Leading the 5G IoT Race: Key Industry Insights Series. Omnibus version. The Full 5-Part Story

By **Robin Duke-Woolley**, CEO, Beecham Research

This series of reports 'Leading the 5G IoT Race: Key Industry Insights Series' demonstrates how Fibocom is addressing the needs of 5 prominent application areas that are leading the introduction of 5G in the IoT market. This Master report provides an Executive Summary for the series and is followed by each report in full to form a complete Omnibus Edition.

Reports included for: **Fixed Wireless Access, Private Networking**, **Asset Tracking**, **Edge AI** and **5G RedCap**.

1. Fixed Wireless Access

- 5G Fixed Wireless Access (FWA) is a wireless broadband technology that utilizes the 5G network to provide high-speed internet access to homes and businesses. It is gaining popularity as an alternative to traditional fixed-line broadband technologies, such as cable or DSL, especially in areas where wired infrastructure is not available or very expensive to install.

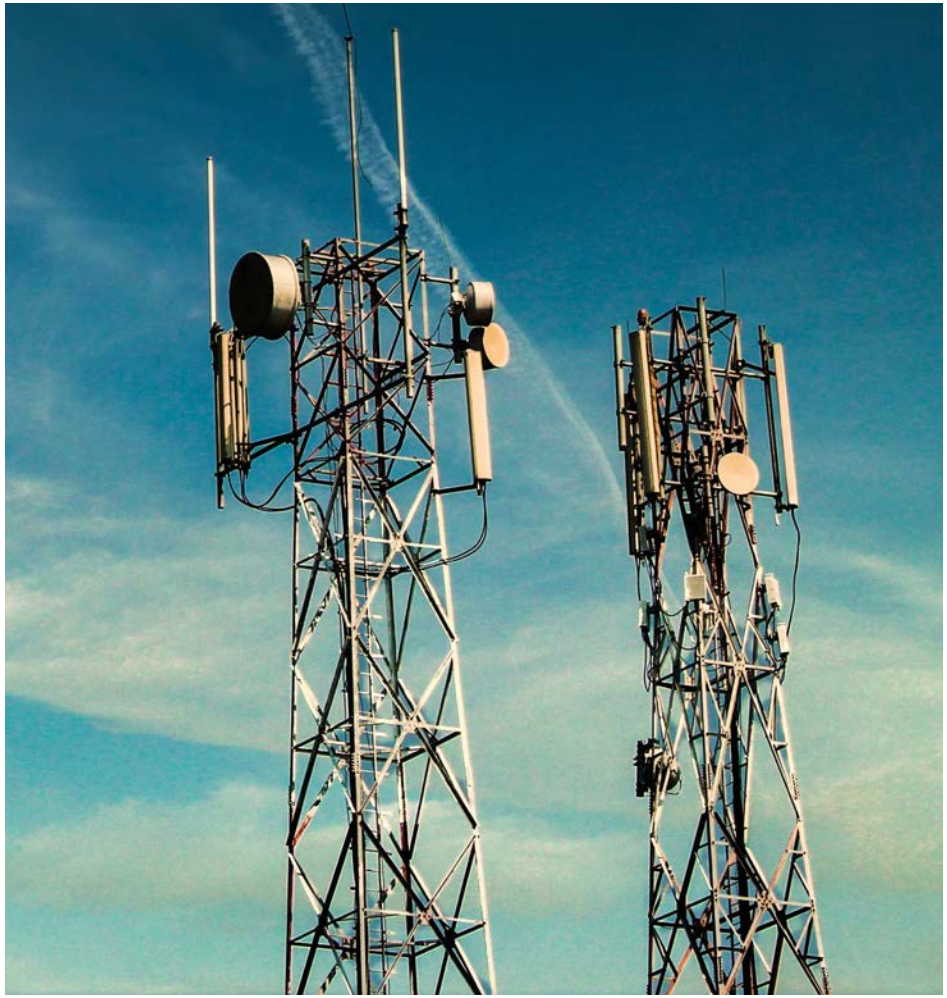
- Many operators have deployed FWA selectively for decades to offer customers internet service, typically in areas where wired internet connections are unavailable. Until now, FWA has not achieved widespread operator adoption. However, 5G is changing that.

- 5G FWA can provide an economical solution both in cities and in less populated areas. Being wireless, it can reduce the massive upfront cost and time needed to secure permissions, dig trenches, lay last-mile fiber, and deploy technician-installed equipment at households and businesses.

- In addition, operators can look to roll out 5G FWA using their new 5G mobile wireless networks as they are deployed, speeding up market entry. Many network operators worldwide are viewing 5G FWA as a way to expand revenue opportunities and help monetize investments in 5G and wireless spectrum.

- According to an Ericsson report, there are now over 100 service providers offering FWA over 5G, with North America and Western Europe represent nearly 70% of those. Annual growth of 20% in FWA connections is expected in the period 2022-28, with 5G representing 80% of the total by 2028.

- To cater for this rapid growth, Fibocom has launched a series of module solutions, bringing together the following key capabilities:
  - Reliable network quality for home and business with 5G network slicing
  - Material protection in the device to make it more robust, including heat, power consumption, humidity and other parameters
  - Close liaison with chipset makers Qualcomm and Mediatek, supporting Carrier Aggregation for higher data throughput
  - Network safety
  - Software design
  - 3Tx (3 Transmit antennas) to enhance the speed
  - Merging together and easing the R&D process



2. Private Networking

- IoT in business operations has the proven ability to boost operational efficiency, improve product and service performance, and enhance operational agility. The overall result is a significant uplift to a company's competitive offer and its bottom line.

- In the coming years, constraints on existing network capacity will mean that industries must increasingly turn to dedicated private options to meet their needs, especially in terms of digital transformation and the increasing demand for IoT connectivity.

- The use of Private Cellular Networks (PCN) has grown at a modest pace over recent years, but this is now set to change dramatically with 5G introduction. Analyst forecasts indicate spend increasing from $1 billion in 2023 to nearly $10 billion globally by 2028 with the number of private networks deployed reaching over 60% growth per annum in the period.

- The main benefits of 5G private networks for business operations include:
  - Consistent localised campus coverage, both indoors and outdoors, designed to meet on-site needs.
  - A highly secure environment, with enhanced network security and data remaining on-site.
  - The provision of enough network capacity to meet connectivity and data handling requirements at all times.
  - Local management control over network traffic and use, including seamless integration with enterprise IT/OT.
  - Very high and controllable network reliability.
  - Predictable and ensured low latency – data control.
  - High data throughput and support for high density devices

- Fibocom is active in the 5G private networking market, for example in a large industrial park. This is a joint cooperation involving Fibocom together with network operator China Telecom and the ICT Manufacturer to deploy a 5G private network for a very large industrial park.

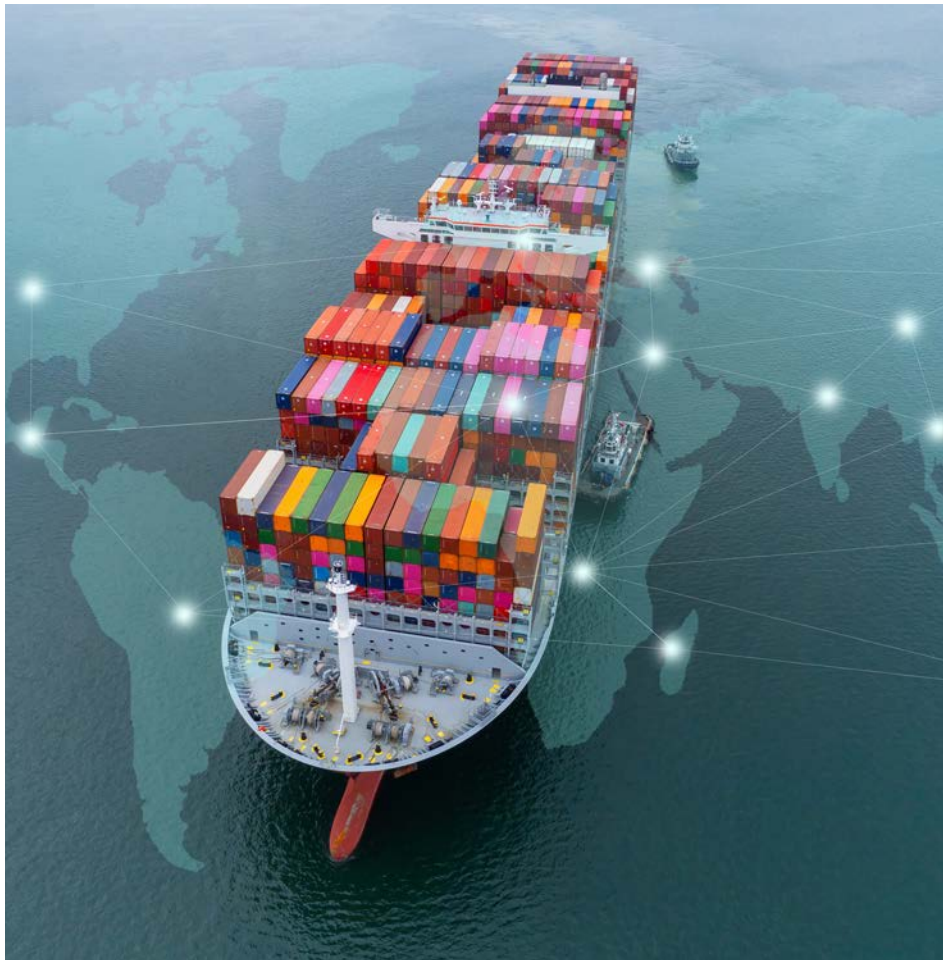
- In response to these requirements, Fibocom has introduced a series of 5G modules that support the private radio bands in regional markets, including Asia Pacific, Australia, Brazil and Europe.

- In addition, and importantly for private network build-out, the company also has a range of smart modules for 5G terminal devices. These are used for a wide range of terminal devices such as Industrial PDAs, Drones, Access Control, Robots, and In-vehicle infotainment applications.

- Private cellular networks are set to become the new gold standard across a range of industries and applications, with device manufacturers increasingly incorporating PCN network accessibility into their flagship products. Fibocom, in partnership with chipset companies and other IoT pioneers, is proud to be at the cutting edge of this innovation, driving the development and adoption of LTE and 5G PCN-compatible wireless modules.

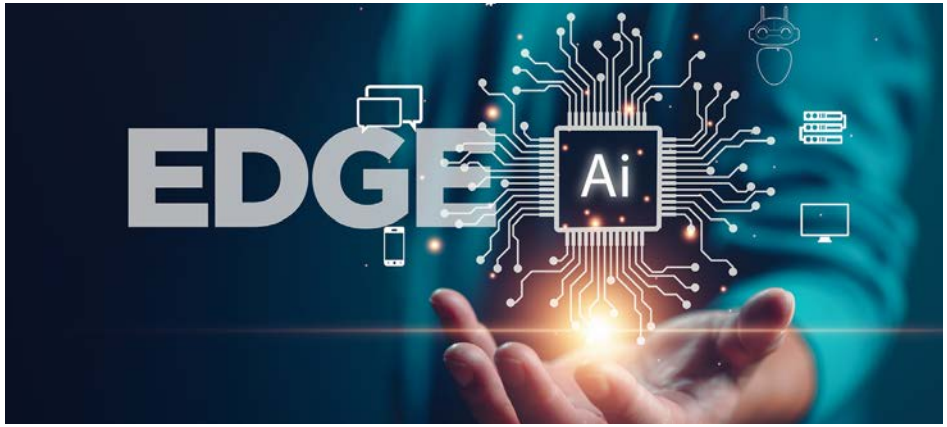
3. Asset Tracking

- Logistics is about the safe transportation of goods to customers across the world. This entails tracking goods from production, storage, through delivery and receipt by the customer. Suppliers increasingly need to know where their assets are at all times and its condition, since late delivery may hold up further supply chain processing by partners.
- Trailer and cargo container tracking is a specialized area within asset tracking focused on enhancing operational efficiency and security within transport chains. In the period 2021-26, the installed base of trailer and cargo container tracking units worldwide is expected to grow by 25% per annum
- The main subsegments of this are general cargo, air freight, intermodal containers and trailers. Key challenges for these include cargo theft, cost and battery life, coverage limitations and device durability.
- Each of these issues has been addressed by Fibocom in its design of modules for the asset tracking market.
- A particular area is addressing coverage limitations, and for this there is now an opportunity to use satellite coverage integrated with cellular, to provide uninterrupted coverage worldwide. As part of the continuing development of 5G, 3GPP Release 17 has specified the use of satellites (Non-Terrestrial) for IoT connectivity.
- This introduces the opportunity to use standardised hardware made by many different suppliers for both Terrestrial and Non-Terrestrial use. This will significantly increase the addressable market. Fibocom is addressing this market opportunity with its 3GPP R17 compliant LPWA and 5G LPWA modules.
- Fibocom's modules are used in a wide variety of IoT asset tracking scenarios, including fleet management and cargo tracking, utilities payments, smart cities, after-market auto location and many more. Fibocom has been working in this area since 1999 and in that time has focused on the research and development of wireless modules for 2G through to 5G and beyond towards 6G. Building the foundation for the digital world and everything associated with a 'smart life' has always been Fibocom's mission.



4. Edge AI

- Edge AI is one of the most notable sectors of artificial intelligence, providing the ability to run AI processes without the latency issues of data transmission to the cloud. Edge AI is enabling greater, more widespread use of AI, providing the means for smart IoT devices to respond quickly to new inputs and to new application opportunities.
- Edge AI is the deployment of AI applications in devices at the network edge throughout the physical world. It is called "Edge AI" because the AI computation is done near the user at the edge of the network, close to where the data is located, rather than centrally in a cloud computing facility or private data centre.
- Cloud AI is where data processing and storage occur in centralised data centers managed by cloud service providers, usually situated far away from end-users. By offering cloud computing service over the internet to the cloud, it offers flexible resource accessibility and economics of scale.
- Edge AI and Cloud AI are therefore complementary technologies. Particular advantages of Edge AI include the following:
  - Lower data transfer volume
  - Speed for Real-time computing
  - Privacy and security
  - High availability
  - Cost and energy efficiency
  - Scalability and Adaptability
- These advantages offer substantial enhancement of IoT applications and, as a result, high growth of over 24% per annum in global Edge AI revenues is expected during the period 2022-30.
- Edge AI will be used in all IoT sectors for a wide range of applications that will evolve over time. Application scenarios where Edge AI is already evident include:
  - Smart Homes, for voice recognition, natural language processing, and activity recognition locally. It also enables local automation within the smart home ecosystem.
  - Healthcare Monitoring, enabling real-time monitoring and analysis of health data from wearable devices, immediate detection of abnormal patterns, personalized healthcare recommendations, and timely alerts for medical interventions.
  - Smart Manufacturing, enhancing applications like predictive maintenance, quality control, and robotics. Enabling real-time analysis of sensor data, anomaly detection and autonomous decision-making, improving operational efficiency and reducing downtime.
  - Outdoor Robots and Human-Robot Collaboration, enabling robots to analyse and process data in real-time, make intelligent decisions, and interact with humans efficiently.
  - Unmanned Aerial Vehicles (UAVs), enabling autonomous navigation, power management, security and privacy, formation control, computer vision, and communication.
- Significant growth in all these areas is anticipated. As an example, the global outdoor autonomous robot market is expected to grow from $163 million in 2022 to $701 million by 2032, an annual growth rate of 15.7%.
- Fibocom has been active in Edge AI for several years, and offers a set of three modules:
  - 5G Smart high level solution, supporting the industrial grade PCBA solution with high computing power, suitable for complex indoor and outdoor scenarios, such as autonomous logistics vehicles, patrol inspection robots and guiding robots.
  - 4G Smart medium level solution, suitable for scenarios like patrol robot for smart grids, industrial campus, logistics warehouse, hospitals and more.
  - 4G Smart entry level solution, suitable for scenarios like automatic lawn mower for home use.
- In view of its perceived importance, Fibocom also offers a Robot Intelligent Chassis comprising a Motion body, a Sensor body and a Decision-Making body. This chassis is suitable for use as a common robotics element for a wide variety of different robot applications, with the customer then adding the end application and shape.



