Private LTE Networks & CBRS

Democratizing cellular for enterprise: New uses, new rules, new stakeholders

A Disruptive Analysis thought-leadership eBook

Disruptive Analysis

iBwave

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Private LTE networks come of age

Private and enterprise cellular: Executive Summary

Private cellular networks are not new. They are already used at some mining sites, oil and gas extraction facilities, military bases, and other locations where public cellular carrier coverage is absent or unsuitable. But they are rare – maybe a few hundred worldwide, often designed and deployed at considerable cost by specialist providers and managed by expert staff.

This situation is about to change. We are likely to go from 100s to 1000s – and perhaps even tens of 1000s – in the next few years. We are seeing "democratization" of private LTE (and soon, 5G), with localized spectrum allocations, cloud-based core networks, and a rapidly-growing ecosystem of vendors and integrators. Many governments and regulators are coming around to the view that enterprise (or "vertical") requirements need specialized solutions, whether that is for industrial sites, rural areas or deep in-building.

The US market's new CBRS spectrum band, and its fast-expanding array of enthusiastic suppliers and service providers, exemplifies this trend. Compared with other initiatives, it has amassed an impressive cross-spectrum group of supporters, from enterprises, to device/silicon vendors, to integrators and, importantly, the traditional carriers and cable MSOs. It spans both enterprise and consumer-focused use-cases. While not every proposed CBRS use-case may prove viable in the short term, it probably has enough momentum to make the overall concept successful. Other countries are watching, and evolving the CBRS approach, or at least benefiting from the scale, experience, and awareness curves.

This feels like an inflection point.

But it would be wrong to characterize this as negative for the traditional cellular carriers and MNOs (mobile network operators). While they do face some risks of cherry-picking by specialist MSPs (managed service providers) or enterprises' direct self-ownership of private LTE, they have a range of new opportunities of their own to exploit.

At one level, telcos are in a good position to install and manage private LTE networks for businesses – much as they did with enterprise phone systems (PBXs). They can offer connectivity and backhaul, managed services for components such as multi-tenant core networks or SIM lifecycle management, and so on. There will also be a desire for some private networks to interconnect with the public cellular domain, with various hybrid or roaming options. And in future, they may be able to combine on-site private cellular networks with 5G's new "network-slicing" capabilities, or perhaps telco-managed edge computing services.

Despite many assertions about an impending battle between private LTE and Wi-Fi for enterprise sites, this is being overhyped. Wi-Fi will continue to be ubiquitous, especially with the new capabilities of Wi-Fi 6. And while private LTE is hoping for 1000s or 10000s of sites, Wi-Fi addresses tens of millions. The specific applications addressed by private LTE are largely those that Wi-Fi cannot, such as mobility or outdoor/indoor coverage on a site.

Certain uses that Wi-Fi struggles with may be better served with private cellular. For example, on-site voice communications or time-sensitive industrial connectivity for machines may be better served with private cellular. But the main rivalry is between Private LTE and fiber, industrial ethernet, proprietary wireless, or DECT and other cordless and PMR systems, not Wi-Fi. Less clear is the degree to which Wi-Fi and private cellular systems will be integrated and converged.

The next sections of this eBook examine the following topics:

- The types and scale of private LTE and 5G networks
- Motivations & use-cases for deploying private LTE / 5G
- Where CBRS fits in
- The role(s) of mobile carriers
- The new Private LTE/5G value chain
- The fit with Wi-Fi: complementary, substitutional or orthogonal?
- Key technology & deployment elements and challenges
- Conclusion and forecasts

The scale & scope of private cellular networks

Definitions

One of the challenges in defining and assessing the market for private cellular is the diversity of network types and use-cases that are being deployed compared to the "traditional" national MNOs.

That said, the 3GPP's term "non-public network" is not particularly useful, as various current "public" networks (defined as having a government-issued PLMN ID) are oddities such as railway operators, government agencies, MVNOs, and wholesalers.

Many in the mobile (especially 5G) world refer to "verticals", "enterprise" or "private networks" synonymously. Yet there is a lack of clarity about what these terms actually mean, especially when topics such as radio spectrum and broader government industrial policy are blended into the discussion.

They broadly cover three options:

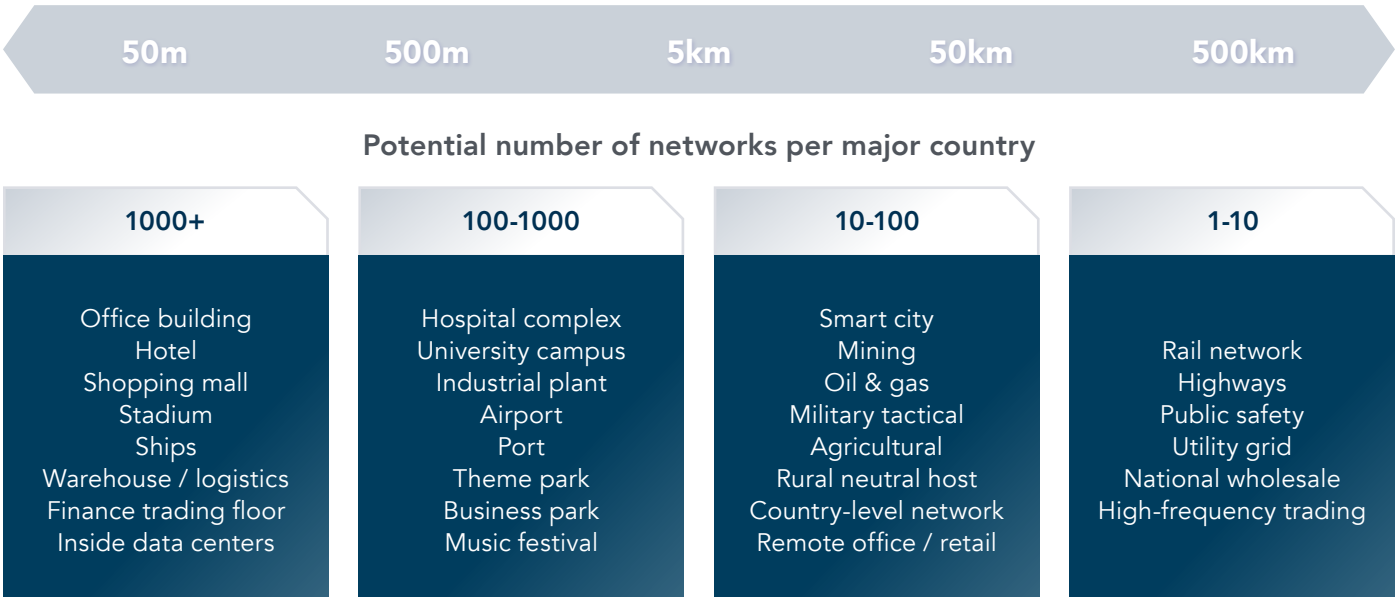
- Mobile network services and applications sold to, or used by, industrial and enterprise customers
- Mobile networks optimized, extended, or virtualized for industrial and enterprise requirements
- Mobile networks built exclusively for, or owned by, industrial companies and other enterprises

