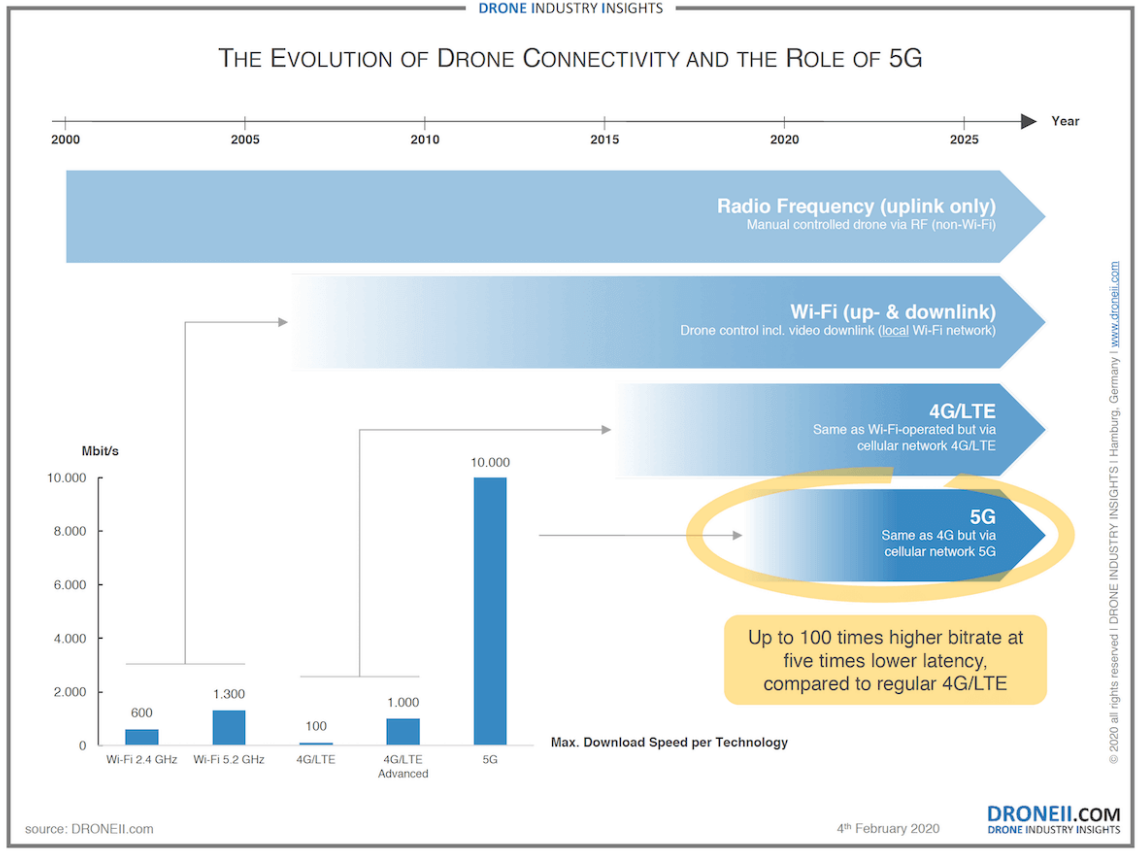
02 BENCHMARK – Monitoring and Fighting Fires with 5G Drones

TECHNICAL ANALYSIS

- Type of Drones: 5G and BVLOS Drones (Beyond Visual Line of Sight)
  - Ex.: Qualcomm Flight™ RB5 5G (WiFi6/LTE)
- Communication Network: 5G Private / 5G Emergency (SIRESP)
- Type of Data Transmitted (Cloud <-> Drones, Control Tower):Localization, Identification, Control, Video HD, Notifications, Speed, Altitude
- Characteristics: Distances > 12 km and altitudes > 1 km (Current limits: 120 m altitude, 3 km VLOS distance)
- Accessories: IR cameras, 4K UHD & Full HD cameras, Zoom, Altimeter, GPS

MAIN REGULATIONS

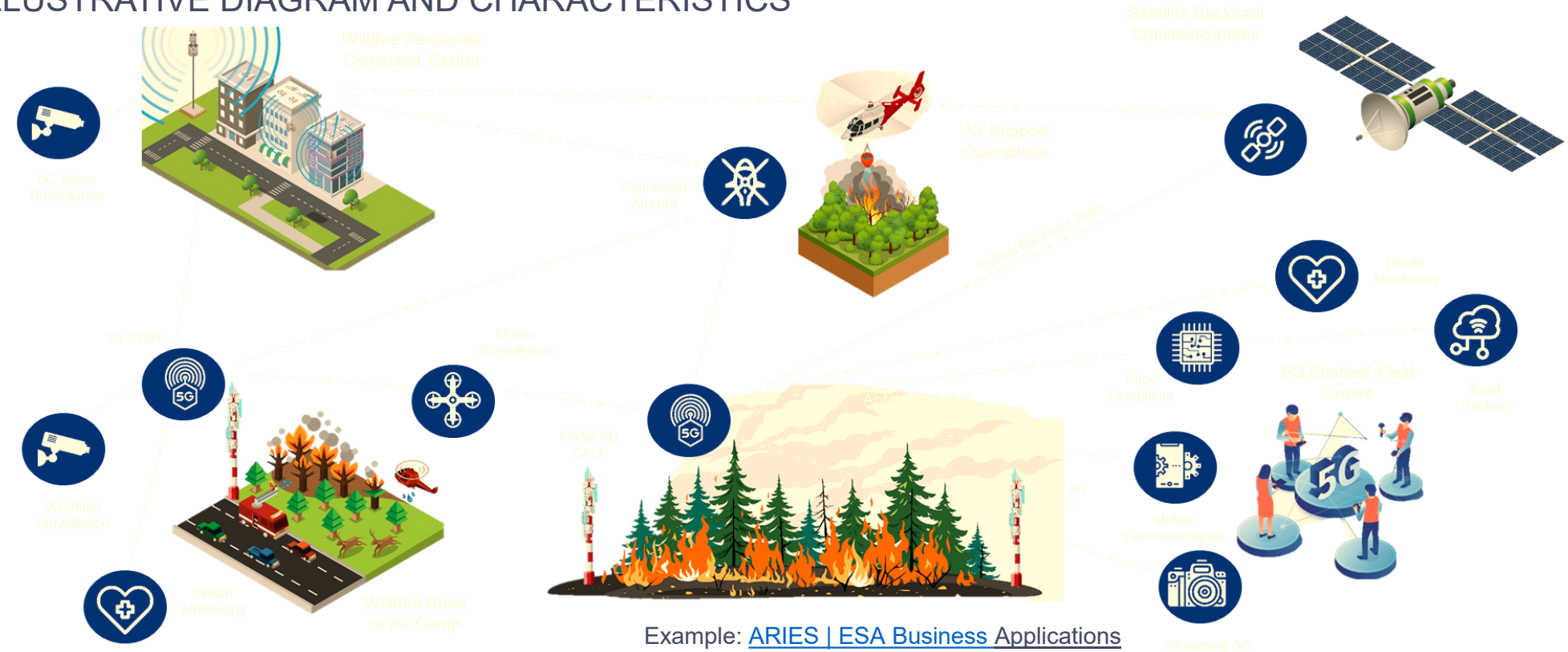
- ANAC Regulations for UAV- https://www.anac.pt/vPT/Generico/drones/enquadramento_regras_procedimentos/enquadramento_uas/Paginas/Enquadramento_uas.aspx
- EASA Regulations for UAV-https://www.easa.europa.eu/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulation-eu
- EU Regulations for UAV - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1166



https://droneii.com/5g-and-drones-part-1-what-is-5g

02 BENCHMARK – Monitoring and Fighting Fires with 5G Drones

ILLUSTRATIVE DIAGRAM AND CHARACTERISTICS



Example: ARIES | ESA Business Applications

- Satellite communication for backup
- M2M communication with other aircraft (helicopters and firefighting planes)
- Integration of different video circuits
- IoT and Health sensors in real time
- Use of Cloud and Big Data computing for data storage and processing of large amounts of information

02 BENCHMARK – Emergency Services Response

The launch of 5G will enable the use of aerial controllers to accelerate emergency response.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
EMERGENCY SERVICES RESPONSE

POTENTIAL PUBLIC SECTOR(S):
Central Government, Ministry of Health, State Secretariat for Civil Protection

CATEGORY:
Health, Public Safety

REFERENCES:
- UK
- Belgium

SUMMARY:
This case study enables improved emergency response through the use of IoT devices and/or drones.

Functions	Advantages	Disadvantages	Risks/Challenges	Time Estimate
• Identification of situations/incidents more quickly	• Faster emergency response	• GDPR • Legislation • Significant investment in acquiring the devices	• Network failure • Privacy	• Medium term

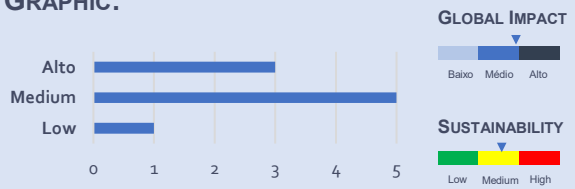
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ 5G Emergency Network
- ✓ Drones
- ✓ IoT sensors
- ✓ AI
- ✓ *Cloud*
- ✓ *Edge Computing*

POTENTIAL PARTNERS:
- ✓ SAFIR-Med
- ✓ Verizon
- ✓ IBM
- ✓ Caltta Technologies
- ✓ Intrado
- ✓ EENA

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – M
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Improvement – M
- ✓ Emergency Response Improvement – L
- ✓ Impact on Other Strategies – M

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and fixed and infrastructure costs (CAPEX) are variable and depend on the number and type of drones acquired. For this reason, total Sustainability is classified as Medium.

02 BENCHMARK – Emergency Services Response

TECHNICAL ANALYSIS

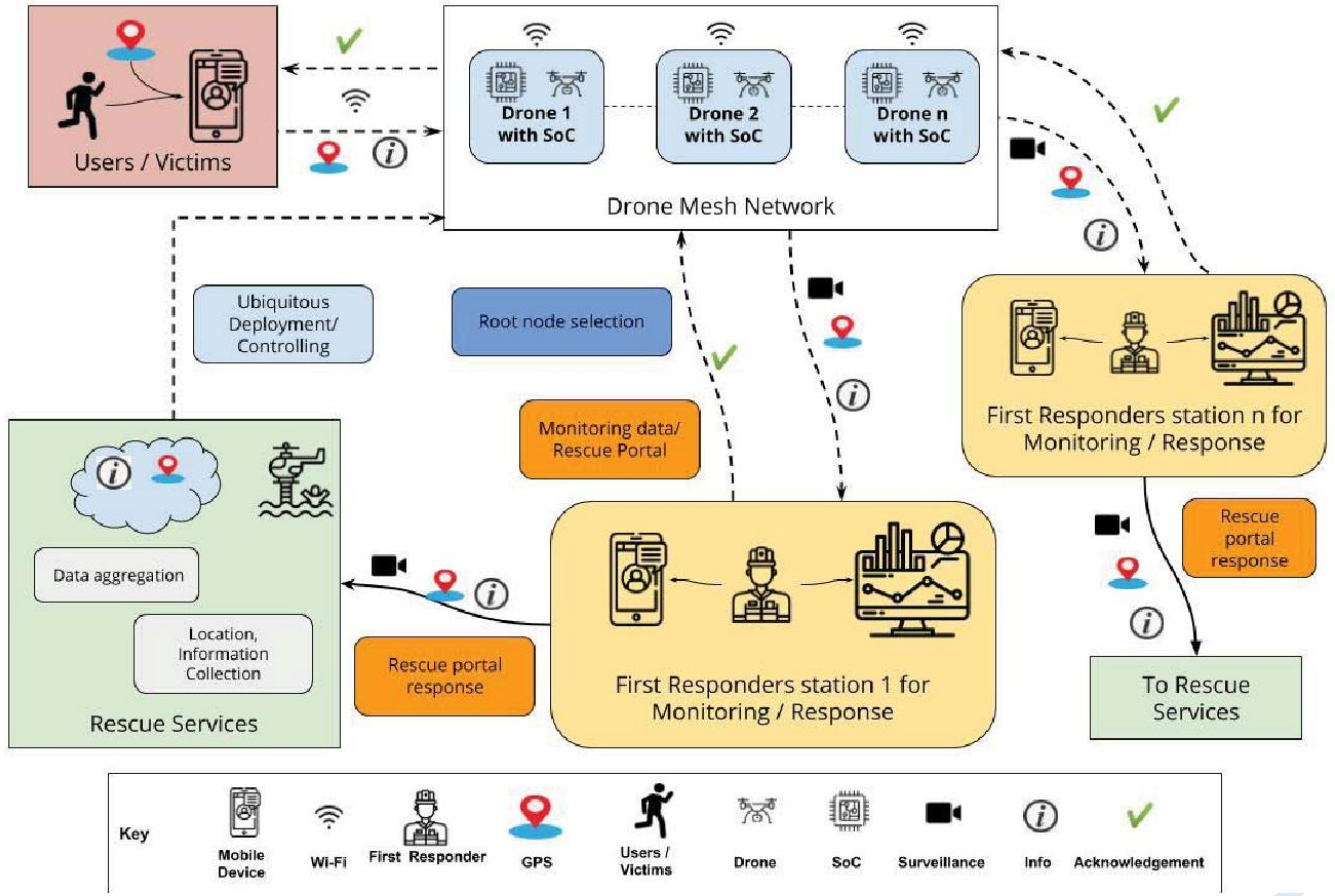
•Type of Data Transmitted: Drones deployed on the ground assess the situation in real time and transmit data to doctors and/or police for deeper analysis, enabling an automatic (and faster) response.

•Characteristics: Real-time analysis of emergency situations

•Accessories: Drones, HD cameras

MAIN REGULATIONS

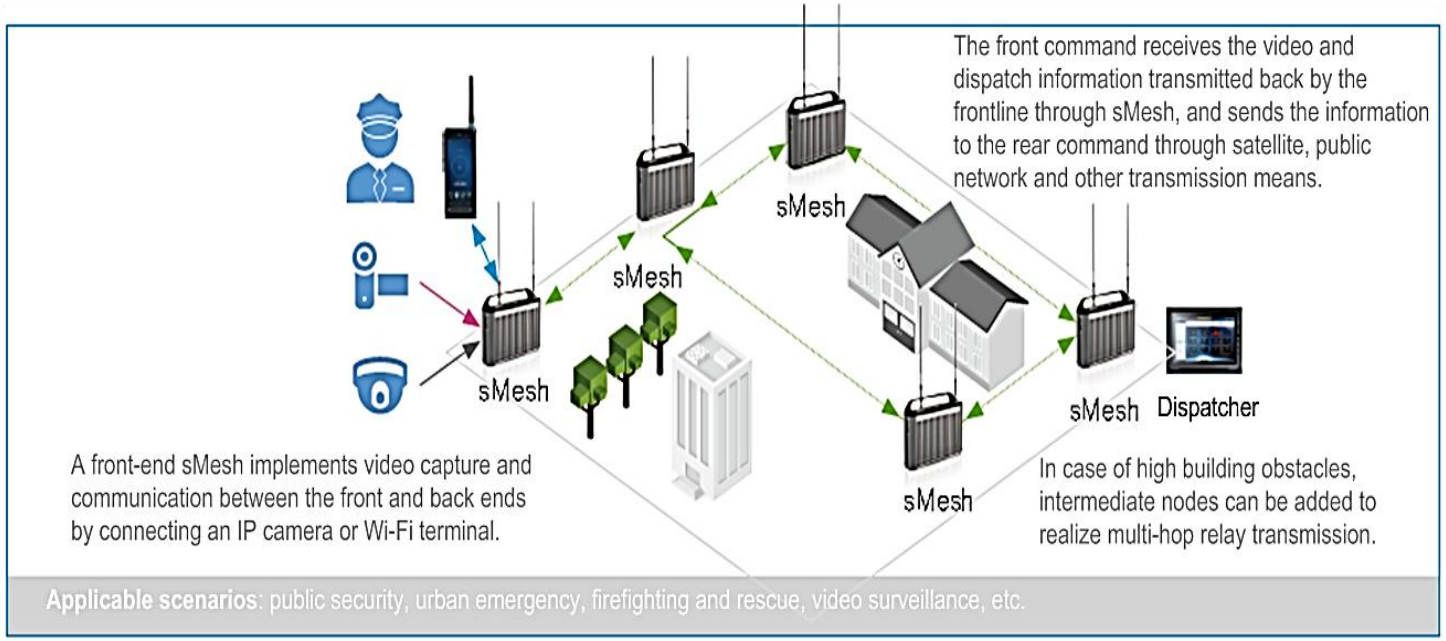
- https://cordis.europa.eu/project/id/101017701
- https://www.anac.pt/vPT/Generico/drones/enquadramento_regras_procedimentos/enquadramento_uas/Paginas/Enquadramento_uas.aspx
- https://www.easa.europa.eu/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulation-eu



Source: https://www.semanticscholar.org/paper/Architecture-for-Drone-Assisted-Emergency-Ad-hoc-Ganesh-Gopalasamy/bcd25500bf71e761b7bec1e2023dd467bf44b7b5

02 BENCHMARK – Emergency Services Response

ILLUSTRATIVE DIAGRAM AND CHARACTERISTICS



Source: http://www.caltta.com/en/SolutionsNew.aspx?nc=162010005002

- Capture a comprehensive view of an incident in real time, providing a holistic overview of emergency situations to the competent authorities.
- Drones could enable security authorities to monitor imminent situations with reduced risk.
- More efficient use of rescuers' time and resources.
- By using sensors, it is possible to track the geolocation of rescuers as well as monitor local environmental conditions.
- Drones can capture videos that allow computer vision and artificial intelligence (AI) applications to identify various types of emergency situations that may occur in large crowds.

