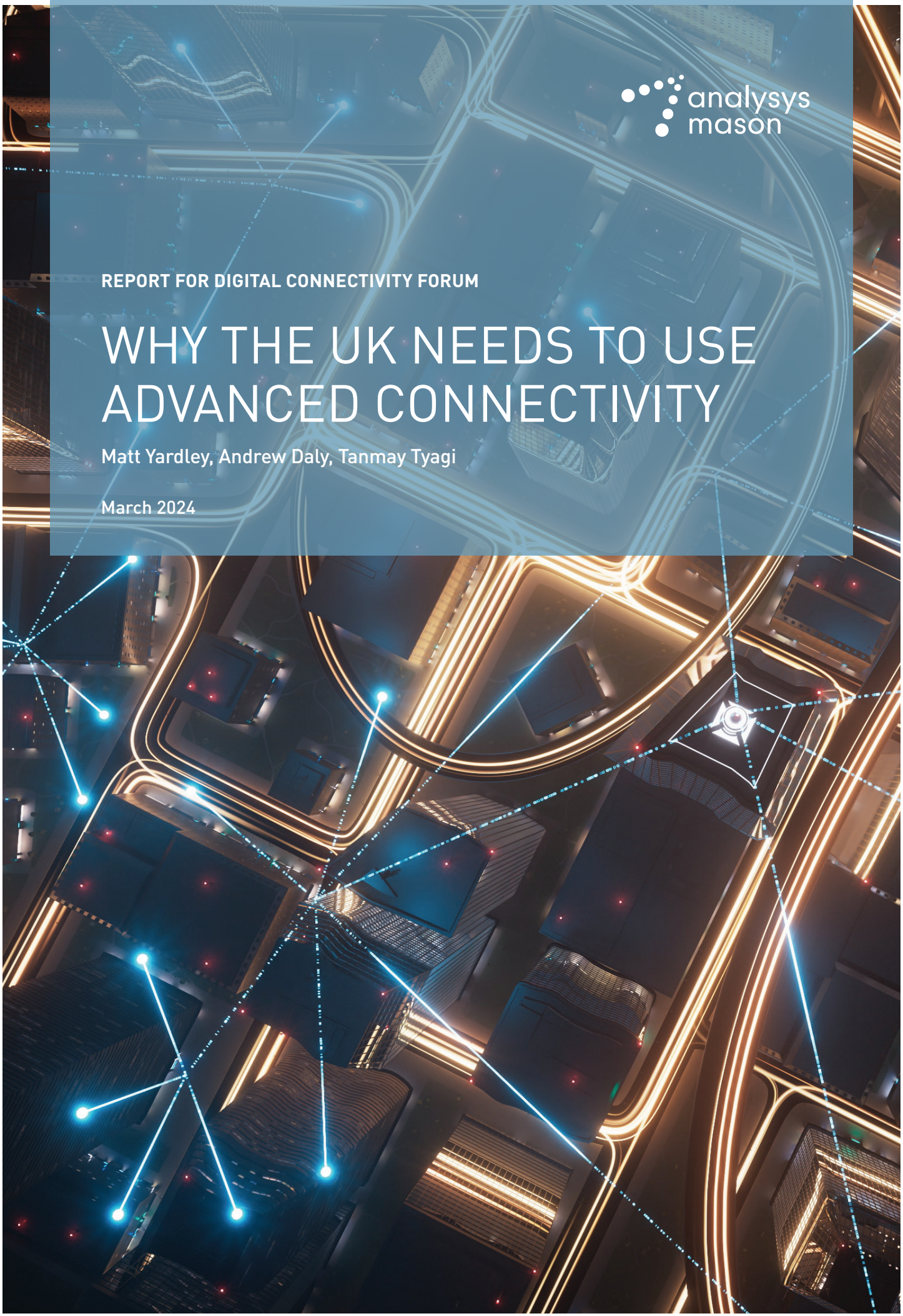

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REPORT FOR DIGITAL CONNECTIVITY FORUM

WHY THE UK NEEDS TO USE ADVANCED CONNECTIVITY

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March 2024

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1 Executive summary

Take-up of advanced connectivity services is essential to realise the benefits of those networks

Advanced connectivity networks, like 5G 'standalone' (5G SA) and fibre to the premises (FTTP), are not just about speed, they possess the power to facilitate novel functions, applications, and services. These networks can deliver significant benefits – from economic growth to social wellbeing and environmental sustainability.

Industry players are investing in deploying these networks, unlocking the potential of these benefits for consumers, businesses, government entities and community organisations. However, realising these advantages hinges on widespread adoption of services that take advantage of the capabilities offered by these networks.

This paper explores a selection of the most compelling use cases to showcase the impact of advanced connectivity networks. It highlights how these networks can be harnessed to innovate and do new things, bringing benefits to a wide array of end users, industries and applications.

Advanced connectivity networks deliver a step change in quality of service

Both 5G SA and FTTP networks bring significant gains in the quality of data services:

- 5G SA networks have the capability to perform 'network slicing', which allows a specific part of the network's capacity to be reserved for a certain application. This ensures that the traffic for that application is given priority within the allocated capacity, guaranteeing a high degree of reliability. Additionally, 5G SA networks can 'break out' traffic near the end user or device, directing it to an edge computing server with minimal delay. As a result, 5G SA can offer connectivity for applications that require extremely low latency.
- FTTP networks offer a highly dependable fixed broadband connection for end users, especially when compared to fibre-to-the-cabinet (FTTC) networks that use twisted-pair copper. This is because fibre is more resistant to electromagnetic interference than twisted-pair copper, and is less likely to be affected by issues related to water penetration.

We have focused on a small number of examples to showcase the benefits of advanced connectivity

5G SA and FTTP networks are true 'innovation' platforms, due to their potential to support a very wide range of current and future applications and use cases across multiple sectors of the economy. For this paper, we have selected a small number of the most compelling ideas to showcase the networks' capabilities. These are:

Remote health monitoring

Some of the current burden on healthcare services can be alleviated by using sensors to monitor a person's health and wellbeing both at home and whilst on the move. End users also benefit from a reduced need to visit healthcare facilities (e.g. for check-ups). Benefits to the health service have been estimated to be a material saving of social care costs. Advanced networks, including both 5G SA and FTTP are key to have confidence in the system.

Connected ambulances

Providing advanced connectivity to ambulances allows paramedics to do more from the ambulance, including getting specialist input from hospital staff (e.g. consultants). This capability allows earlier triage and diagnostics, and earlier application of specialist care in the first few minutes of an emergency. Patient handover from ambulance to hospital triage is also assisted if there is uninterrupted connectivity between the ambulance and the hospital. Advanced connectivity networks provide the reliability and quality which is essential to have confidence in new emergency care working practices.

Advanced connectivity in railways

Advanced wireless connectivity for the rail network enables new capabilities to increase capacity and reduce the impact of delays. Train-to-train communication of braking and acceleration information allows the distance between trains to be reduced, increasing the capacity of the system. Remote monitoring of infrastructure from a massive network of track-side sensors can reduce the number of delays. In both cases, advanced connectivity provides the 'mission-critical' reliability required to enable these features, while maintaining the safety standards required in the rail network.

Connectivity for electric vehicle charging

As demand for electric vehicles (EVs) continues to grow, so too does demand for charging infrastructure. Connectivity to chargers is essential, to manage electrical loads, process payments and monitor for faults. Advanced connectivity ensures that the end-user charging experience is hassle-free, which is key to supporting the continued adoption of EVs.

Remote monitoring of industrial equipment

Sensors are applied to machinery used in a wide variety of industries, measuring various indicators of machine health. The collected data can be combined with cloud-based artificial intelligence (AI) analytics to predict when a failure will occur, reducing the instances of unplanned maintenance. Advanced connectivity networks provide the robust and continually available data links required for industrial processes to be reworked to rely on a new approach to maintenance.

