Introduction

The deployment of private mobile networks has emerged as an important market. In fact so important that the market could – according to Arthur D Little¹ – be worth as much as €60–70 billion by 2025. This implies rapidly growing adoption among the 14–15 million potential sites for private LTE networks identified by Nokia last year in an interview with EnterpriseIotInsights².

The demand for private LTE (and increasingly, 5G) networks has been driven by the spiralling data requirements of modern business and government entities. Organisations of all types are combining connected systems with big data and analytics to transform operations, increase automation and efficiency, or to deliver new services to their users. Wireless networking with LTE enables these transformations to take place even in dynamic, remote or highly secure environments, while offering the scale benefits of a technology that has already been deployed worldwide.


The arrival of LTE-Advanced systems has delivered a step change in network capacity and throughput, while 5G networks have brought improved density (support for larger numbers of users or devices), even greater capacity again, as well as dramatic improvements to latency that enable use of mobile technology for time-critical applications.

In addition to companies looking to develop their own private mobile networks for the first time, there is a large base of potential customers who currently operate LMR/PMR private networks based on technologies such as TETRA, P25 and DMR. These customers - through the TCCA (see side box) - are demanding critical broadband services that are simply not available from alternative technologies and consequently, private LTE and 5G networks have the potential to eventually replace much of this market.

The exact number of existing private LTE deployments is hard to determine, as details are not often made public. GSA is aware of more than 150 private LTE deployments, but estimates the actual number of existing private LTE networks to be much higher than this, and to have grown quickly during 2019. We will be tracking deployments in the coming months, and reporting on the speed of the market’s evolution.

Benefits and buyers

The benefits of deploying private mobile networks based on LTE or 5G can include:

- security and data control: with full separation from wider public mobile networks.
- access to services: in locations not reached by public networks (improved coverage indoors, in remote areas, or in underground locations).
- flexibility: mobile networks can be used in dynamic environments where equipment needs to move about and where fixed cabling either gets in the way or is costly to reconfigure or relocate.
- improved quality of service: where licence-exempt technologies such as WiFi cannot meet an organisation’s capacity, availability, latency, failover, or throughput requirements. Mobility and coverage are key issues experienced by customers deploying WiFi networks.
- customisation: the parameters of the networks can be configured (and reconfigured) to meet an organisation’s exact specifications.
- integration with wider public mobile networks where services are required outside the private campus or regional network (only realistically possible through roaming onto a public mobile operator’s network).

Tracking Private LTE & 5G Networks

GSA is tracking developments and progress of Private LTE and 5G networks and will be adding details of networks to its GAMBoD database. This will be searchable for additional analysis of this expanding mobile networks segment.

Contact GSA for more information.
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Private mobile networks can deliver voice (including VoLTE or soon, voice over new radio), text, data and video services, and can be used to connect machines, sensors and devices (IoT) and computing systems, as well as people. As a result of substantial and ongoing work by 3GPP, private mobile networks can also support mission-critical communications requirements, making them suitable as legacy LMR/PMR replacements for government and emergency service organisations.

- The various capabilities and benefits listed above all combine to mean that private mobile networks based on LTE or 5G can offer advantages over all other means of connecting systems, including legacy technologies (such as PMR), alternative wireless technologies (such as WiFi), or cabled systems (including fibre).
- The types of organisations deploying private LTE and 5G networks are shown in Table 1.
- There are a number of approaches to deploying private networks. Organisations can build and operate their own networks, buy solutions from equipment vendors or systems integrators, or even buy private LTE-as-a-service from a public mobile operator. They can be deployed as standalone networks, or integrated/semi-integrated with existing public mobile operator networks. Some will build the network but outsource operation, maintenance or support.