5. 5G RedCap

- 3GPP has introduced three primary use cases for 5G New Radio (NR) – enhanced Mobile Broadband (eMBB), massive Machine Type Communications (mMTC), and ultra–Reliable Low Latency Communications (uRLLC). Many IoT application do not quite fit one of these primary cases – often requiring a bit of each. That is where 5G RedCap (Reduced Capability) comes in.
- 5G RedCap is also known as New Radio lite (NR lite).
- There are also two releases of 5G RedCap – 3GPP Release 17 (R17) and Release 18 (R18). RedCap R17 compares with LTE Categories 4 and 6, while RedCap R18 compares with LTE Category 1. Essentially, those applications that require low latency and high reliability, but less bandwidth than eMBB, and low power consumption.
- This makes RedCap ideal for a wide range of applications – including smart wearables, smart grids, livestreaming and industrial automation.
- For smart wearables, RedCap encompasses three key application categories: industrial wireless, video surveillance, and intelligent wearable devices. These applications prioritize stable, seamless data transmission rather than ultra-low latency. RedCap strikes a balance between enhanced Mobile Broadband (eMBB) and ultra–Reliable Low Latency Communications (uRLLC).
- For smart grids, with the low latency and high reliability of 5G, RedCap meets the safety and control requirements of the smart grid and significantly reduces the cost of 5G terminals. This makes it well-suited for applications such as inspection robots, drones, patrol cameras, and concentrators in power generation, transmission, and consumption scenarios.
- For FWA (Fixed Wireless Access), in 72% of countries globally, the average downlink experience speed for mobile users is below 50Mbps. Currently, 5G FWA products tend to be high-performance and high-priced, meaning there is a significant suppressed demand for entry-level market users. With a downlink peak of 223Mbps, RedCap presents a strong choice to meet the demands of this market segment.
- 5G Redcap is also a strong contender as an ideal wireless solution for FWA device manufacturers such as mobile hot spot and PC to migrate 4G to 5G solutions. It offers an optimized 5G network experience and larger bandwidth capacity compared with the 4G solution.
- Fibocom anticipates RedCap R17 will gradually start appearing in IoT terminals in small batches in 2024. Starting from 2025 the R17 version of RedCap is expected to enter a period of rapid development. As for RedCap R18, predicting timescales is challenging since the technical standards are not yet being finalised. R18 IoT terminals are likely to start coming to market in 2026.
- In line with this, Fibocom currently has two series of 5G RedCap modules. Both of these are compliant with 3GPP Release 17.
- RedCap presents a significant commercial opportunity, particularly in the IoT market. Operators have well-defined plans for RedCap network iteration. RedCap can also be applied to vehicle terminals, industrial sensors, medical monitoring devices, and more.

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5G Fixed Wireless Access (FWA) is a wireless broadband technology that utilizes the 5G network to provide high-speed internet access to homes and businesses. It is gaining popularity as an alternative to traditional fixed-line broadband technologies, such as cable or DSL, especially in areas where wired infrastructure is not available or is prohibitively expensive to install.

The resurgence of FWA with 5G

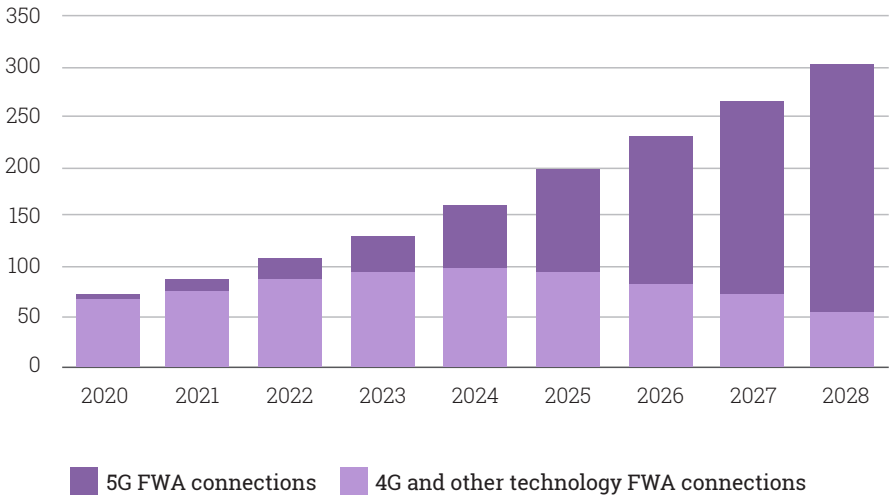
Many operators have deployed FWA selectively for decades to offer customers internet service, typically in underserved areas where wired internet connections are unavailable. Until now, FWA has not achieved widespread operator adoption outside of a few countries such as Austria and Finland. However, the introduction of 5G is changing that, with more governments now providing funding to address digital divides and the need for levelling up broadband access. In addition, more regulators are viewing 5G wireless as an acceptable alternative to wireline connections for delivering broadband internet services.

It is often challenging to justify broadband investments in less populated areas with few paying subscribers or inaccessible terrains such as mountains or islands. It is also challenging in cities where local laws and regulations may make it expensive and time-consuming to connect to customer premises. 5G FWA can provide an economical solution. Being wireless, it can reduce the massive upfront cost and time needed to secure permissions, dig trenches, lay last-mile fiber, and deploy technician-installed equipment at households and businesses.

In addition, operators can look to roll out 5G FWA using their new 5G mobile wireless networks as they are deployed, speeding up market entry. Many network operators worldwide are viewing 5G FWA as a way to expand revenue opportunities and help monetize investments in 5G and wireless spectrum.

According to Ericsson's latest Mobility Report, dated June 2023, there are now over 100 service providers offering FWA over 5G. Regionally, North America and Western Europe represent the highest adoption rates with nearly 70% of FWA service providers in those regions offering it over 5G. As shown in the chart, FWA connections are expected to grow from just over 100M in 2022 to 300M in 2028, an annual growth rate of 20%. By that time, 5G is expected to represent 80% of the total. This is a huge growth in prospect.

FWA connections (millions)



Source: Ericsson Mobility Report June 2023

In fact, operators have many deployment options depending on their service area demographics, spectrum availability, and technology portfolios. For example, in dense city locations, 5G FWA can be used to augment existing fixed or mobile phone networks to offer pop-up wide area networks, such as for small or medium businesses networks, live events, or construction sites. It also can enhance redundancy and surge capacity. As the recent pandemic has shown, using wireless connections as a gap filler and backup for fiber to provide uninterrupted internet access is growing in importance. FWA can also be offered more broadly as a competitive alternative to existing home internet, such as in a suburban area with no or few other options. In most cases, operators will selectively roll out 5G FWA in those areas where they have suitable spectrum, excess wireless network capacity, and adequate supporting infrastructure, but also where fixed wireline is otherwise uneconomical or slow to deploy.

These scenarios raise a number of challenges for MNOs (Mobile Network Operators), as follows:

1. In order to meet the diverse needs of different customer segments, telecom operators need to clarify the customer segmentation for refining the strategy, including FWA end-device and network services. For instance, customers have different speed requirements based on different scenarios.

2. To cater to the distinct requirements of enterprise and consumer-level customers, telecom operators are assigning different network performance and feature characteristics to FWA hardware. Enterprise-level customers may prioritize higher security, customization, and dedicated bandwidth, while consumer-level customers may place more emphasis on pricing and entertainment performance.

3. Operators are intensifying their utilization of the C-Band by managing and upgrading mid-band 5G networks. This strategy aims to provide broader coverage and enhanced network performance, particularly to meet the connectivity needs of consumers residing in remote suburban areas.

Fibocom's recent announcements to drive 5G FWA forward

Four recent announcements illustrate Fibocom's continuing work to improve the 5G FWA experience and the opportunity for MNOs:

1. In February 2023, the company announced a collaboration with MediaTek for a 'Fast-to-deploy' 5G FWA solution based on the FG370 module.

   The innovative "Fast-to-deploy" 5G FWA solution includes the reference designs of two forms of FWA devices, CPE and mobile hot spot, integrating with Fibocom 5G Sub-6GHz module FG370, significantly simplifying the hardware design of FWA devices and reducing the time to market. Leveraging multiple key features of the latest advanced Wi-Fi 7 technology, the CPE supports tri-band Wi-Fi 7 solution delivers a high throughput and seamless in-home connectivity, while the mobile hot spot supports dual-band Wi-Fi 7 solution brings a reliable and stable network connectivity for mobile hotspot users.

   The module supports 4CC CA (Carrier Aggregation) and up to 300MHz of spectrum on the downlink, as well as 2CC CA and up to 200MHz of spectrum on the uplink. This significantly improves the utilization of spectrum resources and ensures an extended 5G coverage. In addition to new features such as 8RX (Receive Antennas) and Power Class 1.5 (PC1.5) High Power User Equipment (HPUE), the FG370 module is capable of delivering maximum 7.01Gbps on the downlink and 2.5Gbps on the uplink. This will help CPE and Mobile hotpot customers to implement the migration from previous generation to the newest platform in a very short term, bringing ultra-fast gigabit experience.

   "The advent of 5G has bolstered the use of FWA solutions, huge opportunities come with challenges, the utilization of 5G spectrum, the complexity in device design, and the reliability of network connection are the obstacles of FWA roll-out," said Simon Tao, VP of MBB BU at Fibocom. "By working closely with MediaTek, we have achieved several product milestones ahead of the market. We believed that by launching the reference design for both CPE and mobile hot sport, FWA customers worldwide can upgrade to the latest 5G solution smoothly and easily, significantly reduce the time to market and maximize the ROI."

2. In June 2023, the company introduced a new 5G FWA solution based on the latest generation 5G modules FG190 and FG180. The solution offers a wide range of flexible configurations and multiple enhancements to CPE and mobile hot-spot customers, significantly reducing the complexity to deploy advanced 5G solutions and accelerate the time to market.

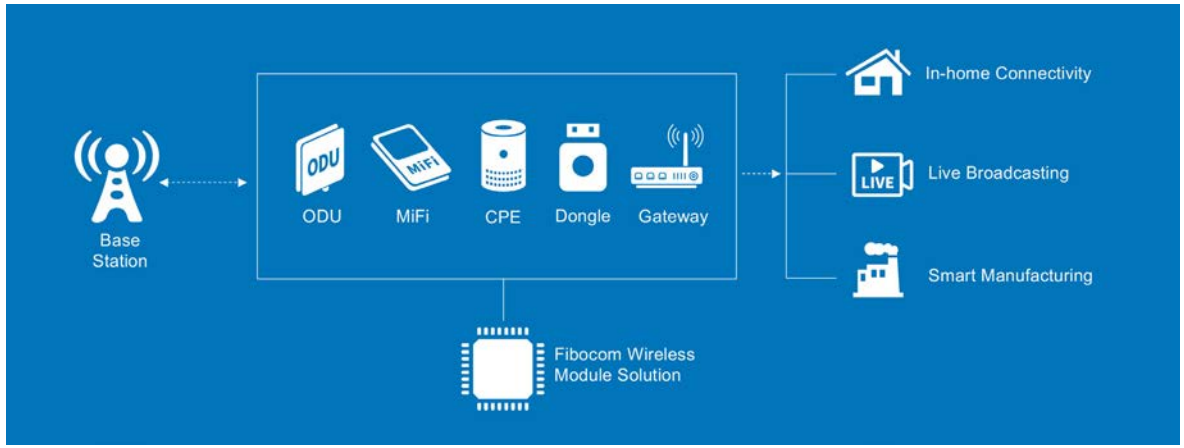
   Powered by the Qualcomm Snapdragon® X75 and X72 5G Modem-RF System, Fibocom FG190 and FG180 is compliant with 3GPP Release 17. With Snapdragon®X75, Fibocom FG190 supports 5G Sub-6GHz and mmWave dual-connectivity, thus capable of NR 10CA with up to 1000MHz bandwidth in the mmWave spectrum, and NR 5CA with up to 300MHz bandwidth in the Sub-6GHz, significantly elevating the maximum downlink speed to 10Gbps. Followed by the FG180, the module integrated with Snapdragon® X72, offers an agile solution for various 5G FWA customers by supporting up to 400MHz bandwidth of NR 4CA under mmwave bands, and 200MHz bandwidth of NR 3CA under Sub-6GHz. Both FG190 and FG180 have adopted LGA form factors, making both modules particularly suitable for a diversified FWA market.

   As 5G technology has improved, mobile broadband service providers are no longer limited to older technologies. They are looking for agile and high data throughput network connectivity solutions. The 5G FWA solution, specialized in CPE and mobile hot-spot use cases, embedded with Fibocom's latest generation 5G Sub-6GHz and mmWave modules FG190 and FG180. The 5G CPE solution is architected with a set of rich interfaces plus flexible dual-band/tri-band Wi-Fi 7 combinations. For example, an FG190 can simultaneously connect three PCIe and two USXGMII ports, in addition to the Wi-Fi 7 selections, CPE customers can adjust the combinations between QFW7114 and QFW7124 to utilize the band capacity from maximum BE21000 to BE5000. Regarding the wired configurations, either the10GbE+2.5GbE or 2.5GbE+2.5GbE could be the most recommendable and efficient options to unleash the full potential of cable access.

   The solution for 5G mobile hot spot offers a range of top-quality wireless performance to mobile scenarios. In support of a highly integrated WCN7851 chip, the multi-channel options will be utilized efficiently to increase the data rate. Depending on the requirements, the dual-band options can be switched to 2.4GHz/5GHz/6GHz to achieve maximum throughput up to BE5800. The seamless Wi-Fi 7 connectivity also benefits from the contribution of MLO (Multi-Link Operation) and 4K QAM modulation schemes, offering a highly reliable connectivity service, especially in congested environments like airport terminals, sports venues, and hospitals.

   In software design, the FG190 and FG180 is loaded with OpenWRT, which allows maximum customization for CPE and mobile hot-spot customers.

FWA has evolved from the traditional AP+Modem -based architecture to a new SoC-based architecture



3. Also in June 2023, the company demonstrated the 5G RedCap module portfolio. Along with the FG132 module series, the brand new FG131 series was introduced to scale up the 5G NR light deployment for use cases such as CPE, ODU, mobile hot-spot, and USB Dongle, etc.

   Leveraging ubiquitous cellular coverage, optimized power-saving, and reduced complexity, 5G RedCap is gaining more and more attention within the IoT industry. The newly launched Fibocom 5G RedCap module FG131 series offers a high-performance and ultra-reliable wireless solution for application scenarios that are cost-sensitive and power-enduring. Packaged in LGA form factor at the size of 37mm*39.5mm, Fibocom FG131 is pin-compatible with Fibocom LTE Cat 6 module FG101 and FG621 series that allows smooth migration from 4G to 5G RedCap. Compliant with 3GPP Release 17, it supports 5G SA and reaches peak rates of up to 226Mbps downlink and 120Mbps uplink theoretically. With these key features combined, the Fibocom 5G RedCap module FG131 series delivers a new level of 5G network experience while maintaining high reliability and cost-effectiveness, especially for terminal devices used in mobile scenarios.