Here, we are defining "private" networks as business-focused cellular networks where the enterprise has some degree of ownership or control over the infrastructure, operation, services – and, sometimes, the physical radio network itself. This mostly fits the second and third bullets on the list above.

Some are standalone networks that are entirely isolated from public mobile networks. This is quite common with existing deployments in areas for mining, oil, and so on.

As the opportunity broadens, we will also see more hybrid designs, which use dedicated infrastructure / management, alongside shared radio or core-network elements provided by an MNO.

Private LTE / 5G networks will be deployed at a wide range of scales



Source: Disruptive Analysis

It is worth stressing that private LTE deployments vary widely in scale. They can be nationwide networks (for example, for utility grids), or localized, such as for an individual factory or hotel.





4G or 5G?

This eBook focuses on Private LTE, but it is worth noting that there is also huge interest in some sectors about leapfrogging straight to Private 5G. Promises of ultra low latency (URLLC) connections and sophisticated "slicing" techniques make this an enticing possibility for enterprises.

However, when these wishes are scrutinized, it rapidly becomes clear that they will depend on technologies that are still pre-standardized. Standalone 5G cores, time-sensitive network (TSN) technology, indoor mmWave radios, and easily-controlled network slicing will only mature around 2023-24. Also, many of the most demanding applications tend to relate to the most conservative enterprises, with the longest planning time-scales and testing rigour. We should not expect URLLC 5G to be deployed at scale in factories, hospitals, or utility networks until the middle of the 2020s.

Disruptive Analysis expects most deployments over the next 3 years to be 4G, for which the core elements are readily available although they will have easily-upgradeable elements for the next step. It is worth noting that initial versions of CBRS products are based on LTE, although 5G specifications should be available soon as well.

Motivations & use-cases

Rationales for Private LTE / 5G

As noted in the introduction, there are many types of private network being deployed or designed. Every vertical and every site will have its differences. Together, they span a broad array of applications, organization types, and underlying rationales. However, some general themes can be seen. The key business reasons for considering private cellular networks include:

Coverage: Lack of optimal 4G or future 5G coverage from public MNO networks at relevant sites (and a lack of willingness, time, and budget to improve it). This is important for:

- Coverage in large buildings, such as factories
- Rural and remote areas, such as agricultural regions, mines, and oil & gas sites
- Alongside roads and railway
- Industrial sites such as chemical plants, quarries, ports etc.
- Islands and offshore facilities

Cost: Desire to avoid being locked-in to specific MNOs or paying per-use for connectivity that could more cost-effectively be delivered via Capex rather than Opex. Also:

- A desire to replace legacy equipment with modern, multi-functional and cheaper alternatives – while keeping historical levels of performance and migrating gradually over time from one to the other. This includes industrial network protocols, DECT and private two-way radio systems, and wired networks in offices.
- Ability to create flexible and reconfigurable workplaces, without the need to re-wire fiber connections. This is an important element of Industry 4.0 and Smart Factories.

Control: Localized and optimized installations of cellular networks enable better visibility and management of key performance characteristics such as throughput and latency. They also permit improved security and compliance – for instance, ownership of encryption and identity credentials, or insistence that sensitive data does not go off-site. Also:

- Accountability and liability for downtime or other problems. Few MNOs are prepared to offer cast-iron SLAs with financial guarantees or recompense for losses.
- Longevity matters – for instance, utility companies want to invest in assets with 10-30-year life. They do not want continued demands to upgrade to 6G, 7G, and 8G with older networks being switched off.
- Ability to develop customized or modified versions of the technology, for instance combining 4G/5G radios with a non-3GPP core, using new forms of authentication or identity technology, and so on. Traditional operators are unlikely to be interested in one-off customizations unless at very large scale (e.g. for national public safety networks).
- Unwillingness to rely on unlicensed spectrum (and Wi-Fi in particular) for sensitive or business-critical systems.

Compensation: Some businesses want private LTE networks as a profit center in its own right, or to form part of other products and services. There may be a desire to add Wi-Fi style local free access, offer wholesale propositions such as neutral-host sharing, or create localized wholesale / concession models (e.g. venue-specific or time-limited MVNOs).

Numerous reasons for enterprises wanting to adopt private cellular

COVERAGE

- In-building
- Rural
- Industrial
- Offices
- Road / Rail
- Utility
- Metro areas
- Military / Govt.

CONTROL

- Security
- Sovereignty
- Customized
- Beyond Wi-Fi
- Deployment
- Lifecycle
- Mobility
- Private QoS

COST

- Replace legacy LMR
- Factory 4.0
- Fiber replace
- Avoid carrier per/GB fees
- Own IoT connectivity

COMPENSATION

- Productivity
- Private SIMs
- Roaming
- Local MVNO
- Govt. funding
- Local FWA
- MNO offload

Source: Disruptive Analysis

Vertical sectors & use-cases

Much of the historic focus of private cellular has been around wide-area operations such as railways and utility grids, or remote industrial locations such as mines or oil rigs. These will continue to grow in adoption, but a wide variety of other sectors will also start to deploy private LTE or 5G capabilities.