02 BENCHMARK – Maritime Port Management

The launch of 5G will enable the control of vessels and the identification and management of all cargo positions within the terminal.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
MARITIME PORT MANAGEMENT

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Infrastructure and Housing,Ministry of Agriculture and Food, Ministry of Economy and the Sea

CATEGORY:
Maritime Ports

REFERENCES:
- Portugal – Port of Aveiro

SUMMARY:
This case study enables monitoring and managing cargo in real time through digital replication solutions and applications using virtual and augmented reality devices.

Functions	Advantages	Disadvantages	Risks/Challenges	Time Estimate
• Monitoring and control of all port equipment remotely	• Wireless port infrastructure • Enhanced security	• Inadequate equipment and machinery for cargo handling	• Network failure • Inadequate road infrastructure within the port area	• Short to Medium term

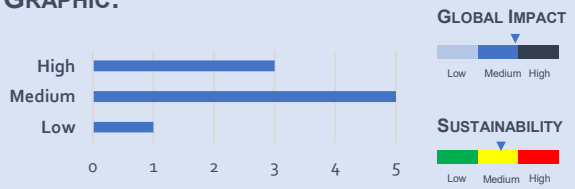
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ *AI*
- ✓ *Cloud*
- ✓ *Edge Computing*
- ✓ AR&VR

POTENTIAL PARTNERS:
- ✓ Tianjin – China
- ✓ Antwerp – Orange
- ✓ South Korea
- ✓ Mobile Operators
- ✓ IBM, Huawei, Nokia
- ✓ Maritime
- ✓ Verizon
- ✓ Associated British Ports
- ✓ TechMahindra

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – M
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Improvement – M
- ✓ Emergency Response Improvement – M
- ✓ Impact on Other Strategies – M

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and fixed costs (CAPEX) of implementing the 5G solution depend on the level of automation to be deployed and on the existence of other port management solutions (e.g., 4G).In the long term, these solutions help minimize environmental impact and reduce operational costs.

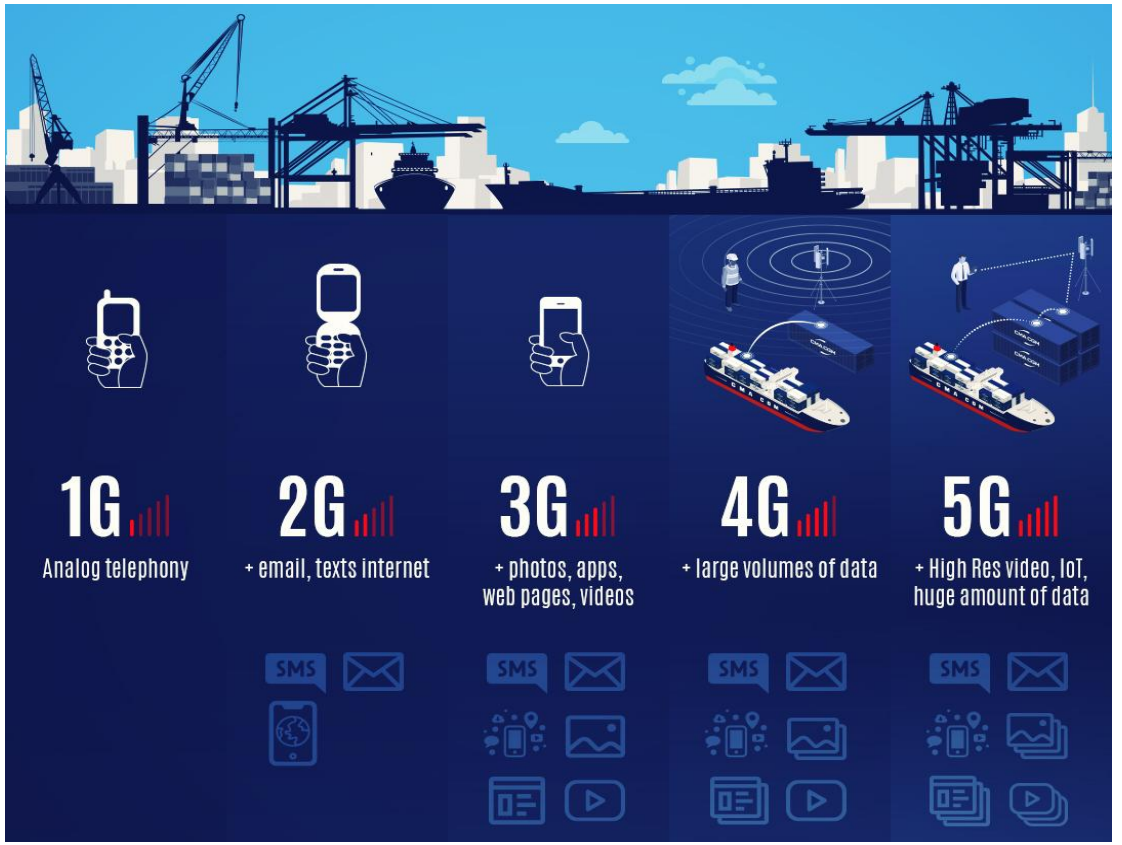
02 BENCHMARK – Maritime Port Management

TECHNICAL ANALYSIS

- Communication Network: Port and Maritime Transport Institute (IPTM)
- Type of Data Transmitted: The data captured by the cameras are transferred to the servers, allowing the geolocation of vessels to be obtained.
- Features: Real-time monitoring of vessels
- Accessories: Cameras, VR Headset

MAIN REGULATION

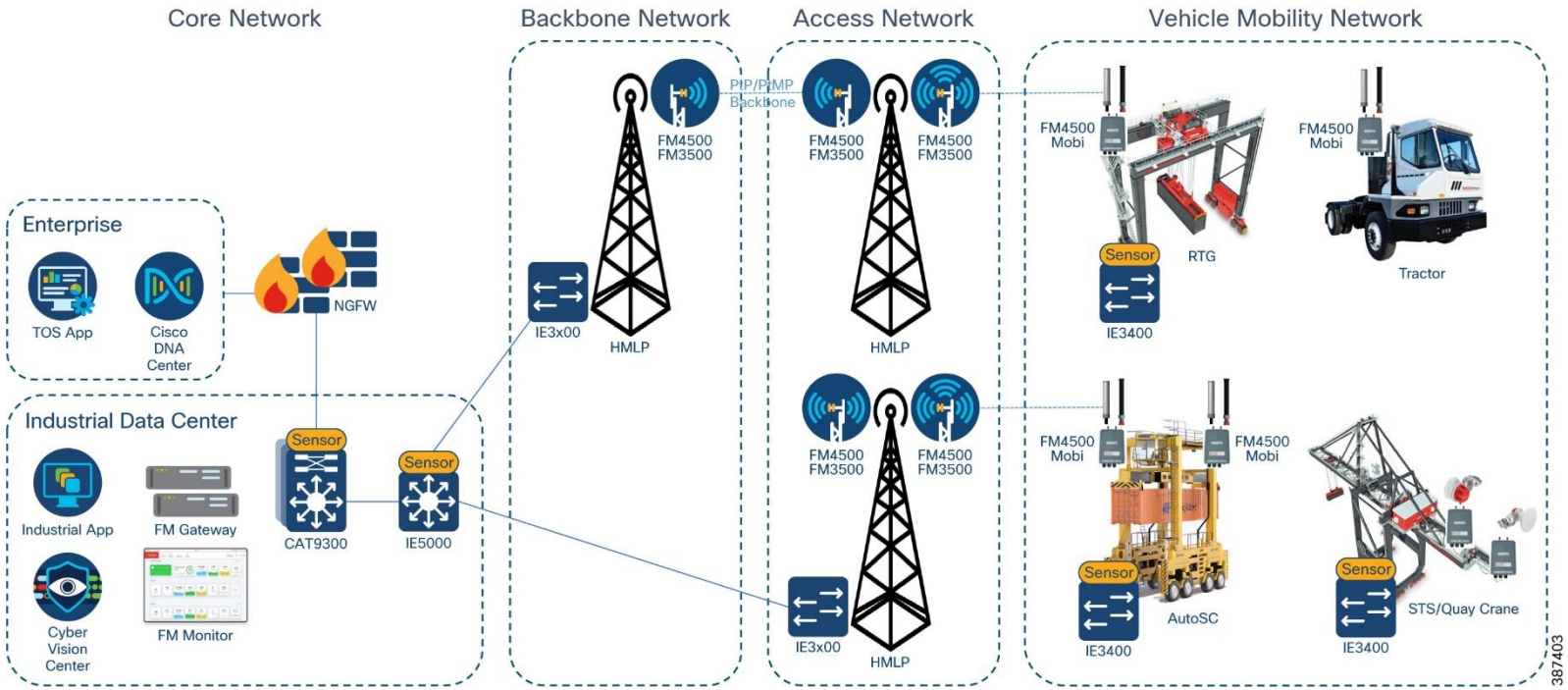
- https://www.portugal.gov.pt/pt/gc21/comunicacao/noticia?i=modernizacao-dos-sistemas-de-controlo-de-navegacao-dos-portos-de-lisboa-e-de-setubal
- https://www.dgrm.mm.gov.pt/defesa



Source: 5G: CMA CGM at the Forefront of the New Shipping Revolution (cmacgm-group.com)

02 BENCHMARK – Maritime Port Management

EXEMPLIFICATIVE DIAGRAM AND CHARACTERISTICS



- Monitoring of containers (e.g., position, temperature, etc.)
- With the use of AI, it is possible to recognize vessels, and UHD cameras capture ship entries in real time
- Minimize environmental impact
- Reduction of operational costs, improving efficiency, safety, and profitability of maritime port operations
- With the use of VR, it will be possible to simulate a complete cargo operation, checking freight and its position, and defining the best strategy for the operation

Source: Ports and Terminals Design Guide - Ports and Terminals Design Guide [Design Zone] - Cisco

02 BENCHMARK – Autonomous Vehicles

The launch of 5G will increase road safety and consequently reduce the number of accidents.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
AUTONOMOUS VEHICLES

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Internal Administration

CATEGORY:
Transport, Automotive

REFERENCES:
- Germany
- Singapore

SUMMARY
This case study enables vehicles to transmit location and traffic data to other vehicles, communicate with road services and infrastructure, and receive notifications on weather conditions, accidents, or road surface status in real time.

Functions	Advantages	Disadvantages	Risks/Challenges	Time Estimate
• Autonomous vehicle driving	• Safety • Faster arrival at destination	• Maintenance • High investment	• Network failure • Cyberattacks	• Long term

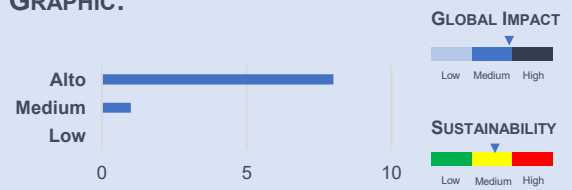
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR&VR
- ✓ IoT sensors
- ✓ 4G (*Backup*)
- ✓ DSRC (*Dedicated short-range communications*)
- ✓ *Big Data*
- ✓ MEC

POTENCIAL PARTNERS
- ✓ Singapore
- ✓ 5GAA
- ✓ Mercedes
- ✓ IEEE
- ✓ Mobileum
- ✓ Codete

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW):
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – H
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Impact – H
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – H

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and infrastructure costs (CAPEX) are significantly high, but road transformation will exist through the deployment of sensors (optical, radar, infrared, etc.), cameras (that help monitor other vehicles, pedestrians, etc.), improving safety and operational intelligence.

02 BENCHMARK – Autonomous Vehicles

TECHNICAL ANALYSIS

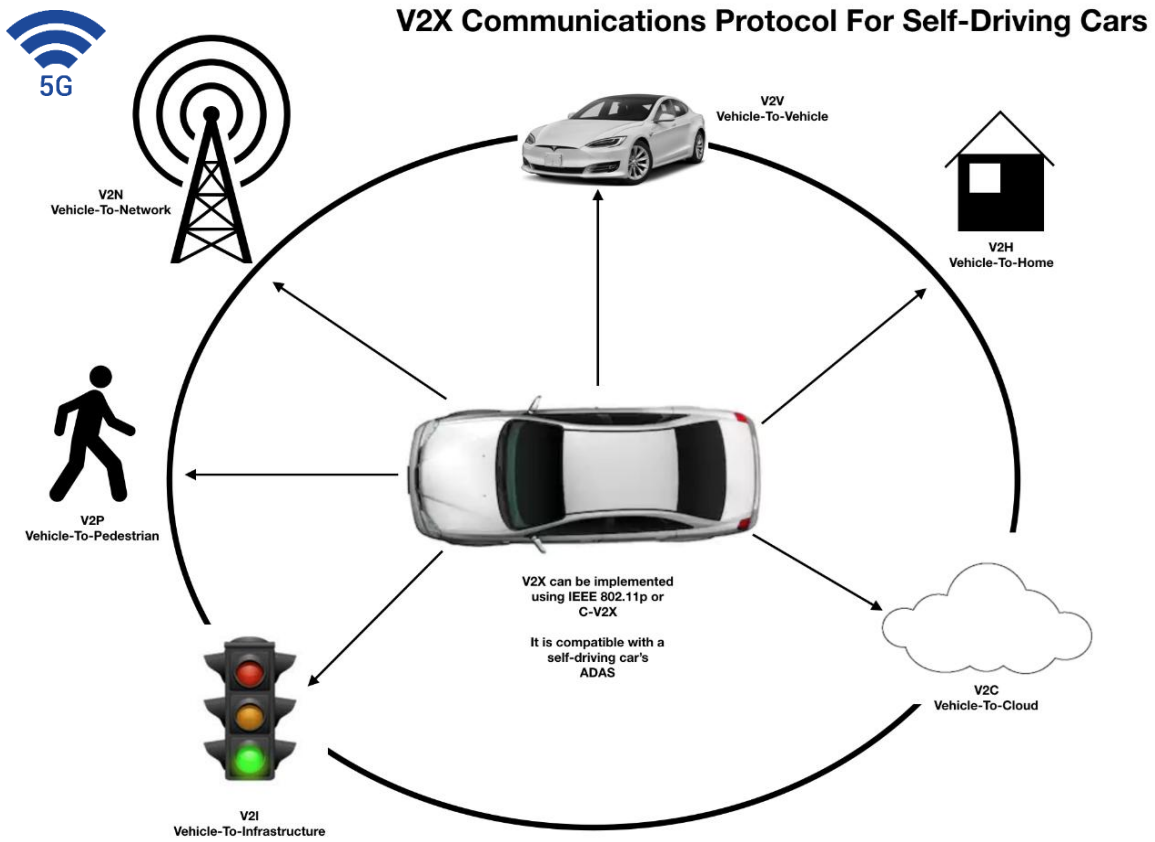
•Communication Network: National Road Safety Authority (ANSR)
•Type of Data Transmitted: The vehicle creates and maintains data based on sensors and cameras placed in different areas inside and around it.
•Features: Cruise control, automatic braking, blind-spot detection, and distance control between vehicles
•Accessories: Sensors, cameras