4. In September 2023, the company announced that its FM160-NA 5G module had received certifications by all three of the leading operators in US. This will help customers in the North America market to reduce the time-to-market, accelerating the 5G FWA commercialization. The module supports NR Carrier Aggregation (CA) to optimize 5G user experience with extended coverage, boosting throughput, and increasing capacity. It is also backward compatible with LTE-TDD and LTE-FDD network standards. It delivers maximum downlink rates of 3.5Gbps and uplink rates of 900Mbps under 5G.

   The upgrade demand for higher data throughput for both 4G FWA service providers and early-stage 5G FWA service providers keeps growing. Customer Premises Equipment (CPE), as the access point to provide seamless and reliable connectivity service for homes, enterprises, and industries, is the key enabler in boosting FWA adoption. The FM160-NA module narrows down the digital divide for FWA customers by enabling gigabit connectivity for end devices such as CPE, ODU, mobile hot spot and USB dongles.

One-on-one interview with Fibocom

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Simon Tao
VP of MBB BU
Fibocom

Following on from these announcements, the author of this report (RDW) interviewed Simon Tao (ST), VP of MBB BU at Fibocom to understand in more detail how Fibocom is meeting market needs for 5G Fixed Wireless Access (FWA).

RDW: What are the key applications that Fibocom is addressing in this space?

ST: The global carriers, in particular, are looking to deliver the best broadband experience in FWA and build custom apps so their users – subscribers – can get the most out of their broadband networks. As a result, Fibocom offers small enterprises proper OS and tools like RDK-B (Reference Design Kit for Broadband) for flexibility and scalability. RDK-B is a standardised open-source software platform for broadband devices and services. For home users, the home controller 'hub' enables the smart home and provides ultra-reliable and Gigabit speed for applications like gaming and video streaming. In our work with the chipset makers, we use our experience to assist in developing support for these tools to help make broadband applications much easier to use and a smooth experience for users.

RDW: How big is FWA for high speed 5G use?

ST: We see FWA as the biggest high speed user application for 5G, both for the home and small business. This needs a high network capacity and data throughput, because in the home scenario there are often many users – the parents need to work and the children need to do online studying. In addition, there is growing use of smart phones and many other devices. The streaming download and upload need to be in parallel – simultaneous use – for good quality. The massive data use is becoming more common and only 5G can support the data requirement. To put this in perspective, 4G can support up to 30 connections at the same time but with that many connected devices the service slows appreciably. 5G can support up to 100 connection devices at once so has considerably more capacity.

RDW: What do you see as the most important performance issues that must be met to support these?

ST: This is where we add real value. 5 years ago, most of the CPE architecture was based around AT-based modems and command sets. The modem essentially just transformed the message for send/receive. But the evolution to System on Chip (SoC) architectures has moved many more tasks on to the modem – it now needs to provide the environment for all the applications, software and data coming in. The software needs smart memory and then CPU power is needed to run custom applications. In addition, we need to optimise use of power and the ability to maximise efficiency in response to customer use of applications.

The hardware may be in the home basement, so the network quality is sometimes very poor. We draw on our experience in use of massive data and in our experience of components from different vendors to create a set that utilises the main chipset to best advantage. The aim is to make sure that the uplink transmission power and the downlink sensitivity is optimised for best performance. In addition, we provide consulting services to our customers to make sure that the best performance is being achieved in the specific frequency bands required.

Everything we do is to give customers the best user experience on the transmission from uplink and downlink to make sure that, even if their network quality is very poor, they can still reach other networks.

RDW: To what extent do you get involved in software services?

ST: The software services are normally designed by our customers - the carriers and ODMs/OEMs. We also provide basic software samples to customers to make sure they can ramp up very quickly. The software ecosystem is evolving very quickly so we work with a number of software associates. We release the latest version of their software – open-source software – to all our customers so they can ramp up more quickly. This is especially the case for smaller and medium sized customers who often do not have the resources to keep up to date with all the software releases.

RDW: How does Fibocom meet or exceed the requirements in this market?

ST: Fundamentally, everything on the hardware side is doable. The choice of components used has an impact on performance of the uplink and downlink, as well software tools. Firstly, we have more than 10 years of experience in working with the most advanced carrier and OEM requirements to make sure that our products are stable and perform well. Secondly, we have stringent quality control and have been working for a long time with international customers who have very strict quality controls, in particular the top PC suppliers. The Tier 1 carriers also have very strict quality requirements. We utilise our experience and knowledge in different segments to make sure that the reliability is very high. Thirdly, we have local services for supporting customer devices. R&D and certification is also a key strength of ours because for more than 10 years we have provided network certification for all the carriers at certification lab.

We support Tier 1 carriers all over the world, in every region, working closely with more than 50% of all Tier 1 carriers. This means we are confident we can cover the most stringent field requirements.

RDW: How do you see the market need developing in the FWA market over the next few years?

ST: New requirements are always happening, especially for the FWA segment which has been moving very fast over the last 3 years as a result of the Covid pandemic – much more home working and home studies behaviours. We are continually assessing new requirements and analysing the changes required. We see that a key area, from the home to the small and medium sized business, is that users need more connection reliability for each device. When working in the home or small office scenario or even working in a public area, 5G network slicing together with other new technologies can provide higher levels of support for each end user to get a good channel to connect to the network. The connection speed can also be guaranteed by software so the user can be provided with at least their minimum requirement for that.

Another area is device protection. If people are using their devices outside, we need to put more material protection in the device to make it more robust. We need to consider the whole device for heat, power consumption, humidity and other parameters. We do a lot of work to optimise the heat on devices.

RDW: Is that an industrial grade?

ST: Depending on the scenarios and environmental requirements, Industrial grade is a higher grade that most Tier 1 carriers normally need. There are customers in some regions, for example Southeast Asia and Africa, that look for lower cost, so we have different grades depending on the local market need.

RDW: Do you see new standards coming up in the marketplace that you will need to adopt?

ST: We are involved in a lot of innovation. For example, our advanced research on the hardware side is covering areas of more advanced 5G chipset use for Carrier Aggregation. We are working on new chipsets based on Qualcomm and Mediatek for that. We are also looking at the Wi-Fi 7 requirement since 5G is getting the data input from the base station and there is a need to transfer the data from IoT devices using Wi-Fi. For this, the Wi-Fi speed needs to match with the 5G speed. Since 5G can go to 10Gbps, only Wi-Fi 7 can match that. Also, Wi-Fi 7 has a lot of base technologies that are very similar to 5G, such as OFDMA (Orthogonal Frequency-Division Multiple Access) which allows for simultaneous transmissions to and from multiple clients.

We are also looking at some new technologies for some market requirements. As a pioneer of the 5G area we see the 3TX (3 transmit antennas) and AI features coming up now. These will considerably enhance user experience especially at the network edge where signal coverage is not so good. In addition, in the future there will be more Carrier Aggregation and also more higher power transmission. We are also looking at the business case across borders – in particular satellite connection upgrades so that the user working in remote areas such as a boat on the sea can also get 5G, with satellite as a backup. We think this is a case where better communication everywhere is good for the world.

The satellite connectivity with 5G is covered in a major way in Release 17 as part of NTN – Non-Terrestrial Networks, which is coming up soon.

RDW: For OEMs and your customers, what other support do you provide them with in their design of new products?

ST: In addition to the support already mentioned, we aim to ensure that our different platforms can inter-operate. Our main chipset vendors – Qualcomm, Mediatek– each with its own software environment. We build a middle tier scenario to make sure our customers can switch for example between Mediatek and Qualcomm solutions when they need that flexibility. That can significantly speed up their development process.

Summary of Fibocom 5G FWA activities

The 5G FWA market is now set for substantial growth over the next 5 years and Fibocom is setting out a comprehensive range of unique module offerings to lead in this market. In summary, Fibocom is bringing together the following key capabilities:

- Reliable network quality for home and business with 5G network slicing
- Material protection in the device to make it more robust, including heat, power consumption, humidity and other parameters
- Close liaison with chipset makers Qualcomm and Mediatek, supporting Carrier Aggregation for higher data throughput
- Network safety
- Software design
- 3Tx (3 Transmit antennas) to enhance the speed
- Merging together and easing the R&D process

Fibcom Core-Competitiveness in FWA Industry

Global Certification Service

Understanding FWA Industry & Operator Requirements

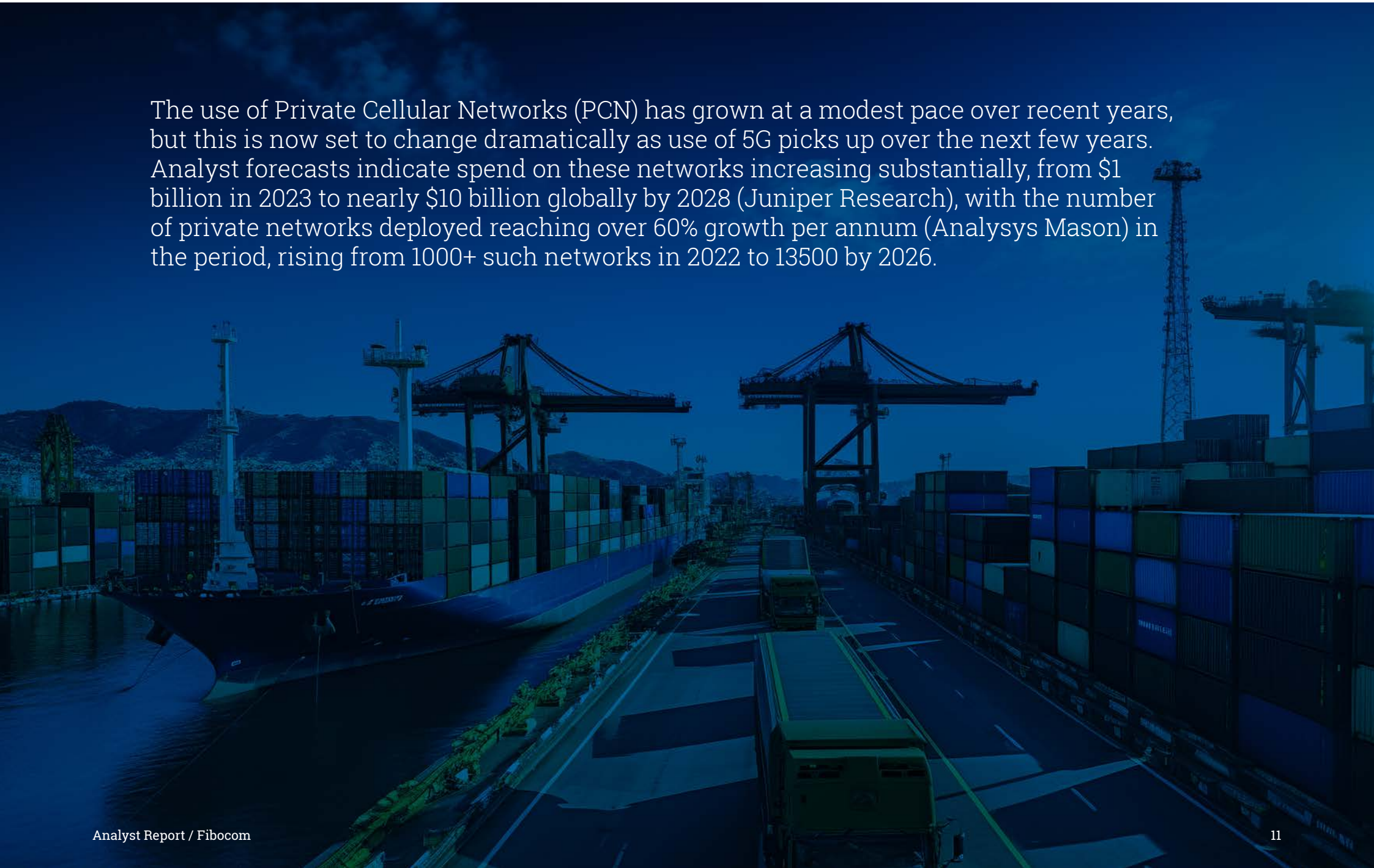
Comprehensive Product Matrix & Reliable Product Quality

7x24 Local Support & Service through Product Life Cycle

Leading the 5G IoT Race: Key Industry Insights Series 2. 5G Private Networking

By **Robin Duke-Woolley**, CEO, Beecham Research

The use of Private Cellular Networks (PCN) has grown at a modest pace over recent years, but this is now set to change dramatically as use of 5G picks up over the next few years. Analyst forecasts indicate spend on these networks increasing substantially, from $1 billion in 2023 to nearly $10 billion globally by 2028 (Juniper Research), with the number of private networks deployed reaching over 60% growth per annum (Analysys Mason) in the period, rising from 1000+ such networks in 2022 to 13500 by 2026.



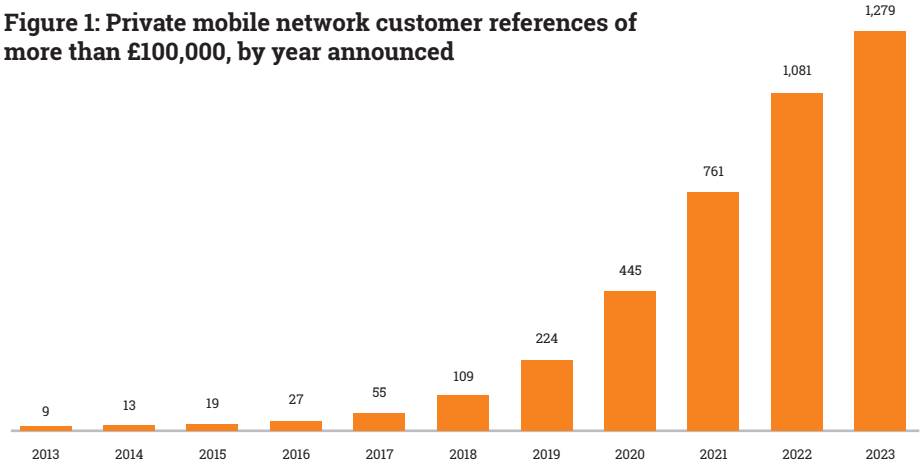
1. The growing case for private 5G

Use of 5G for public networks is already reaching high numbers. As of August 2023, GSA identified 265 live 5G networks worldwide, 45 live 5G standalone networks, and expected 45% population coverage by end 2023. An update in November 2023 showed that in 2022, 321 new private network customers categorised by GSA were announced. This number eclipsed net growth in previous years, with 2021 representing 312 announcements. It should be noted that slowdown in the number of announcements is not representative of slowing growth in market activity — rather, existing customers are continuing to scale trials to multisite deployments, and announcements will greatly vary in the size of contract value. Figure 1 shows customer announcements grew at a compound annual growth rate of 81% from 2017 to 2022.

A further forecast from Omdia indicates that revenue from 5G Enterprise private networks will reach nearly $7 billion by 2027, up from $2.5 billion in 2022, and ABI Research predicts that the total number of digital factory terminal connections will reach 4.7 billion by 2030, up from just 500m in 2023.

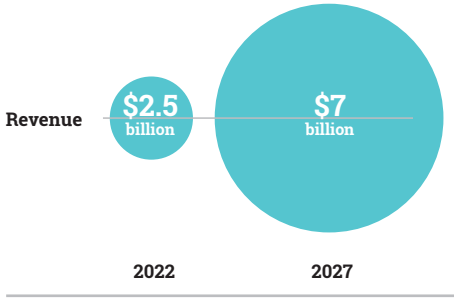
What all of these forecasts have in common is strong expectation that the evolution to private 5G will significantly open up the private network market over the next few years.