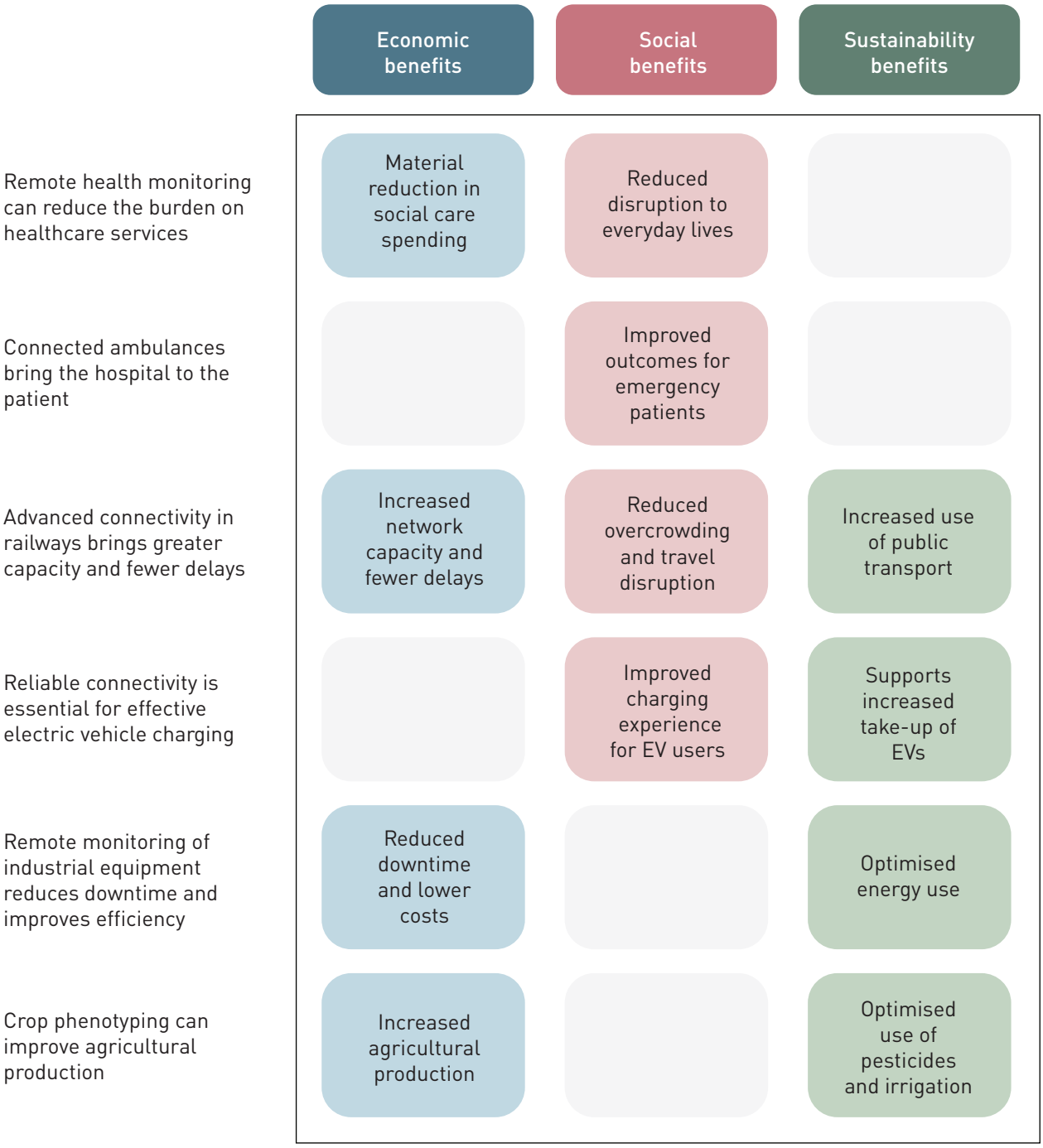
Crop phenotyping

In-depth photographic and video data of crops (phenotyping) is collected and examined to ascertain the precise health status and traits of the plant. This data can be used to identify problems with plant health and diseases, as well as to control weeds. The usage of irrigation and pesticides can be fine-tuned, and plants with higher yields can be chosen for future crops. Advanced connectivity enables the processing of images to be carried out in the cloud, rather than on the phenotyping device, which lowers the system's cost.

Advanced connectivity can deliver economic, social and sustainability benefits

These use cases show that advanced connectivity networks, including 5G SA and FTTP, have the potential to deliver a wide range of benefits for the UK, including across economic, social and sustainability themes, as summarised in Figure 1.1.

Figure 1.1: Summary of benefits of selected advanced connectivity use cases [Source: Analysys Mason, 2024]



It should be noted that the use cases focused on in this paper are a small selection of the very wide range of possible applications that 5G SA and FTTP networks can potentially support. As these networks are used for other use cases, the benefits described above, including across economic, social and sustainability themes, may increase.

Further action is required to drive take-up and realise these benefits

For some use cases, it may be possible to enable a version of the use case with standard (not advanced) connectivity networks. In these examples, the use of advanced, rather than standard, connectivity makes the use case more compelling, often by increasing

confidence that the network can reliably support the new application. This heightened confidence might be enough to prompt a shift in work or business practices, unlocking benefits. However, a more in-depth examination may be needed to compare the costs and benefits of standard and advanced connectivity. This could influence how advanced connectivity is commercially marketed for particular applications, considering the link between adoption and cost.

In terms of timescales, all of the use cases we examined have the potential to be implemented in the near future. Our recommendations are focused around building on the current situation to accelerate the adoption of these use cases:

- Regarding the healthcare-related use cases, a useful next step would be to build on the previous trials of remote health monitoring[1] and connected ambulances,[2] and transition to broader and more extensive trials with selected NHS trust(s). These more comprehensive trials could aim to implement both use cases, focusing on NHS trust(s) with a significant proportion of rural residents, where the benefits of the two use cases could be most substantial.

- The advanced connectivity use cases examined for the rail network can build on Network Rail's existing Intelligent Infrastructure programme.[3] The existing network monitoring activities can be improved with the additional information provided by a 5G-enabled sensor network, leading to further gains in predictive maintenance. Regarding the deployment of virtual coupling, which may require a longer implementation period, all parties involved in the rail industry, including track and train operators and providers of advanced connectivity, should collaborate to identify and address any operational, safety and regulatory challenges,[4] and to set a clear timeline for rolling out the technology.

- The installation of EV chargers is ongoing, with numerous charging infrastructure providers setting up new sites, both on a commercial basis and on behalf of local authorities. Providers of advanced connectivity services should engage with EV charger providers to conduct comprehensive feasibility studies for the use of 5G SA and FTTP to provide connectivity.

- Numerous providers of industrial remote monitoring services already exist in the market, with companies of various sizes reaping the benefits of increased efficiency. However, there is likely to be value in the UK government promoting the technology, so that more businesses are aware of its potential, in order to boost the global competitiveness of UK industry.

- Like the above-mentioned use cases, the next steps to reap the benefits of crop phenotyping would involve progressing beyond the trials[5] that have already been conducted and using the technique on a larger scale. A natural next step would be to introduce phenotyping robots across numerous farms. There could be an opportunity for government involvement in offering financial aid, which could cover the cost of the phenotyping system and the expansion of the required 5G SA infrastructure into rural regions (at least on a targeted basis).

Across all the themes and scenarios we have explored, we have found strong arguments for maximising the use of advanced connectivity networks. Both 5G SA and FTTP offer superior service quality compared to some existing networks, and they hold the promise of enhancing everyday life across consumer, business, and public service environments.

[1] https://liverpool5g.org.uk/health-social-care-testbed/

[2] https://www.wm5g.org.uk/wp-content/uploads/2021/07/Connected-Ambulance-Trial.pdf

[3] https://www.networkrail.co.uk/running-the-railway/intelligent-infrastructure/

[4] https://www.railtech.com/innovation/2022/08/02/how-virtual-coupling-can-bring-the-needed-rail-capacity-for-the-future/?gdpr=accept

[5] https://uktin.net/how-to-deploy-5G/agriculture

2 Advanced connectivity networks provide high reliability and quality of service

In this report we present research into use cases that make use of the capabilities of advanced connectivity networks, and describe the benefits that these use cases bring. The aim of the report is to accelerate take-up on those networks.

2.1 Take-up of advanced connectivity services is essential to realise the benefits of those networks

Advanced connectivity networks, such as 5G 'standalone' (5G SA) and fibre to the premises (FTTP) have the capability to support many new functions, applications and services that have the potential to deliver a wide range of economic, social and sustainability benefits.

The connectivity industry is making significant investments to *deploy* these networks, providing the potential for consumers, businesses, government and community organisations to benefit from their capabilities. However, these benefits can only be realised if there is large-scale take-up of services on these networks.

This paper showcases a range of use cases which highlight how advanced connectivity networks can be used to do new things, with benefits across a broad range of end users, industries and applications.

2.2 Advanced connectivity networks deliver a step change in reliability alongside capacity

Both 5G SA and FTTP networks bring significant improvements to the provision of mobile and fixed broadband services:

5G SA

5G network availability is increasingly widespread in the UK, with coverage focusing on cities and other urban areas, and being gradually pushed out towards more rural areas. However, initial deployments of 5G used a 5G 'access' network (i.e. the base station and spectrum) in combination with the existing 4G-based core network. This 5G+4G combination is known as a 'non-standalone' 5G network.

A 5G SA network adds a new 5G core to the 5G access network. This 'end-to-end' 5G network enables two new capabilities:

- 5G SA networks support 'network slicing' whereby a portion of the network's capacity can be allocated, in an assured way, to a particular application. Traffic for that application can be prioritised within the capacity allocated such that a very high level of reliability is ensured, which makes 5G SA networks suitable for providing wireless connectivity to 'mission-critical' applications.
- The network now includes the ability to 'break out' traffic much closer to the end user or device. The capability is enabled by the software-defined nature of 5G core network functions (as opposed to functions which are defined by the specific hardware which provides them). By breaking traffic out closer to the end user or device, the traffic can be directed to an edge computing server with very low delay. This means that 5G SA can provide connectivity for applications which require very low latency.

These core network capabilities provided by 5G SA networks are complementary to the significant increases in bandwidth already being provided by the access technology and spectrum of non-standalone 5G networks.

FTTP

FTTP networks differ from previous generations of fixed broadband networks by providing a fibre connection all the way to the end-user premises. Previous generation networks, such as fibre to the cabinet (FTTC), used pre-existing twisted-pair copper for the final connection to the premises.

The upgrade to fibre gives a more reliable fixed broadband connection for end users because:

- Fibre is less prone to electromagnetic interference than twisted-pair copper, which can result in signal degradation and data loss.
- Fibre is less susceptible to problems caused by water ingress, which can again interfere with proper electrical conductivity performance required by twisted-pair copper-based networks.

We note that the reliability of broadband networks can be affected by a range of factors, including issues with the in-home (Wi-Fi) network, and congestion in the core. However, as an important component of the end-to-end connection, having FTTP in the 'access' network is likely to deliver a reliability improvement for many users.

The upgrade to FTTP is already delivering results, with the following improvements being reported:[6]

- a 60% reduction in overall fault rates compared to twisted-pair copper broadband
- bad weather-related faults fell from a 10% increase on twisted-pair copper broadband to just a 1% increase.