Multi-dwelling units (MDUs), retail sites, hospitals, warehouse & logistics centers, transport hubs, universities, hotels, and shared-office spaces and others will diverge \in terms of wireless requirements, and the network infrastructure required to support them.

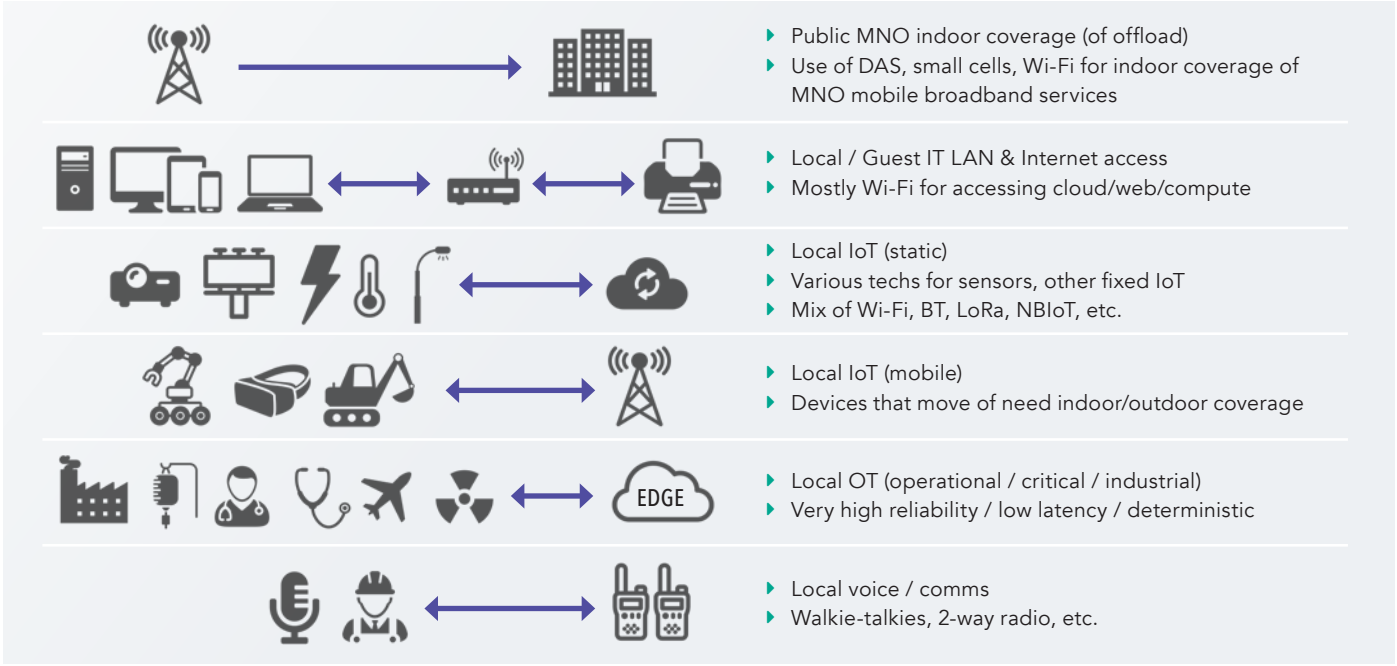
Disruptive Analysis expects to see "vertical-specific" integration and implementation to come to the fore, including domain specialism within carriers' enterprise teams, and in some cases the emergence of specialist managed-service providers (MSPs).

Behind the business case for enterprises deploying private 4G/5G are the more specific application-level uses. The key application "tenants" on a private cellular network are connections for:

- Indoor or on-site coverage for public MNOs' subscribers. In the past this would typically have involved a system with the telcos' radios as "signal sources" connected to a shared set of antennas and cables (DAS – distributed antenna system). Now, some venue owners want to deploy their own radio networks, with MNOs acting as roaming partners or wholesale customers.
- IT/LAN connections: Localized wireless access to IT resources (e.g. servers, printers), corporate LAN/WAN infrastructure and normal Internet access for cloud and compute.
- Static IoT devices such as lighting, ventilation, access-control security systems, environmental sensors, pipeline monitoring, and so forth.
- Moving IoT devices such as vehicles, robots, wearables and drones. A category here is the use of "geofencing" so that dangerous machinery is halted when humans get too close to it.
- Operational technology (OT) with high reliability and predictable latency requirements, including business-critical production systems in manufacturing, safety-critical machinery, or public-safety assets.
- Voice connectivity over a local or wide area, that encompasses two-way radios, push-to-talk systems, public address, and so forth. This may also include critical/safety-related voice systems with priority pre-emption rights.

The exact nature and mix of these will vary by company and marketplace – a key feature of private LTE / 5G is a greater level of heterogeneity than is seen on public telecom networks. In many ways, this is closer to the range of applications seen on enterprise Wi-Fi, which can support anything from meeting-room videoconferencing terminals to industrial machinery controls.

Key use-cases for indoor wireless networks



- Public MNO indoor coverage (of offload)
- Use of DAS, small cells, Wi-Fi for indoor coverage of MNO mobile broadband services
- Local / Guest IT LAN & Internet access
- Mostly Wi-Fi for accessing cloud/web/compute
- Local IoT (static)
- Various techs for sensors, other fixed IoT
- Mix of Wi-Fi, BT, LoRa, NBIoT, etc.
- Local IoT (mobile)
- Devices that move of need indoor/outdoor coverage
- Local OT (operational / critical / industrial)
- Very high reliability / low latency / deterministic
- Local voice / comms
- Walkie-talkies, 2-way radio, etc.