Figure 1: Private mobile network customer references of more than £100,000, by year announced



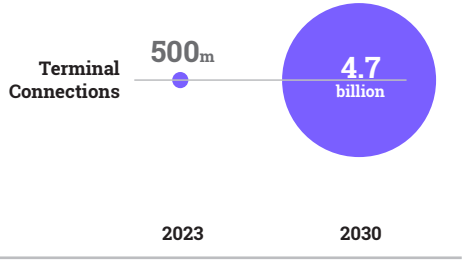
Source: Private-Mobile-Networks November 2023 Summary Report - GSA)

Revenue from 5G Enteprise Private Networks



Source: Omdia

Terminal Connections of 5G Enteprise Private Networks

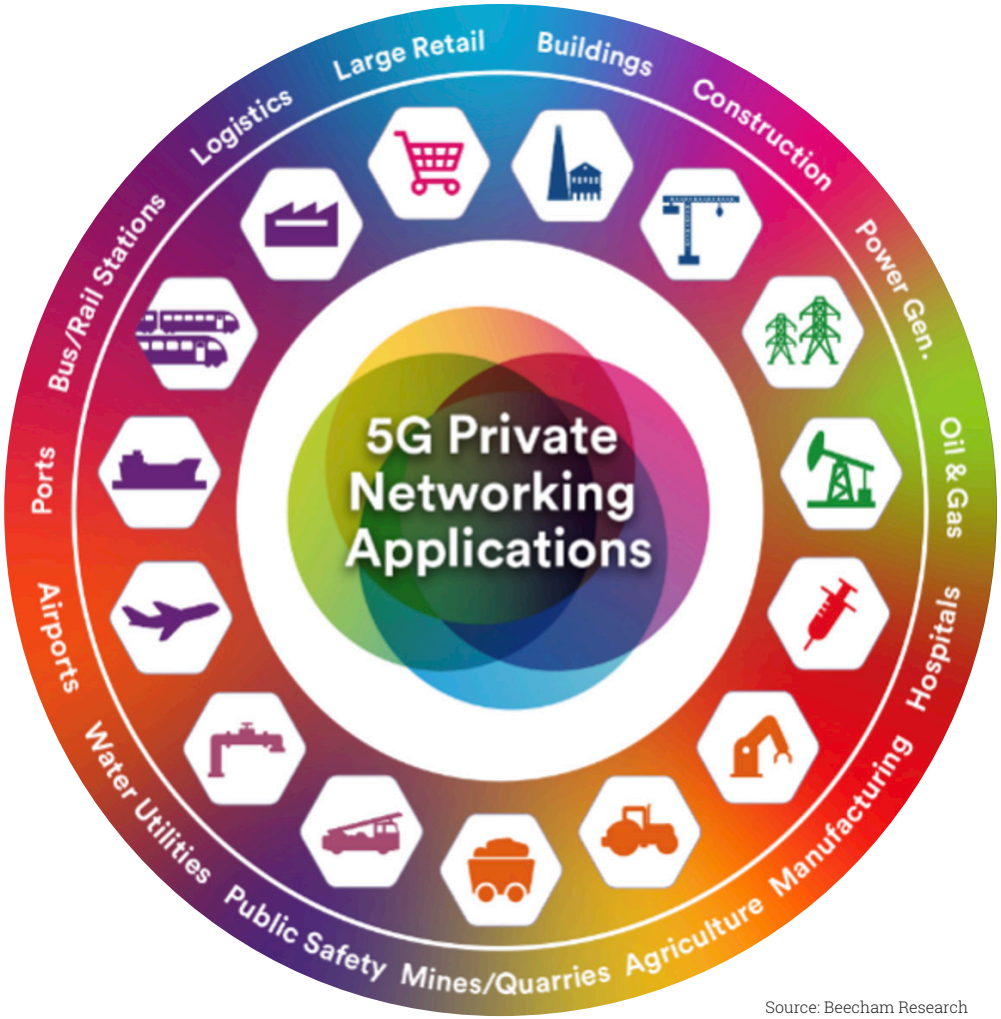


Source: ABI Research

Why is that?

IoT in business operations has the proven ability to boost operational efficiency, improve product and service performance, and enhance operational agility. The overall result is a significant uplift to a company's competitive offer and its bottom line. IoT has truly moved from 'nice-to-have' as a low cost, remote monitoring activity to 'strategic necessity' in many business operations as the emphasis moves more towards control and automation. This trend is set to continue at a fast pace over the next decade.

As a result, in the coming years, constraints on existing network capacity will mean that industries must increasingly turn to dedicated private options to meet their needs, especially in terms of digital transformation and the increasing demand for IoT connectivity. Frontrunners in the adoption of Private LTE and Private 5G include industries such as oil and gas, and mining which rely on critical communications to coordinate their operations in real time. Areas requiring high levels of security and data throughput, such as airports and ports are also early adopters, along with smart manufacturing and smart logistics facilities.



Source: Beecham Research

2. What are the benefits of Private 5G Networks?

Private 5G can be deployed in several different ways – isolated, shared and network sliced, as follows:

Isolated network - The entire private network is owned and operated by the user and completely isolated from the public network.

Shared network - A hybrid configuration that leverages part of the telecom service provider's infrastructure together with private network elements, such as additional Radio Access Network (RAN) elements to ensure the required site coverage.

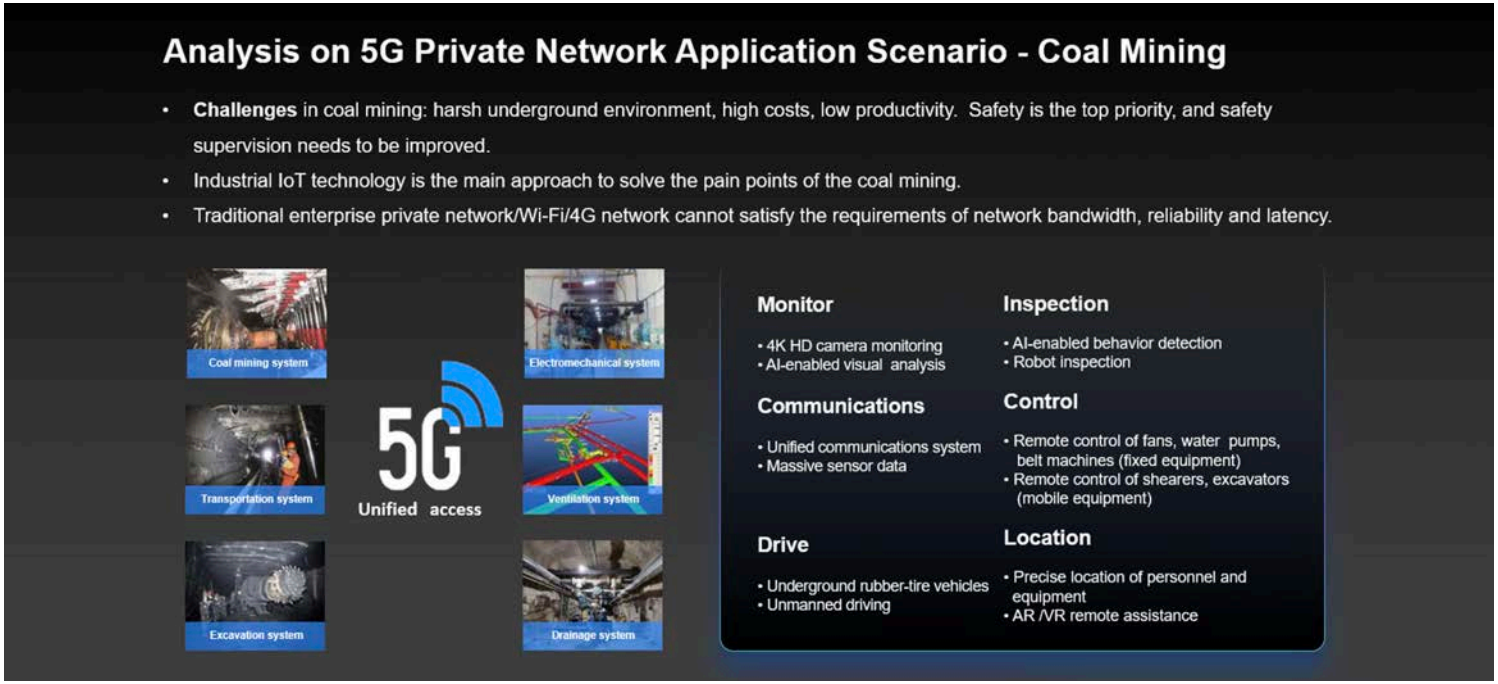
Private network slice under public network - The private network is realized by network slicing. This leverages the operator's existing public network infrastructure and offers private connections through the software-defined network slice.

Private 5G networks are a means to an end, that end being the conversion of massive amounts of IoT data into actionable local and distributed information and intelligence that is securely accessible for authorised personnel and third parties in corporate ecosystems. Private 5G networks are part of the broader organisational trend towards digital transformation. The term digital transformation refers to the deep integration of digital enabled processes into all aspects of an enterprise, along with an associated cultural change. The key objective is to enhance customer experiences by implementing fundamental operational changes. Private 5G, with its combination of greater device density, high bandwidth and low latency services, enables transformative connectivity, which in turn allows enterprises to realise their transformation strategy.

In this way, private 5G is a catalyst to elevate industrial operations. The main benefits of private networks for business operations include:

- Consistent localised campus coverage, both indoors and outdoors, designed to meet on-site needs.
- A highly secure environment, with enhanced network security and data remaining on-site.
- The provision of enough network capacity to meet connectivity and data handling requirements at all times.
- Local management control over network traffic and use, including seamless integration with enterprise IT/OT.
- Very high and controllable network reliability.
- Predictable and ensured low latency – data control.
- High data throughput and support for high density devices

An example of how private 5G can aid operations is illustrated in the case of coal mining.

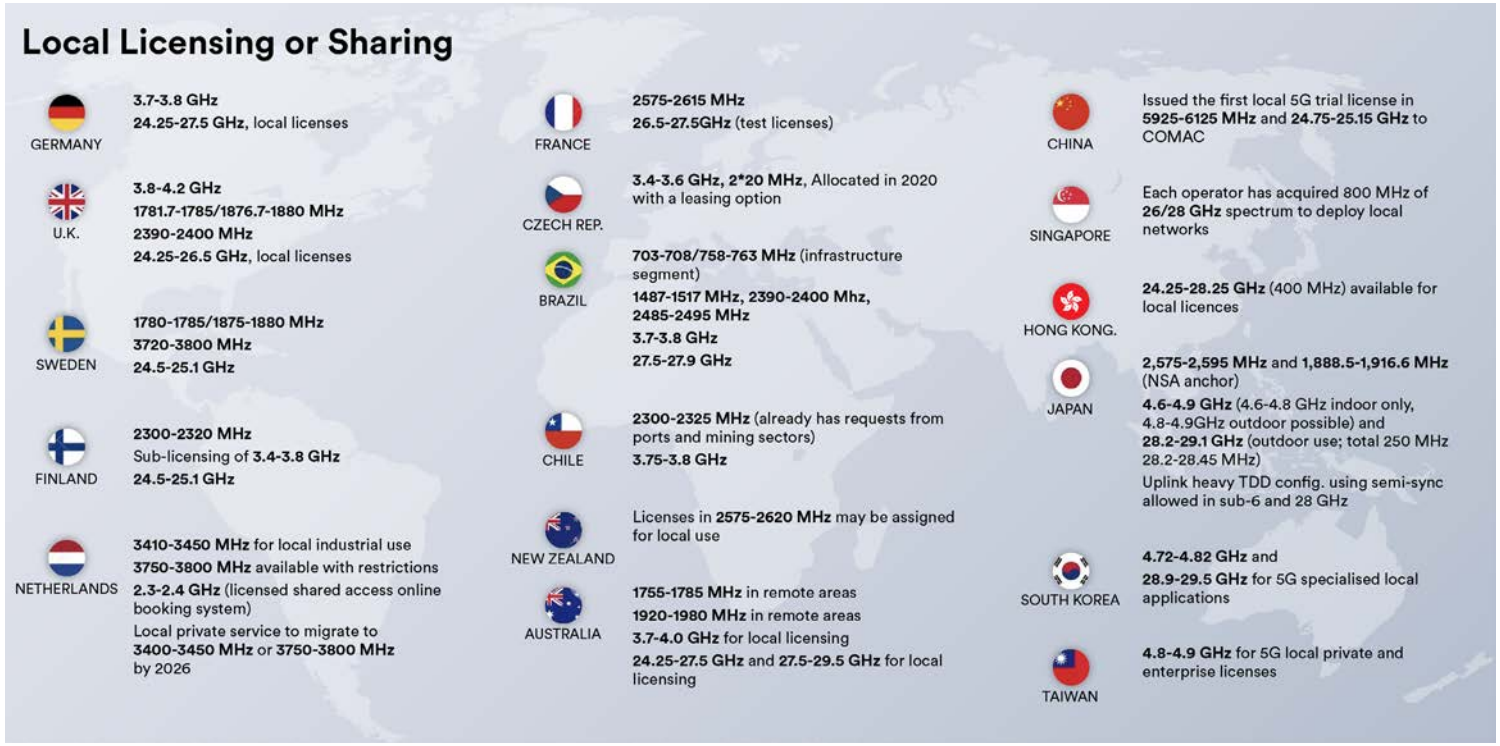


As the chart indicates, key challenges for coal mining include – a harsh underground environment, high costs, low productivity, with safety supervision needing to be improved as safety of personnel is the top priority. Operation activities where private 5G can make a substantial contribution are in Monitoring, Inspection, Communications, Control, Drive and Location, in at least 12 key application areas.

Within the 5G framework, Massive Machine Type Communications (mMTC) can support up to one million devices per square kilometre; Enhanced Mobile Broadband (eMBB) can transmit data at 10 gigabits per second; and Ultra Reliable Low Latency Communications (URLLC) offers extremely low, down to 1ms latency. These services are set to drive the expansion of a massive hyperconnected ecosystem where networks serve the connectivity requirements of very large numbers of low power consumption devices, with acceptable performance trade-offs between speed, latency, and cost.

Private 5G is essentially a wireless LAN that delivers unified connectivity and a secure means of wireless communication within a specific area. It functions as a wireless extension of an enterprise's wireline LAN.

To implement private networking requires wireless spectrum, and the chart below shows current examples of local spectrum licensing or sharing for 17 different countries worldwide to illustrate the extent of spectrum allocations that have already been made.



