WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

5G Global Accelerator Programme

Compendium of use cases

5G Outlook Series

September 2020

Overview

This compendium of 5G use cases and examples of 5G-enabled solutions is a supporting document to the second publication of the 5G Outlook Series “Transforming Essential Services for Economic Recovery in the Great Reset”. As the publication focuses on three key sectors – healthcare, public transport and the workplace – the use cases and examples in this compendium are categorized accordingly.

The framework used includes a mapping of 5G functional drivers, key industry advancement areas and the impact on other industry verticals and on society, using the United Nations Sustainable Development Goals (SDGs) as a reference and applying an impact pathway methodology to arrive at key tangible measures. A simple maturity roadmap of 5G functional drivers indicates potential enhancements.

Health

Use case	COVD-19 related benefits	Improvement area/business benefits	Societal benefits (based on UN SDGs)	5G functional drivers
Smart asset management	• Faster and effective capacity management of critical bed availability • Improved resource management of critical equipment (ventilators, PPE, etc.)	• Improved visibility and control over assets, enabling better resource management and capacity management • Cost savings delivered to health system with more effective procurement – NHS case study estimated 25% more equipment was purchased than what was required for operational needs	Good Health and Well-being Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency
AI-enabled remote diagnostics	• Faster diagnostics compared to manually done by doctors, helping hospitals to reduce waiting times and free up doctors' time • Efficient detection over naked eye and automatic report creation • Allow specialists to be safe without any direct contact with patients	• Solutions has a screening and reporting function that saves doctors 80% time from a traditional diagnosis • For gene sequencing the time is nearly 10 times faster than standard gene sequencing	Good Health and Well-being Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency
VR education and training	• Allow hospitals to conduct essential training for new residents reducing risk of virus exposure and reducing costs • Scalability means reduced costs, when healthcare funding is strained	• Scalable and consistent training programmes, maintaining quality of delivery • More efficient education and training programme with ability to roll out solution to thousands of trainees in a session • High network capacity and ultra-reliable low latency enables real-time exchange of video and VR content	Good Health and Well-being Reduced Inequalities	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency
VR/AR therapy	• Allow access to non-COVID-19 related healthcare services safely	• Scalable and consistent therapy programmes, maintaining quality of care • Ability to track patient progress and adherence • High network capacity and ultra-reliable low latency enables real-time exchange of video and VR content	Good Health and Well-being Reduced Inequalities	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency
Robotics assisted surgery	• Free up time of specialists for complex surgeries as hospitals face surge in demand and long waiting lists arising from months of postponed and cancelled elective surgery	• Reduced costs from access to expertise regardless of location • Ultra-low latency and high capacity means high resolution video communication and remote controlled robotics are seamless and in real-time, enabling this mission critical application	Good Health and Well-being Reduced Inequalities	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency

Use case	COVD-19 related benefits	Improvement area/business benefits	Societal benefits (based on UN SDGs)	5G functional drivers
Connected ambulances	• Through on the spot diagnostics and communication with doctors reduce need to transfer patients to hospitals • Dynamic routing to hospitals with bed capacity and practitioner availability	• Cost savings from reduction in unnecessary conveyance to hospitals with more patients being treated in the community • Ultra-low latency and high capacity means high resolution video communication and remote diagnostics capabilities are seamless and in real time	Good Health and Well-being Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable low latency comms. Massive Machine type comms. Security critical Power efficiency
Medical drone deliveries	• Provide emergency response faster than ambulances in rural areas (defibrillators) • Transport critical equipment and medicines between healthcare facilities • Improved health access and outcomes due to improved distribution and management of blood bags, test kits, vaccines, PPE, etc.	• Improved health outcomes due to faster and targeted response • Cost savings from reduction in unnecessary hospital conveyances with more patients treated in the community • Expand the distance of drone piloting beyond visual line of sight (BVLOS)	Industry, Innovation and Infrastructure Reduced Inequalities Industry, Innovation and Infrastructure Reduced Inequalities	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency
Remote patient monitoring	• Allow clinicians to monitor patient conditions for vulnerable patients	• Reduced cost to deliver health services • Improved outcomes through improved patient data	Good Health and Well-being Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable low latency comms. Massive machine type comms. Security critical Power efficiency

Smart Asset Management

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- IoT technology to track healthcare assets, such as beds, clinical equipment, clinical staff and other building assets (doors, power, etc.) within and between clinical care settings
- Components include RFiD, Bluetooth and BLE, Cellular, Mesh, LPWAN
- Increase visibility of and efficient management of assets into a single health command centre to manage patient flow

COVID-19 Impact

- Faster and more effective capacity management of critical bed availability
- Improved resource management of critical equipment (e.g. ventilators, PPE, etc.)

Business Benefits

- Improved visibility and control over assets, enabling better resource management and capacity management
- Cost savings delivered to health system with more effective procurement – NHS Trust case study estimated 25% more equipment was purchased than what was required for operational needs

Key Players

Use case ecosystem:

Network provider, device manufacturers, application developers, clinicians

Use case impact on the other sectors

Artificial intelligence	Internet of things (IoT)	Analytics

Potential Societal Value

- Improved access to and quality of healthcare
- Increased health system productivity and efficiency, freeing up clinician time from digitization and automation of manual checks

SDG impact

Good Health and Well-being

Industry, Innovation and Infrastructure

Example Deployment

- Bradford teaching hospital and The Johns Hopkins trust partnered with GE healthcare to build a command centre resulting in 60% faster transfers, reduced waiting times in A&E by 25% and 70% reduction waiting in the operating theatre for post-surgical bed
- Sichuan hospital in China has deployed a private 5G network for healthcare applications across hospital and with smart asset management

Smart Asset Management

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Increased operational efficiency

- Improved bed turnaround time – 2% increase in capacity
- Up to 25% reduction in equipment purchased by estates teams
- Increased theatre utilisation by 10%
- Up to 20-40% reduction in A&E wait time

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- **Massive machine type comms.**
- Security critical
- **Power efficiency**

Key actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Wide coverage of entire hospital site with <1 GHz and specialist LPWA technology (e.g. NB-IoT, LoRa, etc.)	• Private 5G network with advanced encryption and/or isolated network (i.e. not shared with others) • 5G compatible of IoT sensors or sensors backward capability to Wi-Fi or RFID • Data lake for IoT data to be combined with hospital IT systems	• 5G-enabled handheld mobile or tablet devices for practitioners, or currently standard smartphones connected through Wi-Fi	• Long service-based contracts with payments linked to outcomes within year and end of contract • Build awareness of solutions with hospital executives • Change of public health tenders to procure connectivity, assets and services in one contract	• Measure the impact of services through monitoring of following KPIs: ○ Bed occupancy rates ○ Length of patient stay ○ Bed turnaround time ○ A&E waiting times ○ Use of operating theatres

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Simple asset management in only in-patient wards

Short Term (1-3 yrs)

- Private 5G network with use in accident and emergency with live high uplink sensors

Long Term (3+ yrs)

- Complete digital control of all hospital assets in to single command centre with medical internet of things

AI-enabled Remote Diagnostics

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- AI-assisted medical imaging and gene sequencing for diagnostics with results sent over a 5G network to cloud based neural network for assessing imaging
- Completes and interprets tests and results (x-rays, mammography, tissue slides), generating reports automatically for clinician review and sign off
- High capacity and ultra-reliable, low-latency features enable sharing of high-resolution video and image data in real time
- Enables patients to access experts not in the local area and reduce errors in diagnosing

COVID-19 Impact

- Faster diagnostics compared to manually done by doctors, helping hospitals to reduce waiting times and free up doctors' time
- Efficient detection over naked eye and automatic report creation
- Allow specialists to be safe without any direct contact with patients

Business Benefits

- Solutions has a screening and reporting function that saves doctors 80% time from a traditional diagnosis
- For gene sequencing the time is nearly 10 times faster than standard gene sequencing