Source: Disruptive Analysis

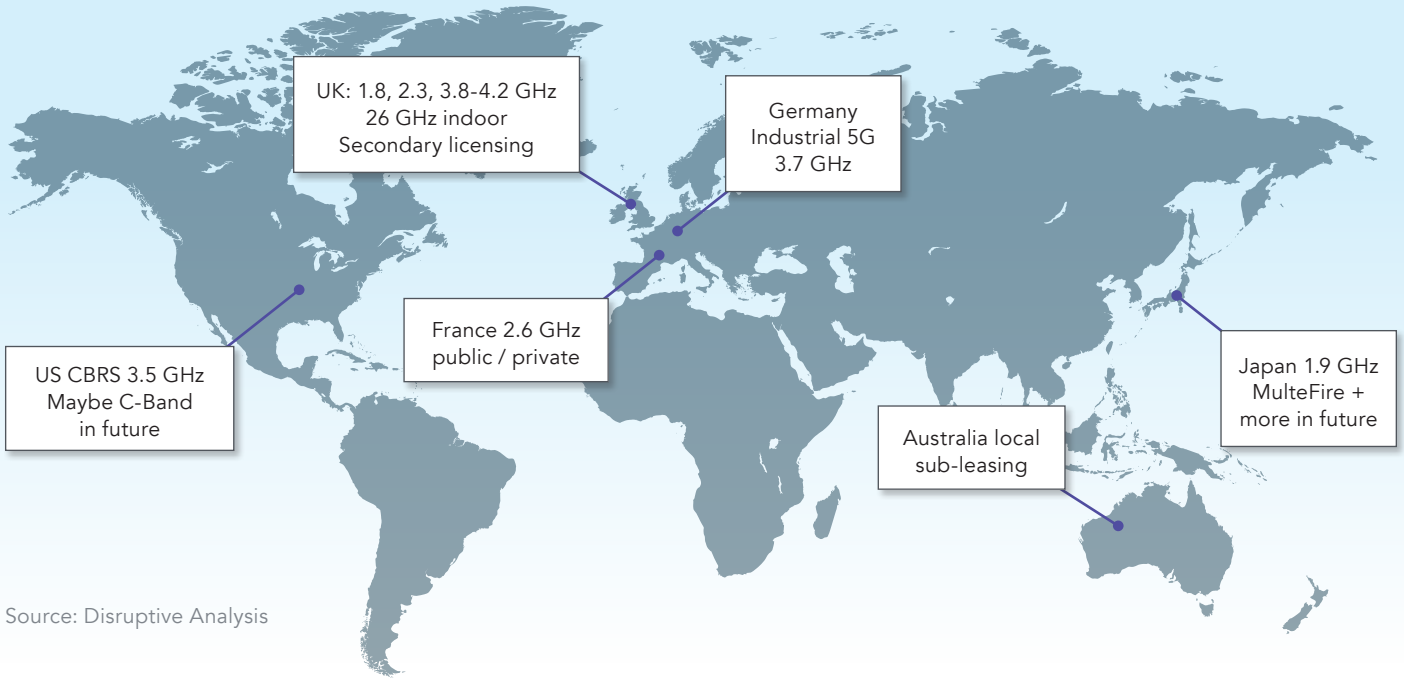
Local spectrum & CBRS: A critical market catalyst?

Except in cases where mobile carriers provide a dedicated local system or network "slice" (see next section), a critical element for enterprises building private LTE or 5G networks is access to suitable spectrum. While private Wi-Fi and other networks have long been created with (free) unlicensed spectrum, this does not give the protections against interference that formal licensing enables – and which enterprise use-cases often demand.

In the past, localized spectrum licenses have been given for point-to-point fixed links, temporary outside broadcast & events – but not cellular networks for normal mobile users and businesses. In recent years, regulatory authorities have started to localize mobile licenses, which are suitable for covering enterprise sites or wide areas such as cities. There are various models emerging for this:

- Dedicated local licenses for specific areas or sites. Germany is releasing 3.7-3.8 GHz frequencies for private 5G networks at industrial sites.
- National spectrum allocations sub-leased by MNOs to enterprises operating in specific areas. This occurs in markets such as Finland and Australia.
- Spectrum-sharing models using "dynamic access" and a database-driven system for allocations. The US CBRS model (see below) is an example of this.
- Secondary licensing of national MNO bands for private use where they are not being used by the main licensee. The UK has recently adopted this model.
- Indoor-only permissions for using bands that avoid long-range interference with incumbent users. The UK is adopting this model for 26 GHz.
- Release of previous "guard bands" for unlicensed or "lightly-licensed" use, such as some 1.8 GHz spectrum in the Netherlands.

Globally, many regulators are adopting localized mobile spectrum allocations



Source: Disruptive Analysis

There are also discussions about making more wide-area spectrum available for mobile use in specialized verticals such as utilities.

CBRS in the US: A catalyst for change

Currently, the most interesting spectrum release (and associated business models) for Private LTE is the CBRS band in the US. This is between 3.55-3.7 GHz and has historically been used for naval radars and point-to-point links.

CBRS three-tier model for spectrum allocation

3550 - 3700 MHz

Protected Access Licenses (up to 70 MHz)	General Authorized Access (up to 150 MHz)

WIRELESS INNOVATION FORUM

3000 country-level territories

ALLIANCE cbrs

Source: Disruptive Analysis

It is now being released for wider use with a complex 3-tiered scheme. The US Navy retains priority in coastal areas, but only uses the band occasionally. The rest of the time, the spectrum is divided between 70 MHz of dedicated PAL licenses, in 10 MHz chunks, plus 80 MHz of general access (GAA) frequency, all allocated to county-sized areas. The general access expands to extra range, if all priority licenses (due to be auctioned in mid-2020) are not yet taken up.

A database-driven "spectrum access system", provided on a commercial basis by several companies, is used to manage resource allocation on a dynamic basis. SAS providers get input from coastal sensor systems, as well as CBRS user organizations requesting spectrum allocations.

Dynamic spectrum access is not new. A few countries have "TV white space" programs which allow access to spectrum left empty by broadcasters.