MAIN REGULATION

- Technological Free Zones (Technological Free Zones | ANI)
- Legislation in Portugal (still non-existent):i) -> Portugal muito atrasado na regulamentação de sistemas de condução autónoma – Observador
- Ordinance n.º 189/2022
- United Nations (unece.org)

Others Links:

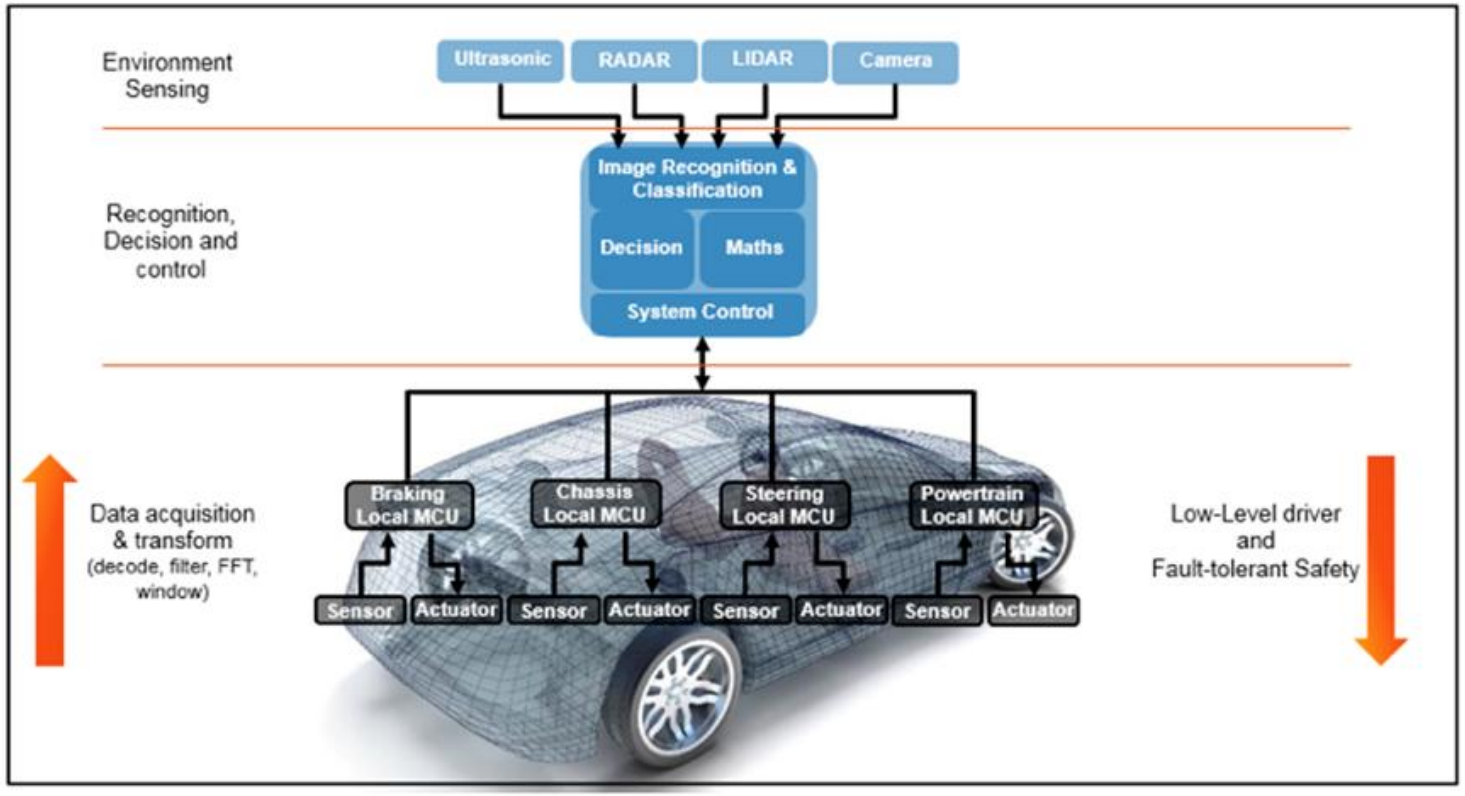
- Regulation (UE) 2019/2144 of the European Parliament and of the Council - EUR-Lex (europa.eu)
- https://visaozero2030.pt/



Source: Improving Self-Driving Car Safety And Reliability With V2X Protocols | by Vincent Tabora | Self-Driving Cars | Medium

02 BENCHMARK – Autonomous Vehicles

EXEMPLIFICATIVE DIAGRAM AND CHARACTERISTICS



- Sensors that measure the position of objects near the vehicles
- Cockpit that analyzes all inputs received from sensors and implements rules for steering, acceleration, and braking
- Radar and video cameras that monitor what is around the vehicle through V2X (e.g.: road, other vehicles, pedestrians, nearby infrastructure, drones, etc.)
- Autonomous driving based on Portuguese regulations
- Accident anticipation
- Holistic traffic analysis using various data inputs
- Greater safety (ACC, AEBS, LIDAR, CAS, and Lane Control)

Source: Electronic control system partitioning in the autonom... eeNews Europe

02 BENCHMARK – Traffic Optimization in Cities in Real Time

The launch of 5G will improve traffic flow and the use of public transportation, reducing waiting and travel times.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
TRAFFIC OPTIMIZATION IN CITIES IN REAL TIME

POTENCIAL PUBLIC SECTOR(S):
Central, Regional, and Local Government, Ministry of Internal Administration

CATEGORY:
Automotive, Public Transportation

REFERENCES
- Helsinki
- Stockholm

SUMMARY
This case study will allow public transport systems to connect with each other and with pedestrians, providing accurate location data to facilitate waiting times and improve the use of public transport.

Functions	Advantages	Disadvantages	Risks/Challenge	Time Estimate
• Better use of travel time	• Safety • Faster arrival at destination4	• Capacity management • Vehicle metrics	• Network failure • Geolocation failure	• Long term

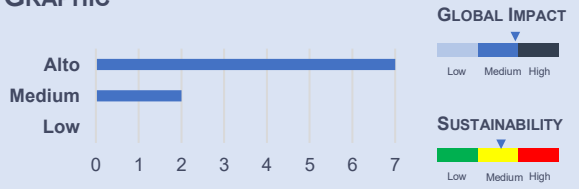
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ IoT sensors
- ✓ GPS
- ✓ WiFi
- ✓ IA
- ✓ MEC
- ✓ *Big Data* e *Cloud*

POTENCIAL PARTNERS:
- ✓ NOKIA
- ✓ 5GAA
- ✓ THALES
- ✓ TFL London
- ✓ AT&T
- ✓ Ericsson
- ✓ Siemens

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – M
- ✓ Sustainability – M
- ✓ Replicability and Generalization – H
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Impact – H
- ✓ Emergency Response Improvement – H
- ✓ Impact on Other Strategies – H

GRAPHIC



OBSERVATIONS:
Operating costs (OPEX) and fixed costs (CAPEX) in this use case may be significant depending on the number of sensors to be implemented, as well as the number of cameras to be installed.

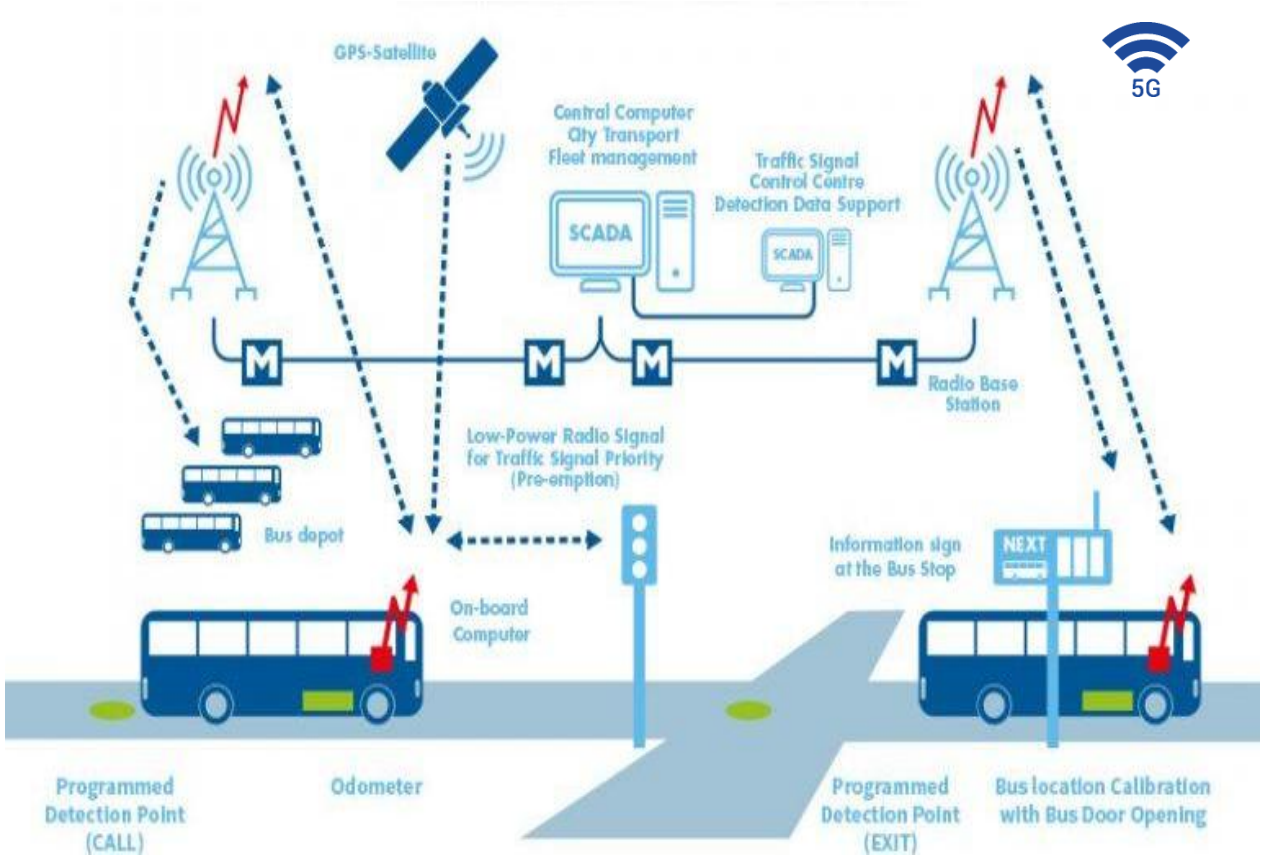
02 BENCHMARK – Traffic Optimization in Cities in Real Time

TECHNICAL ANALYSIS

- Type of Vehicle: Public transport, private vehicles
- Communication Network: Mobility and Transport Authority (AMT)
- Type of Data Transmitted: Information exchanged between sensors and traffic cameras
- Features: Emission reduction, 5G slicing
- Accessories: Mobile app, sensors

MAIN REGULATION

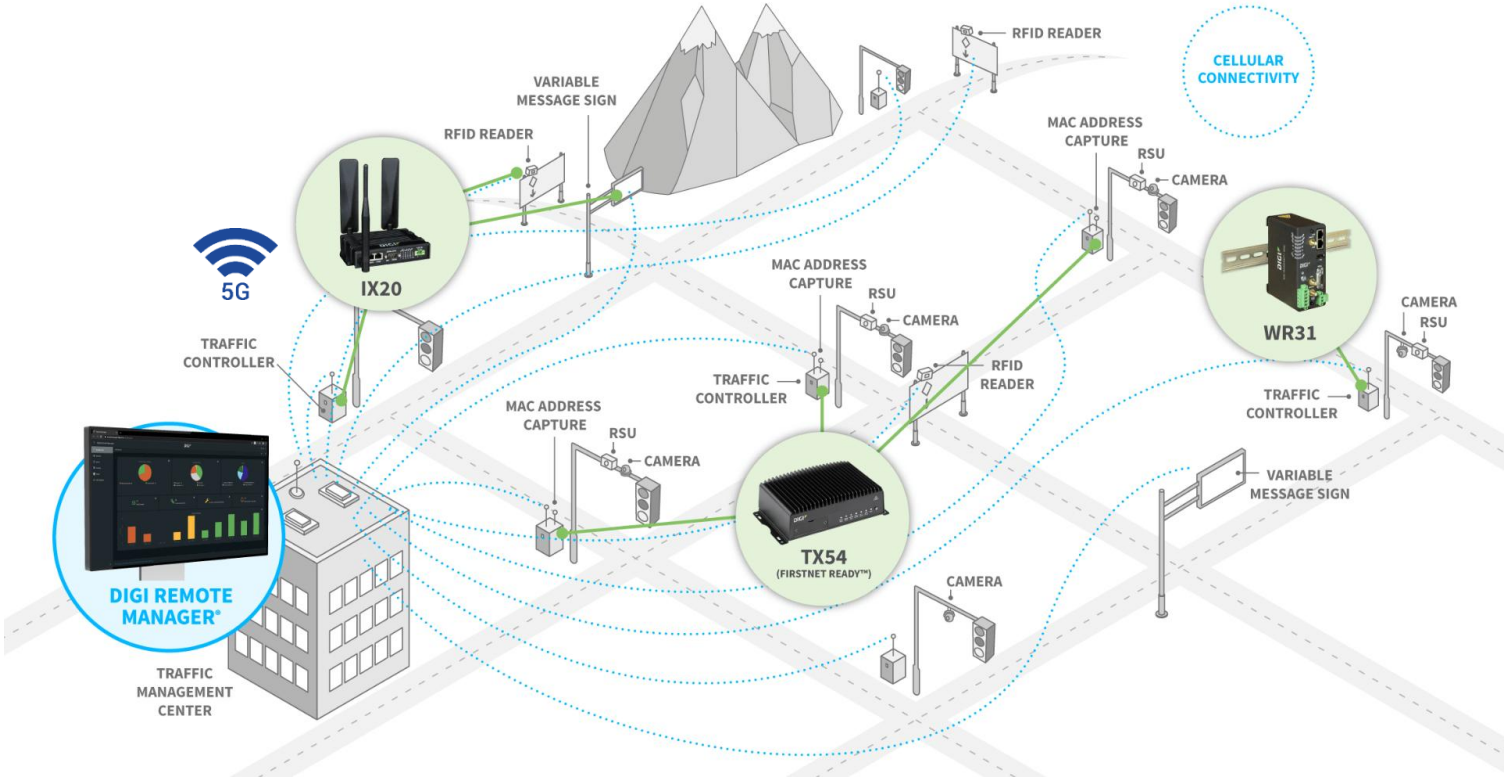
- https://www.imt-ip.pt/sites/IMTT/Portugues/RJSPTP/Documents/FAQSdoRJSPTP_26Fev2016.pdf



Source: https://www.satel.com/references/traffic-system-public-transport-helsinki/

02 BENCHMARK – Traffic Optimization in Cities in Real Time

EXEMPLIFICATIVE DIAGRAM AND CHARACTERISTICS



Source: Traffic Management & Traffic Control Solutions | Digi International

- Sharing of traffic information
- Automated traffic signals to improve and optimize traffic flow
- Traffic reduction enabling faster arrival at the destination
- Less fuel waste
- Reduction of greenhouse gas emissions
- Automatic license plate recognition (subject to privacy laws)*
- RFID readers
- Dynamic and autonomous traffic messages and signs

02 BENCHMARK – Territorial Cohesion (e.g., Education)

The launch of 5G will boost broadband access in remote areas of the country, facilitating, for example, access to multimedia content for schools and students in rural regions.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
REMOTE, INTERACTIVE CLASSES AND BEHAVIOR ANALYSIS

POTENTIAL PUBLIC SECTOR(S):
Central and Regional Government, Ministry of Education, Ministry of Science, Technology, and Higher Education

CATEGORY:
Education, Teaching

REFERENCES:
- UK
- US

SUMMARY:
This case study enables access to broadband networks in remote areas and promotes virtual classes using AR & VR technologies and high-definition content.