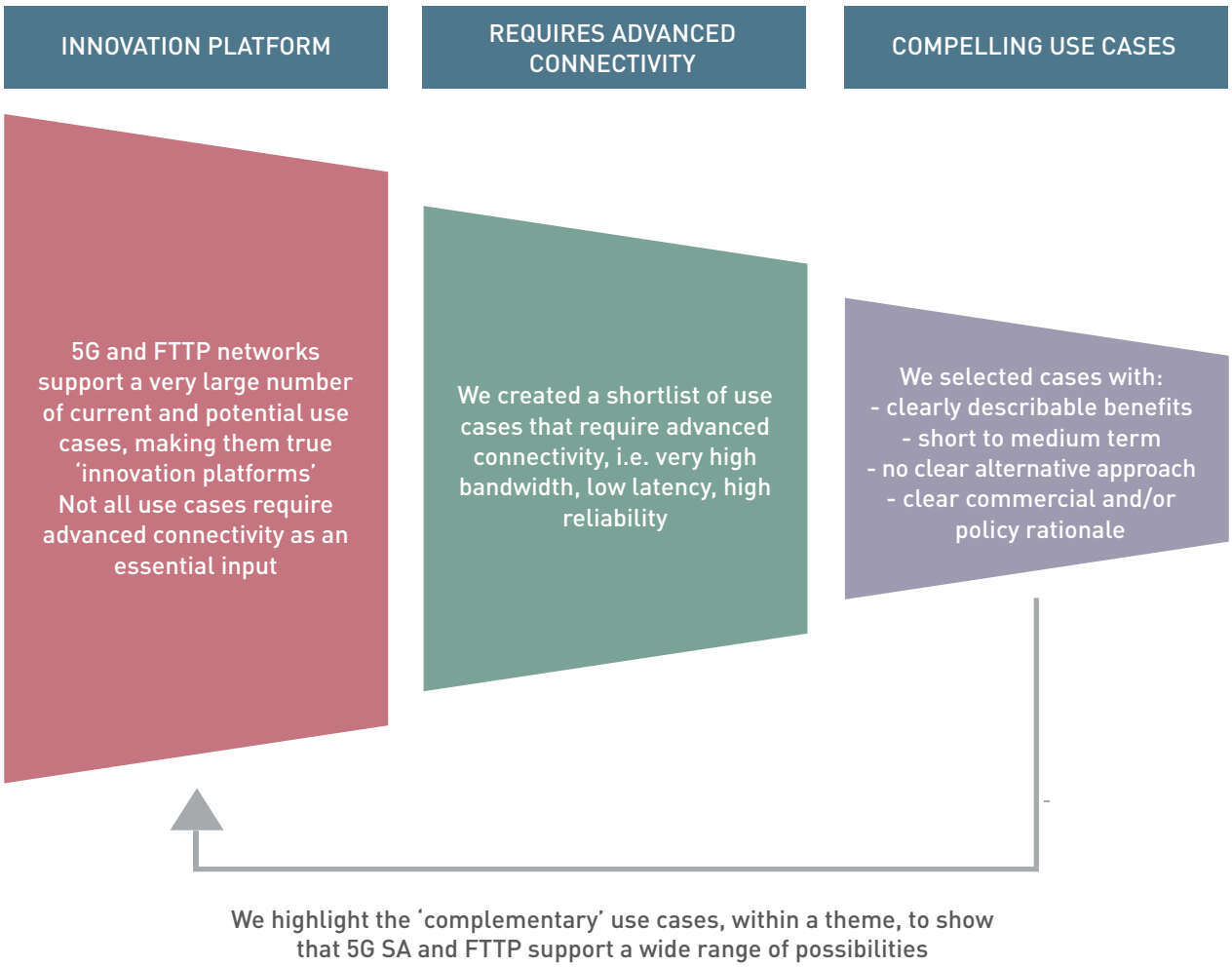
FTTP networks also have the capability to deliver services with significantly greater bandwidth., compared to FTTC networks that use twisted-pair copper.

[6] https://www.openreach.com/content/dam/openreach/openreach-dam-files/new-dam-(not-in-use-yet)/documents/regulatory-compliance/Investor-Brief-2023-online.pdf

2.3 We have focused on a small number of examples, chosen from a long list of possibilities

5G SA and FTTP networks are true 'innovation' platforms, due to their potential to support a very wide range of current and future applications and use cases across multiple sectors of the economy. For this paper, we have selected a small number of the most compelling ideas to showcase the networks' capabilities, using the process shown in Figure 2.1.

Figure 2.1: Process to select use cases [Source: Analysys Mason, 2024]



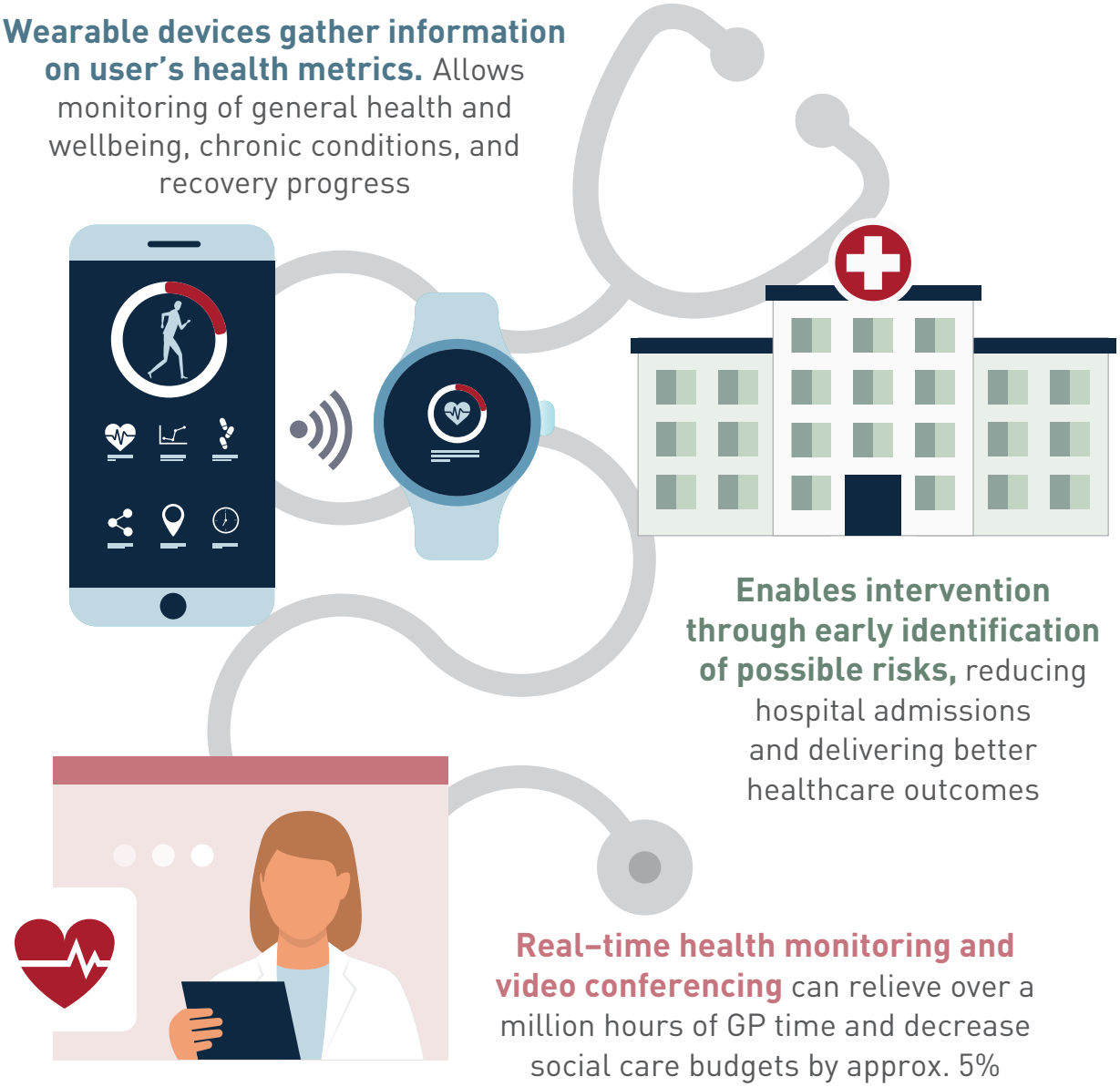
In the remainder of this document, we describe six use cases which showcase how making use of the capabilities of advanced connectivity networks can deliver a wide range of benefits:

- remote health monitoring can reduce the burden on healthcare services
- connected ambulances bring the hospital to the patient
- advanced connectivity in railways brings greater capacity and fewer delays
- reliable connectivity is essential for effective electric vehicle charging
- remote monitoring of industrial equipment reduces downtime and improves efficiency
- crop phenotyping can improve agricultural production.

In the final section, we present our conclusions and recommendations.

3 Remote health monitoring can reduce the burden on healthcare services

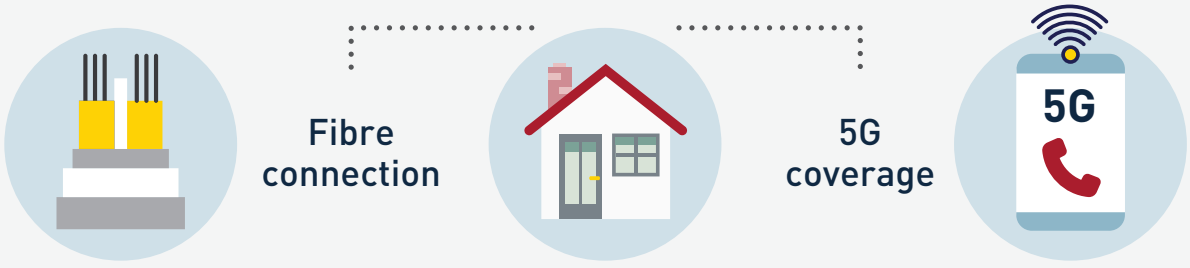
Wearable devices gather information on user's health metrics. Allows monitoring of general health and wellbeing, chronic conditions, and recovery progress



Enables intervention through early identification of possible risks, reducing hospital admissions and delivering better healthcare outcomes

Real–time health monitoring and video conferencing can relieve over a million hours of GP time and decrease social care budgets by approx. 5% (i.e. GBP890 million)

Fibre connection to the home, and 5G coverage away from the home



CASE STUDY

3.1 What is it?

A person with healthcare needs is remotely monitored, allowing that person to go about their everyday lives without the disruption of having to visit a medical facility to receive check-ups.[7]

3.2 How does it work?

Remote monitoring includes a range of techniques and devices, including:

- Wearable devices collect information on a user's health metrics, such as heart rate, movement and activity, body temperature.
- More 'passive' sensors in the home can monitor movement (e.g. for elderly people). These can be deployed in different models, ranging from:
  - multiple visible sensors on doorways, cupboard doors, fridge door, etc. to track movement and activity around the home; to
  - a single hidden sensor attached to the electricity supply, which monitors changes in electrical demand (e.g. from boiling the kettle, watching TV, turning on lights).
- Remote upload of data for metrics that still require a visit from a healthcare professional (e.g. taking blood pressure).
- Home consultation, via video conference, with healthcare professionals such as general practitioners (GP), nurse practitioners and pharmacists (i.e. to guide taking of medication).