What makes CBRS (and its clunky commercial brand-name OnGo) different is the extent of the ecosystem exploiting this new band. The design of the system has enticed normally fractious constituencies to embrace it. Major carriers, cable MSOs, local ISPs, enterprises, chipset and device manufacturers, equipment providers, systems integrators, and software players are all involved. And while they have long debated the details of the scheme, there now appears to be critical mass, with initial commercial deployments having started in late 2019.

There are numerous use-cases for CBRS spectrum, including dedicated private networks for warehouses, improved indoor coverage serving different IoT use-cases to Wi-Fi, or new "neutral host" models that allow the building owner to act as a wholesale provider to carriers. Some commercial arrangements are still in early stages – will carriers really pay venue-owners in a similar fashion to roaming partners? But there are enough options – and a broad diversity of interested organizations, from airports to Las Vegas resorts – that innovations will occur.

Some CBRS use-cases are outside the scope of this report as they are predominantly outdoor, but are nonetheless interesting. Fixed wireless access and urban network "densification" (again, maybe with neutral-host models) are on that list.

CBRS use cases span indoor & outdoor domains

Indoor CBRS uses	Outdoor CBRS uses
Indoor cellular (one public network)	Fixed-wireless access
Indoor cellular (multiple networks)	Campus networks (e.g. ports, mines)
Private / enterprise cellular	Densification for macro 4G networks
Local IoT connectivity	Mid-band option for 5G networks
"MVNO onload" e.g. by cable MSOs	Rural private networks (e.g. AgTech)
Wi-Fi complement	Rural neutral-host networks
Neutral host / indoor wholesale model	MNO / MVNO hybrids

Source: Disruptive Analysis

What is the role of mobile carriers in Private LTE?

It is wrong to imagine that mobile carriers are going to be disenfranchised as enterprises ubiquitously build their own cellular networks. Carriers have many roles in private LTE and 5G, but these are rapidly changing. This will vary between:

- Large venues with many members of the public as visitors
- Offices with employees seen as potential groups of corporate-sponsored users
- Industrial and other "non-carpeted" sites, with potential for IoT connectivity or complex "vertical" solutions
- Multi-site companies, such as retail chains

Government, public-safety, utility and transport organizations with wide-area requirements for specialized or super secure networks.

In the past, carriers have viewed enterprises and business sites as "special projects". They have usually only helped to fund indoor or site-wide coverage in the most strategic locations, where their customers expect to find well-performing networks, such as stadiums and airports. Often, they have tried to use outdoor-to-indoor coverage, for example with siting antennas on nearby rooftops.

Depending on the market, MNOs have often tried to create indoor systems on an individual basis, negotiating with venues separately. In other markets there has been joint coordination to create cost-effective multi-operator installations. Otherwise, systems integrators have had to painstakingly create in-building designs, trying to sign up operators as well as possible.

One statistic about US installations of DAS systems suggested an average of 1.7 carriers' equipment is attached.

Operators have different strategies for public locations used by visitors versus enterprise offices where they hope to cut deals with the occupying company for employees working there. For locations such as HQ offices, some MNOs have agreed to install improved indoor / on-site coverage in return for major corporate contracts.

The shift towards 4G mobile broadband and the potential of 5G high-performance networks is changing the situation. This is partly because MNOs perceive potential revenue streams from connected vertical solutions, but also because 5G's frequencies make outdoor-to-indoor coverage worse than in the past.

Several operators are now pitching "campus networks" for 4G and 5G. These incorporate both localized and customized radio coverage, and more control for the enterprise by offering "private core" functions – perhaps physically locating systems on-site, or on a cloud platform in a nearby "edge" data center. This is also where the concept of "network slicing" crops up, although full versions of this require later versions of 5G standards and are mostly at the "labs" stage of development.

As these scenarios increasingly revolve around IoT systems and high-reliability, low-latency scenarios, we can expect radio designs to become more sophisticated. Disruptive Analysis believes that most telcos will focus on a few sectors – perhaps choosing to build expertise in the radio and application needs of hospitals, or retail, or industrial plants, or warehouses. They may build ecosystem partners to help fill in gaps in experience or deliver particularly complex solutions.

At the moment, nobody knows how successful carriers will be in offering such "managed" private LTE / 5G networks, or whether they have sufficient staff and flexible business models to do the required level of "mass-customization". The boundary between telco-run enterprise cellular, direct privately deployed/owned networks, and new classes of MSP is yet to be determined.

In theory, even in fully-private or MSP-led scenarios, the MNOs could also become platform providers for certain "layers" of the overall stack – perhaps number/SIM management, radio network operation and maintenance, or core-network-as-a-service.

There will also be various hybrids and nuances to all of this, such as private networks interconnecting with the world of public networks. It may be possible for users to roam between the two domains, for instance when a truck leaves a logistics facility with a local private network, and switches to the telco while on the road. This will require some form of interoperability agreement – and will also require both parties to be satisfied with security and regulatory arrangements.

The new private LTE / 5G value chain

Today, mobile networks have a straightforward value chain. MNOs obtain spectrum and licenses from governments; network infrastructure and software from major vendors and a few specialists; use contracted engineering companies for physical deployment and maintenance; and third-party tower and property owners for cell sites.

National MNOs sell retail network and content services to consumers and mostly standardized connections to enterprises. Some have growing IoT businesses, with vertical specialisms in areas such as connected cars. Some have limited wholesale units that do heavily-customized deals with MVNOs and MVNAs.

This value chain is now drastically changing with the advent of private and neutral-host networks, shared/local spectrum, the integration of IoT with many complex industrial processes, and the all-pervasive nature of Internet and cloud businesses.

The 5G world will look much like today's IT industry– heterogeneous delivery models, complex webs of strategic partnerships, "co-opetition", integrators and sub-contractors, OEM and white-label business models, and a broad array of service providers willing to move from adjacent domains into running private or shared networks.

We should expect to see more involvement from enterprise IT systems integrators, industrial systems (often "operational technology") vendors, specialists in critical-communications systems, Internet/cloud players, wireless towerco's, and larger property developer looking at the value derived from better connectivity in their buildings.