Key Players

Use case ecosystem:
Network provider, cloud service provider, device manufacturers, application developers, clinicians, regulator

Use case impact on the other sectors

Artificial intelligence	Education	Robotics

Potential Societal Value

- Bridge digital divide/proportion of population covered by a network
- Scalability of solutions and faster proof of concepts creates flexibility and resilience in responding to crises

SDG impact

Good Health and Well-being

Industry, Innovation and Infrastructure

Example Deployment

- Doctors from Chinese PLA General Hospital have performed B-scans of quarantined patients in Wuhan via 5G platforms, achieving real-time feedback and diagnosis and reducing the burden of front-line workers.
- Lunit AI is deploying AI-powered image reading software is supplementing human failure in disease detection with an almost 100 percent probability of success when it comes to lung and breast cancer image reading

AI-enabled Remote Diagnostics

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Increased efficiency in diagnosis

- Bridge digital divide/proportion of population covered by a network, technology
- Scalability of solution
- Reduction in diagnostic time by 6-10x
- Free up clinician time

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- **Security critical**
- Power efficiency

Key actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Provide middle spectrum bands(1-7 GHz)	• Public or private 5G network with advanced encryption at application level for security due to sensitive medical information • Provide dense small network across site	• Medical imaging machinery with required 5G wireless protocols to send high-resolution images to on-premise or cloud services for scanning	• Service players to provide either on-premise or highly secure cloud solutions due to sensitive nature of data • Training of doctors for use of imaging – to be able to spot any potential errors, confirm diagnosis and standardized terminologies for communication	• Measure the impact of services through monitoring of: ○ Reduction diagnostic time compared to without ○ Reduction in errors ○ Reductions in fines or legal settlements from errors

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Robotic imaging of grey scale in diagnostic imaging

Short Term (1-3 yrs)

- Advanced gene sequencing early detection of diseases

Long Term (3+ yrs)

- Combine imaging with remote wearables and population health factors for diagnosis of healthy patients

Detailed Use Case Example: Huawei

AI-enabled Remote Diagnostics

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- OEM (original equipment manufacturer) that manufactures mobile phones and telecoms infrastructure equipment
- World's second largest smartphone supplier after Samsung
- First company to launch industry 5G commercial chip (Balong 5G01)
- In 2019, US issued an executive order to ban US companies buying telecoms equipment from Huawei
- In July 2020, UK banned mobile providers buying new Huawei 5G equipment effective from end of 2020 with full removal of 5G kit from UK networks by 2027

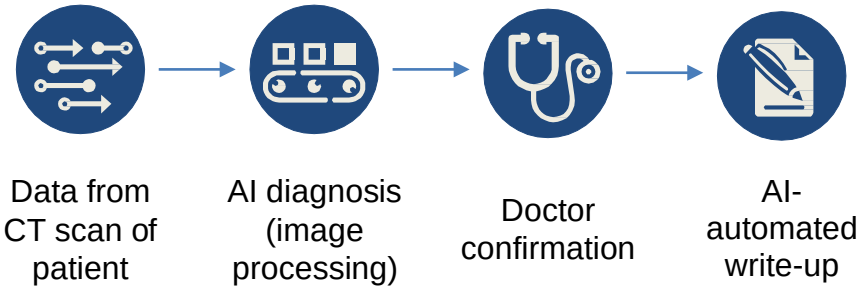
Ecosystem players

- Huazhong University
- Partner
- Public science research university in Wuhan

Description

- Huawei's AI cloud enterprise service team launched an AI-assisted medical imaging and diagnostic tool, collaborating with Huazhong University of Science & Technology and Lanwon Technology
- Solution quickly and accurately generates CT scan analysis and report write up

How it works?

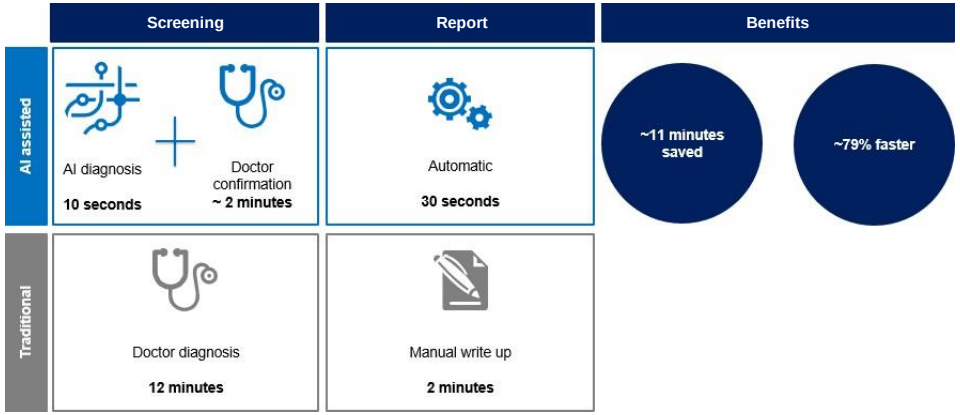


Technologies used

- Artificial intelligence
- Simulation/imaging
- Cloud

Benefits

- Productivity benefits: diagnosis is faster, frees up clinician time for other clinical activity through AI



World Economic Forum and PwC analysis | Sources: Interview with Huawei, https://blog.huawei.com/2020/03/20/outsmarting-covid-19/, https://carrier.huawei.com/en/spotlight/5g, https://www.bbc.co.uk/news/newsbeat-47041341

VR Education and Training

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Virtual reality technology to provide remote and immersive training experiences at scale
- Components include headset devices, training applications, hands-free voice control applications, 5G connectivity for low latency and high-capacity video transfer

COVID-19 Impact

- Allow hospitals to conduct essential training for new resident clinicians without the risk of exposure to COVID-19 by delivering the training on site
- Scalability means reduced costs, when healthcare funding is strained

Business Benefits

- Scalable and consistent training programmes, maintaining quality of delivery
- More efficient education and training programme with ability to roll out solution to thousands of trainees in a session
- High-network capacity and ultra-reliable, low-latency enables real-time exchange of video and VR content

Key Players

Use case ecosystem:
VR device original equipment manufacturers, network provider, application developers, AI developers

Use case impact on the other sectors

Artificial intelligence	Education	Gaming

Potential Societal Value

- Bridge digital divide/proportion of population covered by a network
- Cost savings for healthcare system and increased access to healthcare due to local availability of skills

SDG impact

Good Health and Well-being

Reduced Inequalities

Example Deployment

- The Scotland 5G centre in partnership with BT, Glasgow City Council and the University of Glasgow ran a live demonstration for the First Minister on how the use of 5G technology will enable teaching to be done through the use of VR headsets.