Functions	Advantages	Disadvantages	Risks/Challenges	Time Estimate
• Access to broadband networks • Learning quality in remote areas	• Territorial and digital cohesion • Personalized education	• Internet access • Need for IT equipment	• Network failure	• Short to Medium term

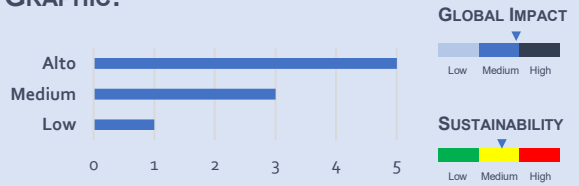
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR & VR
- ✓ WiFi6/7
- ✓ UHD & *Full* HD
- ✓ IoT sensors
- ✓ *Cloud*
- ✓ *Big Data*

POTENCIAL PARTNERS:
- ✓ UK School Education
- ✓ Austria College Education
- ✓ India Gov., Department of Telecom (DoT)
- ✓ China

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – M
- ✓ Replicability and Generalization – H
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – H
- ✓ Environmental Impact – M
- ✓ Emergency Response Improvement – L
- ✓ Impact on Other Strategies – M

GRAPHIC:



OBSERVATIONS:
Operating costs (OPEX) and capital costs (CAPEX) in this case may be moderately high, depending on the level of implementation (e.g., computers, sensors, cameras, etc.).

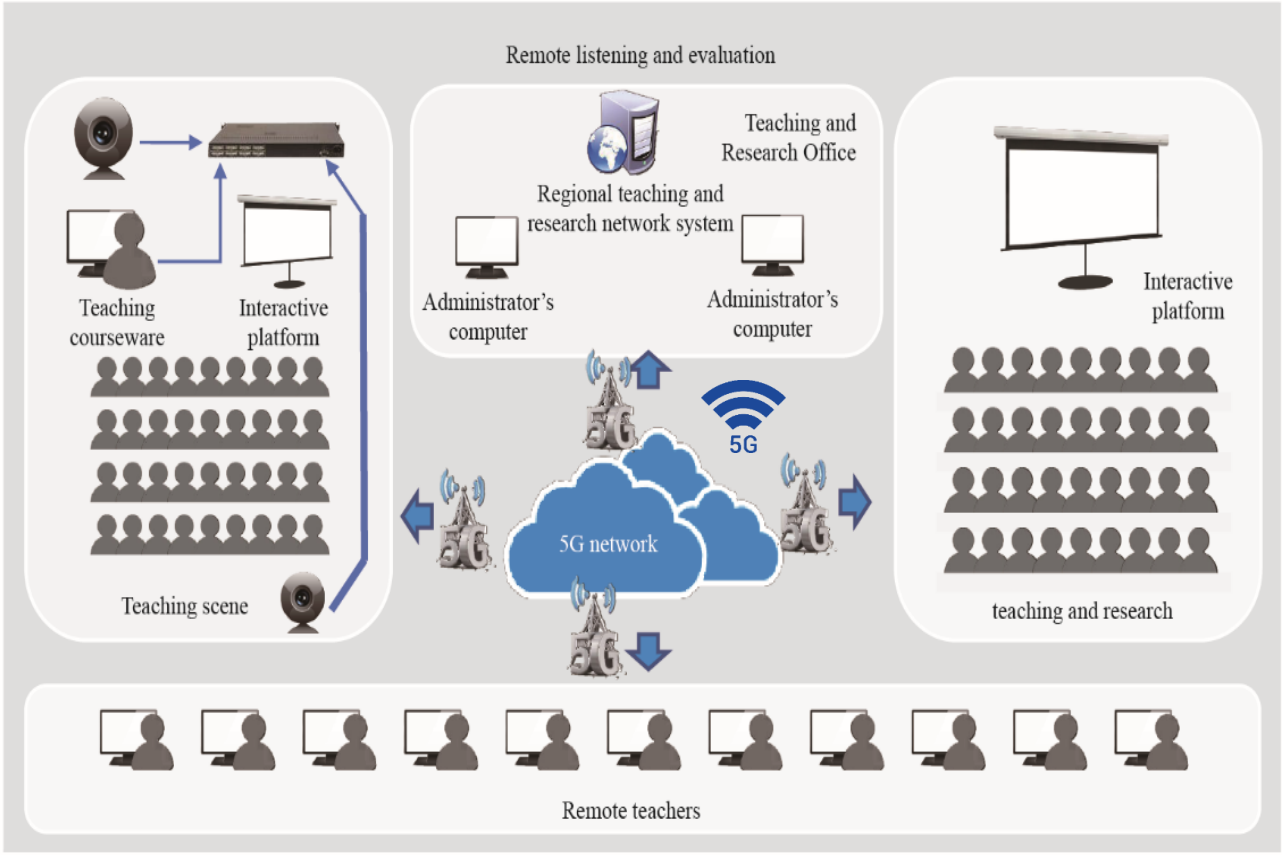
02 BENCHMARK – Territorial Cohesion (e.g., Education)

TECHNICAL ANALYSIS

- Communication Network: Directorate-General for Education
- Type of Data Transmitted: UHD or Full HD, document sharing (between teacher and students) via cloud
- Features: Interactive monitoring, 4K resolution, personalized teaching
- Accessories: Computer, video camera, WiFi, projectors

MAIN REGULATION

- https://pesquisa.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/pt/covidwho-1267061
- https://www.ncsc.gov.uk/blog-post/home-learning-technology-securing-tools-for-remote-education



Source: https://www.engineering.org.cn/en/10.15302/J-SSCAE-2019.06.020

02 BENCHMARK – Territorial Cohesion (e.g., Education)

EXEMPLIFICATIVE DIAGRAM AND CHARACTERISTICS

- The use of virtual reality provides immersive experiences to develop new skills
- Remote teaching methods using High-Definition video and VR applications
- Educational opportunities in rural areas
- 5G Applications: Localization; Access to UHD educational materials; Logistical management of resources and classrooms; Voice recognition; Translation; Teacher evaluation; Motivation and focus analysis of students

Source: Application of 5G Technology in Education Informatization (engineering.org.cn)

02 BENCHMARK – Smart Agriculture – Sensorization, Telemetry

The launch of 5G in agriculture will enable resource optimization, reduced water consumption, and increased productivity.

5G USE CASE IN PUBLIC ADMINISTRATION

NAME:
SMART AGRICULTURE – SENSORIZATION, TELEMETRY

POTENCIAL PUBLIC SECTOR(S)
Central and Regional Government; Ministry of Agriculture and Food

CATEGORY:
Agriculture

REFERENCES:
- Australia
- UK

SUMMARY:
This case study enables the assessment of crop yields, as well as the measurement of soil humidity and temperature to determine irrigation needs, reducing water consumption.

Functions	Advantages	Disadvantages	Risks/Challenges	Time Estimate
• Smart irrigation • Real-time soil monitoring	• Greater sustainability • Greater sustainability	• High number of sensors • Maintenance	• Batteries • Network coverage	• Short to Medium term

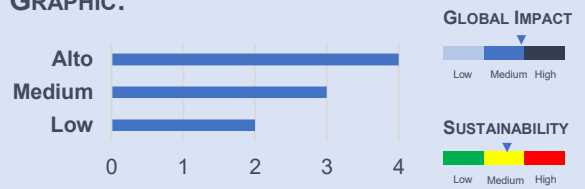
DESCRIPTION

COMPLEMENTARY TECHNOLOGIES:
- ✓ AR & VR
- ✓ IoT sensors
- ✓ *Drones*
- ✓ 4G
- ✓ WiFi
- ✓ *Cloud*
- ✓ IA

POTENCIAL PARTNERS:
- ✓ KPN
- ✓ Austria
- ✓ IEEE
- ✓ John Deere

IMPACT DIMENSIONS (HIGH, MEDIUM, LOW)
- ✓ Relevance for Society – H
- ✓ Technical Feasibility – H
- ✓ Sustainability – M
- ✓ Replicability and Generalization – M
- ✓ Sector/PA Transformation – H
- ✓ Economic Impact – M
- ✓ Environmental Improvement – H
- ✓ Emergency Response Improvement – B
- ✓ Impact on Other Strategies – B

GRAPHIC:



OBSERVATIONS:
Initial infrastructure (CAPEX) costs are significant, depending on the number of sensors to be installed, as well as the number of machines and animals to be monitored. In the long term, these costs are offset by process optimization and better resource management.

02 BENCHMARK – Smart Agriculture – Sensorization, Telemetry

TECHNICAL ANALYSIS

•Communication Network: Confederation of Farmers of Portugal

•Type of Data Transmitted: (Cloud ↔ Drones) Location (using sensors and GPS), altitude, control, HD vídeo

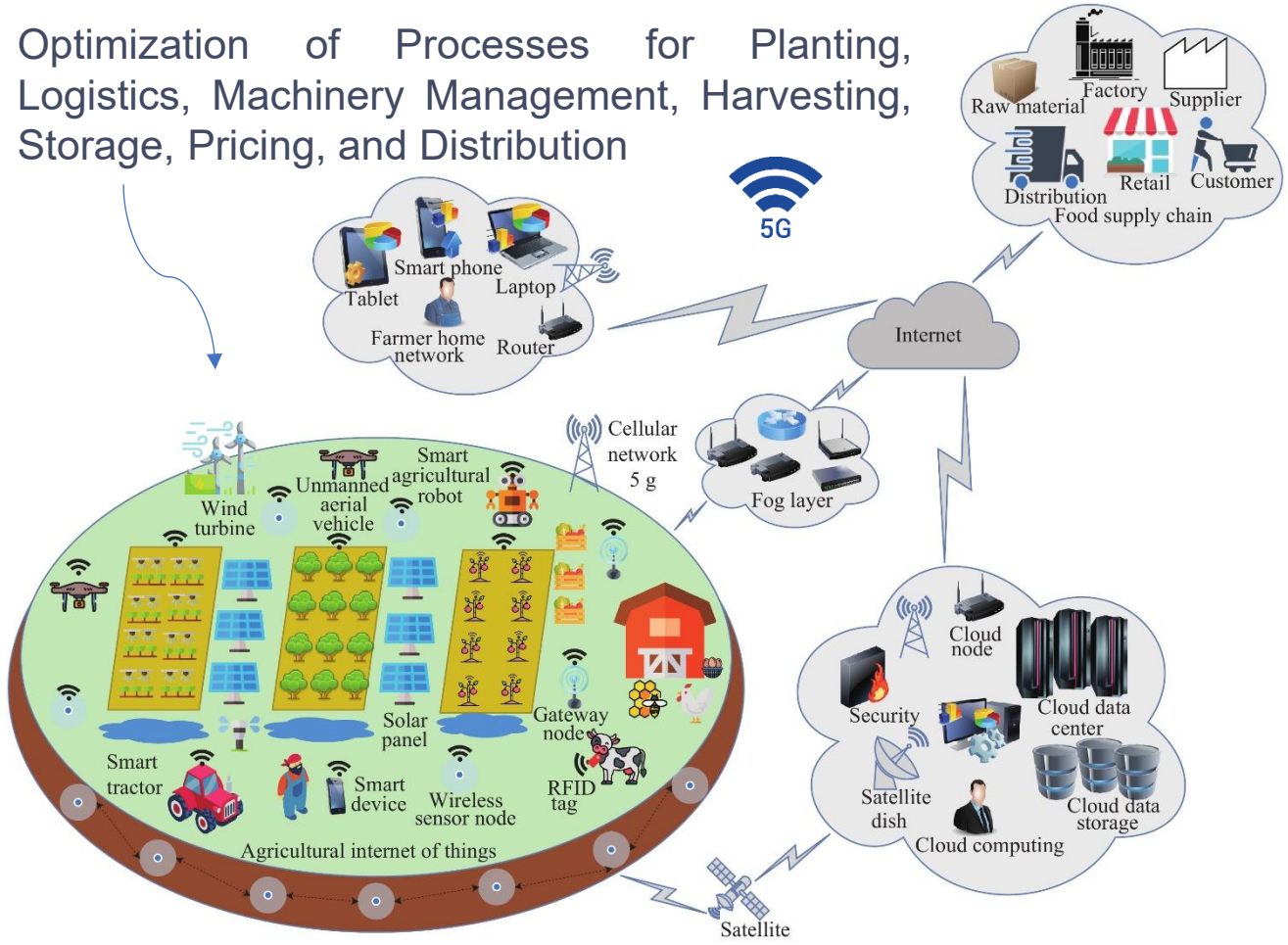
•Characteristics: Distances > 12 km and altitudes > 1 km (Current limits: 120 m altitude, 3 km VLOS distance)

•Accessories: 4K UHD & Full HD cameras, GPS

MAIN REGULATION

- https://www.anac.pt/VPT/GENERICO/DRONES/REGISTO_UAS/Paginas/OperadoresdeUAS.aspx
- https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2022-d3-03-04
- https://www.govinfo.gov/content/pkg/USCODE-2011-title7/html/USCODE-2011-title7-chap1.htm
- https://www.state.gov/reports/2022-investment-climate-statements/montenegro/

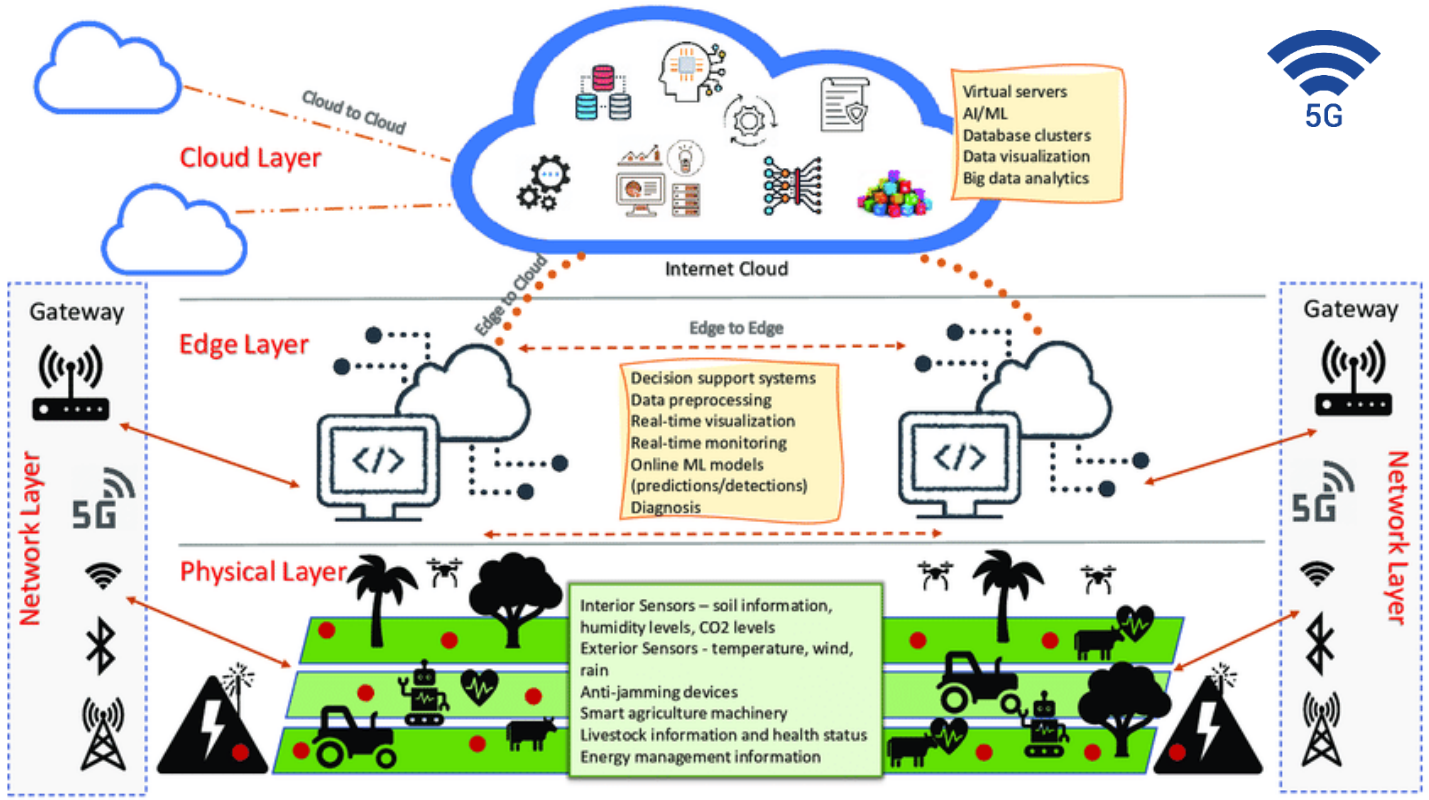
Optimization of Processes for Planting, Logistics, Machinery Management, Harvesting, Storage, Pricing, and Distribution



Internet of Things for the Future of Smart Agriculture: A Comprehensive Survey of Emerging Technologies (ieee-jas.net)