Where health metrics, including activity and movement, are gathered, this data is securely uploaded to the cloud, whereby it is automatically stored, and upon which artificial intelligence and machine learning techniques can be deployed to identify patterns and predict issues.

3.3 What are the benefits?

One of the main benefits is preventative healthcare. By continual monitoring of key healthcare metrics, the early signs of a healthcare issue can be spotted before it becomes an emergency, with better outcomes for the person and a reduced load on hospitals and emergency care. This application is relevant for both recovery from acute conditions and ongoing monitoring of chronic conditions. Where the condition requires a visit from a healthcare professional (see above), the remote link means that the professional can complete the visit more quickly (avoiding the need to write up notes) and can see more patients each day.

The UK's population is getting older. According to Age UK, *"In 2023 there [were] 11 million people aged over 65 in England. This is projected to increase by 10% in the next five years and by 32% by 2043 (1.1 and 3.5 million people respectively)."* Remote monitoring of elderly people has benefits for a wide range of stakeholders. The elderly person themselves can receive medical care without disruption to their everyday lives. The general monitoring happens in the background, and if they do need to speak to a professional, this can be done from their own home via video link. Remote monitoring also provides comfort to

[7] Sources for this use case include: https://uktin.net/how-to-deploy-5G/health/wellness

https://www.ageuk.org.uk/globalassets/age-uk/documents/reports-and-publications/reports-and-briefings/health--wellbeing/age-uk-briefing-state-of-health-and-care-july-2023-abridged-version.pdf

Tour of BT Showcase at Adastral Park

https://www.public.io/report-post/the-future-of-digital-government

family and friends, who can rely on the additional 'safety net' of the automatic systems recording the data feeds. And similar to the preventative care benefit mentioned first, monitoring provides an early alert system for any deterioration in a person's health, enabling timely intervention before it escalates into an emergency.

It is estimated that in the UK, remote health monitoring, including video conferencing, has the potential to relieve over a million hours of GP time, amounting to a GBP890 million saving (or around 5% of social care spending).

3.4 How do advanced networks help?

The reliability of advanced networks is key to end users, their dependants and relatives and healthcare organisations having confidence in the remote monitoring system as a whole.

While any good quality fixed broadband infrastructure could provide the necessary connection to the home, the high reliability of FTTP (working in conjunction with a modern Wi-Fi access point) is well suited to ensuring that the data-flows from the wearable and passive sensors are not disrupted. FTTP is also ideally suited for supporting high-quality video interactions with healthcare professionals in the home: for users to be confident in this method of consultation, the network connection needs to be of the highest quality.

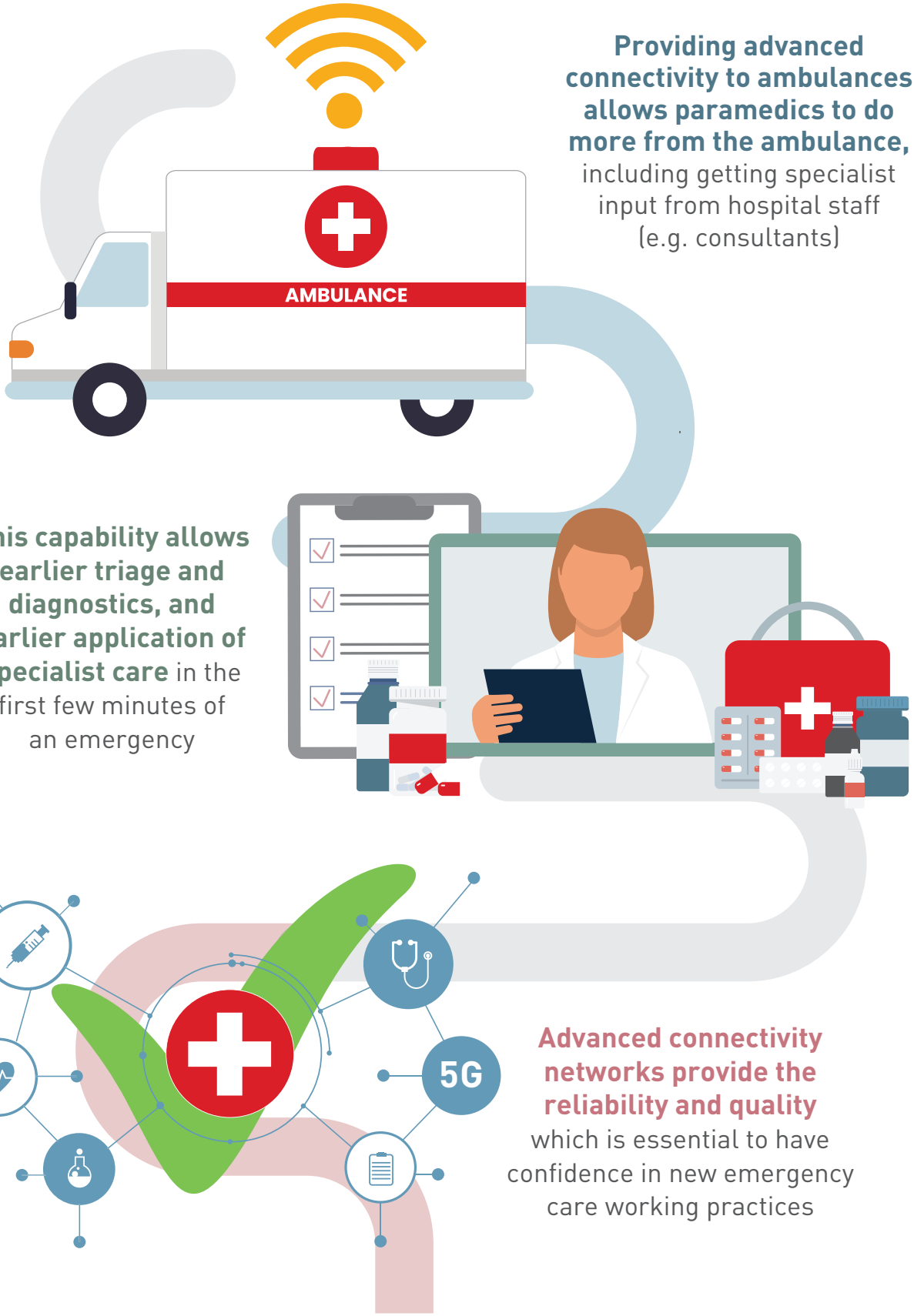
When on the move, 5G SA is well suited to providing wireless connectivity. The highly reliable wide-area coverage allows the person to continue as normal with their everyday lives, supported by an ultra-reliable uplink from their personal or wearable device to the monitoring systems in the cloud.

3.5 What are the complementary use cases?

The FTTP and 5G SA network platforms have the potential to support a range of healthcare-related use cases, including:

- connected ambulances (see next)
- remote robotic surgery
- tracking of medical equipment/assets in hospitals
- drone delivery of medicines
- predictive maintenance of healthcare equipment
- remote access to medical records.

4 Connected ambulances bring the hospital to the patient

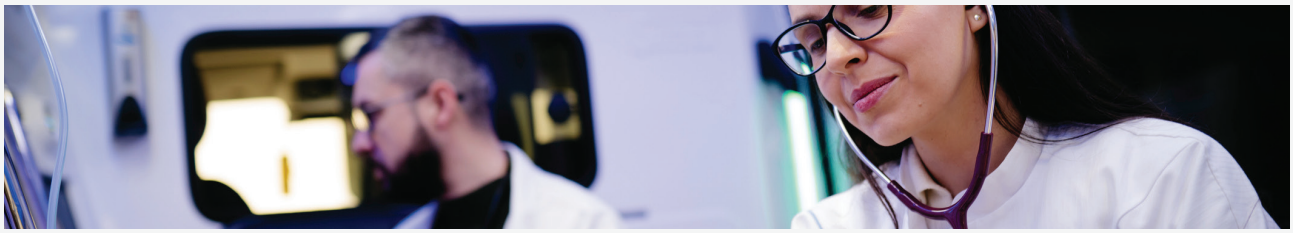


Providing advanced connectivity to ambulances allows paramedics to do more from the ambulance, including getting specialist input from hospital staff (e.g. consultants)

This capability allows earlier triage and diagnostics, and earlier application of specialist care in the first few minutes of an emergency

Advanced connectivity networks provide the reliability and quality which is essential to have confidence in new emergency care working practices

CASE STUDY



4.1 What is it?

Ambulances are upgraded with advanced connectivity capability, enabling high quality information flows to and from the ambulance, allowing paramedics to do even more to help patients.[8]

4.2 How does it work?

Paramedics are extremely well trained, highly skilled medical professionals, but deep specialist expertise (e.g. consultants) is normally located at the hospital. By enabling the ambulance with advanced wireless connectivity, the paramedics can receive additional specialist support, including:

- transmission of vital statistics (e.g. heart rhythm, blood pressure) back to the hospital, to allow hospital staff early sight of a patient's condition
- ultra-low lag video link to allow the hospital staff to effectively engage with the patient and paramedics, to provide guidance and diagnostics
- enhanced diagnostic techniques, such as ultrasound, can be guided remotely from the hospital, with the paramedic responding to physical cues from a haptic glove.

The connectivity can be utilised in advance of the ambulance getting to the patient. If the patient is wearing a medical device, or is in a sensor-enabled home, information from those sensors is provided to the paramedics in advance of their arrival (see previous case study). Information can also be transferred from the ambulance to the hospital triage via a secure data connection assuming ambulance connectivity and hospital connectivity networks work together.