VR Education and Training

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Reduction in costs

- Increase class sizes for training
- Improve effectiveness of training with life-like simulations
- Reduction in costs compared physical training and education

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- **Ultra-reliable, low-latency comms.**
- Massive machine type comms.
- Security critical
- Power efficiency

Key actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• General availability of spectrum for ultra-fast broadband	• Availability of public 5G networks on both training and user ends or equivalent fast internet (e.g. fibre)	• Affordable 5G-enabled VR devices with ability for different education modules to be installed • Motion control devices • Surgical training tools	• User support required • Maintain hygiene between different users • Training for current trainers for education and training • Medical schools incorporate VR module trainings within curriculum • Off-the-shelf training modules for hospital training	• Measure the impact of VR training through: ○ % increased availability of medical skills ○ % reduction in patient deaths due to non-availability of facilities ○ % reduction in travel costs and carbon footprint

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms	Reliability: 99.99% | Latency: <5ms	Reliability: 99.999% | Latency: <1ms
Current State • 4K streaming, ensuring faster delivery of training programmes	**Short Term** (1-3 yrs) • Interactive modules and advanced modules for surgery and therapy	**Long Term** (3+ yrs) • AI-enabled trainer with ability to train practitioners at any location and increase access to medical skills

VR/AR Therapy

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Extended reality technology to provide remote and immersive therapy for a range of conditions including anxiety, neurological disorders, PSTD, stroke rehabilitation
- Components include headset devices, training applications, hands-free voice control applications, 5G connectivity for low latency and high capacity video transfer

COVID-19 Impact

- Allow access to non-COVID-19 related healthcare services safely

Business Benefits

- Scalable and consistent therapy programmes, maintaining quality of care
- Ability to track patient progress and adherence
- High network capacity and ultra-reliable low latency enables real-time exchange of video and VR content
- Network security is critical for healthcare use cases

Key Players

Use case ecosystem:
VR device original equipment manufacturers, network provider, application developers, AI developers

Use case impact on the other sectors

Artificial intelligence	Education	Gaming

Potential Societal Value

- Bridge digital divide/proportion of population covered by a network
- Improved health access and outcomes
- Cost savings for healthcare system

SDG impact

Good Health and Well-being

Reduced Inequalities

Example Deployment

- Pico interactive is partnering with VR health providers to deliver remote care, diagnostics and therapy through its VR headsets
- ICTs Bravemind VR system is used in over 60 sites including VA hospitals, military bases and university centres to treat PTSD; the use of 5G technology would significantly reduce lag time
- Aira is a company that uses VR to offer people with vision impairments assistance with day to day tasks such as shopping taking into account social distancing; again the use of 5G technology would significantly enhance the experience and reduce the lag time

VR/AR Therapy

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Reduction in costs and increased availability of treatment

Increase geographic coverage of specialist doctors	Ability to tailor treatments to patients	Reduction in costs compared to physical appointment	Use data from each session to chart improvement or deterioration of condition

Functional drivers of 5G facilitating the use case's deployment

Enhanced -mobile broadband	Ultra-reliable, low-latency comms.	Massive machine type comms.	Security critical	Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• General availability of spectrum for ultra-fast broadband	• Availability of public 5G networks on both practitioner and user ends or equivalent fast internet (e.g. fibre)	• Affordable 5G-enabled VR devices with ability for different education modules to be installed • Motion control devices • Monitoring devices for specific signs (e.g. heart, blood pressure, etc.)	• User support required • Training for doctors for use of VR therapies • Payers (e.g. insurance providers) to cover VR therapies under coverage • Public health bodies to create standards for companies to pass for general use	• Measure the impact of VR training through: ○ % increased availability of treatments ○ % reduction in patient costs or time ○ % increase in doctor utilization

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms | Reliability: 99.99% | Latency: <5ms | Reliability: 99.999% | Latency: <1ms

Current State

- Digital therapies enabled by videos

Short Term (1-3 yrs)

- Therapy modules delivered live with doctor through VR headsets

Long Term (3+ yrs)

- VR modules customized with remote monitoring devices for each patient based on progress and severity of condition

World Economic Forum and PwC analysis | Sources: PwC Strategy& analysis

Detailed Use Case Example: Pico Interactive VR/AR Therapy

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- Chinese VR company with global reach, operating across the United States, Europe, China and Japan
- Product offering includes innovative VR headsets and software
- In APAC region, channels and product are B2B and B2C
- In all other territories, Pico focuses on enterprise solutions

Ecosystem Players

Concept Health
- Partner
- VR and machine learning software provider for digital precision medicine solutions

Hypno VR
- Partner
- Software solution for anaesthesia under hypnosis for anxiety and stress disorders

Psious
- Partner
- All-in-one VR platform for psychology and mental health therapies

Description

- Pico Interactive partners with VR players in health to deliver virtual reality therapy
- Solution combines Pico headsets with a pre-installed VR therapy application
- Clinical applications include mental health therapies (for PSTD, anxiety disorders, etc.), chronic condition management and monitoring with predictive analytics and intervention, clinician training, pulmonary rehabilitation, pain management therapy

How it works?

Healthcare provider → VR headsets (provided by Pico) + VR health application… → Patient

…sent to patient for remote care and returned for reuse

Technologies Used

- Mixed reality
- Artificial intelligence
- Advanced communication systems
- Simulation/imaging
- Gamification

Benefits

- Productivity benefits: improved asset, labour and resource productivity reported that VR therapies can reduce cost by more than 50%
- Growth/innovation: increased revenue for VR manufacturers, VR SW providers and new type of healthcare service providers, PwC report suggests VR/AR in healthcare will boost GDP by $350.9 billion by 2030 globally

World Economic Forum and PwC analysis | Sources: Interview with Pico; https://www.pico-interactive.com/us/about.html; https://www.pwc.com/seeingisbelieving; https://concepthealth.co.uk/home.html; https://psious.com/; https://hypnovr.io/en/

Robotics Assisted Surgery

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Surgical robots are remotely controlled by a surgeon who has 3D vision thanks to VR/AR and video and micromanipulators for hand and foot movement
- Increased surgical precision, dexterity and improved anatomical visualization

COVID-19 Impact

- Free up time of specialists for complex surgeries as hospitals face surge in demand and long waiting lists arising from months of postponed and cancelled elective surgery

Business Benefits

- Reduced costs from access to expertise regardless of location
- Ultra-low latency and high-capacity means high-resolution video communication and remote controlled robotics are seamless and in real time, enabling this mission critical application

Key Players

Use case ecosystem:
Medical device manufacturers, robotics manufacturers, VR/AR application developers, network provider, regulator

Use case impact on the other sectors

Artificial intelligence	Manufacturing	Robotics

Potential Societal Value

- Bridge digital divide/proportion of population covered by a network
- Improved health outcomes and access to healthcare due to local availability of skills and remote delivery of care

SDG impact

Good Health and Well-being

Reduced Inequalities

Example Deployment

- Doctors have performed the first 5G remote brain surgery on a patient suffering from Parkinson's disease. The procedure was controlled 1,500 miles away from Beijing in the surgeon's base location of Sanya City using China Mobile and Huawei's 5G network.
- In November 2019, Professor Matteo Trimarchi carried out the first remote surgery in Italy using 5G in collaboration with the Italian Institute of Technology (IIT) and the IRCSS Hospital San Raffaele.

Robotics Assisted Surgery

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve effectiveness of surgeries

- Increased efficiency of surgeon time
- Ability to access specialist skills
- Reduces need for travel
- Reduce waiting lists quicker

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- **Ultra-reliable, low-latency comms.**
- Massive machine type comms.
- **Security critical**
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• High mm wave bands >26 GHz	• Install private 5G network, with network slicing dedicated to application, robotic surgery to ensure low latency, minimal packet loss, high throughput for video feed and end-to-end security • RAN virtualization and a distributed cloud are essential to ensure very low end-to-end latency	• Widespread availability of 5G-enabled surgical robots and haptic joystick • 8k screens for HD video feedback to guide surgeon • Affordable 5G-enabled VR devices	• Offers users (hospitals) turnkey solutions for either specific applications • Service platform to be provided that brings together surgeons and patients with host hospital • Provide training to surgeons, nurses and IT support staff for use	• % reduction in complications from surgeries for citizens • % increase in utilization of specialists • % revenue growth through new business opportunities due to enhanced connectivity for operators • % reduction in healthcare costs

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Robotic surgeries exist and have been successfully completed

Short Term (1-3 yrs)

- Increase in robotic surgeries

Long Term (3+ yrs)

- At least 10% of surgeries being done with robotic assistance

Connected Ambulances

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- 5G connection between ambulance and hospital emergency room, enabling ultra-reliable, low-latency video calls between paramedics and clinicians for greater diagnostic and treatment capability in the community
- When conveyance to hospital is necessary, vital signs can be taken and transmitted to the emergency room enabling better treatment
- As the technology matures, there will be opportunity for tactile interaction with the patient using haptics