We may see a new breed of "Vertical Mobile Operators" – perhaps set up as arms of industrial suppliers, or which specialize in hospital connectivity, or MDUs.

We may even see individual enterprises with private LTE deployments looking to monetize their designs elsewhere – for instance, UK online retailer Ocado is turning into a warehouse automation firm, selling solutions that incorporate private cellular networks for control of hundreds of robots.

It is likely that many of these moves will fail to become mainstream. Others will face technical or commercial stumbling-blocks, or see rapid consolidation and merger/acquisition activity after a few years of fragmentation.

The new private LTE & 5G value-chain

Stakeholder group	Roles in era of 4G + national MNO networks	Additional roles on era of 4G / 5G local, national & private networks
MNOs	Spectrum ownership, network deployment & operation, consumer & B2B mass market services	Managed services e.g. core-aaS, network slices, vertical specialisms, tenants on neutral hosts
MVNOs	Consumer & business / IoT service creation / delivery, some with own core networks	Local spectrum, hybrid MNO/MVNO models, new enterprise MVNOs / SliceNOs / VenueMVNOs
Enterprise	Customers of B2B MNO services, use of private on site networks (Wi-Fi, proprietary, some cellular)	Local & some wide-area spectrum, private RANs & core networks, standards development, neutral hosts
TowerCos	Ownership of shared radio-network assets	Small cells-aaS, fiber, indoor systems, neutral hosts
Major network vendors	Provision of large-scale radio, core & transport networks, BSS/OSS and integration / operation	Private network deployment, integration & mgmt for verticals, spectrum mgmt services
Small network vendors	Small cells, niche core networks, indoor systems, planning & design tools, optical tool, optical / backhaul, NFV	Optimized products for private sues, e.g. easy deploy, cloud platforms, tools, a few with spectrum
Fixed / cable SPs	Backhaul & transport, some MVNO services	Hybrid networks, neutral host, vertical solutions
Cloud / Internet providers	Limited role in cell network provision historically	MVNO-aaS, local spectrum/networks, mobile +IoT+cloud APIs PaaS, edge computing
IoT / OT system vendors	Limited role in cell network provision historically	Industrial / process systems with integral 4G/5G, major automation & industry 4.0 projects
Venue / property Cos	Provision of indoor coverage systems & installation of MNO's signal-sources / cells	Local spectrum & neutral host networks, smart buildings & IoT, work with new classes of SP
Critical comms suppliers	Dedicated PMR / TETRA / P25 systems for industrial, transport & public safety users	4G & 5G critical comms for verticals & public safety, legacy system integration & migration
IT systems integrators	Limited role in cell network provision historically	Advisory work on connected verticals, cloud, etc.
Wi-Fi vendors and SPs	Some offload & converged network deployments	Some shift to local cellular e.g. CBRS + Wi-Fi hybrid
Govts & municipalities	Regulation, sites, some private cellular networks	Private networks for public safety, own networks for smart cities / regions, roads, neutral hosts

Source: Disruptive Analysis, STL Partners

Future in-building wireless networks may therefore need to adopt different economic models as well. Today, the biggest question is "who pays?" for in-building infrastructure. Soon we will be asking "what new revenue streams?".

The implications for Wi-Fi

Some observers assert that private LTE/5G, and indeed 5G generally, poses a risk to Wi-Fi, and that use-cases could see applications and value shift away from it.

Disruptive Analysis strongly disagrees with this assertion, on several grounds.

The main point is that Wi-Fi is primarily used in enterprises for "IT" and "LAN" purposes – locally connecting laptops, tablets, printers, and similar devices. It is the wireless alternative to Ethernet LANs, and directly fits into enterprises' IT systems, security mechanisms and workflows. Most of these devices do not have cellular radios, and the economics of design mean few will change in future. Even new classes of products such as AR/VR headsets are almost always Wi-Fi based.

This holds true for both enterprise office sites, and public venues like airports or universities. Travellers or students with laptops almost exclusively connect with Wi-Fi.

Smartphones are different and can use cellular or Wi-Fi – or indeed, both at the same time. There is a complex array of behaviours that determine what a given user will prefer.

While private cellular networks may improve speed, latency and cost of data, not all users may be willing and able to connect to them–complexities of user journeys with SIM/eSIM for a local network can occur. Furthermore, psychological and behavioural drivers make many people feel that Wi-Fi is "different" to cellular. This may change over time, but it will be slow if it happens at all.

The situation with IoT is a bit more complex, and we will see different trends between:

- Consumer and inexpensive devices like watches and smart speakers
- Static IoT devices like heating, air-conditioning, security cameras and access-control
- Moving IoT devices such as robots, drones, or AGVs (autonomous guided vehicles), as well as large equipment such as excavators.
- Operational technology (OT) machines such as conveyors or industrial process controls, with very tight "deterministic" latency needs, and safety-stop functions.

The new private LTE & 5G value-chain

	Wi-Fi	Public 4G / 5G	Private 4G / 5G	Other
MNO indoor coverage (esp. phones)	Wi-Fi offload from cellular		Neutral host	
Local IT / Internet LAN (laptops, phones, etc.)	Key Wi-Fi use case today	Very limited scope	Limited scope	Fiber, Ethernet
Local IoT (static)			Smart buildings	BLE, Zigbee, Ethernet
Local IoT (moving)				Niche Wireless
Local OT (industrial)			Industry 4.0	Fiber, niche wireless
Local voice radio				P25, TETRA, DECT
Sector-specific uses				

some use today/tomorrow | unlikely in near future | unrealistic | future key target | common today

Source: Disruptive Analysis

The more devices that are dangerous or fast-moving, the greater the applicability of cellular technology rather than Wi-Fi, as unlicensed spectrum risks interference and congestion.