4.3 What are the benefits?

The first key benefit of providing ambulances with advanced connectivity is improvements in diagnostics. Depending on the urgency of the condition, this can mean that the patient is triaged in the ambulance, and can be promptly directed to the appropriate hospital setting on arrival, reducing the need to triage in accident and emergency departments.

The second key benefit is providing early treatment. Supported by hospital-based expertise, paramedics can prescribe additional urgent treatment on the way to the hospital, improving the likely healthcare outcome for the patient. This benefit is especially true for:

- patients suffering from certain conditions, e.g. the effects of a stroke, where every minute counts in getting urgent medical care to stop further damage to the brain
- patients who live in rural areas, where there may be a long journey time from their home to the hospital.

[8] Sources for this case study include: https://www.wm5g.org.uk/wp-content/uploads/2021/07/Connected-Ambulance-Trial.pdf

https://www.vodafone.co.uk/business/5g-for-business/5g-customer-stories/connected-ambulance#:~:text=Vodafone%205G%20has%20removed%20the,prevent%20treatment%20delays%20on%20arrival

https://emag.medicalexpo.com/smart-ambulances-revolutionize-emergency-care/

https://www.public.io/report-post/the-future-of-digital-government

https://scotland5gcentre.org/wp-content/uploads/2023/01/ilovepdf_merged-12.pdf

4.4 How do advanced networks help?

Use of advanced connectivity in emergency response has huge potential, but requires new training, systems and working practices to implement fully. The network has to work every time for the healthcare services to embrace these techniques. 5G SA's ultra-reliable wide-area connectivity can provide the required network performance.

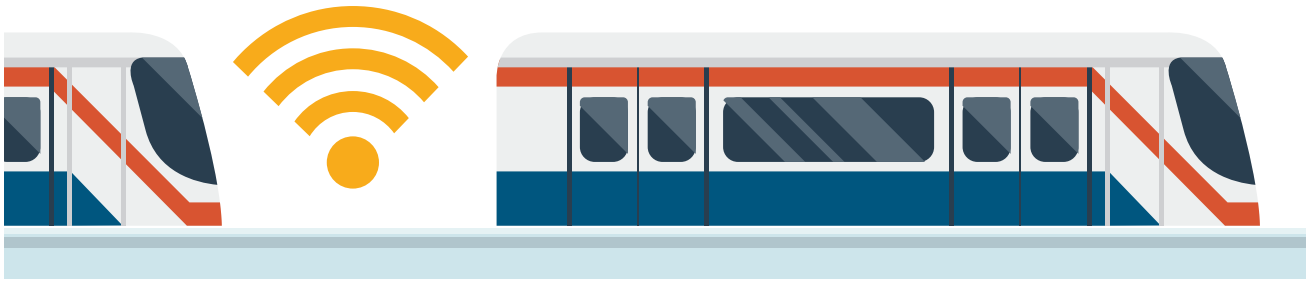
Similarly, low latency (low lag) is key. If a consultant is diagnosing a stroke patient via remote ultra-high definition video link, any delay in the patient responding to a request to raise their arm must not be caused by the network. And in the heat of an emergency situation, where the paramedics and hospital staff are urgently exchanging instructions over the video link, the system must be as natural and responsive as possible, so it does not distract from the task at hand.

4.5 What are the complementary use cases?

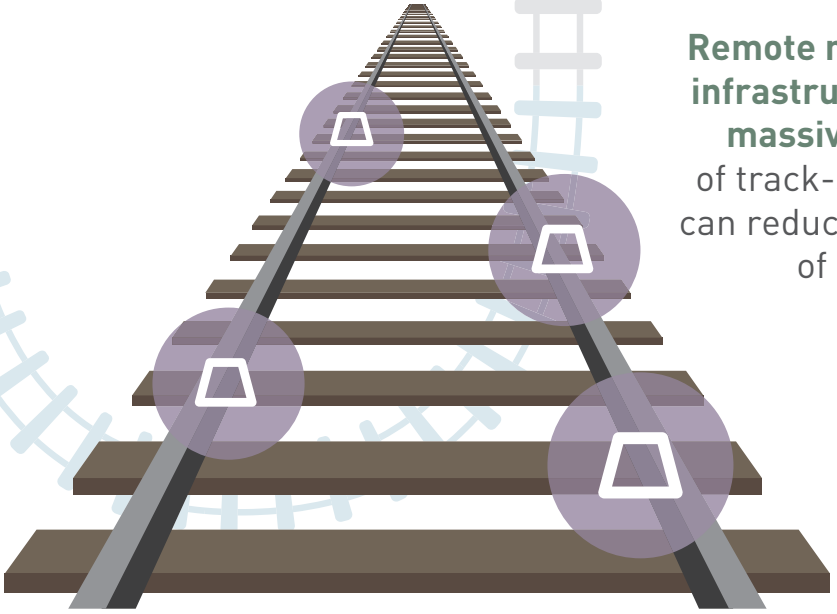
The 5G SA network platform has the potential to support a range of healthcare-related use cases, including:

- remote monitoring (see previous)
- remote robotic surgery
- tracking of medical equipment/assets in hospitals
- drone delivery of medicines
- predictive maintenance of healthcare equipment
- remote access to medical records.

5 Advanced connectivity in railways brings greater capacity and fewer delays



Train-to-train communication of braking and acceleration information allows the distance between trains to be reduced, increasing the capacity of the system



Remote monitoring of infrastructure from a massive network of track-side sensors can reduce the number of delays

In both cases, advanced connectivity provides the 'mission-critical' reliability required to enable these features, while maintaining the safety standards required in the rail network

CASE STUDY

5.1 What is it?

Two main capabilities are proposed to bring the benefits of advanced connectivity to railways:[9]

- Train-to-train connectivity enables 'virtual coupling' whereby train separation distance is reduced and multiple trains move as a single convoy or 'platoon'.
- Track-side sensors enable monitoring of a wide range of safety and reliability aspects, allowing reductions in delays and disruption.

5.2 How does it work?

Advanced train-to-train connectivity allows braking and acceleration information to be transmitted between trains. This allows the separation distance ('headway') between the trains to be reduced: from the full stopping distances to a relative braking distance, i.e. the distance required to reduce speed to the same as that of the train in front. In particular, multiple trains can be treated as a single 'platoon' when passing through junctions, which are typically the main constraint on rail network capacity.

Advanced wide-area connectivity for the railways allows the ultra-reliable monitoring of a massive network of track-side sensors, which can include:

- sensors to monitor the condition and functionality of points systems
- sensors to monitor the temperature of tracks
- sensors on surrounding earth banks to monitor movement and slippage
- sensors on bridges and tunnels to monitor movement and cracking.

5.3 What are the benefits?

Mathematical modelling of the impact of virtual coupling suggests around a 40% reduction in train separation distance could be possible.[10] This would have a direct impact on the capacity of the rail network. With more capacity, more trains could be operated at peak times, improving the experience for passengers (due to reduced overcrowding) and extending the sustainability impact of rail travel.

The track-side sensor network will reduce the incidences of delays and disruptions:

- In the case of points systems, preventative maintenance can be used to fix issues during off-peak periods before they result in a failure.
- In the case of temperature monitoring, train speeds can be reduced when track temperatures reach a

[9] Sources for this case study include:

https://www.sciencedirect.com/science/article/pii/S2210970619300848

https://images.thalesgroup-events.com/Web/THALES/%7B4d2a40bd-d128-46ba-8176-b20930aea83b%7D_Thales_White_Paper_5G_for_railways.pdf?utm_source=TCA&utm_medium=email&utm_content=GTS%20-%205G%20-%20Mail%20Download%20SM&utm_campaign=GTS%20-%205G%20-%20R%C3%A9seaux%20sociaux

https://dualinventive.com/en/use-cases/iot-5g-vodafone-railway/

https://www.gsma.com/5GHub/images/5G-Case-Study-Metro_2022-11-18-035245_pcxr.pdf

https://www.senceive.com/sectors/railroad-track-monitoring?utm_term=rail%20temperature%20monitoring&utm_campaign=SCH_Generic_Search_UK&utm_source=adwords&utm_medium=ppc&hsa_acc=1465457029&hsa_cam=19637765435&hsa_grp=159068638007&hsa_ad=679878549506&hsa_src=g&hsa_tgt=kwd-931299233894&hsa_kw=rail%20temperature%20monitoring&hsa_mt=p&hsa_net=adwords&hsa_ver=3&gad_source=1&gclid=EAIaIQobChMIrYPxhruvhAMVtJBQBh2ERwVYEAAYASAAEgLrn_D_BwE

certain threshold, which lowers the risk of track buckling (and therefore the need to close the line to undertake repairs).

- In the case of monitoring earth banks, bridges and tunnels, preventative measures can again be taken at the first sign of an issue, during off-peak times, to avoid disruption to travel during the busiest periods.

5.4 How do advanced networks help?

The train-to-train communication (known as 'side link') required by virtual coupling is enabled by the 5G-based Future Railway Mobile Communication System (FRMCS). The ultra-high reliability performance of 5G SA is critical to enable this capability, due to the safety considerations associated with optimising train separation distance.

Advanced connectivity networks improve the performance of track-side sensors. The sensors themselves typically create low volumes of data which could be carried by standard connectivity networks. However, like other use cases, the ultra-high reliability of 5G SA allows increased confidence in the system as a whole, supporting changes to maintenance and repair working practices that come to rely on the data provided by the sensor network.