COVID-19 Impact

- Through on the spot diagnostics and communication with doctors reduce need to transfer patients to hospitals
- Dynamic routing to hospitals with bed capacity and practitioner availability

Business Benefits

- Cost savings from reduction in unnecessary conveyance to hospitals with more patients being treated in the community
- Ultra-low latency and high-capacity means high-resolution video communication and remote diagnostics capabilities are seamless and in real time

Key Players

Use case ecosystem:
Vehicle manufacturers, network provider, application developers, device manufacturers, clinicians and paramedics

Use case impact on the other sectors

Automotive	Public sector and government	Public transport

Potential Societal Value

- Improved health outcomes with emergency room prepped before patient's arrival, including access to vital signs and en route diagnostics information
- Cost savings for the health system with some treatments delivered on location rather than being conveyed to and treated in hospital

SDG impact

Good Health and Well-being

Industry, Innovation and Infrastructure

Example Deployment

- In Milan, 5G to enable their connected ambulances which allow the paramedics to be continuously connected to the emergency management centre and hospital doctors; allowing them to share patient details and symptoms prior to arriving at the hospital
- South Central Ambulance NHS Foundation Trust has developed a 5G 'connected ambulance' to enable remote diagnostics and link field practitioners with surgeons and consultants in real time

Connected Ambulances

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Reduce hospital admissions

- Increased efficiency through on the spot diagnostics
- Reduction in hospital admissions
- Evaluates bed capacity and practitioner availability
- Reduction in ambulance wait time

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid-band spectrum available 1-7 GHz	• Availability of public 5G network within ambulance servicing radius	• Ambulances fitted with 5G communications hardware • Video call devices to allow communication between paramedics and doctors • AR devices to help medical professionals react more quickly with prompts such as questions to ask and steps to follow	• Service players to provide highly secure cloud solutions due to sensitive nature of data • Training of paramedics and doctors and standardised terminologies for communication	• Measure the impact of connected ambulances: ○ % reduction in A&E wait time ○ Increase in NHS staff capacity ○ % improved health outcomes from medical emergencies

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Ambulances sending key vital signs to accident and emergency (A&E)
- Rerouting to hospital with availability of beds

Short Term (1-3 yrs)

- Video, remote ultrasound and scans shared with A&E

Long Term (3+ yrs)

- Provide emergency ambulatory care guide by specialist through video

Medical Drone Delivery

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Drone technology used to deliver customized emergency healthcare response where immediacy is essential to prevent health complications (e.g. stroke, cardiac arrests)
- Connected to healthcare wearables to notify emergency services automatically and with greater speed than traditional telephone pathways
- deliver health assets (blood bags, test kits, vaccines, PPE, etc.) between healthcare facilities and suppliers

COVID-19 Impact

- Provide emergency response faster and in a more specialist capacity than ambulances in rural areas (defibrillators)
- Transport critical equipment between healthcare facilities

Business Benefits

- Improved health outcomes due to faster and targeted response
- Cost savings from reduction in unnecessary hospital conveyances with more patients treated in the community
- Expand the distance of drone piloting beyond visual line of sight (BVLOS)

Key Players

Use case ecosystem:
Network provider, drone OEMs, regulatory agencies, risk and legal partners, governments, clinicians, analytics application developers, regulator

Use case impact on the other sectors

Cities/urban infrastructure	Emergency response and rescue	Security

Potential Societal Value

- Bridge digital divide/proportion of population covered by a network
- Improved health access and outcomes due to improved distribution and management of health assets

SDG impact

Reduced Inequalities

Industry, Innovation and Infrastructure

Example Deployment

- Land Rover has built an emergency response vehicle for the Austrian Red Cross, which is equipped with a drone with the aim of reducing search and rescue times
- East Midlands Ambulance Service uses drones to allow crews to look for patients in remote or contaminated areas
- Ofcom, Southampton Hospital and St Mary's Hospital (Isle of Wight) using drones to transport medical supplies between hospitals
- Flirtey, John Hopkins University School of Medicine and non-profit Field Innovation Team (FIT) ship-to-store delivery of medical supplies

World Economic Forum and PwC analysis | Land Rover ,NHS, Ofcom, Maritime Logistics

Medical Drone Delivery

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve emergency response

- Increase geographic coverage of specialist doctors
- Ability to access rural areas faster
- Increase safety of emergency staff
- Reduces fatality rate

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid band spectrum available 1-7 GHz	• Public 5G network with 100% coverage in drone operation area	• Long-distance drones equipped with infrared cameras • Communication devices	• Training of emergency response staff in drone use and standardized terminologies for communication	• Measure the impact of services through monitoring of: ○ Increase in Health Assets availability ○ Reduction in fatality rate

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Send essential medical delivery

Short Term (1-3 yrs)

- Send drones autonomously beyond visual line of sight

Long Term (3+ yrs)

- Send ultra-high resolution video, high-resolution sensors (lidar, spectrum analysis, x-rays, etc.) in complex missions

World Economic Forum and PwC analysis | Sources: PwC Strategy& analysis

Remote Patient Monitoring

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Wearable devices that measure and detect changes in blood glucose levels, vital signs, respiratory patterns that transmit readings in real time to clinicians
- Sensor technology for movement and fall detection to support citizens, monitoring activity like eating, drinking, medication adherence

COVID-19 Impact

- Allow clinicians to monitor patients' conditions in real time, enabling dynamic provision of health services rather than routine, easing increased demand

Business Benefits

- Reduced cost to deliver health services
- Improved outcomes through improved patient data

Key Players

Use case ecosystem:
Wearable device manufacturers, sensor manufacturers, application developers, network provider, regulator

Use case impact on the other sectors

Insurance	Public sector and government	Security

Potential Societal Value

- Increased emphasis on personal care
- Access to healthcare agnostic of gender, location
- Improved outcomes resulting from improved detail and amount of patient data
- Reduced cost to provide healthcare services due to dynamic provision based on need

SDG impact

Good Health and Well-being

Industry, Innovation and Infrastructure

Example Deployment

- Children's health in Dallas uses remote patient monitoring to track the vital signs following an organ transplant and monitor compliance with medication
- Pittsburgh Medical Center uses remote patient monitoring to track patient metrics such as weight and blood pressure; results are transmitted to a call centre staffed with nurses

Remote Patient Monitoring

Health

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve patient monitoring

- Ability to monitor vulnerable patients
- Reduces hospital readmissions
- Reduces fatality rate
- Increase in medication compliance

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- **Massive machine type comms.**
- **Security critical**
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• General availability of spectrum for ultra-fast broadband	• Availability of public 5G networks on both practitioner and user ends or equivalent fast internet (e.g. fibre)	• Wearable devices which record vital signs such as blood pressure • Sensor devices for recognizing falls	• Monitoring centre required to provide support where necessary • User support required	• Measure the impact of services through monitoring of: ○ Improved health outcomes ○ Reduction in cost to serve for public health ○ Reduction in hospital admissions

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms	Reliability: 99.99% | Latency: <5ms	Reliability: 99.999% | Latency: <1ms

Current State

- Faster image/video processing resulting in effective remote healthcare monitoring

Short Term (1-3 yrs)

- Mixed reality (AR/VR) inducing robotic surgeries

Long Term (3+ yrs)

- Internet of medical things and skills through enhanced machine-to-machine communications