### Table 1: Types of organisations deploying Private LTE and 5G networks

<table>
<thead>
<tr>
<th>Organisation type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ports and airports and other transport hubs</td>
<td>Expansive campus networks covering indoor and outdoor locations, high numbers of densely packed users or connected things and a very high security requirement</td>
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<tr>
<td>Power generation facilities</td>
<td>High security requirement, requirement to connecting multiple systems with a high density of sensors and actuators, often in more remote locations</td>
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<td>Manufacturers</td>
<td>Require high density, high capacity, low latency services, indoors and across campuses, to support Industry 4.0 initiatives</td>
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<tr>
<td>Neutral host companies</td>
<td>Often supplying mobile networks in locations not reached by public network operators (and sometimes to public network operators)</td>
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<tr>
<td>Sports stadia</td>
<td>Public networks are not typically configured to be able to meet the requirements of the high density of users, or to deliver the new real-time or near real-time virtual and interactive services that can be offered at stadia</td>
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<tr>
<td>Large enterprise campus networks, and conference centres</td>
<td>Require capacity and density to support large numbers or people and IT systems across campus networks and indoors</td>
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<tr>
<td>Mines and extractive industries (natural resources segment)</td>
<td>Typically in out-of-the-way or underground locations not served by public networks</td>
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<tr>
<td>Town and city networks</td>
<td>To support smart city initiatives with their multitude of applications and users, and high security requirements</td>
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<tr>
<td>Emergency services, government departments, civil contingency and critical national infrastructure operators</td>
<td>Need to upgrade their legacy networks with new, secure systems, with better data and video capability, that function even when public networks are not operational</td>
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<tr>
<td>Utilities</td>
<td>Need to upgrade highly secure national scale control systems and networks to create smart electric, gas and water grids</td>
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<tr>
<td>Railways</td>
<td>Need to upgrade highly secure national scale control systems and networks to improve rail efficiency, safety, and maintenance</td>
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<tr>
<td>Shipping</td>
<td>Require on-board connectivity at sea for system telematics and control, and cargo monitoring</td>
</tr>
<tr>
<td>Healthcare</td>
<td>High density indoor environments, with stringent security requirements, and massive data transfer and analytic needs</td>
</tr>
</tbody>
</table>

**TCCA: Pioneered the addition of mission and business-critical services into 3GPP standards**

The Critical Communications Association (TCCA) – a global industry body with over 130 member organisations, established over 20 years ago to represent the needs of the critical communications sector ranging from governments to industry – was the first organisation of its kind to become a Market Representation Partner of 3GPP in 2013. Since then, it has been instrumental in driving the standardisation of mission and business-critical functionality and services into 3GPP LTE and 5G standard releases, as well as driving the global and regional harmonisation of broadband spectrum across a wide range of critical communication industries. The organisation reflects the contributions made by leading operators, professional users, manufacturers, consultants, academia and other key market participants that serve this vital and important sector of the mobile communications market.
Spectrum for private networks

Whatever the approach to deployment, an organisation cannot operate a private LTE or 5G network without access to sufficient and appropriate spectrum. Private mobile networks based on LTE or 5G can be deployed in licensed, licensed (sub-leased), shared, or unlicensed spectrum.

**Licensed spectrum** can be used where either a public operator provides a private network-as-a-service using the spectrum it has been allocated to run public networks, or where it sub-leases its spectrum to the private network operator, or alternatively where the national regulator has specifically allocated spectrum to be used for local private networks. In many countries, utilities and emergency services have historically been allocated dedicated slices of spectrum for their private networks (although many would argue they don’t have enough spectrum to support future requirements, and are considering hybrid models combining public services and private assets). With the arrival of 5G, regulators in many countries are considering, or are already allocating, more spectrum to enable private network deployment, with the aim of enabling and encouraging digital industry development.

**Shared spectrum** solutions enable the use of the same spectrum range, in a single geographic area, by more than one organisation.

**Unlicensed spectrum** solutions enable use of LTE or 5G to build a network using spectrum that is freely available for public use – such as the spectrum bands set aside globally at 2.4 GHz and 5 GHz that are already widely used for WiFi. Both LTE and 5G have development paths that have or will encompass all three options. LTE was originally designed to work in licensed spectrum, but a variety of technology developments have enabled support of unlicensed networking. LTE-U was developed as a pre-Release 13 technology pioneered in the USA and that has also been deployed in Thailand and trialled in a handful of other countries. It enables use of the 5 GHz unlicensed WiFi spectrum to augment the LTE network. Momentum in the market slowed after the emergence of the 3GPP standard for Licensed Assisted Access (LAA) which enables use of unlicensed spectrum alongside a licensed anchor band and which has now been deployed by operators in six countries. Other approaches include LTE WLAN Link Aggregation (LWA) and LTE WLAN radio level integration with IPSec tunnels (LWIP).

Multefire subsequently emerged enabling deployment of LTE networks in either shared spectrum environments or unlicensed spectrum (2.4 GHz and 5 GHz globally, and 800/900 MHz and 1900 MHz regionally). Citizens Broadband Radio Service (CBRS) is a blended approach being developed in the USA. Access to the spectrum is prioritised for government/military users and after them, for Priority Access Licensed (PAL) users (organisations that have acquired one of the many regional ten-year licences in spectrum auctions) with everyone else (General Authorized Access (GAA) users) able to request access dynamically to use the spectrum via approved SAS (spectrum access server) operators. Initial deployments using GAA spectrum have been authorised. Full CBRS implementation awaits the PAL auctions, expected during 2020.