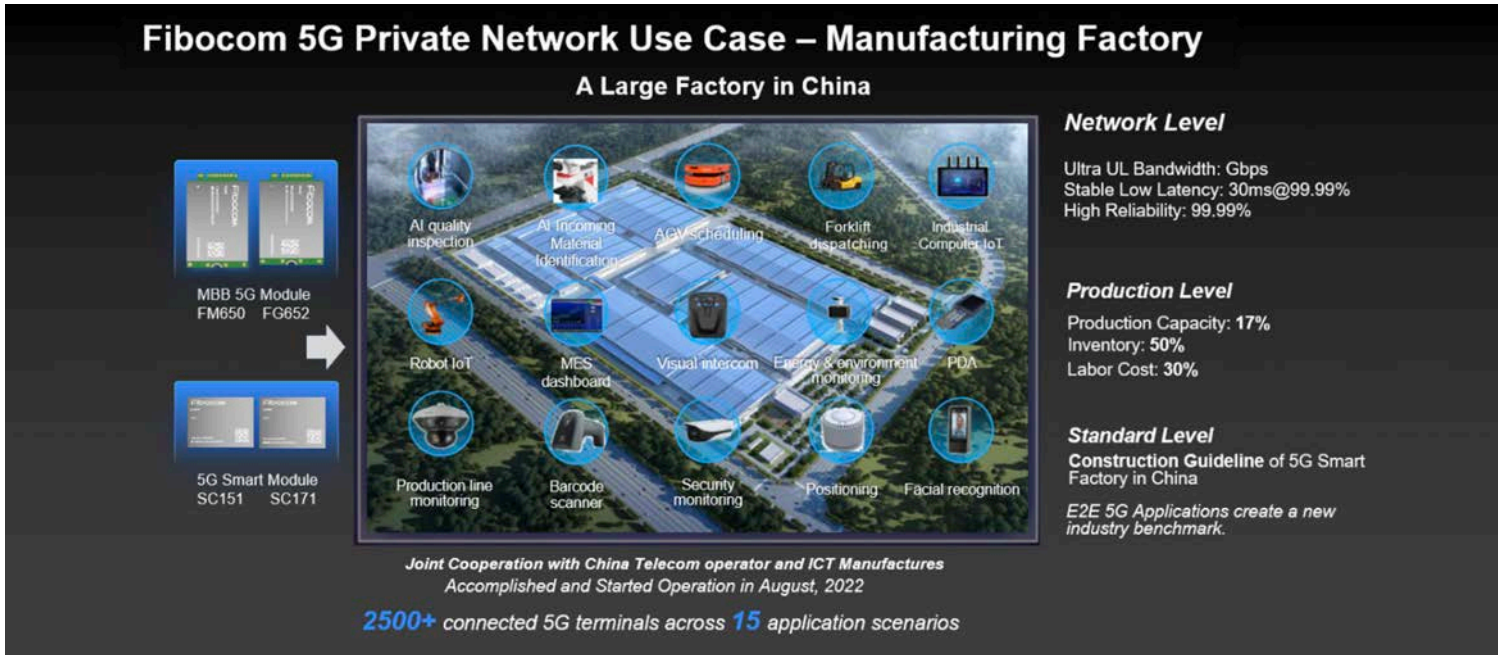
Source: GSA, MFA

Indicating the growing activity in the supply side to support these increasing activities, new players and business models have emerged in the private 5G market, including cloud computing enterprises such as Microsoft, Google and AWS. Relying on their public cloud advantages and industry user resources, these have acquired and collaborated with communication network suppliers and telecom operators to launch cloud centric 5G industry applications and services.

3. Fibocom 5G Private Network Case Studies

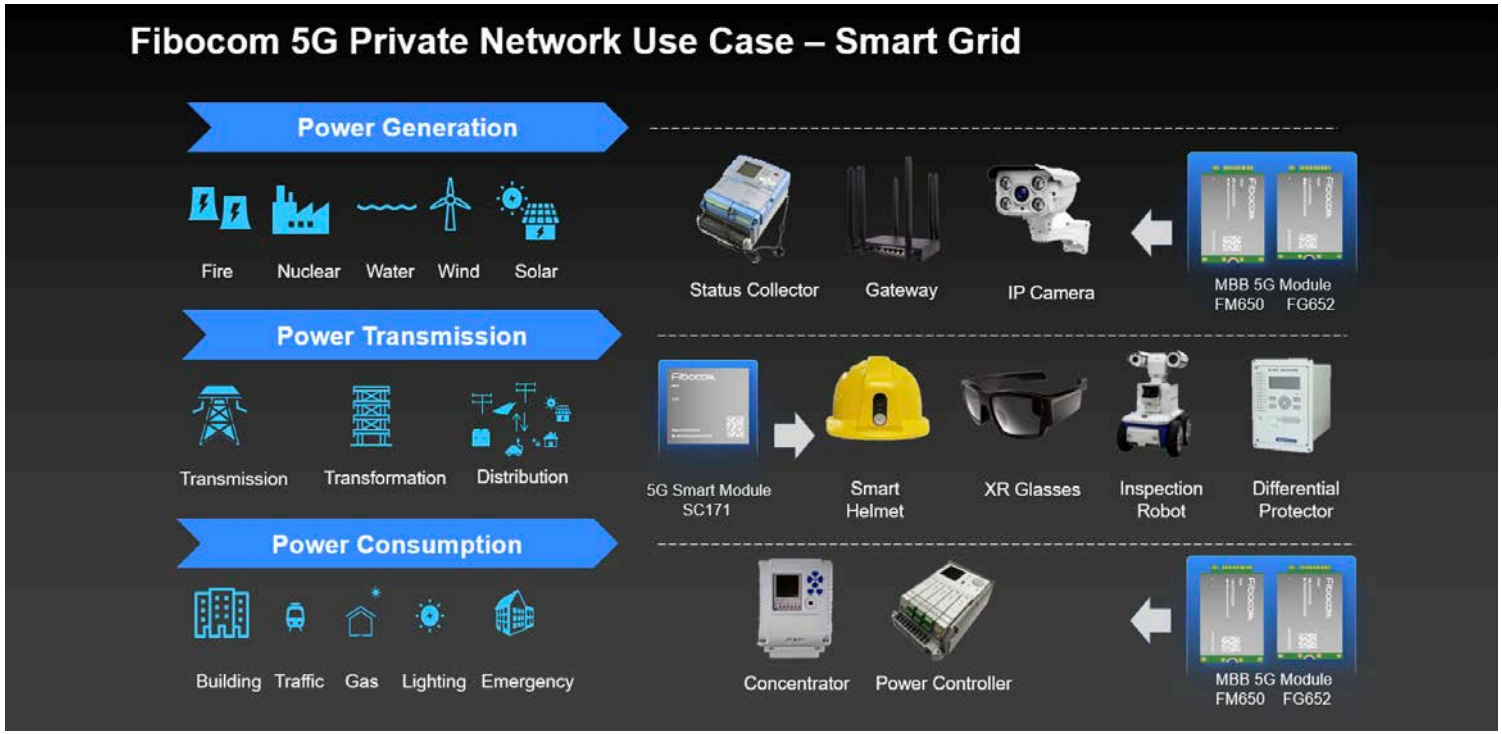
Fibocom is active in the 5G private networking market and the following case studies illustrate some of these activities.

A. Smart Manufacturing Factory



This large industrial park was facing a series of problems such as low production efficiency, high costs pressure, market shrinkage and outdated technology. A joint cooperation was formed involving Fibocom together with network operator China Telecom and the ICT Manufacturer to deploy a 5G private network for this huge industrial park. Fibocom 5G broadband modules FM650 and FG652, which supports the private network bands in China were built into networking gateways, CPE and ODU. In addition, 5G smart modules SC151 and SC171 were adopted in their smart terminals such as PDAs, PTT-over-Cellular radios, wearable cameras and mobile robots, This has enabled support for rich video, image, data and voice applications. These activities have led to achieving 50% improvement in stock, 17% increase in production efficiency and 30% savings in labor cost for this industrial park.

B. Power Equipment for Smart Grids



The construction of smart grids is gradually increasing the size of power distribution networks, and the digitalization of power grids is accelerating. The power equipment is facing an upgrade in demand and functionality. Fibocom 5G modules FM650, which supports the private network bands in China and 5G smart module SC171 have empowered our customers who develop terminal devices for the power industry to achieve commercial scale. They have also helped the power industry to be highly efficient, environmentally friendly, energy-saving, low-carbon, and intelligent. From power generation, through to transformation, to transmission, to distribution and to consumption, the utility company in China is facing challenges such as data synchronization, transmitting real-time HD video for grid patrols and more. By integrating with the 5G module, it can greatly improve accuracy, save labor cost, and improve efficiency.

4. Fibocom recent announcements related to 5G private networks

Fibocom has introduced a series of 5G modules that support the private radio bands in regional markets, for example:

FM160-EAU (Europe, Asia Pacific, Australia) 5G module supports n28 (700Mhz)/n78 (3500MHz) bands for other regional markets:

Fibocom 5G Module FM160-EAU to be the First 3GPP R16-Compliant Module Receiving ANATEL Certification Shenzhen China – February 15, 2022 – Fibocom announced that its 5G module FM160-EAU has been certified by ANATEL, the National Telecommunications Agency in Brazil. Complying with the 3GPP Release 16 (R16) standards, FM160-EAU is the first R16-compliant 5G module receiving this certification, which is an important milestone of the product's entry into the Brazilian market.

ANATEL certification is a mandatory step for wireless communication products gaining access to the Brazilian telecommunications market. Completion of this ANATEL certification ahead simplifies customers' deployment process, laying the foundation for Fibocom's FM160-EAU to support multiple IoT applications in Brazil.

Powered by the Qualcomm Snapdragon® X62 modem chipset, Fibocom's FM160-EAU is an NR Sub-6 module backward compatible with LTE-TDD, LTE-FDD, and WCDMA network standards. The module supports NR CA, delivering maximum downlink rates of 3.5Gbps and uplink rates of 900Mbps under 5G, ideally suitable for IoT applications that require high data throughput such as IIoT, C-V2X, HD live streaming, telemedicine, etc. The Fibocom FM160-EAU module adopts M.2 form factor measuring 30x52x2.3mm, which is compatible with Fibocom's 5G module series FM150.

Along with abundant functionalities such as digital audio, VoLTE, and VoNR, the Fibocom FM160-EAU module supports multi-constellation GNSS receiver, including GPS, GLONASS, BeiDou, and Galileo, which provides high-performance positioning and navigation while greatly simplifying product design. Meanwhile, it supports multiple operating systems (Linux/ Android/ Windows), various Internet protocols as well as industry-standard interfaces, allowing much flexibility and ease of integration for customer's application.

"We are excited to see FM160-EAU to be the first R16-compliant 5G module certified by ANATEL," said Gene Santana, VP of Overseas Carriers Certification Dept., Fibocom. "FM160-EAU is a high-value 5G module providing better 5G network experience for mass data scenarios. Fibocom will continuously empower the digital transformation and bring wireless connectivity to a broader range."

A further version – FM160-JK for Korea – supports n78 (3500MHz)/ n79 (4500MHz) bands.

In addition, and as noted in the case studies above, the company also has a range of smart modules for terminal devices. For 5G, these are the SC171 and SC151, used for a wide range of devices such as Industrial PDAs, Drones, Access Control, Robots, and In-vehicle infotainment applications.

Robin Duke-Woolley
CEO
Beecham Research

Shirley Tang
Director of MC
Product Marketing
Fibocom

5. One-on-one interview with Fibocom

Following on from these announcements, the author of this report (RDW) interviewed Shirley Tang, Director of MTC Product Marketing at Fibocom (ST) to understand in more detail how Fibocom is meeting market needs for 5G private networking.

RDW: who are the most important stakeholders for 5G private networking that you look to support in the market?

ST: We seek to support key stakeholders such as the telecom operators/MNOs, the MVNOs, infrastructure and base station vendors, and traditional ICT vendors – including Nokia, Ericsson, NEC and so on. In addition, the cloud technology enterprises such as Google, Amazon and Alibaba are also important for us. Then the big manufacturers who use 5G private networks for their own operations and vertical industry users – for example in mining, ports, airports, power utilities, and digital smart cities, since these are the final beneficiaries of 5G private networking.

RDW: what do you see as the most important performance issues that must be supported for 5G private networking now and in the future?

ST: The first big issue is interconnection. Because the networks, the base stations, the terminal devices and the gateways will be provided by different manufacturers. Each manufacturer has their own protocols, which are often different. This means the devices from different manufacturers may not work well together so that interconnection protocol should be the most important performance issue for 5G private network vendors.

Then there is compatibility. 5G private networks set up as new technology, which is needed to be compatible with 4G/5G public networks and other existing private networks such as Tetra system (widely used in EU countries) , and PDT system (in China). The private network users always require a unified, integrated, and efficient management system; so, the compatibility with existing networks is very important.

Other performance issues are timing synchronization and security. Security is well-established for isolated private networks.

There is a further issue – not so much performance-related – of frequency resources. Frequency resources especially in European countries are quite limited and quite expensive.

RDW: So how does Fibocom meet these challenges?

ST: 5G private network has really only got going in the last two years. So, I think firstly we would like to propose drafting an interconnection agreement with 5G private network associations, for example GSMA and 5G ACIA (Alliance for Connected Industries and Automation) in Germany. I think all related manufacturers, including Fibocom, should follow this interconnection agreement, to ensure all devices from different manufacturers can interwork with each other.

Fibocom is a module developer and manufacturer. Our core element is the chipset. So at the start of the design process we will discuss clearly with the original chipset manufacturers about the compatibility and interconnection issues. It is very important to work closely with our chipset partners on these challenges.

Besides that, we also need to work together with private network users concerning the issues of interoperation, compatibility and security. We are aiming to understand their requirements better and integrate the related protocols into our modules during our R&D process, to avoid the issues mentioned above as much as possible.

RDW: Your press releases talk about modules you have available for 5G private networking. Can you give examples of how these are being used?

ST: Yes. Fibocom 5G modules have been adopted for private network gateways and routers, which have been used for a China power utility, coal mining operations and some large smart digitalized manufacturers. We also launched modules dedicated for the private network market worldwide, supporting the regional private network bands.

RDW: Are you supporting other connectivity types for private network besides 5G? For example, 4G and Wi-Fi. Are you looking to integrate any of these with your 5G implementation?

ST: We have a series of 4G smart modules integrated with Wi-Fi & Bluetooth for smart terminals which are used in vertical industries private networks.

Normally, several wireless communication technologies are integrated and work together when building a 5G private network. So Fibocom integrates multiple connectivity technologies into individual modules, including but not limited to 4G, 5G, Wi-Fi, Bluetooth and GNSS to meet different customers' requirements.

RDW: What support do you provide for Wi-Fi?

ST: We have series of 4G & 5G smart modules integrated with Wi-Fi & Bluetooth for smart terminals which are used in vertical industries private network. Fibocom is also developing Wi-Fi modules supported with Wi-Fi 2.4G & 5G, 6E and Wi-Fi 7, so that we can provide more professional and more complete 5G FWA solutions, which will be used in gateways and routers for private networks.

RDW: Can you cater for roaming between public and private networks with this?

ST: Yes, the gateways integrate public and private cellular modules and protocols. Multi-mode smart modules integrate public and private cellular protocols for multi-mode PN terminal devices, which can cater for roaming between public and private networks.

6. In conclusion

After modest growth in recent years, analyst forecasts predict substantial pickup in growth is now in prospect for 5G private networks over the next few years. IoT in business operations has the proven ability to boost operational efficiency, improve product and service performance, and enhance operational agility. 5G private networks are part of this trend towards digital transformation.

These expectations are highlighted by increasing acquisition and investment activity among market players, as they position themselves for growth in this market. Cloud computing enterprises, telecom service providers, industry giants and others are highly motivated to expand the 5G private network market based on their own core strengths in cloud, network and application areas. Supporting these trends, Fibocom has introduced private network modules covering 4G and 5G Sub-6GHz. In addition, and importantly for private network build-out, the company has also introduced a range of smart modules for 4G/5G terminal devices.

With private cellular networks set to become the new gold standard across a range of industries and applications, device manufacturers are increasingly incorporating PCN network accessibility into their flagship products. Fibocom, in partnership with chipset companies and other IoT pioneers, is proud to be at the cutting edge of this innovation, driving the development and adoption of LTE and 5G PCN-compatible wireless modules. With these technologies in place, we envision networks that are not only smarter, but will also deliver a safer, more efficient, more connected future.