Public Transport

Use case	COVD-19 related benefits	Improvement area/business benefits	Societal benefits (based on UN SDGs)	5G functional drivers
Transport proximity management	• Allow monitoring the passenger load of the means of transport in order to ensure full compliance with social distancing rules • Sensors to allow passengers to know which carriages or seating areas are not crowded • Real-time screening of passengers before entry into train stations for COVID-19 • Support government track and trace scheme with immediate reporting of cases to public health authorities	• Short, medium and long-term network planning based on real-time data rather than historical trends • Real-time crowd info for passengers to re-route journeys and ticketing systems for peak booking	Sustainable Cities and Communities Industry, Innovation and Infrastructure Good Health and Well-being Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
Community or enterprise epidemic control	• Ability to implement targeted lockdowns by identifying at risk citizens from license plates of cars from areas with recent COVID-19 outbreaks • Using video analytics with smart CCTVs to enable immediate reporting	• Early detection of infection and containment amongst workforce, protecting employees and preventing mass infection and absence from work	Sustainable Cities and Communities Good Health and Well-being	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
Smart city sensors and vehicle to infrastructure connectivity	• Make bus terminals smart by reporting on crowds to moving buses and updating train schedules (dynamic) • Allow cities to enable localized lockdowns through reporting through smart CCTVs and crowd sensors	• Allow vehicles to interact with other vehicles and roadside infrastructure • Provide route planning, energy savings strategies, high precision regional maps and other applications to buses using 5G network • Safe and precise parking for buses	Sustainable Cities and Communities Industry, Innovation and Infrastructure	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency

Transport Proximity Management

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Sensor technology and cameras linked to AI visual processing assess passenger loading on vehicles and crowding on vehicles and at stations
- Thermal cameras use infrared technology to measure heat radiating from citizens
- This data can then be processed, potentially with support of AI, with alerts sent out if someone is found to be at risk
- Limited and pre-booked access to stations in peak hours
- Real-time data capture of passenger flow enables dynamic network planning, adding additional vehicles to the fleet when demand is high

COVID-19 Impact

- Allow monitoring the passenger load of the means of transport in order to ensure full compliance with social distancing rules
- Sensors to allow passengers to know which carriages or seating areas are not crowded

Business Benefits

- Short, medium and long-term network planning based on real-time data rather than historical trends
- Real-time crowd info for passengers to reroute journeys and ticketing systems for peak booking
- Real-time screening of passengers before entry into train stations for COVID-19
- Support government track and trace scheme with immediate reporting of cases to public health authorities

Key Players

Use case ecosystem:
Network provider, equipment manufacturers, citizens, local administration, regulatory agencies, mobile application developers

Use case impact on the other sectors

Artificial intelligence	Public sector and government	Security

Potential Societal Value

- Report to external stakeholders (governments, local authorities, private providers) on present and future state of transport system enabling better city/community planning
- Online updates and information shared with passengers with reroute suggestions, early warning on crowding and integration with ticket system, driving citizen comfort

SDG impact

Sustainable Cities and Communities

Industry, Innovation and Infrastructure

Example Deployment

- In Beijing, officials are trialing a subway by appointment systems which entails the user obtaining a QR code allowing entry to the subway in a specific time period
- BAI communications is trialing the use of cellular technologies to manage social distancing (see next slide)
- Open Space was deployed by the department of transport to assist St Pancras Station in understanding real-time overcrowding as well as predicting future overcrowding (see next slide)

World Economic Forum and PwC analysis | New York Times, Pressat, ITS International, Catapult, Interview with BAI Communications, 'Moving Millions' BAI Communications Case Study

Transport Proximity Management

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve transport management

- Enables monitoring of passenger load to comply with social distancing
- Allows passengers to know which areas are not crowded
- Reduces congestion
- Provides trends and analysis to historic data

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid-to-low bands (sub-1GHz – 7 GHz) for massive machine type communication and video analytics	• Install private 5G network, high throughput for video feed and end-to-end security • Distributed edge cloud for real-time processing of video and motion data	• Affordable 5G-enabled motion sensors, asset availability and motion sensor-enabled gates within station • Analytical tools	• Training of analysts on using the system • Raise awareness of technological ability with transport departments • Meeting data regulations regarding storage and use of data	• Measure the impact of services through monitoring of: ○ % reduction in rush hour congestion ○ Increase in ridership and financial position of transport operators ○ Improve citizen experience

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Reporting of crowding within stations
- Integration with bookings to show crowd risk

Short Term (1-3 yrs)

- Integration of video analytics to provide safety on train stations and carriages

Long Term (3+ yrs)

- Automatized gates to manage crowds in rush-hour

Detailed Use Case Example: BAI Communications *Crowd management*

Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- BAI Communications designs, builds and operates cellular, Wi-Fi, broadcast, radio and IP networks
- Operates in the US, Canada, Hong Kong, Australia and the UK
- Sector expertise in public transport, providing connectivity infrastructure to large-scale transport systems in New York, Toronto and Hong Kong

Ecosystem Players

- Toronto Transport Commission (TTC)
- Transit riders
- Other regional transport agencies (hub)
- City planners
- Emergency services
- Ride share services such as Uber or Lyft

Description

- In June 2019, Toronto Raptors won their first NBA basketball championship, which was accompanied by a celebratory parade four days later, putting significant pressure on the public transport system
- Overcrowding resulted in Dundas station being closed
- Near real-time Wi-Fi network usage data could be used to improve station safety through monitoring passenger flow, enabling precautionary interventions

How it Works?

Device association data (Wi-Fi) across transport system → Near real-time analytics on passenger flow → Near-real time operations management

Technologies Used

- Wi-Fi
- Cloud technology
- Custom business intelligence (based on proprietary algorithms)

Benefits

- Improved operational efficiencies: Near real-time resource management and transport planning
- Increased safety from near real-time data reporting of passenger flows and notifications of station overcrowding

Detailed Use Case Example: Open Space *Crowd management*

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- Open Space uses vision technology and AI to create digital twins of the environment to measure pedestrian flow and patterns
- UK-based start-up digital twin platform
- Largely used in public transport systems such as St Pancras to analyse passenger movement trends

Ecosystem Players

Department for Transport

- Sponsor
- Public transport agency operating through the UK

NetworkRail

- Partner
- Owner, operator and infrastructure manager of Britain's railway network

University of Birmingham | BCRRE

- Partner
- Leaders in railway science and education

Description

- In September 2019, Open Space was deployed by the department of transport to assist St Pancras Station in understanding real-time overcrowding as well as predicting future overcrowding
- Since March 2020 following the COVID-19 lockdown, the technology has been adapted to enable it to monitor social distancing in the station

How it Works?

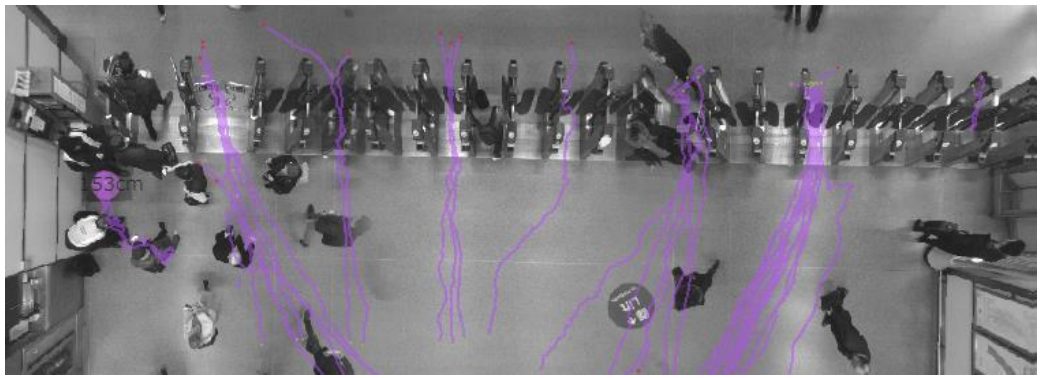
1. Wi-Fi usage data across transport system
2. Live analytics on passenger flow
3. Real-time demand management

Technologies Used

- Artificial intelligence
- Digital twin

Benefits

- Ability to monitor compliance with social-distancing measures
- Improved operational efficiencies through predicting overcrowding and mitigating the potential issue



World Economic Forum and PwC analysis | Source: Pressat, ITS International, Catapult