02 BENCHMARK – Smart Agriculture – Sensorization, Telemetry

EXEMPLIFICATIVE DIAGRAM AND CHARACTERISTICS

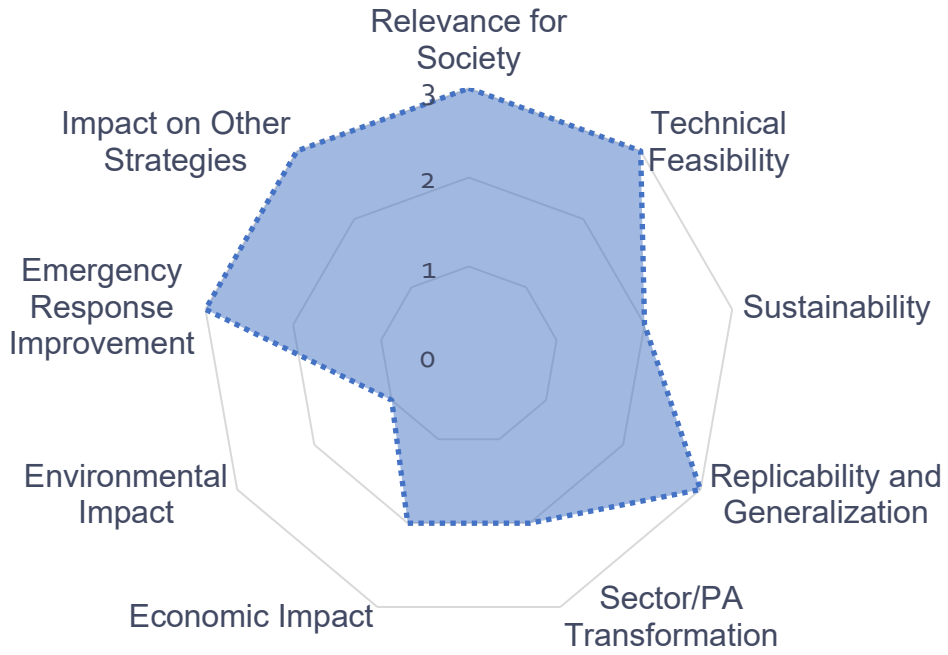


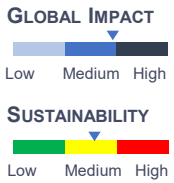
Source: (PDF) Security and Privacy in Smart Farming: Challenges and Opportunities (researchgate.net)

- Smart tractors using optimized route planning to reduce soil erosion and save fuel costs
- Monitoring of irrigation and water flow
- Sensors attached to livestock, enabling monitoring of animal health and well-being
- Drones that can uniformly and efficiently distribute chemical products, improving crop quality
- Centralized management at regional or national level of the entire infrastructure
- Autonomous control and optimization systems
- Process optimization using AI for: Planting, Machinery management/logistics and rental, Harvesting, Storage, Pricing, Distribution

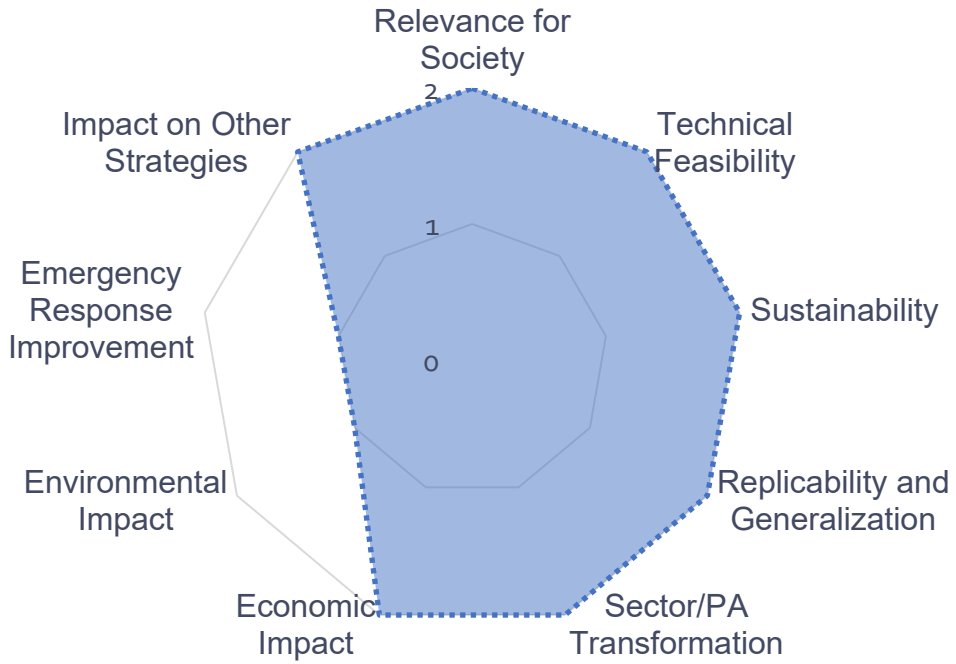
02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