5.5 What are the complementary use cases?

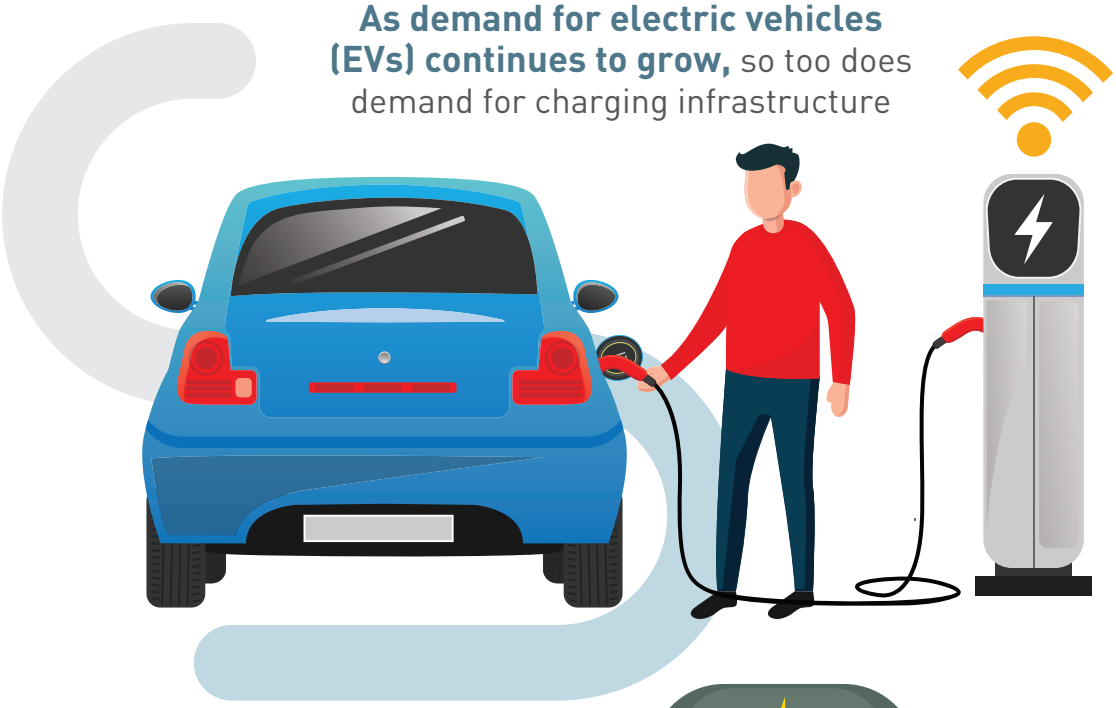
Once enabled for use across the railway network, the 5G SA platform can support a wide range of additional complementary uses cases, including:

- high-speed, high-reliability internet access for passengers
- high-resolution closed-circuit television (CCTV) and video monitoring
- smart 'invisible' ticketing systems
- enhanced information for passengers on train arrivals and departures.

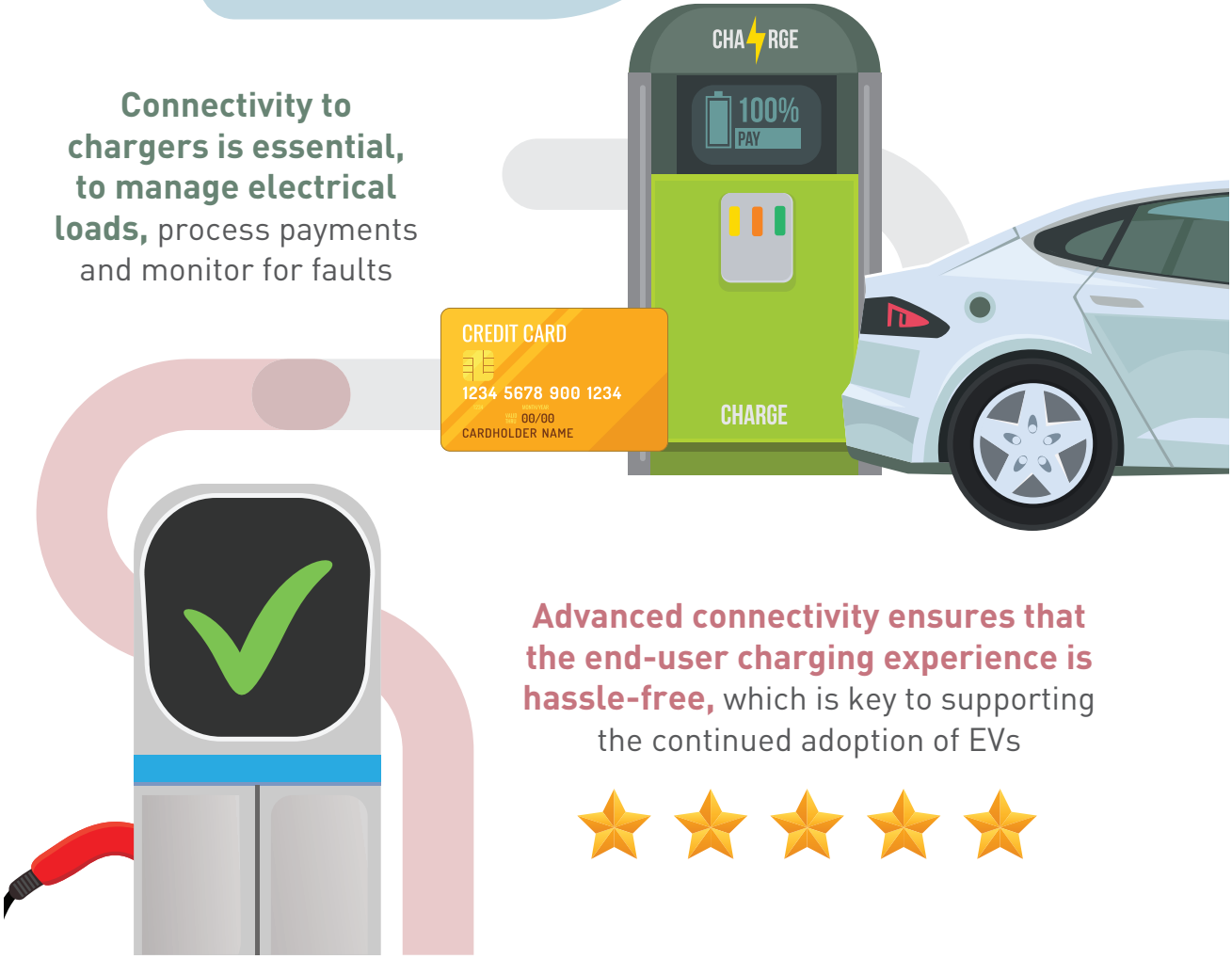
[10] https://www.sciencedirect.com/science/article/pii/S2210970619300848

6 Reliable connectivity is essential for effective electric vehicle charging

As demand for electric vehicles (EVs) continues to grow, so too does demand for charging infrastructure

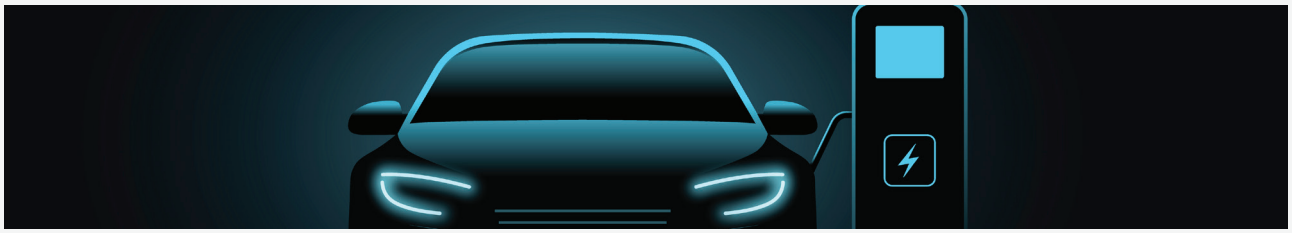


Connectivity to chargers is essential, to manage electrical loads, process payments and monitor for faults



Advanced connectivity ensures that the end-user charging experience is hassle-free, which is key to supporting the continued adoption of EVs

CASE STUDY



6.1 What is it?

EV charging infrastructure requires connectivity to manage electrical loads, process payments and monitor for faults.[11]

6.2 How does it work?

Charging is an essential part of operating an EV. EVs typically have a shorter range than internal combustion engine (ICE) vehicles, and must be charged on a regular basis. Charging takes materially longer than refilling with petrol or diesel: around 30–60 mins to increase charge from 20% to 80%, depending on the vehicle and power of the charging infrastructure.

Connectivity to the charger is essential to:

- process payment and activate the charging session
- manage the electrical load across vehicles and chargers, to ensure that vehicles with a high state of charge (SoC) are not prioritised over vehicles with a low SoC
- monitor the charger for faults.
- If the charging session cannot begin (due to payment system failure or fault) or runs slowly (due to sub-optimal balancing of electrical load between chargers/vehicles), the user's overall experience and travel time can be significantly disrupted.

6.3 What are the benefits?

EVs are expected to be a strong contributor to the UK reducing its carbon emissions. Unlike ICE vehicles, EVs do not create any local emissions. Even though the energy consumed by EVs may currently contribute to carbon emissions due to the national grid's partial use of fossil fuels, as the UK progressively transitions towards more sustainable energy sources, EVs will benefit from their energy source having a reduced carbon footprint. Manufacturing of EVs, including their batteries, incurs significant carbon emissions, but over the lifecycle of the vehicles EVs are expected to deliver a material reduction in carbon emissions compared to ICE alternatives.

These benefits will not be realised without the widespread adoption of EVs by consumers, with the current target being that by 2035, no conventional petrol-and diesel-powered vehicles will be allowed to be sold.

Aside from the cost of purchasing the vehicles, issues with the charging experience is one of the main barriers to EV adoption. Reliable connectivity, as discussed above, is essential to ensuring a good experience and helping the UK to reach its EV ambitions.

[11] Sources for this case study include:

https://assets.publishing.service.gov.uk/media/623b0fb28fa8f540f3202c12/lifecycle-analysis-of-UK-road-vehicles.pdf

https://assets.publishing.service.gov.uk/media/6245ba40e90e075f15381cf0/taking-charge-the-electric-vehicle-infrastructure-strategy.pdf

https://maps.dft.gov.uk/ev-charging-map/index.html

https://www.businessinsider.com/5g-chargers-may-be-key-electric-vehicle-road-trips-2023-7?r=US&IR=T#:~:text=This%20is%20important%20for%20electric,ensuring%20a%20speedy%20user%20experience

6.4 How do advanced networks help?

The UK is expected to need between 300 000 and 700 000 public charge points to effectively support the phase-out of petrol- and diesel-powered vehicles.[12] The wide range of the estimates is due to uncertainty over general charging behaviour, including how people will use home- or work-based chargers alongside public facilities.