Community/Enterprise Epidemic Control

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Contact track and trace capability using location tracking, QR codes, vehicle tagging through mobile devices
- Identifies individuals at risk and patterns of infection, recommending optimized routes for travel to limit risk of infection

COVID-19 Impact

- Ability to implement targeted lockdowns by identifying at risk citizens from license plates of cars from areas with recent COVID-19 outbreaks
- Using video analytics with smart CCTVs to enable immediate reporting

Business Benefits

- Early detection of infection and containment amongst workforce, protecting employees and preventing mass infection and absence from work

Key Players

Use case ecosystem:
Mobile device manufacturers, application developer, network provider

Use case impact on the other sectors

Automobile	Healthcare	City infrastructure

Potential Societal Value

- Travel data will encourage more sustainable routes
- Technology to increase resilience and improve response to future pandemics

SDG impact

Sustainable Cities and Communities

Good Health and Well-being

Example Deployment

- The NZ COVID Tracer app allows residents to keep a digital diary of where they have been by scanning QR codes placed at the entry of buildings
- The NI COVID app notifies users if they were in contact with someone who has tested positive as the app exchanges “keys” with anyone other user they are in contact with for a significant amount of time

World Economic Forum and PwC analysis | Ministry of Health , NI Direct

Community/Enterprise Epidemic Control

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve epidemic control

- Ability to implement targeted lockdowns
- Immediate reporting through smart CCTV
- Safety to residents
- Increase in response time

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid-to-low bands (sub-1GHz – 7 GHz) for massive machine type communication and video analytics	• Public 5G network available	• Mobile devices needed for location tracking and scanning QR codes • Smart CCTV	• End user support for scanning QR codes • Operator training	• Measure the impact of services through monitoring of: ○ Success rate of implementing targeted lockdowns ○ Decrease in delay of reporting through smart CCTV

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Track and trace being used via Wi-Fi and 4G network

Short Term (1-3 yrs)

- Track and trace becomes more reliable as all mobile devices connected to 5G in urban areas

Long Term (3+ yrs)

- Track and trace is expanded to cover a wider areas as 5G network is expanded

Smart city sensors and vehicle to infrastructure connectivity

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Vehicle to infrastructure connectivity enables communication between vehicles and road systems with the aim of making our roads safer and reducing congestion

COVID-19 Impact

- Make bus terminals smart with by reporting on crowds to moving buses and updating train schedules (dynamic)
- Allow cities to enable localized lockdowns through reporting through smart CCTVs and crowd sensors

Business Benefits

- Allow vehicles to interact with other vehicles and roadside infrastructure
- Provide route planning, energy savings strategies, high precision regional maps and other applications to buses using 5G network
- Safe and precise parking for buses

Key Players

Use case ecosystem:
Mobile device manufacturers, application developer, network provider

Use case impact on the other sectors

Healthcare	Retail banking and payments

Potential Societal Value

- Vehicle to infrastructure connectivity will help to reduce carbon emissions
- Technology to increase resilience and improve response to future pandemics

SDG impact

Sustainable Cities and Communities

Industry, Innovation and Infrastructure

Example Deployment

- Smart traffic lights are being trialed in York with the aim to reduce emissions; the traffic lights will advise the drivers of a speed to arrive at the next traffic lights when they are green

Smart city sensors and vehicle to infrastructure connectivity

Public Transport

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve effectiveness of surgeries

- Increased efficiency of transport network
- Ability to enact localized lockdowns
- Reduction in traffic congestion
- Reduction in carbon emissions

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of low bands (sub-1 GHz)	• Availability of public 5G networks • IoT gateway for collecting sensor data	• Vehicle to infrastructure connectivity needs to be rolled out to all infrastructure and vehicles • 5G-enabled sensors and installation	• Services to cities with clear applications of use with end to end solution	• Measure the impact of services through monitoring of: ○ Reduction in traffic congestion ○ Success rate in enacting localised lockdowns

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms	Reliability: 99.99% | Latency: <5ms	Reliability: 99.999% | Latency: <1ms
Current State • Vehicle to infrastructure connectivity slowly being trialed and not using 5G network	**Short Term** (1-3 yrs) • Vehicle to infrastructure connectivity being used more widely but still not using 5G network	**Long Term** (3+ yrs) • Vehicle to infrastructure connectivity starts utilized with a 5G network

World Economic Forum and PwC analysis | Sources: PwC Strategy& analysis

Workplace

Use case	COVD-19 related benefits	Improvement area/business benefits	Societal benefits (based on UN SDGs)	5G functional drivers
VR/AR onboarding and training	• Enable effective and efficient onboarding and training of employees when workforce is working remotely	• Standardized and scalable training, ensuring more equitable access to upskilling opportunities • More efficient education and training programme with ability to roll out solution to thousands of trainees in a session • High-network capacity and ultra-reliable, low-latency enables real-time exchange of video and VR content	Quality Education Decent Work and Economic Growth	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
VR/AR enhanced maintenance and remote repairs	• Allow access to non-local experts when remote work and mobility restrictions are in place	• Increased efficiency in workforce deployment and resource management • Cost savings from reduced travel and ability to see multiple clients in one day • Environmental benefits from reduced travel • Improvements in quality control and plant safety	Industry, Innovation and Infrastructure Sustainable Consumption and Production	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
Long-range drone infrastructure inspections	• Enable more work from home, safeguarding employees	• Automated inspections of critical infrastructure, enabling more efficient maintenance • Cost savings from predictive maintenance	Industry, Innovation and Infrastructure Sustainable Cities and Communities	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
Digital twin simulation for manufacturing	• Rapid testing, prototyping and ability to pivot to new outputs, e.g. adapting factory floor to produce PPE	• Customized and personalized products • Faster process from prototyping to full production	Industry, Innovation and Infrastructure Sustainable Consumption and Production	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency
Tele-operated mobile robotics for manufacturing	• Reduced need for employees to be on premise, ensuring compliance with social distancing measures • Rapid reconfiguration of factory floor to flex to new products, e.g. PPE	• Rapid figuration of shop floor, enabling flexibility in output • Improved precision and quick decision-making	Industry, Innovation and Infrastructure Sustainable Consumption and Production	Enhanced mobile BB Ultra-reliable, low-latency comms. Massive Machine type comms. Security critical Power efficiency

VR/AR Onboarding and Training

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Virtual reality technology to provide remote and immersive training experiences at scale
- Components include headset devices, training applications, hands-free voice control applications, 5G connectivity for low-latency and high-capacity video transfer

COVID-19 Impact

- Enable effective and efficient onboarding and training of employees when workforce is working remotely

Business Benefits

- Increased efficiency in workforce deployment and resource management
- Cost savings from reduced travel and ability to see multiple clients in one day
- Environmental benefits from reduced travel
- Improvements in quality control and plant safety

Key Players

Use case ecosystem:
VR device original equipment manufacturers, network provider, application developers, AI developers

Use case impact on the other sectors

Artificial intelligence	Education	Gaming

Potential Societal Value

- Standardized and scalable training, ensuring more equitable access to upskilling opportunities

SDG impact

Quality Education

Decent Work and Economic Growth

Example Deployment

- Walmart is working with STRIVR to create a Black Friday simulator in order to train staff to deal with the rush
- BP have partnered with Igloo Vision to train their employees in the emergency exit procedures at their oil refinery

VR/AR Onboarding and Training

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve onboarding and training

- Enables efficient onboarding
- Allows for effective training
- Ability to run programmes with remote staff
- Allows ability to record training

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- **Ultra-reliable, low-latency comms.**
- Massive machine type comms.
- **Security critical**
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid-bands (1-7GHz) with indoor coverage	• Availability of public 5G networks for user ends or equivalent fast internet (e.g. fibre) • Distributed cloud edge network for real-time processing	• Affordable 5G-enabled VR devices with ability for different training modules to be installed	• User support required • Maintain hygiene between different users • Training for current trainers for onboarding and training	• Measure the impact of services through monitoring of: ○ Reduction of length of onboarding ○ Success rate of running training remotely