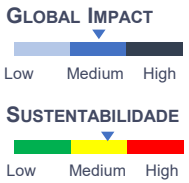
MONITORING AND MANAGEMENT OF PUBLIC INFRASTRUCTURE





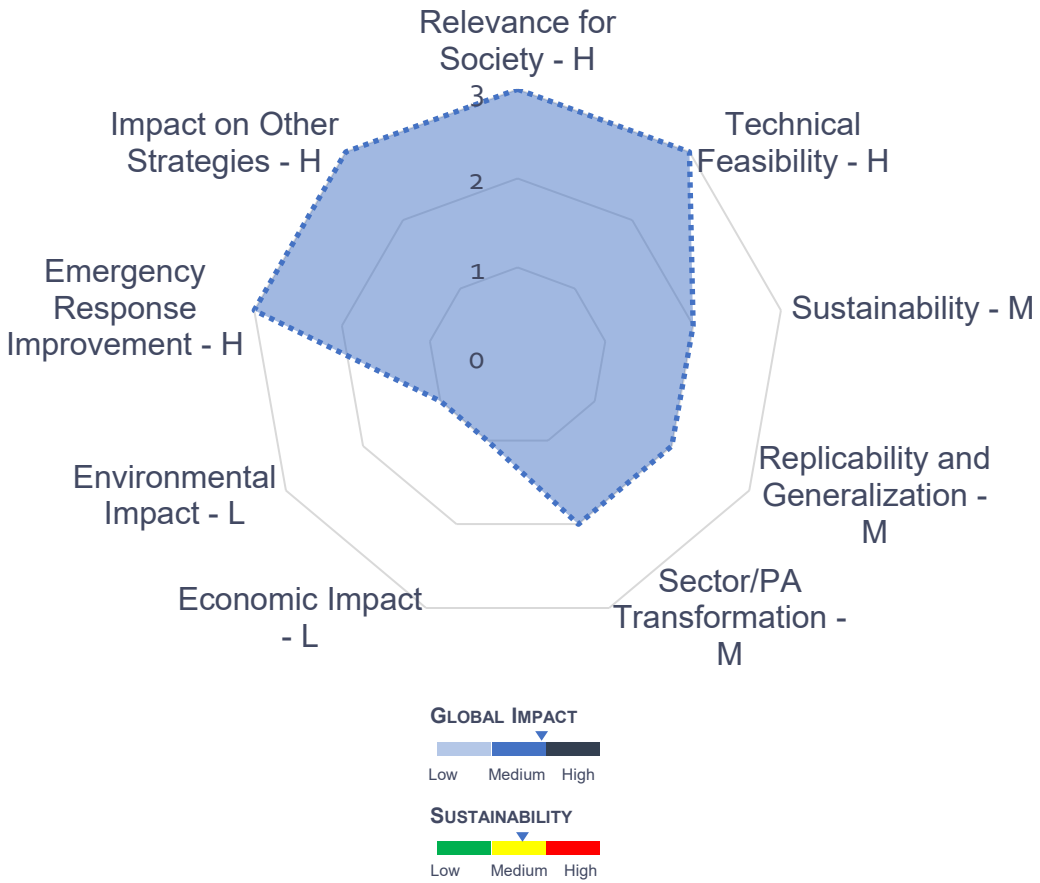
SAFETY IN CONSTRUCTION



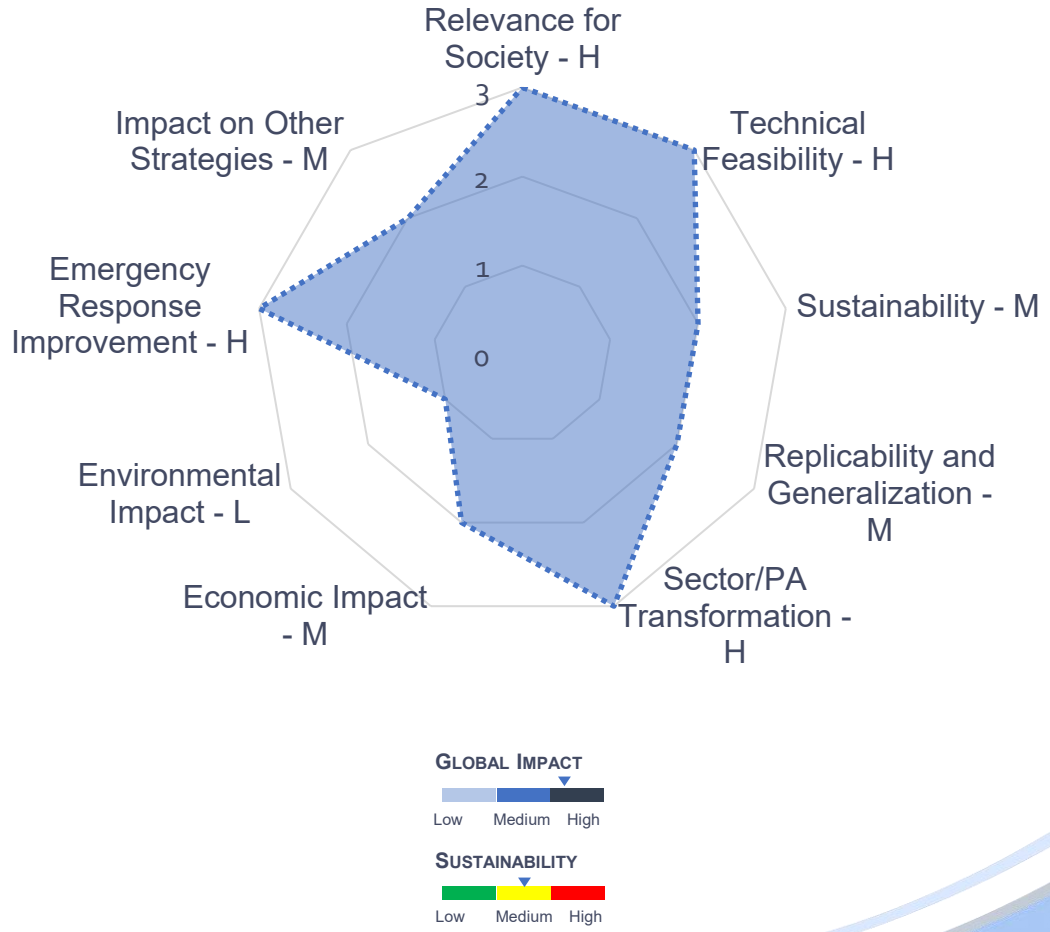


02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

5G AMBULANCES FOR THE EMERGENCY MEDICAL SERVICE

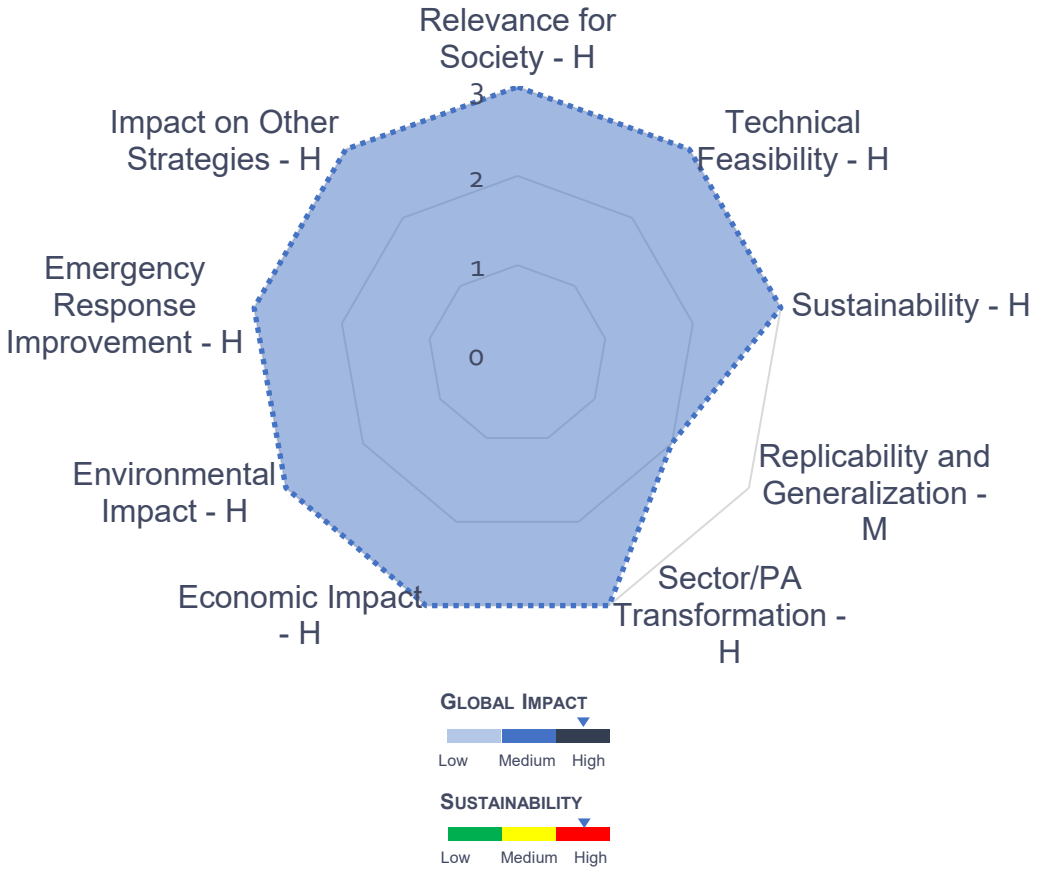


REMOTE SURGERIES IN THE NATIONAL HEALTH SERVICE

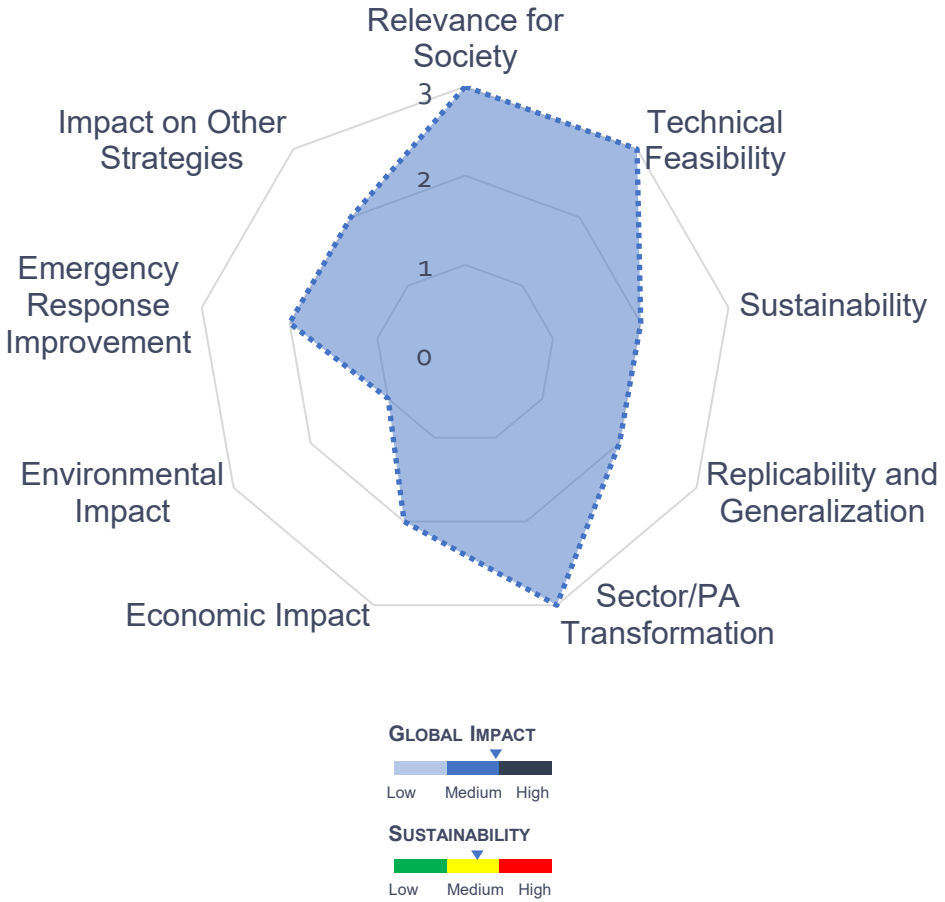


02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

5G HOSPITAL IN THE NATIONAL HEALTH SERVICE

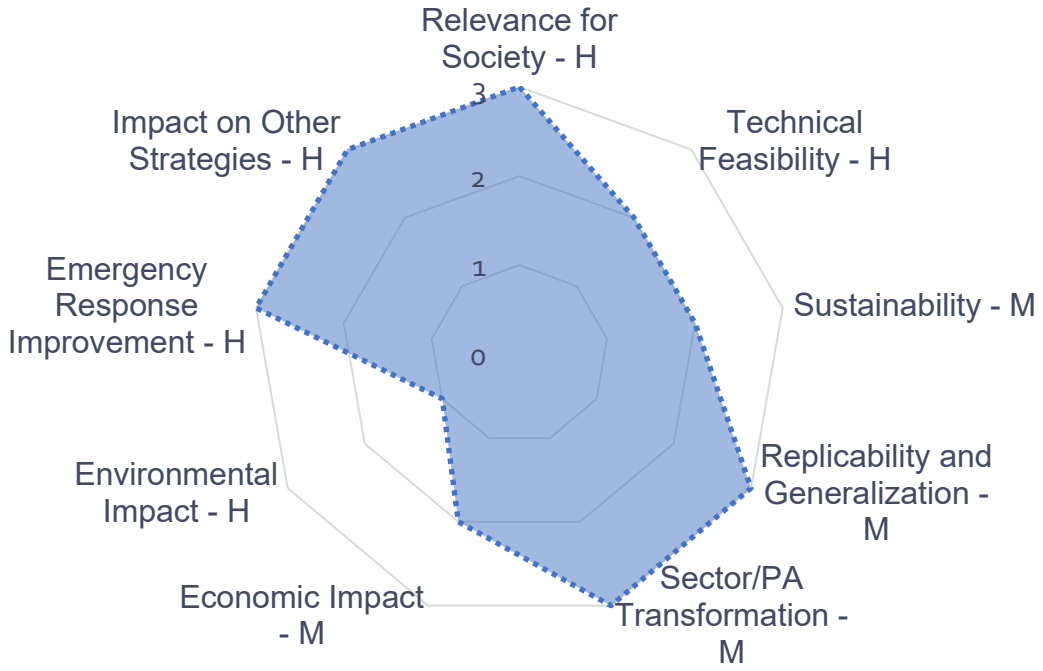


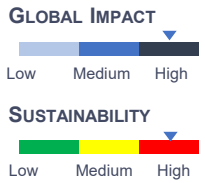
CONTINUOUS HEALTH MONITORING



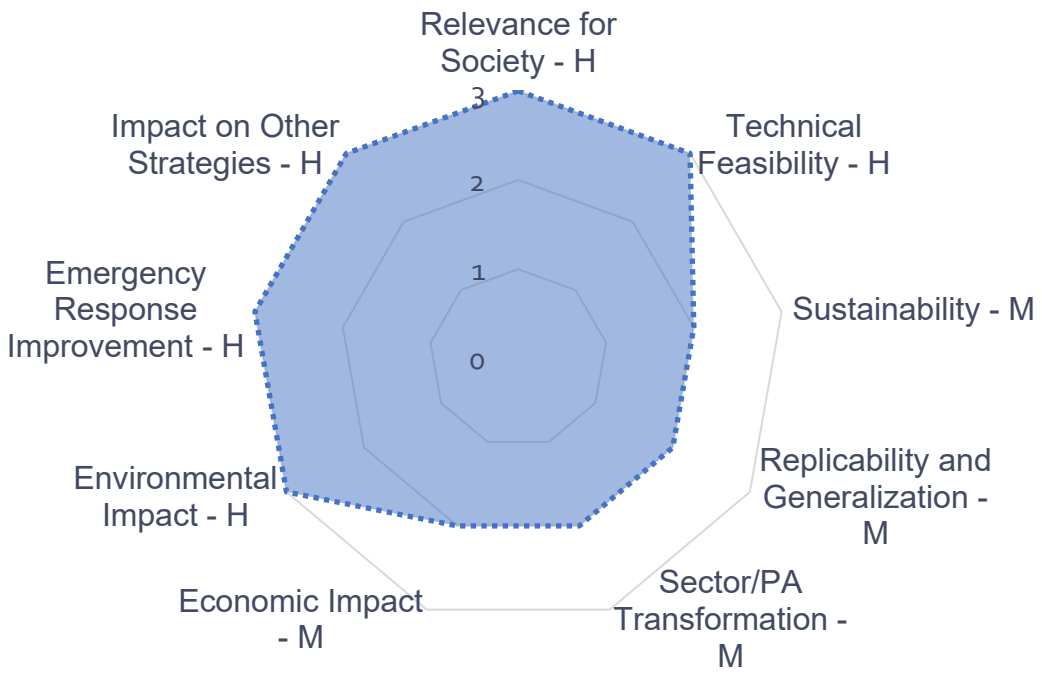
02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

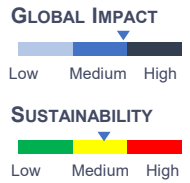
MIGRATION OF EMERGENCY NETWORKS TO 5G





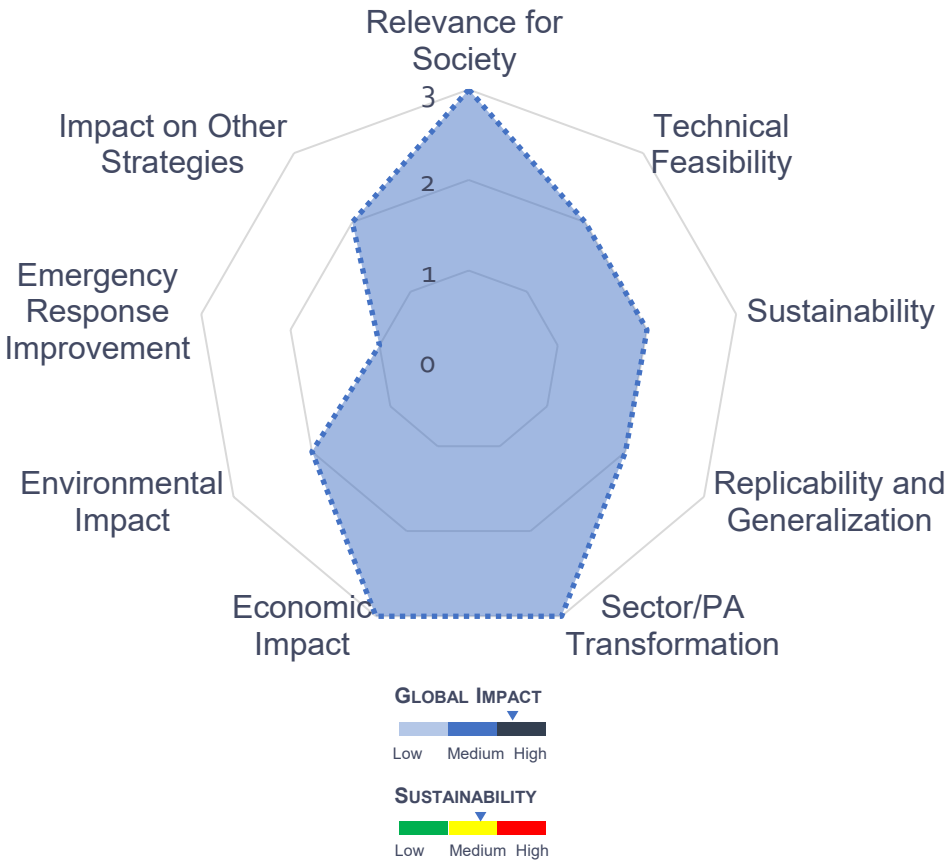
MONITORING AND FIRE-FIGHTING WITH 5G DRONES



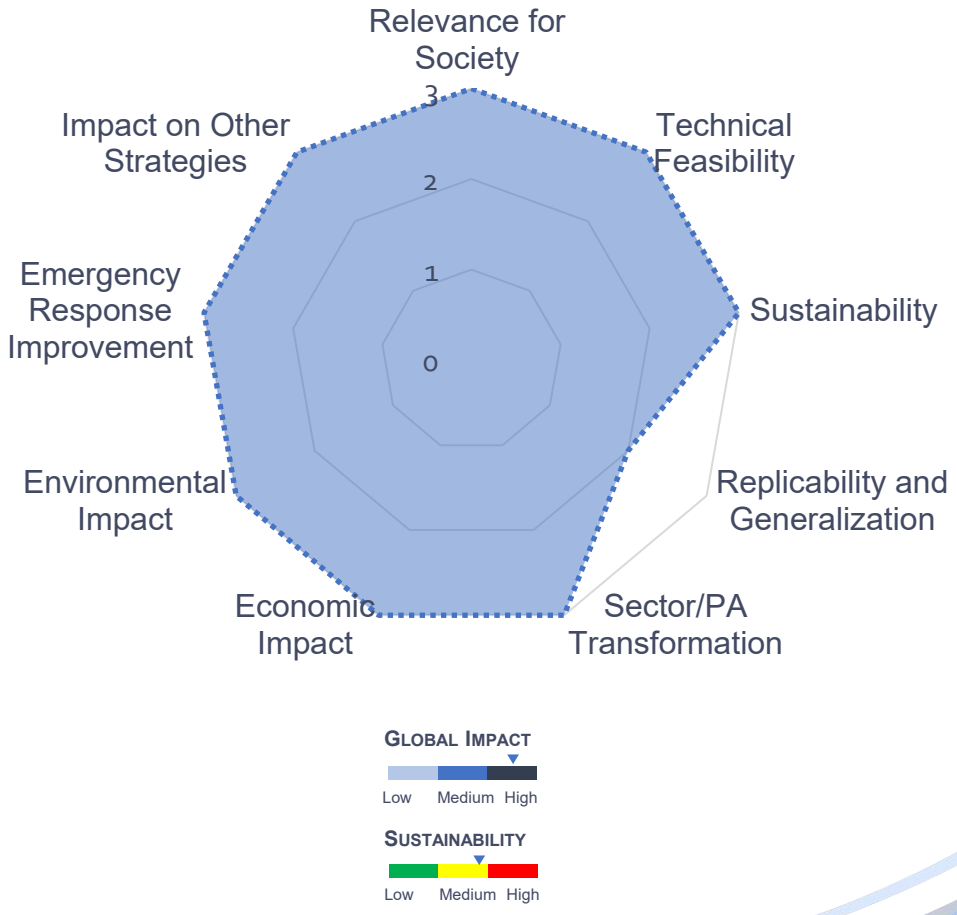


02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

MARITIME PORT MANAGEMENT

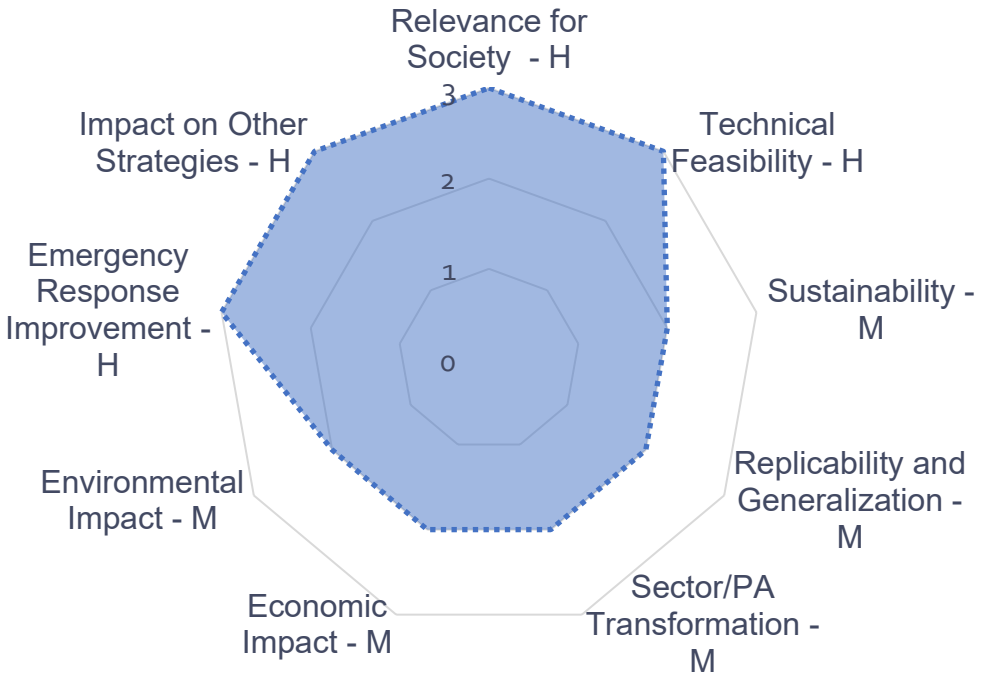


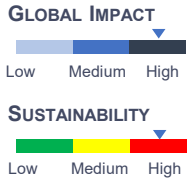
AUTONOMOUS VEHICLES



02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

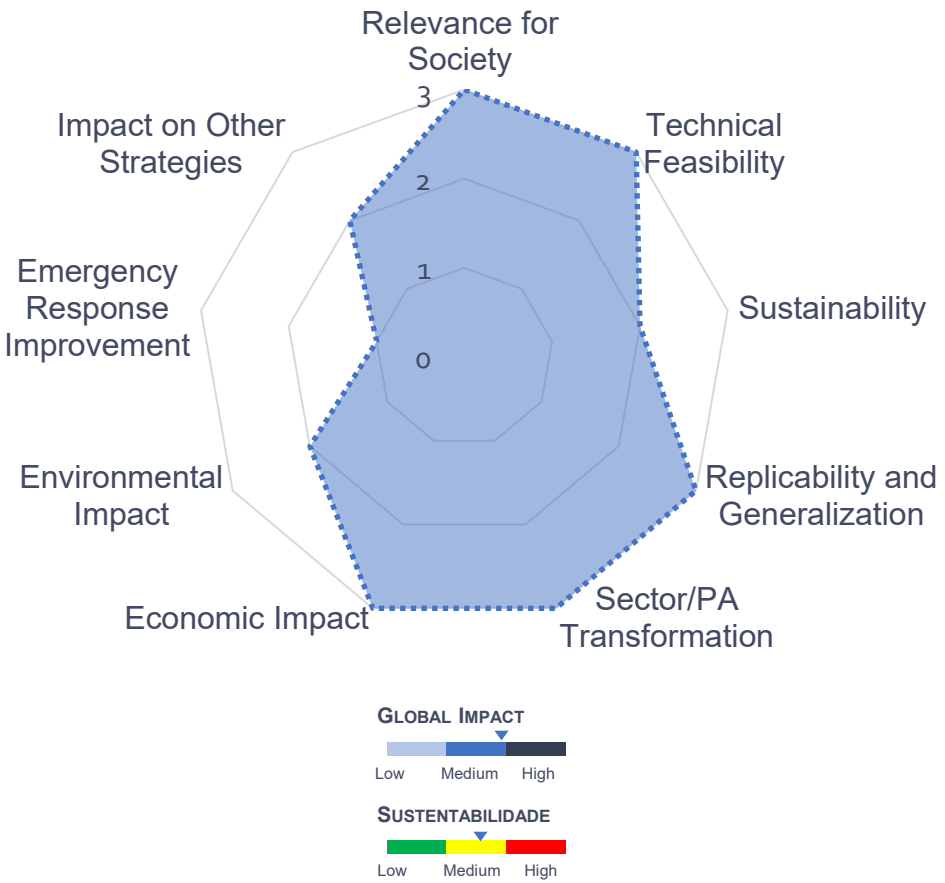
TRAFFIC OPTIMIZATION IN CITIES IN REAL TIME