Nevertheless, these estimates mark a huge increase from around 54 000 public charge points available today. Each additional charge point location will require connectivity, alongside the power supply from the national grid.

Where there is FTTP at the charge point location, this can provide a highly reliable connection. The wide-area coverage offered by 5G SA wireless connectivity provides a more flexible option, removing the need for an additional wireline connection to the telecoms network (which may follow different routes to the power network). While any good quality wireless network has the potential to support this use case, the ultra-high reliability of 5G SA is well suited to the needs of EV users, who have a strong interest in avoiding any of the issues associated with poor connectivity, including issues with payment, charging speed and hardware faults.

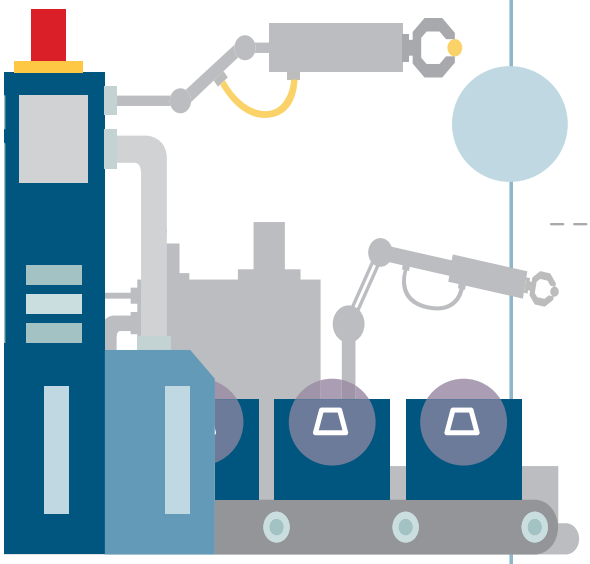
6.5 What are the complementary use cases?

The 5G SA and FTTP connectivity platforms can also support a range of complementary use cases across public and private road transport, including:

- enhanced digital road signs
- live parking information, including guidance to available spaces
- in-car infotainment
- traffic and emissions monitoring.

[12] https://assets.publishing.service.gov.uk/media/6245ba40e90e075f15381cf0/taking-charge-the-electric-vehicle-infrastructure-strategy.pdf

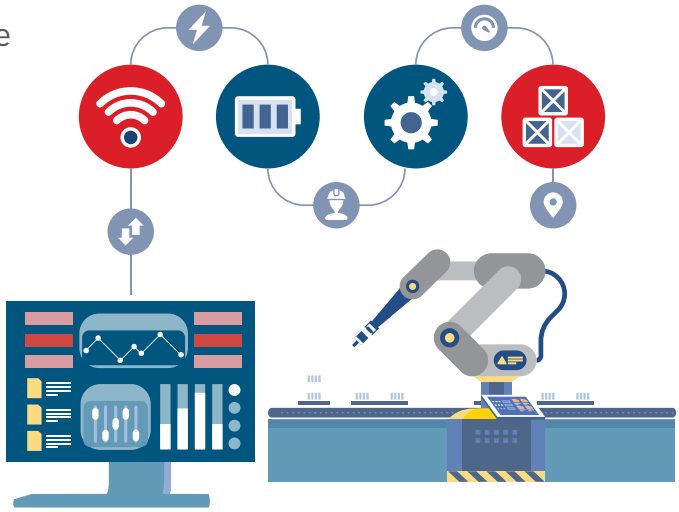
7 Remote monitoring of industrial equipment reduces downtime and improves efficiency



Sensors are applied to machinery used in a wide variety of industries, measuring various indicators of machine health.

The collected data can be combined with cloud-based AI analytics to predict when a failure will occur, reducing the instances of unplanned maintenance.

Advanced connectivity networks provide the robust data links required for industrial processes to be reworked to a preventative maintenance model.



CASE STUDY

7.1 What is it?

Sensors are attached to machinery used in a range of industries, to monitor the health of the machine, and predict when maintenance will be required.[13]

7.2 How does it work?

Depending on the machinery to be monitored, different types of sensors can be used:

- vibration sensors 'listen' to the noise of the machine
- magnetic and electrical current sensors monitor the operation of electric motors
- gas and humidity sensors monitor the composition of the air around the machinery
- temperature sensors can detect when machinery is running too hot (which may indicate wear)
- pressure sensors can detect when that metric is too high or too low.

The data from these sensors is collected and compared using AI against a library of data from previous measurements, using analytic functionality typically based on servers located in the cloud. By comparing the current indicators of the machine against the history of other machines that were subject to failure, issues can be predicted weeks or even months in advance of when they would otherwise occur.

The techniques are applicable across a wide range of industrial settings, including:

- manufacturing
- water
- airports
- energy
- agriculture.

7.3 What are the benefits?

Unplanned downtime is a significant issue in any industrial setting, especially when multiple processes are being used in succession, and if one machine fails, the whole process has to stop. By using remote monitoring and predictive maintenance, corrective action can be taken in downtime or off-peak periods, so that production processes are not unduly disrupted.

The data and analytics can also be used to optimise normal running, especially in the case of equipment that uses electrical power such as motors and pumps. Optimised equipment may use less electricity than unoptimised equipment, incurring lower power costs and resulting in lower associated carbon emissions.

[13] Sources for this case study include:

https://www.qualcommventures.com/insights/blog/founder-spotlight-part-2-augurys-saar-yoskovitz-on-using-ai-powered-listening-to-protect-the-global-supply-chain/

https://samotics.com/industries/airports

https://upkeep.com/learning/sensors-for-predictive-maintenance/

7.4 How do advanced networks help?

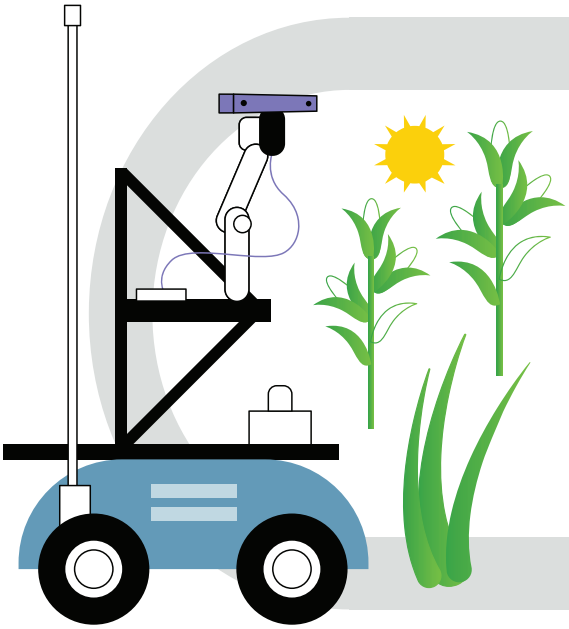
Advanced connectivity networks are well suited to supporting remote monitoring of industrial equipment. Where wireless sensors are used, 5G SA provides a more robust and reliable connection option than locally installed access points. And where it is available, FTTP provides complementary reliability performance, for example to provide the backhaul connection back towards the cloud analytics platforms. As industrial organisations change their working practices to rely on a predictive maintenance model, the capabilities of advanced connectivity networks are well suited to provide the uninterrupted data feeds that these models require.

7.5 What are the complementary use cases?

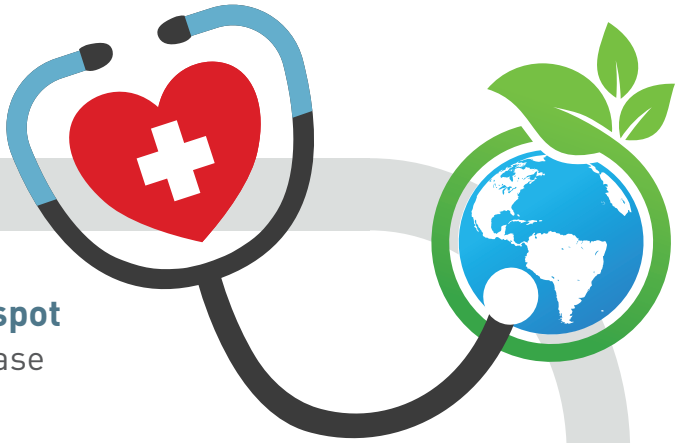
Once installed in industrial settings, 5G SA and FTTP advanced connectivity networks can support additional complementary use cases, including:

- autonomous and automated vehicles
- identification, tracking and quality control of goods
- augmented reality (AR) maintenance support
- ultra-high definition video/CCTV.

8 Crop phenotyping can improve agricultural production

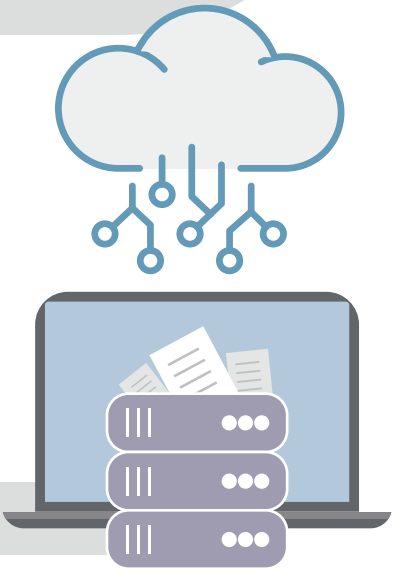


Detailed photo and video imagery of crops (phenotyping) is gathered and analysed to determine the detailed health and characteristics of the plant



The information can be used to spot issues with plant health and disease and to manage weeds

Use of irrigation and pesticides can be optimised, and higher yield plants can be selected to see future crops



Advanced connectivity allows the image processing to be undertaken in the cloud, rather than by the phenotyping device, reducing the cost of the system

CASE STUDY

8.1 What is it?

Connected robots collect detailed plant 'phenotyping' data which can be analysed to optimise the growth and productivity of crops.[14]

8.2 How does it work?

Field-based robots, either aerial (i.e. drones) or ground based (with wheels or tracks), equipped with high-resolution imaging sensors collect detailed plant phenotyping data (e.g. visible information on crop growth, physiological and genetic traits) and transfer it to the cloud for processing and analysis. Using this data, various assessments can be made on the status of the crops.