Leading the 5G IoT Race: Key Industry Insights Series 3. Asset Tracking

By **Robin Duke-Woolley**, CEO, Beecham Research

Logistics is about the safe transportation of goods to customers across the world. This entails tracking goods from production, storage (such as warehouses), through delivery and receipt by the customer. As a result, asset tracking is at the heart of modern life. Suppliers increasingly need to know where their assets are at all times and its condition, since late delivery may hold up further supply chain processing by partners.

1. Asset tracking is growing rapidly, addressing key concerns

Trailer and cargo container tracking is a specialized area within asset tracking focused on enhancing operational efficiency and security within transport chains. This approach typically involves real-time tracking solutions that include data logging, satellite positioning, and data communication to a back-office application through cellular or satellite networks. These devices enhance decision-making, improve asset utilization, save costs, and reduce environmental impact for supply chain stakeholders.

Figure 1 indicates the rate of growth over the next few years in this sector of the market. Such tracking devices are adaptable for monitoring various assets such as trailers, intermodal containers, rail freight wagons, air freight Unit Load Devices (ULDs), or the cargo itself. In more detail, a further breakdown for these subsegments is shown in Figure 2.

As is clear from this, the main subsegments are general cargo, air freight, intermodal containers and trailers. Key challenges for these are as follows:

(a) **Cargo Theft:** Tracking solutions are essential for preventing theft, especially of high-value goods, by enabling door-to-door tracking and alerts for unauthorized events such as opening container doors while in transit, or temperature variations of the cargo.

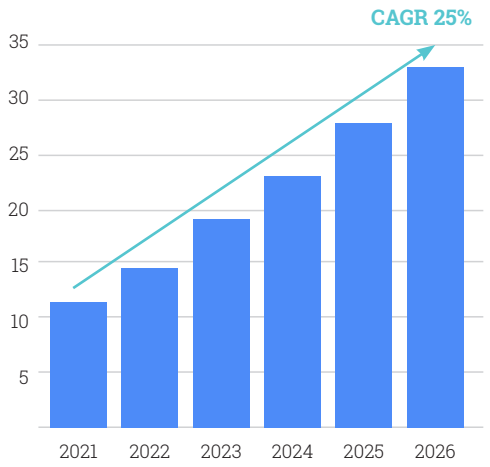
(b) **Cost and Battery Life:** Lower hardware costs have broadened the application of real-time tracking, but low cost and long battery life in devices is still a high requirement.

(c) **Coverage Limitations:** While cellular technology (2G/3G/4G) offers sufficient performance in terms of area coverage, network latency, and data bandwidth, its coverage at sea and in rural areas is limited.

(d) **Device Durability:** For long-haul sea transports, tracking devices need to be durable. For example, the tracking device includes a humidity sensor, and a higher IP classification (IP67), making it suitable for long-haul transport on sea and rail.

Each of these issues has been addressed by Fibocom in its design of modules for the asset tracking market – see later. A particular area is addressing coverage limitations, and for this there is now an opportunity to use satellite coverage integrated with cellular, to provide uninterrupted coverage worldwide.

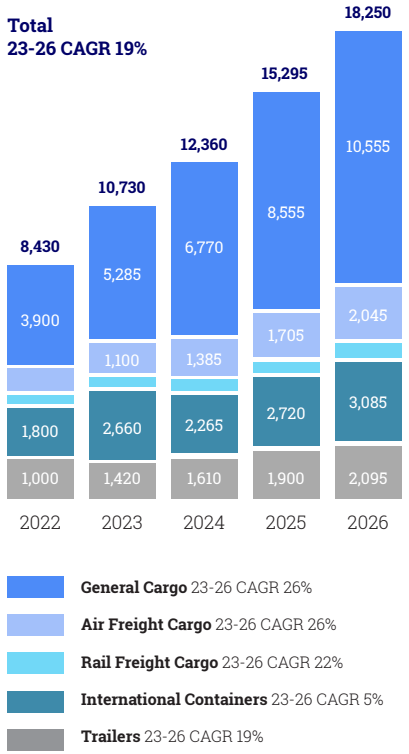
Installed base of trailer and cargo container tracking units worldwide



Source: Berg Insight

Figure 1: Forecast of installed base growth for trailer and cargo tracking (m units)

World trailer and container tracking device shipments
(k units)



Source: Berg Insight

Figure 2: Breakdown of trailer and cargo container tracking forecast

2. Adding satellite to 5G for uninterrupted worldwide coverage

Different satellite systems – also referred to as NTN or Non-Terrestrial Networks – have been used for years to provide services such as TV broadcasting, navigation, communications, surveillance, weather forecasting and emergency systems. Figure 3 illustrates the orbits of the three main satellite types – geostationary (GEO), medium-Earth orbit (MEO) and low-Earth orbit (LEO) – in comparison to a commercial aircraft and high-altitude platform system (HAPS) providing local service coverage. The opportunity now is to integrate NTN with Terrestrial Networks (TN) like cellular to provide complete coverage of the Earth's surface anywhere.

To that end, as part of the continuing development of 5G, 3GPP Release 17 has specified the use of GEO and LEO satellites for IoT connectivity via NTNs in a track known as IoT NTN. This track includes adaptations to NB-IoT and LTE-M that will enable them to support NTNs.

Essentially, integrating 5G with satellite, as envisaged in 3GPP Release 17, puts a stationary cell tower in the sky when considering GEO, or a fast-moving network of cell towers when considering LEO. It means a single SIM will be able to connect to both TN and NTN-compliant satellite networks.

Taking the case of GEO, incumbent satellite connectivity providers work with proprietary devices and communication protocols. These are relatively expensive due to relying on dedicated devices and high cost of infrastructure. As a result, customers have to invest in equipment that can only be used with one constellation and are therefore locked in. This is justified for critical applications but it limits the range of applications that can be cost effectively served.

In comparison, use of 5G introduces the opportunity to use standardised hardware made by many different suppliers for both TN and NTN use. This will significantly increase the addressable market. Fibocom is addressing this market opportunity with its 3GPP R17 compliant LPWA module MA510 with NTN capability and 5G LPWA MS180 module.

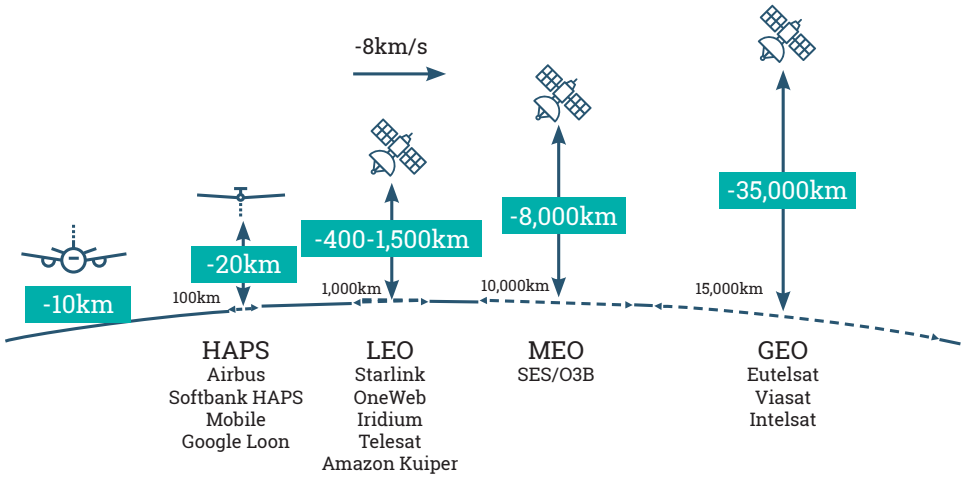


Figure 3: Typical altitudes and footprints of existing satellite systems

Source: Ericsson

3. Fibocom recent announcements related to asset tracking

Fibocom Unveils NTN Module MA510-GL, Enabling Satellite and Cellular Connectivity to IoT Applications

During MWC Shanghai in July 2023, Fibocom announced the global launch of the Non-Terrestrial Networks (NTN) module MA510-GL (NTN) and showcased the live NTN demonstration based on Qualcomm's NB-IoT over NTN technology. The module focuses on enabling satellite and cellular communication for IoT devices at global reach, making it possible to connect reliably and seamlessly anywhere, anytime.

Shanghai, China – July 4th 2023 - Fibocom unveils the Non-Terrestrial Networks (NTN) module MA510-GL (NTN) at MWC Shanghai 2023. Compliant with 3GPP Release 17 standard, the Qualcomm® 9205S modem empowered module MA510-GL (NTN) is capable of exploiting the highly resilient GEO satellite communication and cellular connectivity for IoT scenarios such as maritime transportation, emergency communication, scientific research in rural areas, etc.

Fibocom MA510-GL (NTN) is a high-performance NTN module, which is tailor-made for the global IoT market. Developed on the Qualcomm® 9205S modem, the module supports GEO satellite communication as well as LTE Cat M/NB2/EGPRS cellular communication that is perfectly applied for massive IoT applications. Adopting LCC+LGA form factors, MA510-GL (NTN) integrates multiple interfaces such as UART/ USB/I2C/I2S for industrial customers. Built-in with GNSS and equipped with eDRX capability, the module is suitable for IoT applications with low power consumption and ultra-small size, such as maritime transportation, emergency communication, and scientific research in remote areas while maintaining long battery life.

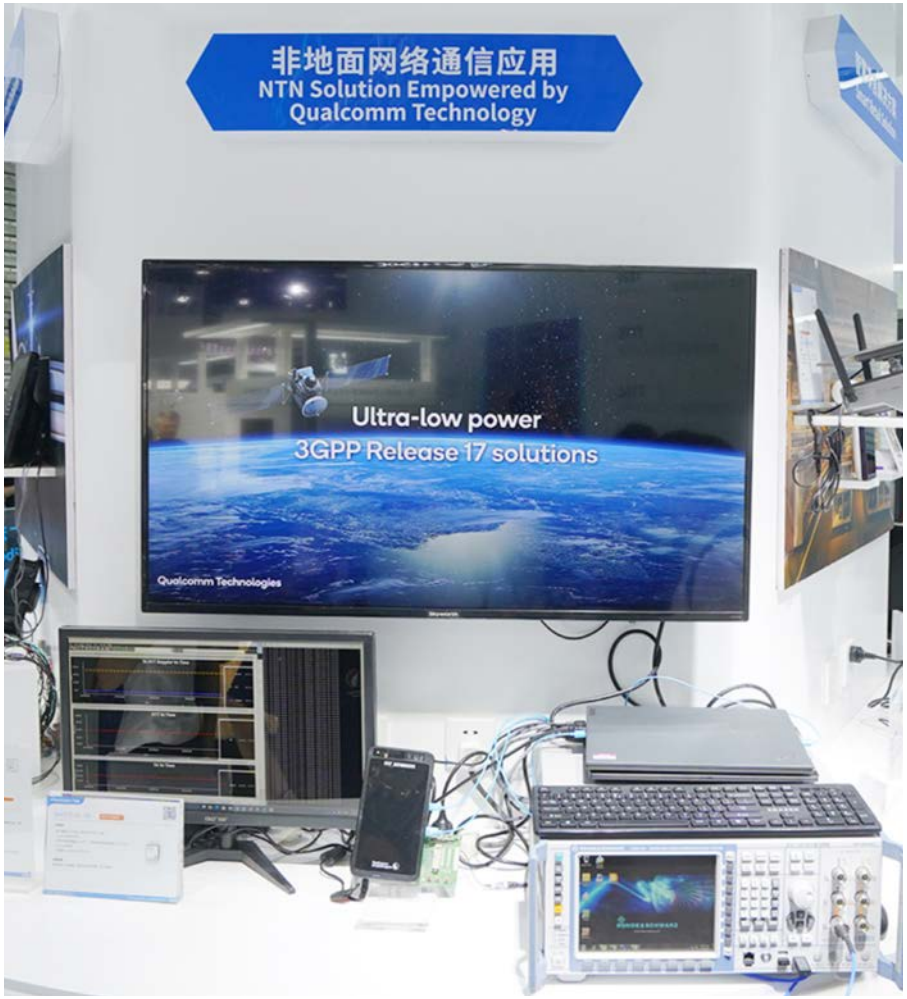


Figure 4: NTN live demo showcased during MWC 2023, integrated with Fibocom's MA510

Fibocom Launches New 5G LPWA Module MS180 Series Based on Sony's Altair ALT1350 Chipset at Embedded World 2023

Nuremberg, Germany – March 13th, 2023 –Fibocom announces the cooperation with Sony Semiconductor Israel (Sony), a leading provider of Cellular IoT chipsets, in launching the 5G LPWA module MS180 series. Powered by Sony's Altair, best in class ALT1350 chipset, the Fibocom MS180 module series is designed to provide ultra-low power consumption and reliable wireless connectivity for the 5G massive IoT market.

With optimized power consumption, Fibocom MS180 series is a SOC integrated LPWA module with an AI engine for edge processing, supports the latest 3GPP Release 14 through 17 of LTE-M/NB-IoT, unlicensed spectrum communications protocols, Non-Terrestrial Network (NTN) satellite communications, Wi-Fi SSID-based location, and Short-range radio. MS180 series will also adopt a compact footprint of less than 200 sq millimeters to be best utilized in the 5G Massive Machine Type Communication (MTC) applications such as smart metering, asset tracking and connected health. The MS18 series adopts LGA form factor, with ultra-compact size and optimized low power consumption, offering unprecedented battery life up to 15-20 years.

Fibocom Announces LTE Cat 1 bis Module MC610 Shaping a Connected Future

Shenzhen China - July 15, 2021 - Fibocom launches its new LTE Cat 1 bis module - MC610. Coming with a rich set of interfaces and supporting multiple operating systems, the Fibocom MC610 module is designed to provide stable and secure connectivity for the low and medium rate IoT market, which is ideal for IoT scenarios such as smart payment, sharing economy, IIoT, asset tracking and telematics.

The Fibocom MC610 module is a high-performance LTE Cat 1 bis module supporting VoLTE (Voice over LTE), Audio, Recording and SMS. Adopting LCC+LGA form factor, the module is pin-to-pin compatible with the Fibocom LTE Cat M module MA510, allowing users to easily switch between different technologies without changing hardware. Supporting LTE FDD frequency band with a theoretical downlink of 10 Mbps and an uplink of 5 Mbps, Fibocom's MC610 module enables seamless 4G experience, which is also backward compatible with GSM frequency band.

The Fibocom LTE Cat 1 bis module MC610 supports Windows, Linux and Android operating systems, coming with a rich extension of interfaces including USB, UART, SPI, I2C etc. MC610 can be widely applied in IoT scenarios such as smart payment, sharing economy, Industrial IoT (IIoT), asset tracking and telematics and so on.

4. Fibocom module range for asset tracking

Figure 5 shows a typical example of a Fibocom tracker solution, with the single module incorporating traditional cellular modem functionality and integrated MCU.

In terms of the key challenges for asset tracking outlined earlier, Fibocom modules offer the following:

Cargo Theft

Tracking devices play a vital role in security. They can show the container's travel history and ensure the integrity of the cargo with intrusion detection sensors, e-seals, and e-locks. Advanced sensors can also detect illegal or dangerous goods or movement inside a container.

Cat 1 bis modules and devices have a single antenna and a single receive RF chain, in contrast to the two antennae needed for Cat 1 devices. LTE-M and NB also offer a cost advantage: the RF front end needs no surface acoustic wave filter (i.e. it is SAWless) due to the half-duplex nature of the communication. As a result, using Fibocom Cat 1 bis and LPWA modules can lower the cost for widely implemented tracking devices.