Meanwhile 3GPP is working on study items looking at the extension of 5G to work in unlicensed bands. Studies under 3GPP Release 16 include work items looking at support for 5G NR in unlicensed spectrum (NR-U), encompassing support for licensed-assisted access NR-U (using anchor channels in LTE or 5G NR) and for stand-alone NR-U (with no LTE or 5G NR anchor). The studies also cover use of unlicensed spectrum at 6 GHz, to complement the existing spectrum at 5 GHz.

While use of unlicensed spectrum offers benefits, it is the case that many organisations are concerned about the risk that they won’t be able to achieve the required deterministic system behaviour, availability and performance using unlicensed or shared spectrum solutions, meaning that dedicated spectrum is required too.
National spectrum plans for private networking

As already mentioned, many countries have allocated dedicated frequency ranges for the operation of utility or emergency service networks. But with growing demand for networks to support IoT, smart city, mission critical, government and Industry 4.0 applications, regulators in some countries have decided to (or are exploring the possibility of) setting aside much more spectrum, either on a dedicated or shared basis, for local private LTE and 5G networks.

Recent examples of spectrum initiatives related to private networking are outlined below (non-exhaustive list).

**Mini case studies:**

In September 2019, JMA Wireless announced deployment of a private LTE network using CBRS spectrum for American Dream, a complex of over 450 shops, entertainment experiences and amenities comprising approximately 3 million indoor square feet, 600 outdoor acres, and serving 40 million visitors annually in East Rutherford, NJ, USA. The initial deployment focuses on delivering private LTE services outdoors to support traffic management, parking and wayfinding information systems, with indoor deployment and use-cases planned to be introduced during 2020. Other applications to be supported by the CBRS network include video cameras, digital displays, vehicle connectivity and IoT for facility operations. JMA’s XRAN, a 100% virtualised, software baseband running on standard Intel Xeon servers, enables CBRS private and dedicated use spectrum surrounding the complex. The deployment is one of the nation’s first Federal Communications Commission (FCC) authorised commercial systems using the new CBRS shared spectrum at 3.5 GHz.

**Belgium:** In December 2019 BIPT launched a consultation on a draft bill and three draft royal decrees concerning among other things, the possibility of authorising local private networks using 4G or 5G in the 3800–4200 MHz band.

**Chile:** A public consultation was launched in October 2019 on the use of 5G for private networks. Envisaging deployments in sectors such as mining, ports and agribusiness, the consultation covers suitability of different spectrum bands for private 5G networks, including the 1700 MHz, 2100 MHz, 3500 MHz and 28 GHz bands, as well as details such as bandwidths and licence timeframes for the spectrum, expected to be allocated through public tender. The consultation closed in November 2019 and on 28 November SUBTEL identified the 3750–3800 MHz range for the deployment of private networks using 5G NR, for future assignment.

**France:** At the end of March 2019 applications were closed for requests to run 5G trials at 26 GHz. The French regulator ARCEP accepted 11 schemes backed by public and private network operators. The various private network projects include inter alia deployment of a 5G network at the National Vélodrome in Saint-Quentin-en-Yvelines, a network at Lyon Part-Dieu station offering both public and private 5G services (the latter to enable station management and train telematics) and a network at The Grand Maritime Port of Le Havre for smart grid and logistics applications.

In May 2019, ARCEP opened up the possibility of wider private use of TDD spectrum at 2.6 GHz (2575–2615 MHz) for very-high-speed mobile networks (Air France KLM has already been trialling private LTE in this band for a number of years). Then in September, after a public consultation, it confirmed that it would be allocating the spectrum on a regional basis in order to improve broadband coverage for enterprises. Enterprises must express interest in using the spectrum, which will either be allocated (in the case of no competition for the spectrum) or ARCEP will determine a (possibly competitive) system of allocation.

ARCEP has also opened the possibility of private network deployment in C-Band spectrum. In July 2019, it launched a consultation on the terms and conditions for allocation of 310 MHz of spectrum in the 3490–3800 MHz band. These include commitments to meet all reasonable requests from enterprise and public sector organisations for the supply of services, either (at the operator’s discretion) through the supply of services on its own network, or through sub-licensing of the frequency on a geographically limited basis.