8.3 What are the benefits?

Crop phenotyping can be used to derive a range of actionable insights regarding the status of the crops, including:

- early identification of pests, to optimise the use of pesticides
- early identification of disease or other health issues, so corrective action can be taken
- assessment of plant hydration to optimise use of water for irrigation
- identification of high-yield plants, which can be selected for providing seeds for future crops.

All these advantages contribute to higher and more sustainable production levels, while requiring fewer resources.

8.4 How do advanced networks help?

The data generated by phenotyping devices can be very large, with ground-based robots using multiple high-definition, stereoscopic and/or infrared cameras generating multiple-hundred Mbit/s of throughput.

5G SA's high bandwidth and low latency enables transmission of this high-throughput data to an edge computer located in the cloud. By undertaking the sophisticated image processing on cloud-based servers, rather than on the robot itself, the cost of the robots, and therefore the system as a whole, can be kept low. The low-latency performance allows the robot to be controlled in real time (ensuring it does not stray into the crops themselves, causing damage).

[14] Sources for this case study include:

https://www.hiphen-plant.com/solutions/

https://advancedwireless.org/outreach/ara-enabled-teleoperation-of-automated-phenobots/

https://chap-solutions.co.uk/blogs/five-benefits-of-digital-plant-phenotyping-for-farmers/#:~:text=Digital%20plant%20phenotyping%20can%20help,available%20synthetic%20pesticides%20and%20fertilisers.

https://www.ericsson.com/en/press-releases/6/2023/ericsson-and-pawr-light-up-5g-network-for-rural-agricultural-research

https://arawireless.org/research/agriculture-use-case/

8.5 What are the complementary use cases?

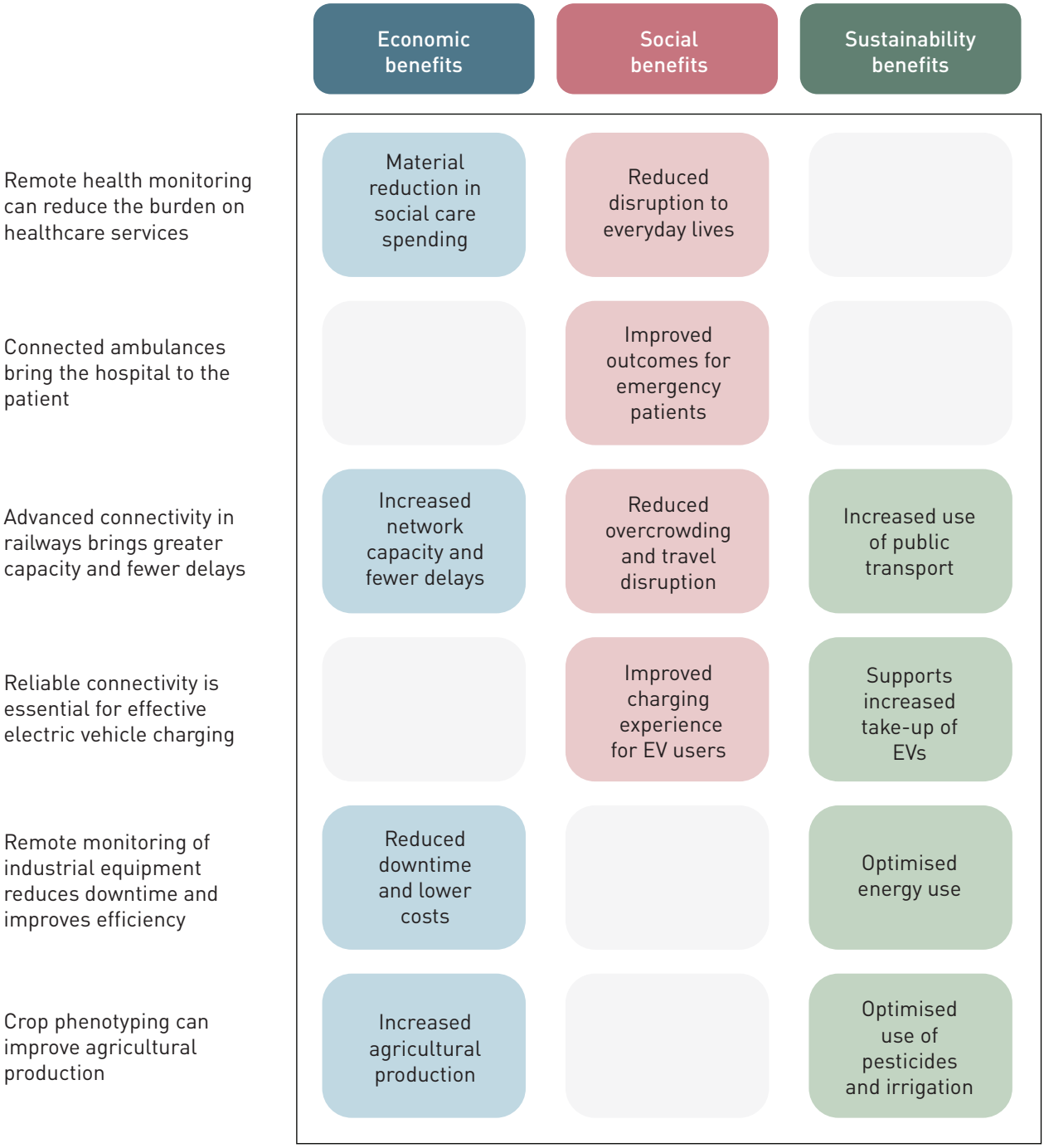
Once enabled in an agricultural setting 5G SA networks can support a range of complementary use cases, including:

- autonomous farming vehicles
- drones for real-time ultra-high definition video monitoring of crops and livestock
- farming asset tracking
- massive networks of moisture sensors
- predictive maintenance of farming vehicles and equipment.

9 Conclusions and recommendations

Advanced connectivity networks, including 5G SA and FTTP, have the potential to deliver a wide range of benefits for the UK across economic, social and sustainability themes, as showcased by our selected use cases (summarised in Figure 9.1 below).

Figure 9.1: Summary of benefits of selected advanced connectivity use cases [Source: Analysys Mason, 2024]



It should be noted that the use cases in this paper represent a small selection of the very wide range of possible applications that can potentially be supported by 5G SA and FTTP networks. As these networks are used for other use cases not covered in detail in this paper, the benefits described above, including across economic, social and sustainability themes, may increase.

For some use cases, it may be possible to enable a version of the use case with standard (not advanced) connectivity. In such cases, the use of advanced, rather than standard, connectivity makes the use case more compelling, often by increasing confidence that the network can reliably support the new application. This increase in confidence may be sufficient to facilitate a change of working or business practices, realising new benefits. Nevertheless, further analysis may be required of the costs and benefits of standard versus advanced connectivity, feeding into how advanced connectivity is sold on a commercial basis for specific applications, given the link between take-up and price.

In terms of timescales, all of the use cases we examined have the potential to be implemented in the near future. Our recommendations are focused around building on the current status situation to accelerate the adoption of these use cases:

- Regarding the healthcare-related use cases, useful next steps would be to build on the previous initial trials of remote health monitoring[15] and connected ambulances,[16] and move to more comprehensive and wide-area trials with selected NHS trust(s). This more comprehensive trial could aim to operate both use cases, and be targeted at NHS trust(s) with a high proportion of rural residents, where the benefits of the two use cases could be highest.
- The advanced connectivity use cases examined for the rail network can build on Network Rail's existing Intelligent Infrastructure programme.[17] The existing network monitoring activities can be improved with the additional information provided by a 5G-enabled sensor network, allowing further gains in predictive maintenance. Regarding the implementation of virtual coupling, which can take longer to be implemented, stakeholders in the rail industry, including track and train operators and providers of advanced connectivity, should work together to identify and solve any operational, safety and regulatory challenges,[18] and to set a clear timeline for deploying the technology.
- The installation of EV chargers is ongoing, with a wide range of charging infrastructure providers setting up new sites, both on a commercial basis and on behalf of local authorities. Providers of advanced connectivity services should engage with EV charger providers to undertake detailed feasibility assessments for the use of 5G SA and FTTP to provide connectivity.
- There are already several providers of industrial remote monitoring services in the market, with a wide range of sizes of company taking advantage of the efficiency benefits. However, there is likely to be value in the UK government promoting the technology, so that more businesses are aware of its potential, in order to enhance the international competitiveness of the UK industry.
- Like the above-mentioned use cases, the next steps to unlock the benefits of crop phenotyping would involve progressing beyond the trials[19] that have already been conducted and using the technique on a larger scale. A natural next step would be to deploy phenotyping robots over multiple farms. There may be a role for government in providing financial support,

[15] https://liverpool5g.org.uk/health-social-care-testbed/

[16] https://www.wm5g.org.uk/wp-content/uploads/2021/07/Connected-Ambulance-Trial.pdf

[17] https://www.networkrail.co.uk/running-the-railway/intelligent-infrastructure/

[18] https://www.railtech.com/innovation/2022/08/02/how-virtual-coupling-can-bring-the-needed-rail-capacity-for-the-future/?gdpr=accept

[19] https://uktin.net/how-to-deploy-5G/agriculture

including towards the cost of the phenotyping system and towards extending the required 5G SA infrastructure to rural areas (at least on a targeted basis).

Across all the themes and use cases we have examined, we have found compelling reasons to make the most use of advanced connectivity networks. Both 5G SA and FTTP deliver increased quality of service compared to current networks, and have the potential to provide improvements to daily lives across a wide range of consumer, business and public service settings.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