Cost and Battery Life

Fibocom LPWA and Cat 1 bis modules have high integration, integrating GNSS, WiFi Scan, BLE, GNSS and iSIM. They also support OpenCPU, saving on MCU cost. They are very small in size, which can save PCB area, and low power consumption to save on battery cost. All of these features can greatly reduce the overall cost of tracking devices. Both also support PSM and eDRX low power modes, which greatly extend the battery life of devices.

Coverage Limitations

LPWA modules provide global network coverage with triple-mode Cat M/NB-IoT/GPRS. For regional deployment, Cat 1 bis is based on the existing LTE network and completely reuses the existing LTE resources. The Cat 1 bis product frequency band covers the 4G band of China, Europe, India and Latin America, while North America, Australia and Japan do not have Cat 1 bis so use the triple-mode LPWA is used there.
In addition, we support satellite connectivity protocol based on 3GPP Release 17 standards (NTN).

Product Features:
- Battery-powered, low power consumption, no need for charging
- MCU with external GNSS chip or Cell ID positioning module
- Periodically reporting of location and temperature information
- Mostly single-use products

Business Scenarios:
- MCU periodically obtains location and temperature information, then powers on the module, and sends the collected location and temperature information to the server through the module
- After uploading the information, the MCU powers off the module and peripherals

Figure 5: Fibocom tracker solution architecture example

Device Durability

Fibocom's modules utilize shielding cover bent components, where the adjacent sides of the bent edges interlock, ensuring a pentagonal gap that remains less than 0.08mm. In addition. Fibocom applies polyolefin resin three-proof paint to the module based on this design and has conducted high-temperature, high-humidity reliability testing. This conforms to IP67 requirements. Rigorous testing has confirmed that this design does not affect RF performance, while also providing more reliable protection for the module.

Fibocom's range of modules for asset tracking cater for different deployment requirements. For global roaming deployment, LPWA options provide for NTN support and integrated Wi-Fi scan with extreme low power consumption. For regional deployment, Cat 1 bis is offered, both with and without 2G fall back:

- MA510 is a high-performance LPWA module compliant with 3GPP R17 standard. Developed on the Qualcomm® 9205S modem, the module supports GEO (Geostationary Earth Orbit) satellite communication as well as LTE Cat M/NB2/EGPRS cellular communication that is perfectly suited for massive-IoT applications.
- MS180 is a SOC integrated LPWA module with an AI engine for edge processing. It supports all the latest 3GPP Releases 14 through 17 for LTE-M/NB-IoT, unlicensed spectrum communications protocols, Non-Terrestrial Network (NTN) satellite communications, Wi-Fi SSID-based location, and short-range radio.
- MC610 is an LTE Cat 1 bis wireless communication module. The product supports LTE, GSM dual-mode communication, as well as VoLTE, Audio, Recording, SMS, Wi-Fi Scan, BLE and other functions. The PIN package is compatible with MA510 module to meet the requirements of Cat 1 and Cat M products.
- MG661 is a high-performance LTE Cat 1 bis module that adopts the LGA form factor. It supports 4G frequency bands in Europe, Southeast Asia, Middle-east and other regions.

5. One-on-one interview with Fibocom

Robin Duke-Woolley
CEO
Beecham Research

Kevin Guan
Director of MTC
Product Marketing
Fibocom

Robin Duke-Woolley (RDW), CEO of Beecham Research, interviewed Kevin Guan (KG), Director of MTC Product Marketing at Fibocom, on how Fibocom is supporting the need in the logistics sector for regional and global asset tracking.

RDW: 3GPP Release 17 introduces the opportunity for 5G cellular integrated with NTN (Non-Terrestrial Networks) – satellite systems. When do you see this becoming available in the market and for what typical applications initially?

KG: Currently, we see the biggest interest in NTN is for asset tracking applications such as trackers on trailers, sea containers, rail freight wagons because most applications may operate in areas beyond the reach of traditional cellular networks. Making real time tracking over oceans and other remote locations will be very important. In that case, many of our clients in this industry are discussing NTN with Fibocom. At the same time, we acknowledge that NTN applications still require time to develop because currently NTN use for asset tracking is mainly using the GEO (Geostationary Orbit) networks. These networks have not completely solved the coverage issue yet. We work with NTN service providers worldwide. Currently, the deployment of satellite networks is still at an early stage and the coverage is limited to certain areas. Another big challenge is the cost. Current tariffs are too high compared with cellular tariffs, so it's less appropriate for large scale commercial use at present. Currently the whole communications ecosystem, including traditional mobile operators, is involved and exploring how to combine those NTN tariffs and cellular tariffs to make a more affordable offering for commercial use. So, in that case our preliminary estimate is for initial commercial trials maybe starting in 2024, then with larger scale commercial use expected after 2025.

RDW: What is required in the module to implement NTN? For example, does it need more power for NTN use compared with TN (Terrestrial Network) use?

KG: This is what our customers are frequently asking us. In fact, our cellular LPWA module MA510 which supports NTN is already in mass production and has been installed in larger quantities because it supports NB/Cat-M/2G triple mode. Now it is extending new capabilities to support NTN, which is compliant with 3GPP R17, so quad mode but what needs to be done is actually very simple. Hardware does not need to be revised because the NTN version maintains the same pin design and the only change is the internal chip. So the module will be replaced with a version that supports NTN. Additionally, customers tell us they most likely do not need to go through a redesign because most linear antennas can be used for NTN. There is no significant increase in power consumption compared with cellular because NTN operates in the frequency band close to NB-IoT, so its operational power consumption is not higher. This makes it very suitable for asset tracking using batteries.

Something that needs to be catered for is a maximum TRP (Total Radiated Power) of 23dBm to ensure regular transmission in power class 3. Also, GPS must be enabled to provide location information for satellite search. This is easy for our customers because Fibocom's MA510 supports GPS as an option.

RDW: Moving on to eSIM and iSIM, how significant do you see iSIM as being in the asset tracking market and would you expect eSIM and iSIM to coexist in this market?

KG: Currently iSIM is a very hot topic, especially this year. But right now, it has not yet been commercialised. We think this is because the cost of iSIM is still higher than traditional SIM cards and the cloud

management also entails additional cost, because the iSIM requires cloud management. For iSIM to be widely applied in asset tracking, it requires collaborative effort among mobile operators, chip manufacturers, module vendors and cloud platforms. Meanwhile, eSIM technology is already mature so we anticipate that eSIM and iSIM will coexist in the market for a long time.

Different asset tracking applications have different requirements. Railway wagons and containers for cargo tracking do not need to save space, so it's not necessary to have the SIM integrated. I believe for smart labels, personal asset tracking and similar applications which need small size and need much less power consumption will be the key market for iSIM. For most asset tracking applications operating right now in the market, eSIM or even traditional SIM cards should be sufficient.

RDW: Where do you see Cat 1 being used compared with NB-IoT and LTE-M? For which typical applications in asset tracking?

KG: In China, Europe, India and Latin America LTE Cat 1bis is already being used extensively in commercial applications, using Fibocom's MC610 and MG661 series modules. This is because the cost of Cat 1bis has significantly dropped and is now only just higher than NB-IoT. Additionally, the power consumption of Cat 1bis has approached that of NB-IoT. Currently we are seeing use in regular asset tracking applications such as trailers and fleet management already using Cat 1bis. However, there are some regions like North America, Australia and Japan that do not support Cat 1bis, so for global applications it is not feasible. In that case Cat-M, NB-IoT and 2G in triple mode are still required for global roaming applications like cargo containers and sea transportation. Also, Cat 1bis modules – which are 4G – do not support NTN because NTN starts in 5G Release 17, so only the Cat-M and NB-IoT LPWA module could extend to support NTN.

RDW: So there is a different solution for regional versus global tracking?

KG: Yes. For regional tracking, for example in China, or in Europe for applications involving fleet management or trailers in one country, Cat 1bis is sufficient. On the other hand, for global roaming especially for applications involving North America, Australia and Japan, they have Cat 1 but not Cat 1bis, so then they need a triple mode LPWA module.

RDW: Some Fibocom modules include Wi-Fi scanning. Can you clarify what that provides?

KG: The Wi-Fi scan feature is primarily used to support indoor tracking. Outdoors, cellular coverage is very good but when you go indoors, if a highly accurate positioning is needed then the Wi-Fi scan feature can be used. In that case, indoor tracking is particular useful for example for warehouses, for in-factory use, for personal asset tracking on-site, and for patient tracking in a hospital. So it is useful for a wide range of additional applications.

RDW: Some Fibocom modules incorporate bent shielding. What is the benefit of that?

KG: The main reason we do this is because asset tracking operates in harsh environments, such as sea transportation and railway tracking. It is essential for them to be moisture proof and salt-spray resistant. To ensure this, the module and the PCB surface are coated with a carbon fibre coating. We use components with very small gaps in the shielding cover to prevent anything entering the module during operation and also for use in high temperatures. To verify this, Fibocom has conducted extensive technical quality validation procedures.

RDW: Are there other key features that Fibocom offers in its modules for the asset tracking market?

KG: Many customers utilise Fibocom's Open CPU functionality to further reduce the overall cost of their solutions. For most applications, our customers normally require use of an MCU in their devices for local data processing and of course a modem for the connectivity. They can replace all of this with the Fibocom module CPU functionality, with the application running on the CPU in the module. This saves on the total cost of the device, which is a key issue in the asset tracking market.

RDW: So they can use the CPU in the module as opposed to one on the device circuit board and therefore save cost. Are there other features that Fibocom modules also offer?

KG: Our module integrates more and more functions to save the total cost. For example, we also offer Wi-Fi scan. In addition, we offer Bluetooth functionality, which is supported by Cat 1bis. Those features are currently the most interesting for our customers.

RDW: By incorporating more of these features in the module, would that also reduce not only the size of the device but also the power consumption?

KG: Customers want to use for example Cat-M and NB-IoT in different countries and then integrate other features both for keeping the size down and for reducing the power consumption – saving the battery. The more integration there is, the better for them. This reduces the battery cost as well as the PCB space. In this way, our module can help customers make their whole solution more competitive in the market.

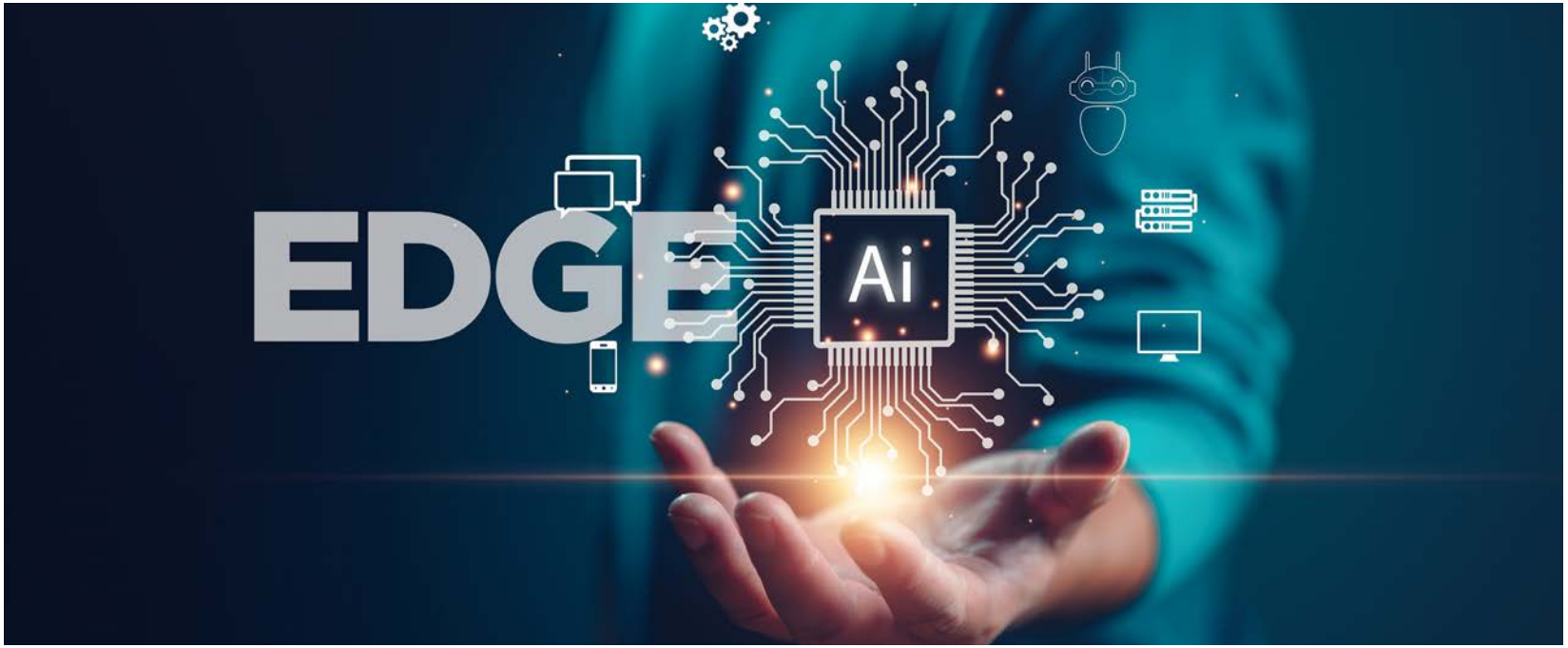
6. Summary

Fibocom's modules are used in a wide variety of IoT asset tracking scenarios, including fleet management and cargo tracking, utilities payments, smart cities, after-market auto location and many more. Fibocom has been working in this area since 1999 and in that time has focused on the research and development of wireless modules for 2G through to 5G and beyond towards 6G. Building the foundation for the digital world and everything associated with a 'smart life' has always been Fibocom's mission.

Leading the 5G IoT Race: Key Industry Insights Series
4. Edge AI

By **Robin Duke-Woolley**, CEO, Beecham Research

Edge AI is one of the most notable sectors of artificial intelligence, providing the ability to run AI processes without the latency issues of data transmission to the cloud. Edge AI is enabling greater, more widespread use of AI, providing the means for smart IoT devices to respond quickly to new inputs and to new application opportunities.



1. What is Edge AI and why do we need it?

Edge AI is the deployment of AI applications in devices at the network edge throughout the physical world. It is called "Edge AI" because the AI computation is done near the user at the edge of the network, close to where the data is located, rather than centrally in a cloud computing facility or private data centre.

Cloud AI is where data processing and storage occur in centralised data centers managed by cloud service providers, usually situated far away from end-users. By offering cloud computing service such as servers, storage, databases, etc. over the internet to the cloud, it offers flexible resource accessibility and economics of scale.