Overall, the Venn Diagram overlap of Wi-Fi vs cellular for enterprise connectivity is quite narrow – whether that's for 4G or 5G, and private or semi-public "sliced" networks. The extra capabilities of Wi-Fi 6 over previous versions puts even more clear water between them. While vendors and standards bodies are trying to talk up 5G-based LANs, this is wishful thinking. Given billions of legacy devices, unexpected shifts will be slow and easy to respond to.

Where we will see integration between Wi-Fi and private cellular is at the infrastructure level. We may see common designs, backhaul and fiber deployments – and Wi-Fi firms adding cellular small-cells to their portfolios. This type of convergence is already being seen among the CBRS vendor community.

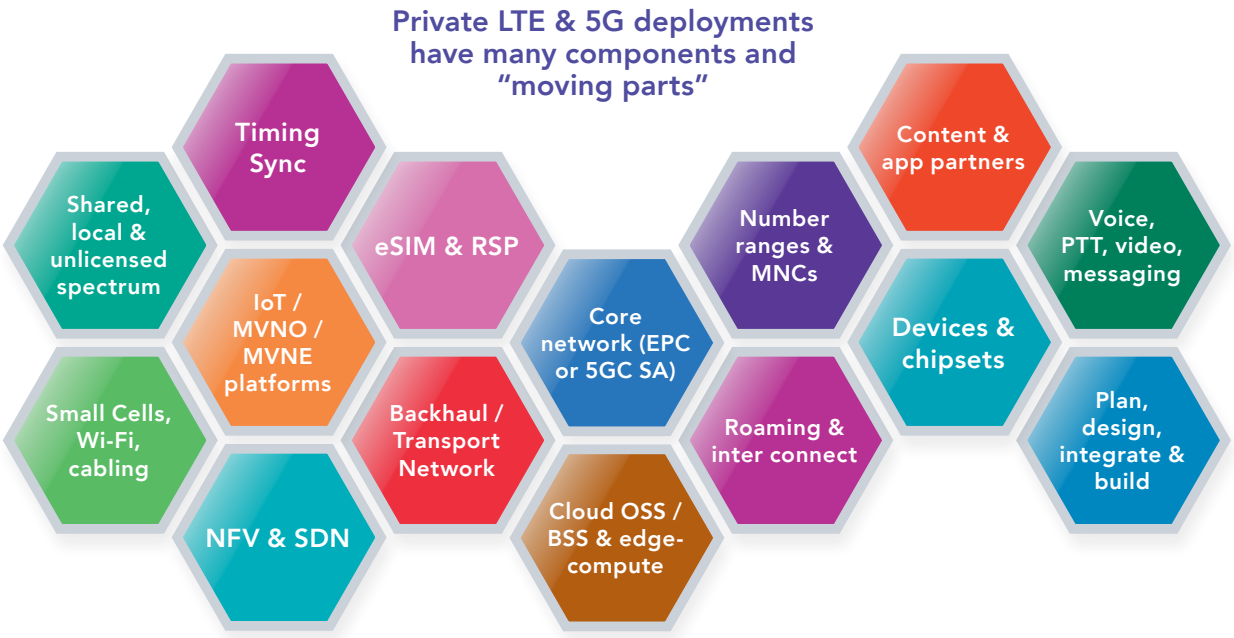
Deploying private LTE: technology & challenges

It would be wrong to suggest that the move towards private cellular networks is going to be trouble-free, even in well-formed ecosystems like the US CBRS marketplace. Clearly, there is a lot of work to be done around spectrum releases, technology standardization, and the economics of deployment.

Beyond that, there are numerous technical, commercial, and regulatory obstacles. Unlike Wi-Fi, which is designed for standalone deployments, cellular technologies have many complex pre-requisites.

Core networks, SIMs, timing synchronization for small cells, roaming and interoperability mechanisms, and operating software are all needed. The architectures were designed for billion-dollar national deployments and scaling down is difficult. Various vendors are trying to create "in-a-box" or "on-a-cloud" simpler or pre-integrated elements.

There are also regulatory considerations, such network identity and whether existing rules on lawful intercept and record-keeping should apply to private networks. These will vary over time and by country. There will also be sector-specific regulations such as cyber-security for networks supporting critical infrastructure, or power emissions, and electrical safety and radiation in industries with volatile gases or explosives (e.g. mining, oil) to consider. We are also presently seeing geopolitical turmoil, which may mean restrictions on specific vendors' cellular network products.



Some other stumbling-blocks that will also need to be closely watched:

- Push-back from telcos - While many operators have signalled a willingness to work with enterprises in areas such as smart factories and cities, they may still try to block paths to creating or interconnecting with new networks.
- Fragmentation – from this report, it should be clear that private mobile networks will vary in size, architecture and vendor/owner alignment. Funding models and ROI calculations will take years to coalesce. Individual deployments will need heavy customization, integration with IT/OT systems, and migration from legacy systems. Trying to find common "horizontals" for private/enterprise cellular will be important for market expansion.
- International coordination for multinationals – it will be hard to build similar private networks in different countries, given the disjointed nature of spectrum releases.
- Device support is a significant issue for private 4G / 5G. Unusual or "orphaned" spectrum bands will get little support from chipset, module or device suppliers – especially smartphones. There is also a question around support for local SIM/eSIM provision – and whether suppliers like Apple will be cooperative with small private network operators that do not purchase phones in bulk.
- Skills and resources are issues that will plague both enterprises and MNOs in the private cellular and 5G era. The world has 100s of thousands of Wi-Fi installation experts for enterprise. The equivalent numbers for private LTE are probably 100x smaller - at least for now. Hardly any engineers understand advanced radio technologies such as mmWave or Massive MIMO. Similar lacks in skill will impact the core network for slicing and other technologies. Training and certification are major themes to be addressed.
- Substitutional approaches will proliferate. While there are many use-cases and rationales for private networks, the problems they attempt to solve are not static. Wi-Fi 6 is as much a leap ahead as 5G is from 4G. New forms of indoor network-sharing between existing public operators could also limit the opportunity for private LTE/5G.
- Planning and design: In Disruptive Analysis' view, the private cellular era – and its rapid evolution– will require new approaches to upfront planning and design, and ongoing monitoring and updates. New spectrum bands, new device and application types, new regulations and new user-expectations will be present in all industries and building types. It is still unclear how future in-building systems will support private LTE, CBRS, and especially 5G elements such as mmWave radio, or "end-to-end" network slicing.