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- 4K streaming, ensuring faster delivery of training programmes

Short Term (1-3 yrs)

- Interactive modules and advanced modules for different business areas

Long Term (3+ yrs)

- AI-enabled trainer with ability to train employees at any location and increase access to skills

Detailed Use Case Example: Facebook Oculus *VR/AR Onboarding and Training*

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- Facebook bought VR gaming company Oculus in 2014
- Oculus products are mainly B2C
- Product offering includes both headset hardware (Rift, Quest) and mixed reality software applications

Ecosystem Players

RED

- RED
- Partner
- Camera manufacturer - professional-grade VR cameras that could work with Oculus headsets

Xiaomi

- Xiaomi
- Partner
- Smartphone maker – 'Mi VR' uses Xiaomi software alongside Oculus headsets for Chinese market

Description

- Oculus is prototyping Facebook hardware and software on VR headsets for future of work use cases
- Pass-through technology and touch controller enables interactive and floating displays and keyboards, activated by gesture
- Customizable screens, productivity-related toolbar and shortcuts create a productivity-boosting mixed reality workspace

How it Works?

Employee working remotely

Oculus headset loaded with mixed reality application

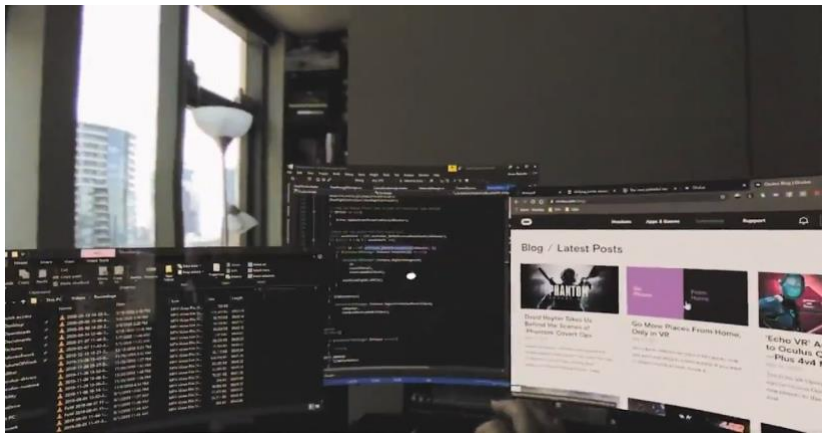
Rest of workforce

Technologies Used

- Mixed reality
- Artificial intelligence
- Advanced communication systems
- Simulation/imaging
- Gamification

Benefits

- Productivity benefits: empower employees via remote work, reduced time spent commuting, enhanced workspace mixing virtual and real spaces
- Growth/innovation: PwC report suggests $294.2bn in contribution of GDP by 2030 from development and training modules on AR/VR



World Economic Forum and PwC analysis | Source: https://www.theverge.com/2020/5/21/21266945/facebook-ar-vr-remote-work-oculus-passthrough-future-tech; https://www.pwc.com/seeingisbelieving; https://www.yicaiglobal.com/news/facebook-oculus-partners-xiaomi-to-bring-vr-device-to-china

VR/AR Enhanced Maintenance and Remote Repairs

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- VR/AR enhanced dashboards on plant equipment to guide engineers for repairs, pulling up detail on equipment status and condition
- Combined with predictive analytics AI to alert engineers and clients when maintenance might be needed

COVID-19 Impact

- Allow access to non-local experts when remote work and mobility restrictions are in place

Business Benefits

- Increased efficiency in workforce deployment and resource management
- Cost savings from reduced travel and ability to see multiple clients in one day
- Environmental benefits from reduced travel
- Improvements in quality control and plant safety

Key Players

Use case ecosystem:
VR/AR device original equipment manufacturers, network provider, application developers, AI developers, regulator

Use case impact on the other sectors

Artificial intelligence	Education	Gaming

Potential Societal Value

- Environmental benefits from reduced travel
- Improvements in quality control and plant safety

SDG impact

Industry, Innovation and Infrastructure

Sustainable Consumption and Production

Example Deployment

- ThyssenKrupp use AR to visualize potential problems with their elevators as well as allowing their engineers to use AR lenses as their virtual assistant
- The US Air Force is replacing its engineer's tablets with glasses so it can access step-by-step instructions or enable another user to tap into the glasses, see what the wearer is looking at and provide remote support.

World Economic Forum and PwC analysis | Construction Tech Review, Fed Tech

VR/AR Enhanced Maintenance and Remote Repairs

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Enables remote repairs

- Access to non-local experts
- Reduces need for travel
- Reduces length of maintenance or repair
- Increase knowledge of engineers

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid-bands (1-7GHz) with indoor coverage	• Availability of public 5G networks on both ends or equivalent fast internet (e.g. fibre)	• Affordable 5G-enabled VR devices with ability for different repair modules to be installed • Motion control devices	• User support required • Maintain hygiene between different users • Training for current trainers for onboarding and training • System integrators with knowledge and capabilities to efficiently integrate solutions and collect and maintain data	• Measure the impact of services through monitoring of: ○ Reduction of length of maintenance/repair ○ Increase in access to non-local experts

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms	Reliability: 99.99% | Latency: <5ms	Reliability: 99.999% | Latency: <1ms

Current State

- 4K streaming, ensuring faster remote repairs

Short Term (1-3 yrs)

- Interactive modules and advanced modules for different maintenance or repair requirements

Long Term (3+ yrs)

- AI-enabled trainer with ability to train engineers at any location and increase access to skills and expertise

World Economic Forum and PwC analysis | Sources: PwC Strategy& analysis

Drone Infrastructure Inspections

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Drones used over long-range distances to inspect critical infrastructure like powerlines and train lines
- Drones combined with cameras, sensors, image processing, analytics technology

COVID-19 Impact

- Enable more work from home and safeguarding employees
- Reduce cost of maintenance of infrastructure for operators

Business Benefits

- Automated inspections of critical infrastructure, enabling more efficient maintenance and better resource management
- Cost savings through making improvements in infrastructure through periodic inspection

Key Players

Use case ecosystem:
Network provider, drone OEMs, regulatory agencies, risk and legal partners, governments, analytics application developers, regulator

Use case impact on the other sectors

Artificial intelligence	Public sector and government	Virtual and augmented reality

Potential Societal Value

- Improved safety and sustainability of critical infrastructure

SDG impact

Industry, Innovation and Infrastructure

Sustainable Cities and Communities

Example Deployment

- Network Rail uses drones to survey the railway for general maintenance as well as following specific incidents while keeping staff safe and reducing cost
- Elios is used in Minnesota for bridge inspections navigating hard to reach areas and confined spaces

World Economic Forum and PwC analysis | Network Rail, Flyability

Drone Infrastructure Inspections

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve efficiency of inspections

- Enables remote working
- Safeguards employees
- Reduces travel costs
- Increases efficiency of inspection

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- **Ultra-reliable, low-latency comms.**
- Massive machine type comms.
- **Security critical**
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of mid band spectrum available 1-7 GHz	• Public 5G network with 100% coverage in drone operation area	• Long-distance drones equipped with 8k cameras	• Training of operators in drone use and standardised terminologies for communication • Service providers than combine digital twins with live drone data to give actionable insights for maintenance	• Measure the impact of services through monitoring of: ○ % decrease in maintenance budgets ○ % decrease in major infrastructure breaks

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Drones sending video speeds over short distances with flying in line of sight

Short Term (1-3 yrs)

- 8k video streams of infrastructure controlled remotely beyond visual line of sight

Long Term (3+ yrs)