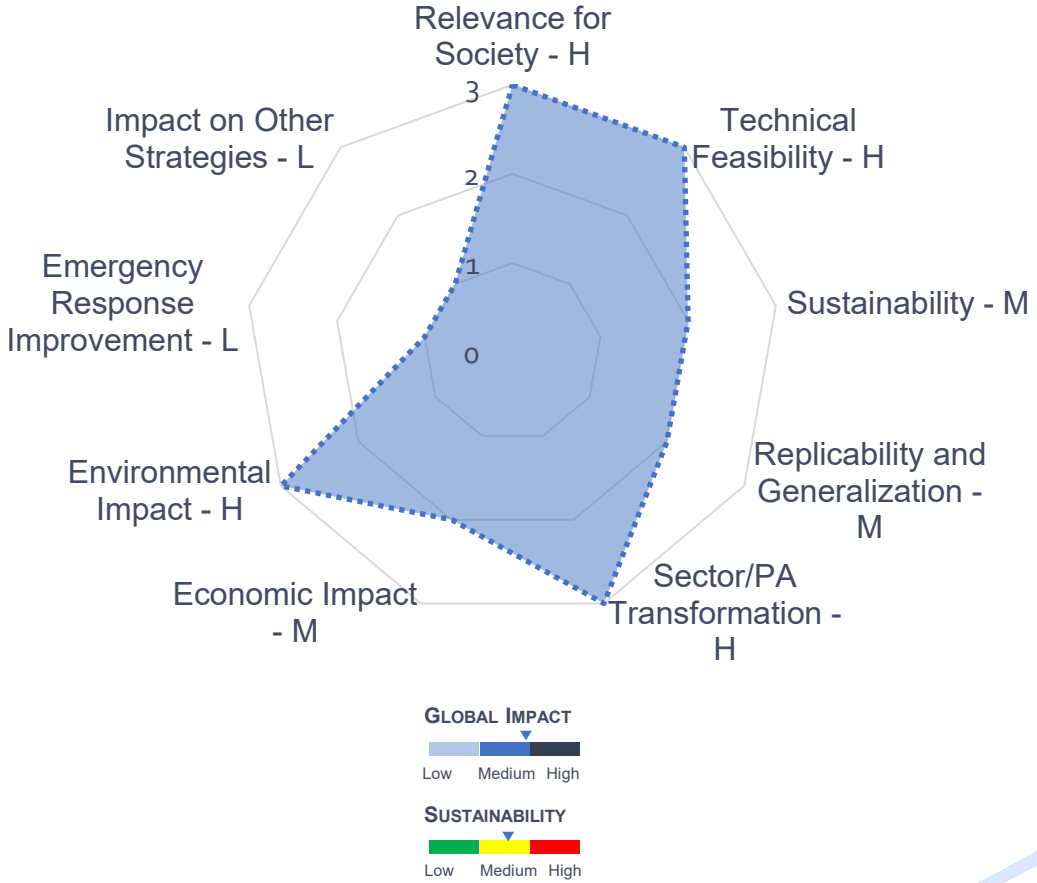


02 BENCHMARK – SUMMARY OF THE IMPACT ANALYSIS OF USE CASES

APPLICATION OF 5G TECHNOLOGY IN EDUCATION

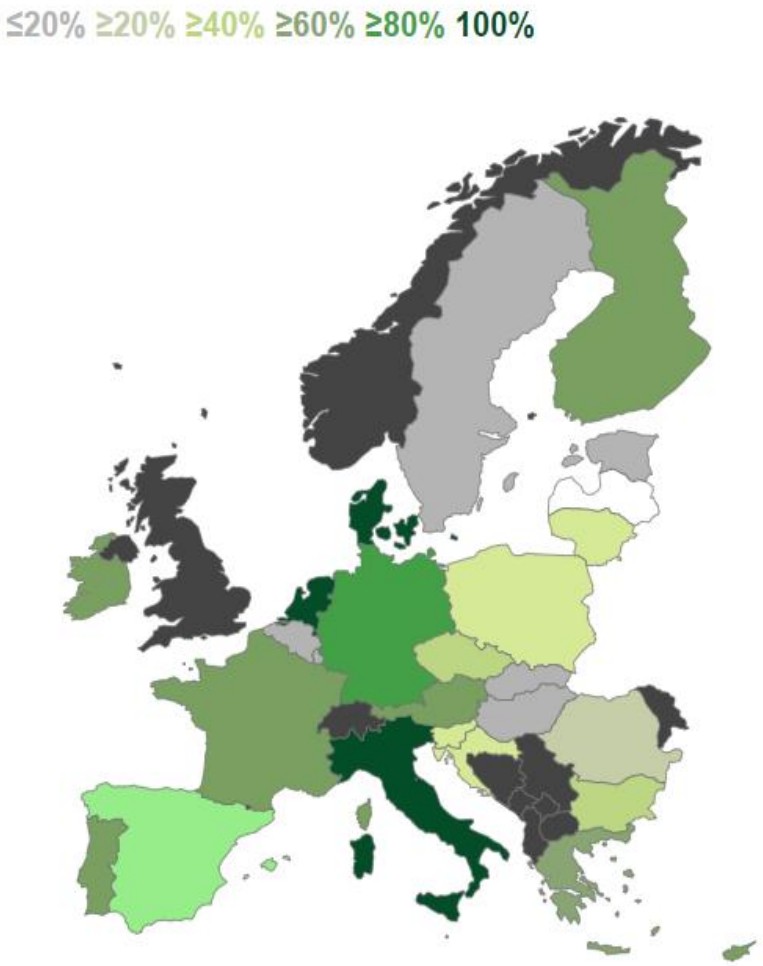


SMART AGRICULTURE – SENSORIZATION, TELEMETRY



03 National and International Practices and Initiatives

03 Practices and Initiatives – 5G Coverage in the EU



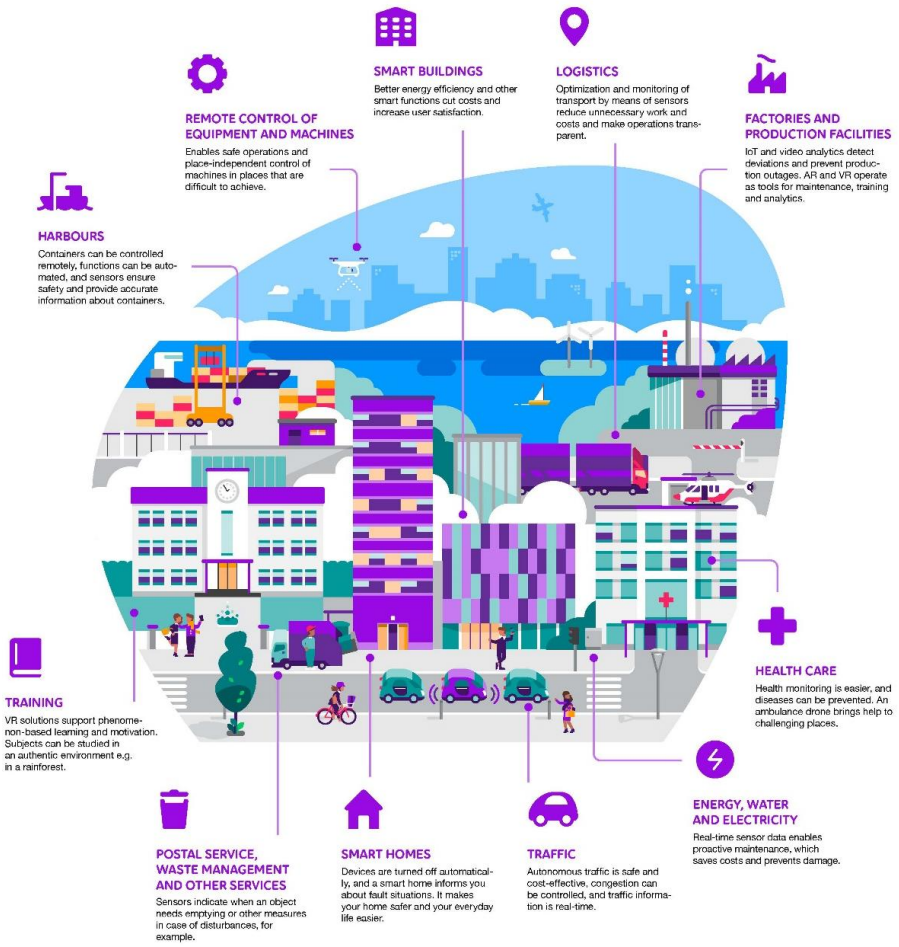
Source: https://alertify.eu/5g-coverage-eu/

Belgium's national broadband strategy was launched in April 2021, with full coverage expected by 2025. Currently, 65% of the market has access to fiber broadband, with Proximus aiming to reach 70% of installations by 2028. Private cloud and database services are available in Belgium from providers such as Combell, with the country's extensive broadband coverage, fast download speeds, and reliable networks making this possible.

Marseille and Paris lead in terms of antennas, while 5G coverage remains unevenly distributed nationwide. In March 2022, the French government announced new measures to promote access to 5G for manufacturers and other sectors. The government also aims to simplify access to the 2.6GHz spectrum to stimulate 5G industrial projects while exploring potential access to the 3.8GHz and 4GHz bands.

Italy was among the main EU countries to launch commercial 5G services. The four operators (TIM, Vodafone Italia, Wind3, and Iliad) launched their 5G networks between June 2019 and December 2020 and have since expanded their services. The migration of public administration to the cloud is one of the main priorities of Italy's National Recovery and Resilience Plan (RRF), with an investment of €6.7 billion.

03 Practices and Initiatives – Finland



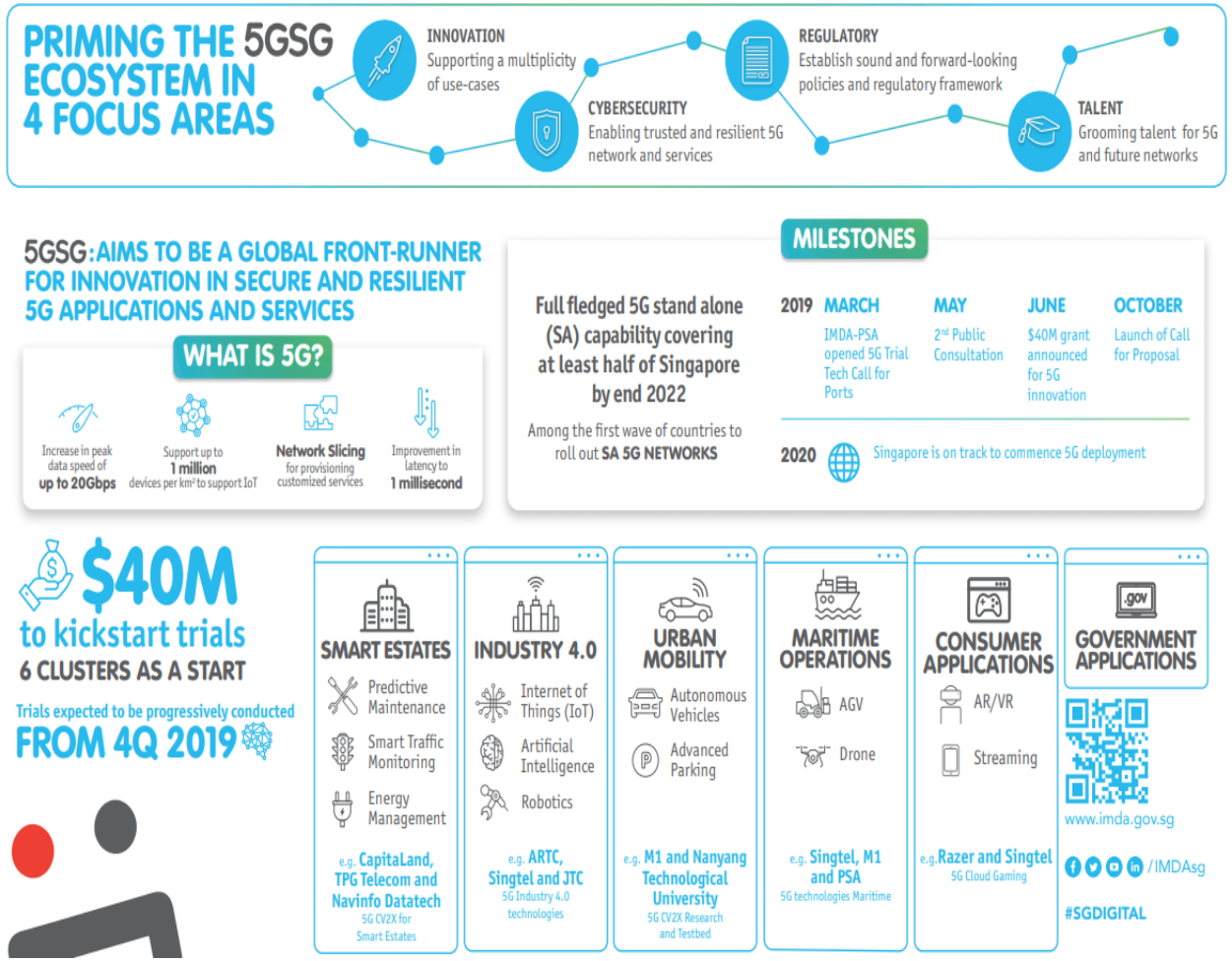
Source: https://www.telia.fi/business/5g/5g-finland

The “5G Finland” initiative created a network of 100 companies and 300 individuals in Finland with the goal of defining new applications, services, and pilot projects for 5G networks.

The initiative involved the participation of several state entities, startups, large corporations, and members of the academic community. The idea was to foster collective participation in identifying the best ways to use this new technology across different areas of society.

Through this network, several projects were launched, including a 360-degree live broadcast from the Telia 5G Arena (the first of its kind in Europe), the use of video support for factory maintenance, facial recognition testing in an ice cream shop, and the use of video analytics for quality control.

03 Practices and Initiatives – Singapore



Source: https://www.imda.gov.sg/programme-listing/5G-Innovation

Under the IMDA 5G Innovation Program, 30 million dollars were allocated to support companies and industries in adopting and implementing new 5G applications in real-world environments.

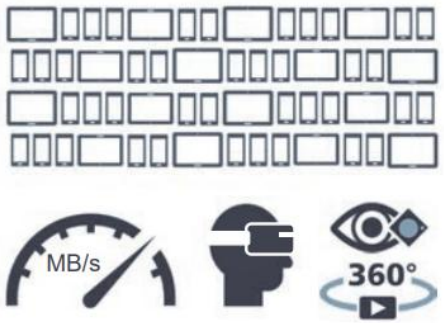
The initiative involved partnerships with universities and telecom operators to develop holographic imaging to enhance healthcare delivery, conduct the region's first cinematic AR experience, and create the first maritime 5G solution using AR/VR in Southeast Asia.

In collaboration with institutes of higher education, technology companies, and other government agencies, open-house trials will be conducted for both governmental and industrial use, helping to foster collaboration and the development of 5G applications and services, thereby accelerating ecosystem growth.