Conclusions and predictions

At the moment, private cellular networks are still a niche market, especially sectors like mining, oil, military and public-safety. There is little deployment in offices, hotels, retail facilities or entertainment/sports venues – even though the concept has been discussed for about 20 years.

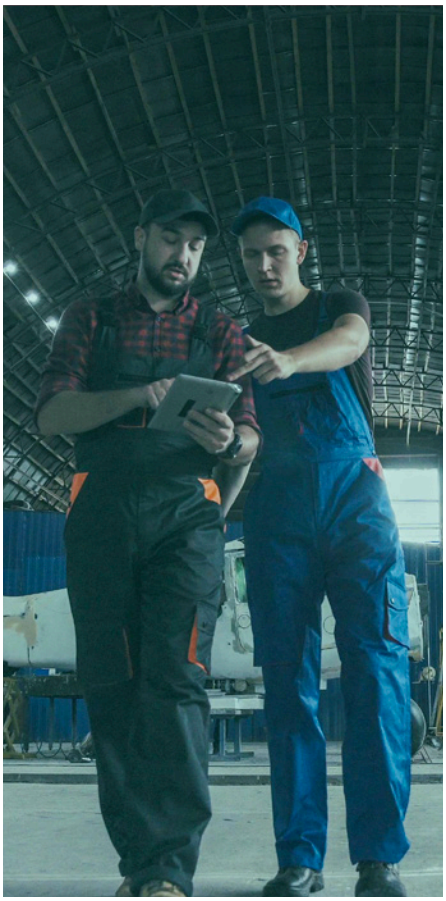
But recent shifts in spectrum policy and ecosystems of vendors/integrators may prove to be game-changers. Many countries are watching the US CBRS deployment closely – although parallel trends in Germany, UK, Japan, and elsewhere are also worth following.

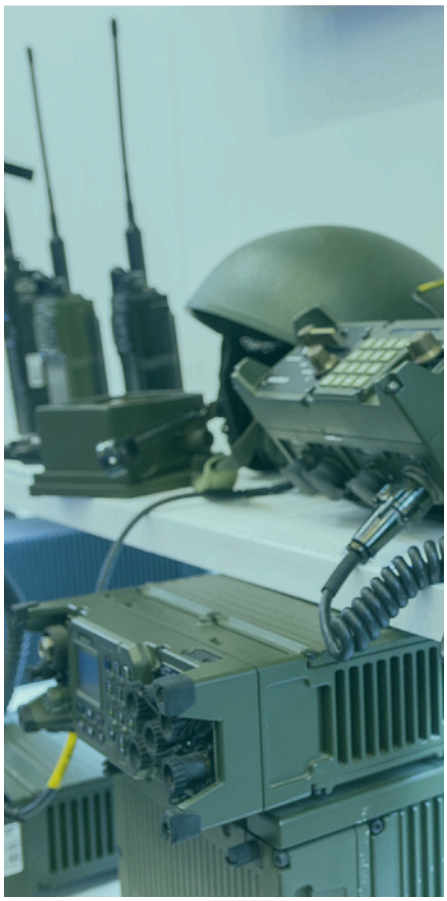
Disruptive Analysis believes that the jury is still out on how far and fast the sector will change, but there are definitely plausible mid-term scenarios in which the number of private networks rises to thousands, or even tens of thousands. To put this into perspective, there are about a million existing commercial buildings worldwide with indoor cellular-coverage systems, and 10 million or more with professional Wi-Fi installations.

Some observers foresee an "Amazon-ization" of cellular, where inexpensive small cells, automated spectrum-sharing allocations, cloud-based cores and back-end systems turn 5G into a Wi-Fi style equivalent. Some would be "pure private" and other installed or managed (or sliced) by MNOs. That sort of scale seems a stretch from today's reality.

The role of MNOs in private cellular is also unclear. They may focus on more prestigious targets such as utility companies, smart cities and large manufacturers, hoping to sell solutions including connectivity, cloud/edge computing, and more. In smaller enterprises and mid-market, we will likely see private cellular driven by a combination of new MSPs, and channel partners working with new, simpler, IT-focused cellular vendors.

This is going to be one of the most dynamic – yet unpredictable – wireless sectors for the next few years. Agility will be essential, as will skills, tools, and a willingness to partner across the value chain.





About iBwave

iBwave Solutions, the standard for converged indoor network planning is the power behind great in-building wireless experience, enabling billions of end users and devices to connect inside a wide range of venues. As the global industry reference, our software solutions allow for smarter planning, design and deployment of any project regardless of size, complexity or technology. Along with innovative software, we are recognized for world class support in 100 countries, industry's most comprehensive components database and a well established certification program. For more information visit: www.ibwave.com.

About Disruptive Analysis

Disruptive Analysis is a technology-focused advisory firm focused on the mobile and wireless industry. Founded by experienced analyst & futurist Dean Bubley, it provides critical commentary and consulting support to telecoms/IT vendors, operators, regulators, users, investors and intermediaries. Disruptive Analysis focuses on communications and information technology industry trends, particularly in areas with complex value chains, rapid technical/market evolution, or labyrinthine business relationships. Currently, the company is focusing on 5G, NFV, IoT networks, spectrum policy, operator business models, the Future of Voice, AI, blockchain & Internet/operator ecosystems and the role of governments in next-generation networks.

Disruptive Analysis attempts to predict and validate the future direction and profit potential of technology markets - based on consideration of many more "angles" than is typical among industry analysts. It takes into account new products and technologies, changing distribution channels, customer trends, investor sentiment and macroeconomic status. Where appropriate, it takes a contrarian stance rather than support consensus or industry momentum. Disruptive Analysis' motto is "Don't Assume".

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