**Germany:** Germany’s regulator, Bundesnetzagentur, has drawn up application procedures for use of the 3700–3800 MHz band for local and regional 5G networks, with applications open from November 2019. Stating that it wants Germany to be a pioneer in Industry 4.0, in addition to industrial users, the regulator anticipates the spectrum being leased out by organisations in the agricultural and forestry sectors. Frequencies can be used immediately after allocation. The right to apply for spectrum derives from ownership or from another legal right to use the associated land, and fees are related to size of the geographic area covered by the licence, the amount of spectrum allocated and the duration.
The regulator has also launched a consultation – closing in February 2020 – on the assignment of spectrum at 24.25–27.5 GHz for local applications. The 24.25–26.5 GHz range is proposed for 5G small cell and FWA applications with spectrum at 26.5–27.5 GHz proposed for local land-related applications (again with industrial, agricultural and forestry users in mind).

Hong Kong: In July 2019, the regulator OFCA announced that it would be making 400 MHz in the 27.95–28.35 GHz range available for Localised Wireless Broadband Licences (using 5G or other advanced mobile technologies) on a geographic-sharing basis. It opened up applications for assignment of the shared spectrum later the same month.

OFCA has also stated plans to assign spectrum at 617–698 MHz and 703–803 MHz for indoor mobile services in 2020, with the spectrum available from 2021 at the earliest.

Japan: In December 2019, the Ministry of Internal Affairs and Communications began accepting applications for local 5G licences. The spectrum available spans 28.2–28.3 GHz and can be used within the applicant’s own building or on its own land to provide broadband fixed wireless services. National carriers are not eligible to apply, as the spectrum is not intended to supplement national carriers’ existing holdings. MIC also stated it would consider allocation of spectrum at 4.6–4.8 GHz and 28.3–29.1 GHz for local private services in the future.

(In 2017, Japan also made the 1.9 GHz band, Band 39, previously used for PHS and DECT available for private LTE networks as a shared band.)

Luxembourg: In line with its 5G strategy, in May 2019, Luxembourg launched a public consultation on the use of spectrum in the 3400–3800 MHz range. Spectrum at 3420–3700 MHz is intended for deployment of national networks. Spectrum at 3700–3800 MHz (which will be the subject of a separate consultation) is intended to be licensed for local applications.

Malaysia: In January 2020, the MCMC stated that spectrum at 26–28 GHz will be assigned in two parts. Spectrum at 24.9–26.5 GHz will be tendered (beauty contest) to licensees on a national basis. Spectrum at 26.5–28.1 GHz will be assigned on a first-come, first-served basis for the deployment of local/private networks ‘for industrial and enterprise services and applications for, but not limited to, healthcare, ports, transportation, manufacturing, agriculture, public safety and smart city projects’.

Netherlands: The government of the Netherlands intends to make spectrum at 3500–3700 MHz available from September 2022. Spectrum at 3400–3450 MHz and 3750–3800 MHz is intended to be made available for local use from 2026. Spectrum at 3450–3500 MHz and 3700–3750 MHz is already used and currently protected for national security reasons.

The Netherlands’ Digital Connectivity Action Plan foresees the use of spectrum at 26 GHz either for a very large number of local permits or for shared use from 2020. Stakeholder consultations are underway.

New Zealand: Spectrum at 2.5 GHz (2575–2620 MHz) is available in New Zealand for local or regional Managed Spectrum Park (private) licences (often for regional wireless broadband services). Eighty licences were awarded in 2009 after an initial round of applications. Subsequent licences have been made available on a first-come, first-served basis, with a number of licences awarded during 2019. Licences last for six years. There are limits on geographic coverage of licences held by any single organisation.

Norway: The Norwegian regulator Nkom is considering a joint assignment of various spectrum bands in 2021, two of which – the 2300–2400 MHz band and 3600 MHz – are under consideration for use for allocation to local/regional permits.

Poland: In April 2019 Poland launched a consultation about the amount of spectrum to be made available at 3400–3800 MHz, with two options: a) 200 MHz in four lots of 50 MHz or b) 400 MHz (four national lots of 80 MHz plus 80 MHz for local use). In December, it announced a new consultation on the details of an auction of four lots at 80 MHz. Local use details had not been released at the time of writing.

Slovenia: In May 2019, Slovenia published its national spectrum strategy, with request for comments. Following the consultation it will revise and seek governmental approval for its plans which include auctions of spectrum across various bands and which envisage setting aside a portion of spectrum at 2300 MHz and at 3400–3500 MHz for local use (including for private use).