03 Practices and Initiatives – Germany

Enhanced Mobile Broadband

eMBB



- Improved user experience
- High device connectivity
- High mobile data rates
- Mobile virtual and augmented reality applications

Massive Machine Type Communications

mMTC

- eHealth applications
- Industry 4.0 applications
- Intelligent logistics
- Environmental monitoring
- Smart grids
- Smart farming

Ultra-Reliable and Low-Latency Communications

URLLC

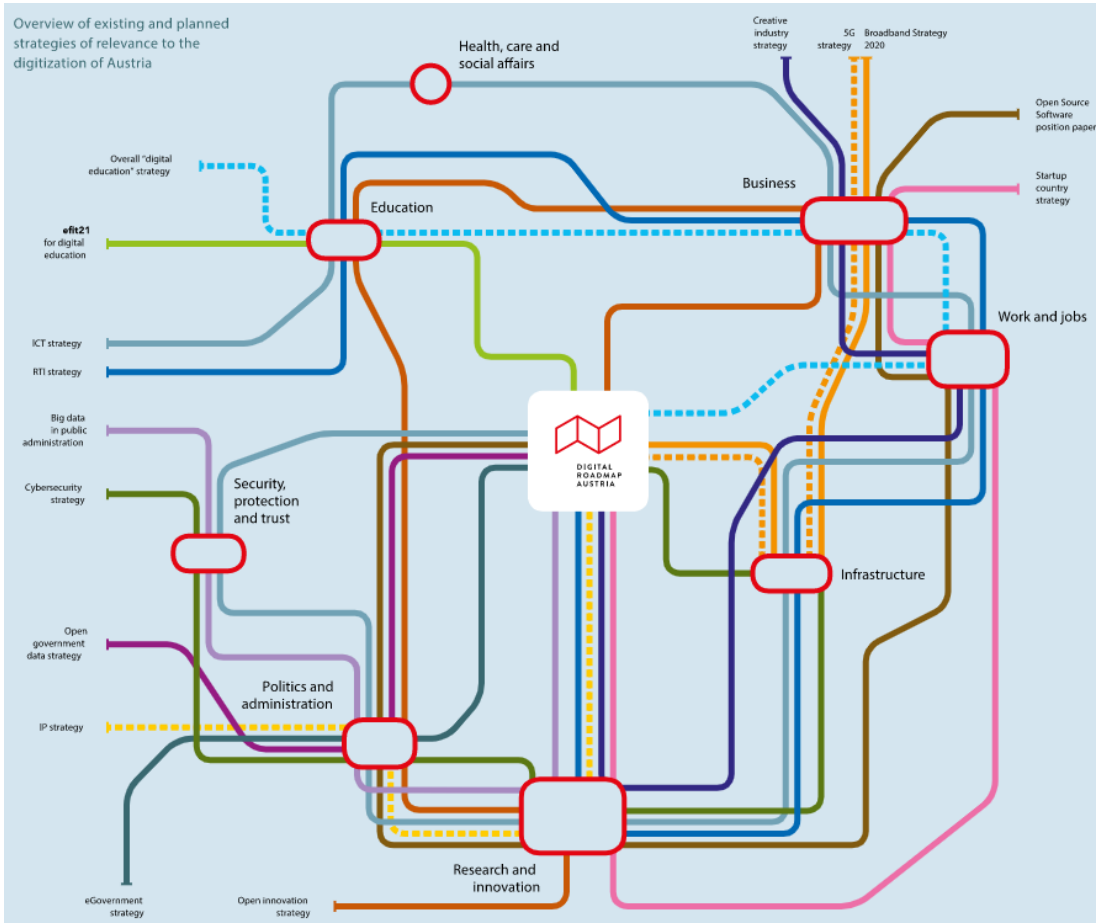
- Car-to-X communication
- Control of parcel drones
- Vital data monitoring
- Smart manufacturing

Germany is one of the ten countries with the highest research intensity in the world. To continue promoting and achieving success in research, initiatives have been created involving startups and small and medium-sized enterprises (SMEs) so that citizens, other companies in the research sector, and civil society organizations can benefit from these approaches.

Source: 5g-strategy-for-germany.pdf (bmvi.de)

Through this initiative, several research areas are prioritized, such as Health, with the development of an application for rapid patient monitoring, and technologies to support nursing care. In the field of Security, AR & VR technologies are being used to create training and simulation programs for security forces, improving their protection methods as well as their ability to combat cybercrime.

03 Practices and Initiatives – Austria

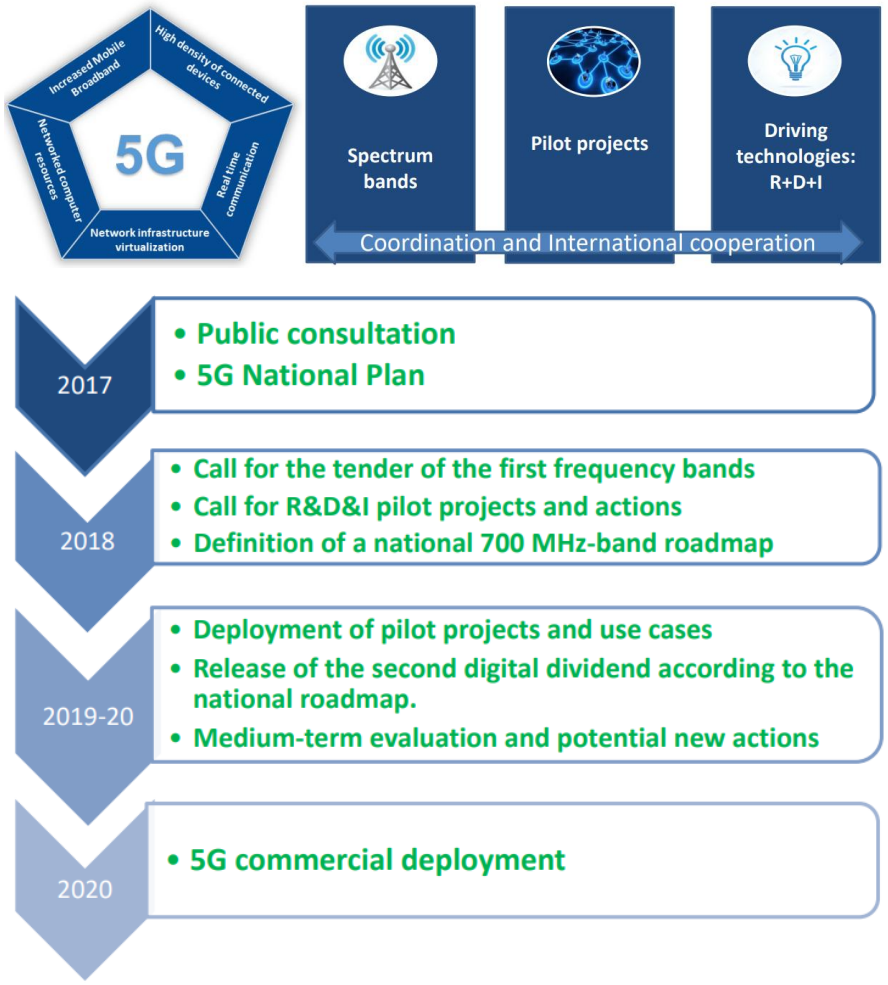


Source: https://www.digitalroadmap.gv.at/en/

The creation of the "Digital Roadmap Austria" involved around 100 people, including ministers, municipal councils, and unions. To develop this project, several key points were highlighted:

1. Develop an educational system – called "EduTech", consisting of online courses, simulators, and personalized learning management systems.
2. Develop a patient portfolio containing medical data such as blood type, allergies, and drug intolerances, which can be viewed in other countries (in compliance with privacy laws).
3. Implement the European Strategy on Cooperative Intelligent Transport Systems in public and private transport, to connect pedestrians, roads, and vehicles to traffic management systems and infrastructure, enabling direct interaction among them and thereby improving safety, efficiency, and sustainability.

03 Practices and Initiatives – Spain



Source: plan_nacional_5G_en.pdf

In Spain, a National 5G Plan was developed, becoming a key driver for Industry 4.0 ecosystems promoted under the "Digital Strategy for a Smart Spain."

This plan analyzed eight sectors, including Health, Automotive, and Agriculture, and is expected to generate benefits of around €14.6 billion as well as a significant number of new jobs.

- In the Health sector, it will be possible to conduct training sessions using AR & VR, as well as remote patient monitoring, etc.
- In the Automotive sector, there will be an impact on traffic and transport optimization (both public and private), improving route management and reducing accidents.
- In Agriculture, sensors will be created to optimize irrigation, soil fertilization, and other related processes.

03 Practices and Initiatives – United Kingdom

Strategy, four phases from research to commercialisation

PHASES	1) RESEARCH & DEVELOPMENT	2) TEST BEDS & TRIALS	3) EARLY DEPLOYMENT, INFRASTRUCTURE	4) COMMERCIALISATION & EXPLOITATION
FOCUS AREAS	TECHNOLOGY BUILDING BLOCKS	VERTICAL USE CASES SYSTEMS INTEGRATION	VERTICAL USE CASES SYSTEMS INTEGRATION SERVICES	VERTICAL USE CASES SERVICES
Community WHO	Government	Government & Regulator(s)		
	Academia & Research		Investors	
	Supply Chain Operators Vertical value chain			
FUNDING AND POLICY REQUIRED	Establish steering group, UK events, meetings and standards / dissemination activities.			
	Support for international work / science bridges.			
GOVERNMENT FUNDING REQUIRED	Increase existing funds. BEIS[3], RCUK & InnovateUK. Implement actions to ensure stronger alignment	Fund a series of test beds and trials. Goal - 5G Phase 1 end to end trial by Q1 2018.	Potential new funds required 2019 to 2020. Informed by previous test beds and trial work from Phase 2.	
INDUSTRY INVESTMENT	Government funding providing catalyst for additional funding and investment			Funding by Industry / Investors
	Policy for 5G & IoT alignment and adoption - ICT and Verticals.			
POLICY & REGULATION	Stronger alignment - academia, industry and government to steer.		Spectrum, Regulatory, planning and other key challenges required – see sections 4 and 5	
STANDARDS & DISSEMINATION	UK alignment activities. Collaborate, share and disseminate. Cross Verticals Workshops. Agree common positions to drive Standards.			

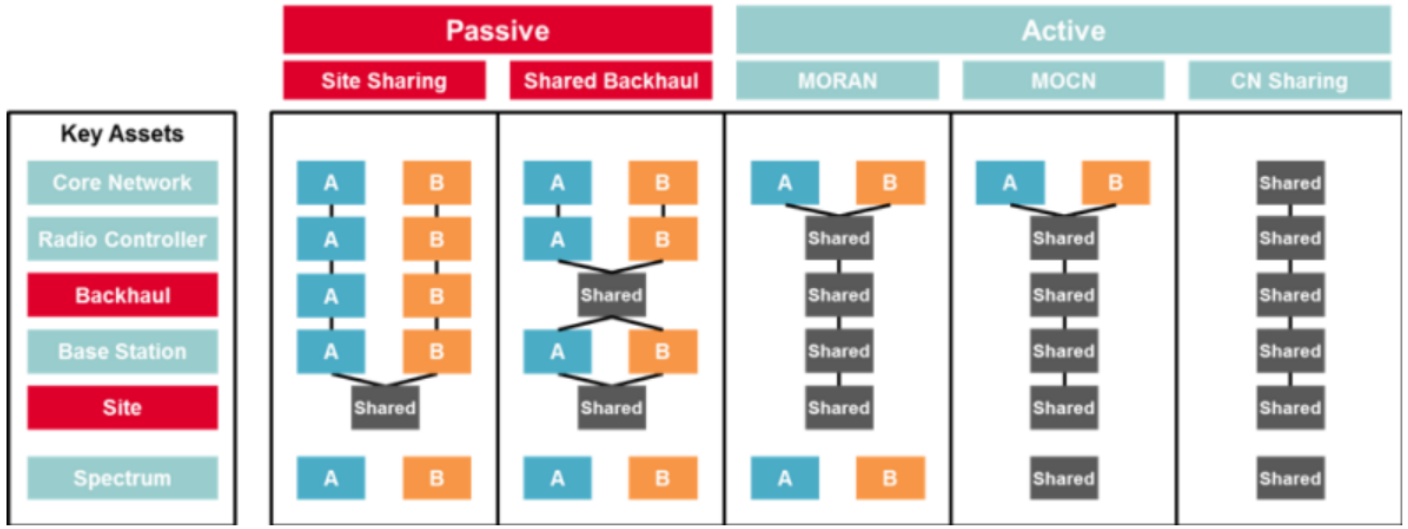
Source: UK Gov, UK 5G Strategy Overview (slideshare.net)

As part of the development of the "Government's Digital Strategy," the United Kingdom has allocated an investment of €16 million, involving industries, investors, regulators, and researchers. The main goal of this strategy is to test use cases in rural and urban areas and to understand the economic impact of building such infrastructures in different locations and scenarios.

Possible use cases include:

- Sports: With AR & VR, it is possible to offer new ultra-realistic applications in games or provide sports fans with the opportunity to "play" alongside their favorite athletes.
- Health: Wearable sensors could help monitor people with health conditions, predicting if someone is at risk of a heart attack or tracking the well-being of the elderly.
- Education: Creating more interactive lessons using AR & VR technologies.

03 Practices and Initiatives – Network Sharing



Source: GSMA | Infrastructure Sharing: An Overview - Future Networks

Advantages:

- Faster network coverage expansion and rollout of new 5G services.
- Reduced operating costs (avoiding the waste of overlapping networks).
- Lower spectrum fees.

In general, the greater the level of sharing, the higher the legal/contractual complexity — but also the greater the benefits.

Passive Sharing: Covers only the physical aspects of the network, such as buildings, power supply, and poles. Easier to implement but provides fewer cost-saving benefits.

Active Sharing: Involves active radio elements (Radio Access Network – RAN), antennas, radio transmitters, base stations, transmission networks, and controllers. When the active infrastructure is shared with the Core network and each operator has its own dedicated spectrum, the model is called Multi-Operator Radio Access Network (MORAN). When the Radio (RAN), Core, and Spectrum are all shared, the model is called Multi-Operator Core Network Sharing (MOCN).
Another 5G solution is Cloud Infrastructure Sharing, meaning that all or nearly all virtual network functions (NFVi) are installed there, and where Network Orchestration (MANO) operates.

03 Practices and Initiatives – Portuguese 5G Operators (Top 3)

VODAFONE

- Created an innovation center called Vodafone 5G HUB for the study and development of 5G in Portugal. Its foundation lies in building an ecosystem that brings together the sector, industry, startups, universities, technology partners, and other entities involved in developing fifth-generation mobile technology. The goal is to develop concrete examples that use this technology.
- The Vodafone 5G Hub has partners such as Ericsson, Altran, and Celfinet, the startups Nimest and Parkio, as well as the universities Instituto Superior Técnico (Lisbon) and the Faculty of Engineering of the University of Porto.

NOS

- NOS and Grupo Luz Saúde created the first 5G hospital in Portugal, which includes Virtual and Augmented Reality for hospital palliative care and patient reassurance, as well as remote home hospitalization monitoring with a medical team available 24 hours a day, seven days a week.
- Sale of B2C commercial packages for Cloud Gaming, Augmented Reality, and Virtual Reality.
- Ookla Award for being the fastest network in Portugal.
- Was the first operator to launch the 5G network in Portugal.

MEO

- Altice Portugal (founder of MEO), the Champalimaud Foundation, and the operator Movistar made history by performing the first breast cancer surgery using 5G technology, connecting Portugal and Spain and demonstrating how this fifth-generation network can serve healthcare innovation.
- Implemented projects for indoor experiences at major sports and cultural events, such as 5G MEO coverage at the Estádio do Dragão, Altice Arena, and the Autódromo Internacional do Algarve.
- Formed a partnership with ANJE (National Association of Young Entrepreneurs) to promote 5G across the country and support national startups, such as the 3D Factory project.

03 Practices and Initiatives – 5G and Multi-Access Edge Computing (MEC)

Several public and private initiatives are supporting research and innovation projects to address the challenges of implementing 5G technology (Public-Private Partnership 5G – 5G PPP) in Europe and the International Mobile Telecommunication 2020 (IMT2020) under the International Telecommunication Union (ITU).

As part of the 5GPPP and European Commission (EC) Horizon 2020 (H2020) initiatives, the 5GCity project focused on the production, development, implementation, and validation of 5G 'neutral hosts' in three European cities: Barcelona (SPA), Bristol (UK), and Lucca (IT). It implemented a three-layer infrastructure and an orchestration platform that allows municipalities and infrastructure providers to create end-to-end slices composed of both virtualized cloud/edge resources and physical network elements to supply or lease to other operators. The developed solution also enables 5G-based edge service lifecycle management and control of the underlying infrastructure available throughout the city.

The 5G 'neutral host' structure allows for diversified implementation across the city by combining the necessary 5G technological advancements with the neutral host model, as well as developing a platform for slicing and orchestrating computing and network resources from a cloud, edge, and radio infrastructure.

A Multi-Access Edge Computing (MEC) network architecture uses advanced resources to enable cloud and IT service processing at the network edge. The neutral host model leverages several MEC applications to meet 5G requirements in terms of bandwidth, coverage, and latency.

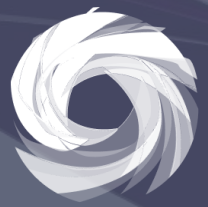
03 DISCLAIMERS

- The benchmark described in this document was based on references found at the international level and excludes, at this stage, possible regulatory challenges regarding its implementation in Portugal.

- The impact classifications in the different dimensions of analysis and cost estimates serve only as a comparative measure between the different use cases.

- For a more rigorous classification and cost estimation, a deeper study and the direct involvement of suppliers and stakeholders of each solution will be necessary.

- All images were associated with their sources, in line with practices related to copyright compliance.



tic.gov.pt

ama AGÊNCIA PARA A MODERNIZAÇÃO ADMINISTRATIVA

PRR Plano de Recuperação e Resiliência

REPÚBLICA PORTUGUESA