- Autonomous fleet of drones monitoring infrastructure periodically sending 8k video stream combined with video analytics

Digital Twin Simulation

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Digital twin technology allows factories to build a comprehensive and functional model for every physical asset with all the relevant information across the life of the asset for evaluation purposes
- These can then be combined with AR and VR technologies to support the training and repairs/maintenance of complex and specialist machinery

COVID-19 Impact

- Rapid testing, prototyping and ability to pivot to new outputs, e.g. PPE production
- Allow issues to be resolved despite business travelling banned by many enterprises through remote control and remote consultation through augmented reality

Business Benefits

- Lower cost of ownership for specialist machinery
- Remote monitoring of machinery and ability to bring in specialist engineering without travelling to location

Key Players

Use case ecosystem:
Network provider, equipment OEMs, digital twin software developers

Use case impact on the other sectors

Artificial intelligence	Healthcare	Public sector and government

Potential Societal Value

- Improved safety of workforce due to better visibility over equipment
- Increased sustainability from ability to design, test and develop products virtually

SDG impact

Industry, Innovation and Infrastructure

Sustainable Consumption and Production

Example Deployment

- Newcastle has used digital twin technology to recreate the city in order to test the city's infrastructure in response to climate change and population growth
- ABB uses Industrial IoT applications to create a digital twin of factory floors and apply AR for maintenance and repair
- Formula 1 teams use digital twin technology to test the reliability and performance of new parts

World Economic Forum and PwC analysis | New Civil Engineer, Institution of Civil Engineers

Digital Twin Simulation

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve manufacturing efficiency

- Enables rapid testing
- Ability to pivot to new outputs
- Ability to access trends and predict future problems
- Reduce reliance on manual inputs

Functional drivers of 5G facilitating the use case's deployment

- **Enhanced mobile broadband**
- **Ultra-reliable, low-latency comms.**
- Massive machine type comms.
- **Security critical**
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of low bands (sub-1 GHz)	• Public or private 5G network with advanced encryption at application level for security • Provide dense small cell network across site • Availability of distributed cloud edge network	• Availability of affordable 5G-enabled sensors	• End user support • Training for operators and analysts • Raise awareness amongst business communities	• Measure the impact of services through monitoring of: ○ % speed of resolving issues ○ % increase in labour productivity ○ % of reduction in travel of specialist engineers ○ % process optimisation

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms

Reliability: 99.99% | Latency: <5ms

Reliability: 99.999% | Latency: <1ms

Current State

- Augmented reality and digital twin combined to give assistance to repair technicians

Short Term (1-3 yrs)

- Real-time maintenance updates with IoT network to support repair technicians

Long Term (3+ yrs)

- Automated maintenance of machines through advanced sensors and in built maintenance feature

World Economic Forum and PwC analysis | Sources: PwC Strategy& analysis

Detailed Use Case Example:

Digital twin simulation and augmentedreality

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Company Background

- Swiss-Swedish global engineering company
- Expertise in robotics, power, industrial electrical equipment and automation technologies
- Product offerings include EV infrastructure, solar inverters, distribution automation, software and analytics, control technologies, mechanical power transmission
- $150 million investment in world-class robotics factory in Shanghai

Ecosystem Players

DASSAULT SYSTEMES

- Partner
- Software provider of industrial CAD technology, e.g. 3DEXPERIENCE platform

IBM

- Partner
- IBM Watson Internet of Things solution for industrial AI and data analytics

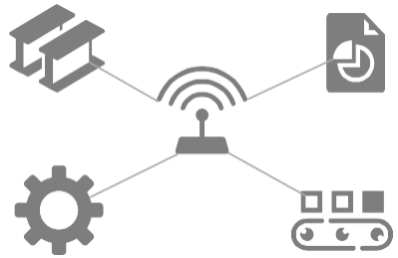
Microsoft

- Partner
- Microsoft Azure intelligent cloud technology used to secure infrastructure for IoT industrial use cases

Description

- Industrial Internet of Things (IIoT) platform ABB Ability™ enables the connectivity of and communication between numerous heterogeneous devices and other assets
- Digital twin technology creates a functional model of assets and equipment with the relevant information across the life of the asset for evaluation purposes and for training and repair

How it Works?



Technologies used

- Internet of things
- Mixed reality
- Robotics
- Artificial intelligence
- Cloud
- Digital twin

Benefits

- Productivity benefits: faster response time for repairs, higher utilization of experts with reduced need to be on site

World Economic Forum and PwC analysis | Source: https://blog.Insresearch.com/abb-customer-world-2019; https://new.abb.com/news/detail/16803/abb-and-dassault-systemes-enter-global-software-partnership-for-digital-industries; https://new.abb.com/news/detail/1411/ABB-and-IBM-partner-in-industrial-artificial-intelligence-solutions; https://customers.microsoft.com/en-us/story/abb-manufacturing-azure

Tele-operated Mobile Robotics

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

Description

- Use of artificial intelligence and advanced wireless robotics to enable automation of factory machines
- Assembly and quality testing of industrial products carried out by robots
- Remote control capability for factory operators with real-time management – key processes in manufacturing:
  - Reliability testing: temperature and humidity analysis
  - Functional testing: use of test benches, automated software tests
  - 100% factory load testing: ensures high reliability

COVID-19 Impact

- Reduced need for employees to be on premise, ensuring compliance with social distancing measures
- Rapid reconfiguration of factory floor to flex to new products, e.g. PPE

Business Benefits

- Rapid figuration of shop floor, enabling flexibility in output
- Improved precision and quick decision-making
- Operational efficiencies through scrap reduction
- Reduction in customer complaints
- Reduction in machine cycle time
- Greater labour productivity

Key Players

Use case ecosystem:
Robotics manufacturers, application developers, network provider, regulator

Use case impact on the other sectors

Artificial intelligence	Healthcare	Logistics

Potential Societal Value

- Improvements in quality control and plant safety

SDG impact

Industry, Innovation and Infrastructure

Sustainable Consumption and Production

Example Deployment

- Audi use VGo robots to increase communication between technicians based at various locations and allow them to work together to repair faults quicker
- Nokia is using robots in its Oulu campus to do the final assembly of some of its products

World Economic Forum and PwC analysis | Computer World, Venture Beat

Tele-operated Mobile Robotics

Workplace

1. Already using 5G
2. Use of 5G will significantly enhance the outcome
3. Exclusive 5G use case

5G Features Mapping

Improvement areas/business benefits: Improve manufacturing efficiency

- Ability to comply with social distancing
- Ability to rapidly reconfigure factory floor
- Increase speed of decision-making
- Increase in quality control pass rate

Functional drivers of 5G facilitating the use case's deployment

- Enhanced mobile broadband
- Ultra-reliable, low-latency comms.
- Massive machine type comms.
- Security critical
- Power efficiency

Key Actions

Key actions across ecosystem for use case realization

Spectrum	Infrastructure	Devices	Services	Impact
• Availability of high spectrum bands >26 GHz for low-latency applications and low-band sub 1 GHz for massive machine type applications	• Public or private 5G network with advanced encryption at application level for security • Provide dense small cell network across site • Availability of distributed cloud edge network	• Artificial intelligence • Advanced wireless robotics • Strong network	• Operator training • Staff training • Service players to provide either on-premise or highly secure cloud solutions	• Measure the impact of services through monitoring of: ○ Decrease in number of staff on the factory floor ○ Increase in agility to reconfigure the factory floor rapidly

5G Maturity Timeline

Speed: 1-5 Gbps | Latency: <20 ms	Reliability: 99.99% | Latency: <5ms	Reliability: 99.999% | Latency: <1ms
Current State • Monitoring machines remotely through cloud	**Short Term** (1-3 yrs) • Real-time AI and ML on operations to aid day-to-day operations	**Long Term** (3+ yrs) • Network slicing allowing the operations for the individual layers to work autonomously with parts of factor