Sweden: PTS intends to enable local permits for the use of spectrum in the 3720–3800 MHz range. These will be awarded and managed through an administrative process.

Mini case studies:

Mercedes-Benz, working with Ericsson and Telefonica, has been constructing a private 5G network at its Factory 56 car plant in Southern Germany. As part of the project, announced in mid-2019, all the production systems and machines at the new-build plant will be connected and operated by 5G. The network, which is managed by Ericsson on behalf of Telefonica, is expected to deliver Gigabit data rates and ‘almost real-time’ latency, that Mercedes-Benz stated will make its factories smarter and more efficient, opening up ‘completely new production opportunities’. Initial applications will be factory automation and use to guide autonomous vehicles.

Siemens, working in collaboration with Qualcomm has established a proof of concept project at the Siemens Automotive Showroom and Test Centre in Nuremberg. The partners have deployed a private 5G stand-alone network in the 3.7–3.8 GHz band to research the capabilities of 5G stand-alone networks for industrial applications. Siemens provided the industrial set-up (including the control systems and the IO devices) while Qualcomm provided the test network and equipment. In announcing the PoC Siemens stated that industrial 5G is ‘the gateway to an all-encompassing, wireless network for production, maintenance, and logistics’. Siemens has been reported in the press as having applied for local licences at six of its factory sites in Germany.

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Mini case studies:
West China Second University Hospital in Sichuan Province has announced a private 5G network deployed in collaboration with Huawei and China Mobile. The 5G network, augmented with mobile edge computing facilities has been used to showcase a variety of new applications including a hospital management system that incorporates data about patients, waiting times, asset location, and live video camera feeds to provide a visual smart hospital management system. This will encompass a 5G and AR system enabling parents to see their prematurely born babies in intensive care (where physical access is restricted), neonatal monitoring in ambulances in transit and 5G-enabled guidance robots for hospital visitors.

Mini case studies:
Zaventem Airport in Brussels has contracted Nokia and Citymesh to deploy a private 5G-ready network. The network, which is scheduled to be ready for use by the end of March 2020, is expected to enable optimisation of the airport’s operations and accelerate digital innovation. The airport intends to use the increased capacity of its new network to deploy a variety of new technologies including IoT systems, automated vehicles, mobile safety systems and track and trace technologies. In a first phase, the 5G network will provide outdoor connectivity. A second phase will deliver 5G services indoors.

UK:
Following consultations, in July 2019, Ofcom announced plans to initiate spectrum sharing with localised licensing of key spectrum bands. Its aim is to open up use of the spectrum to private network operators such as enterprises and utilities. The spectrum that will be available through local licences includes:

- **3800–4200 MHz**
- **1781.7–1785 MHz/1876.7–1880 MHz** (called 1800 MHz shared spectrum by Ofcom)
- **2390–2400 MHz** (called 2300 MHz shared spectrum).

The spectrum is available on a coordinated first-come, first-served basis. Ofcom indicated that localised licences can be applied for immediately.

Ofcom has also decided to enable localised access to spectrum in the 26 GHz band (24.25–26.5 GHz) available on a shared-spectrum basis, but only for indoor use. (Spectrum in the 26.5–27.5 GHz range is used by the military. Ofcom will continue to review possible ways of making this spectrum available in the future.)

USA:
There are dozens of companies planning CBRS deployments in the USA, including for private enterprise purposes. Initial commercial deployments of CBRS were given the go-ahead in September 2019. Full-blown commercial deployments were authorised in January 2020. Those deployments may only use General Authorised Access (GAA) spectrum. An auction of Priority Access CBRS spectrum at 3.5 GHz is scheduled for June 2020.

In December the FCC proposed new rules to open up spectrum at 3.1–3.55 GHz for shared use (with commercial and military users sharing the spectrum) and consequently to remove and relocate the non-federal users in the 3.3–3.55 GHz portion of the band, which currently is allocated for non-federal secondary radiolocation services and amateur use. It also asked for comment on mechanisms for relocating non-federal users in the 3.1–3.3 GHz band.

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Figure 1: Countries allocating or considering allocating spectrum for local private 5G networks
Summary

A wide range of market participants is actively engaged in developing and delivering solutions for private LTE and 5G networks. With so much opportunity and so many regulators planning initiatives to make spectrum available for LTE and 5G private usage, we can expect significant market evolution in the next couple of years. This is the first GSA paper tracking this sector. More will follow during 2020.

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