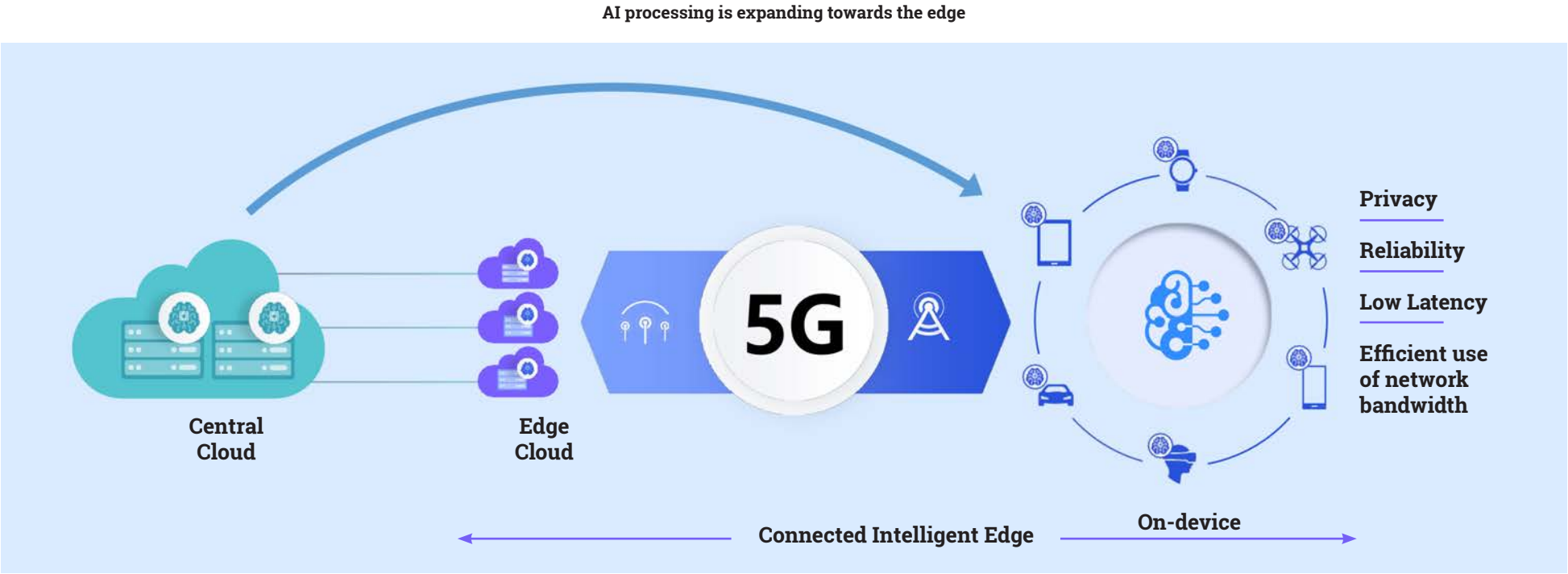


Figure 1: Moving AI from the Cloud to the Edge

Edge AI and Cloud AI are therefore complementary technologies. Particular advantages of Edge AI include the following:

i. Lower data transfer volume
Data is processed by the edge device, and only a significantly lower amount of processed data is sent to the cloud. By reducing the traffic amount across the connection between a small cell and the core network, the connectivity cost can be reduced.

ii. Speed for Real-time computing
Real-time processing is a fundamental advantage of edge computing. The physical proximity of edge devices to the data sources makes it possible to achieve lower latency which improves real-time data processing performance. It supports delay-sensitive applications and services such as remote surgery, tactile internet, unmanned vehicles, and vehicle accident prevention. A diverse range of services, including decision support, decision-making, and data analysis, can be provided by edge servers in a real-time manner.

iii. Privacy and security
Since transferring sensitive user data over networks makes it vulnerable to theft and distortion, running AI at the edge enables keeping the data private. Edge computing makes it possible to guarantee that private data never leaves the local device. For the cases where data must be processed remotely, edge devices can be used to discard personally identifiable information before data transfer, thus enhancing user privacy and security.

iv. High availability
Decentralization and offline capabilities make Edge AI more robust by providing transient services during a network failure or cyber-attacks. In this way, deploying AI tasks to the edge ensures significantly higher availability and overall robustness needed for mission-critical AI applications.

v. Cost and energy efficiency
Moving AI processing to the edge is highly cost efficient because only processed, highly valuable data is sent to the cloud. Sending and storing huge amounts of data to the cloud is costly, while processing locally at the edge saves these costs and is also more energy efficient.

vi. Scalability and Adaptability
Edge AI provides the opportunity for scalable and adaptable solutions that can cater for diverse edge devices and evolving application requirements. It focuses on developing lightweight and efficient AI algorithms that can run effectively on resource-constrained edge devices, ensuring flexibility and compatibility across different hardware platforms. In this way, it provides a natural path for scaling IoT solutions and for enabling mass deployments.

These advantages offer substantial enhancement of IoT applications and, as a result, the opportunities are huge. Figure 2 shows Beecham Research estimates drawn from several different analyst forecasts – all pointing towards high growth of over 24% per annum in global Edge AI revenues during the period 2022 through 2030.

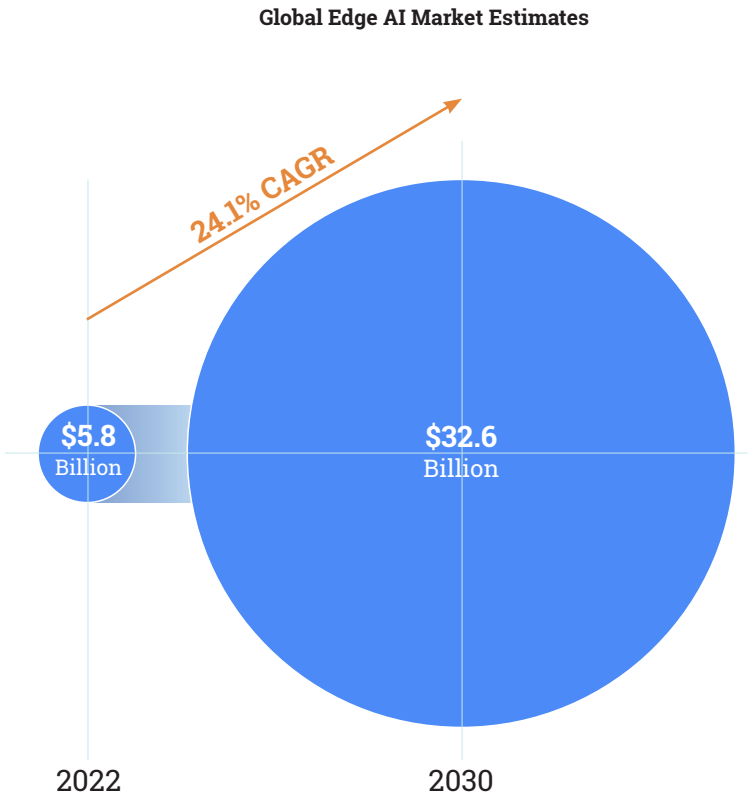


Figure 2: Global Edge AI Revenue Projection

(Source: Beecham Research)

2. Where will Edge AI be used?

Edge AI will be used in all IoT sectors for a wide range of applications that will evolve over time. To give an idea of these, Figure 3 shows 9 application scenarios where Edge AI is already evident.

Figure 3: Key Application Scenarios for Edge AI

A brief outline for some of these is as follows:

- **Smart Homes.** Edge AI allows smart home devices to perform voice recognition, natural language processing, and activity recognition locally. It enables faster response times, enhanced privacy, and local automation of various tasks within the smart home ecosystem.

- **Healthcare Monitoring.** Edge AI enables real-time monitoring and analysis of health data from wearable devices, such as heart rate monitors or glucose sensors. It allows for immediate detection of abnormal patterns, personalized healthcare recommendations, and timely alerts for medical interventions.

- **Smart Manufacturing.** Edge AI plays a vital role in smart manufacturing applications, such as predictive maintenance, quality control, and robotics. It enables real-time analysis of sensor data, anomaly detection and autonomous decision-making at the edge, improving operational efficiency and reducing downtime.

- **Outdoor Robots and Human-Robot Collaboration.** Edge AI plays a major role in enabling human-robot collaboration applications by bringing AI capabilities directly to the edge devices and robots involved in the collaboration. It allows robots to analyze and process data in real-time, make intelligent decisions, and interact with humans efficiently, without relying heavily on cloud resources. The capabilities of outdoor robots are especially important for outdoor operations in harsh and hazardous environment, where human safety can be protected by using robots. Edge AI facilitates various aspects, such as perception, decision-making, and interaction. For example, edge AI algorithms deployed on robot platforms can enable real-time object recognition, tracking, and gesture recognition, enabling robots to understand and respond to human commands and actions.

- **UAVs.** Edge AI enables a whole raft of new capabilities for UAVs. Critical technical challenges of UAVs are autonomous navigation, power management, security and privacy, formation control, computer vision, and communication. Autonomous navigation can be further divided into localization and mapping, path planning, and collision avoidance systems.

3. Outdoor Robots

To illustrate the potential growth for these, the following looks at one of them – outdoor robots – in more detail.

As shown in Figure 4, outdoor robots is a relatively small business at present with a lot of experimenting taking place in terms of application development and shape. Global revenues amounted to around $163 million in 2022, with expectations for strong growth over the next decade to $701 million in 2032 – an annual growth rate of 15.7%. There are three principal types of outdoor robot:

- Delivery Robots, including UAVs and autonomous vehicles that are increasingly being used for last-mile deliveries.
- Security and Inspection, including patrolling secure premises, inspecting infrastructure and pipelines for potential faults and harsh terrain.
- Guide, including use in hospitality and retail environments to guide visitors and provide information.

Of these, the largest and accounting for more than 50% in value is Delivery. Security and Inspection is the next largest, with Guide being the smallest category.

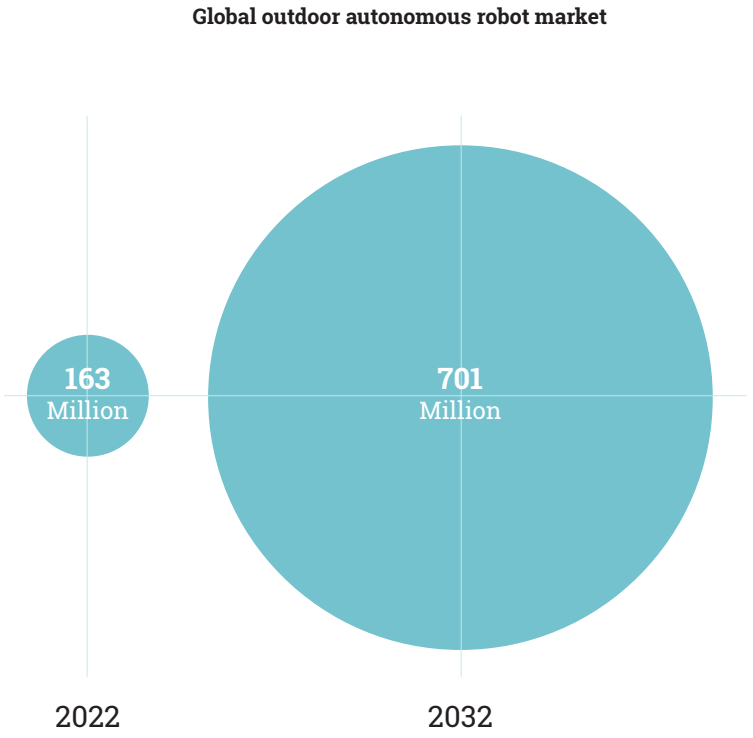


Figure 4: Outdoor Robots Revenue Forecast, with 15.7% CAGR in the period

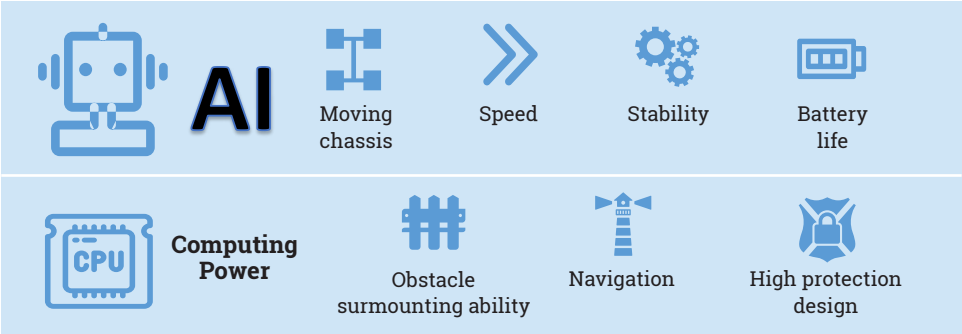
(Source: Grand View Research)

The main application areas are developing rapidly and include factory parks, ports, the power industry, airports, mining, geological prospecting, street patrol and smart agriculture.

There are several key reasons for this expected growth:

1. Increasing government initiatives and investment in robot manufacturing companies.
2. Increasing demand for autonomous last mile delivery.
3. Huge growth in e-commerce and online food industry.
4. Rising demand for security and guide robots.
5. Growth in hospitality and healthcare industries

Key Technologies for Outdoor Robots



Layout of Outdoor Robots

Figure 5: Key Technologies for Outdoor Robots

The technologies required for these robots are illustrated in Figure 5. These combine computing power and decision-making through use of AI with the mechanics to move, sense and navigate.

Fibocom's approach to robotics focuses on three main technology areas – sensing, motion and intelligence. These are referred to as the three robotic core technologies:

- Firstly, there are the components used to realise sensing – different types of sensors, cameras, then ways to detect the environment and other objects. The computing and AI activities associated with these are vSLAM (visual Simultaneous Localization and Mapping), used for mapping, path planning, positioning features and other functions.
- Secondly, the components for motion and navigation. These include the steering engine, electric machinery, torque control, motion control and overall power management. The computing and AI activities associated with these are related to Navigation, including object recognition, avoidance, slope control and boundary distinguish.
- Thirdly, the elements for intelligence and decision-making. Components for this include CPU/GPU/DSP/NPU, the Robot OS, operator optimization and deep learning. The activities are headed under Performance and include speech processing, image recognition, machine learning, Natural Language Processing (NLP), User Interface interaction and the decision-making system.

Fibocom's solution is for a Robot Intelligent Chassis upon which application providers can then mount their overall robot shape (working body) and application (interaction body) for their individual needs. The functional structure of the robot is then divided into 5 parts:

- Motion body
- Sensor body
- Decision-making body
- Working body
- Interaction body

The core of the robot project is the perception/sensing body and the decision-making body. Different chassis (motion body) and operation body (working + interaction) constitute different types of robot. This maximises the common elements across all robot types.

4. Fibocom module range and case studies for Edge AI

Fibocom offers a set of three modules for Edge AI:

(a) Smart Module SC171 for PCBA AI Solution for Robotics – 5G Smart high level solution

The SC171 module supports 5G sub-6GHz connectivity and is based on Qualcomm's QCM6490 SoC. This supports the industrial grade PCBA solution with high computing power, suitable for complex indoor and outdoor scenarios, and can be applied to various types of robots such as logistics vehicles, patrol inspection robots, guiding robots and more.

Advantages:

- The PCBA solution with SC171 series supports 12 TOPS of AI computing power, which has excellent AI performance, supports 4K high-definition video, supports up to 5 cameras running simultaneously, and efficiently calculates and processes data.
- It has a variety of peripheral interfaces, including 8 * USB, 4 * MIPI, 8 * UART, 2 * SPI, 2 * LAN, 2 * CAN, and more ports, supporting intelligent and multiple application scenarios.
- Industrial-grade design: Industrial-grade Ethernet and various industrial-grade connectors.

(b) Smart Module SC138 – 4G Smart medium level solution

The SC138 module supports 4G connectivity and is based on Qualcomm's QCM6125 chipset platform. It has early customers in the Chinese market for devices including: Patrol robot for smart grids, industrial campus, logistics warehouse, hospital and more.

(c) Smart Module SC126 – 4G Smart entry level solution

The SC 126 module also supports 4G connectivity and is based on Qualcomm's QCM2290 chipset platform. An early customer is a Hong Kong stock listed Robot manufacturer, with an automatic lawn mower for home use.

Figure 6: Smart AI module SC171 with high computing power and PCBA Solution

5. One-on-one interview with Fibocom

Robin Duke-Woolley
CEO
Beecham Research

Shirley Tang
Director of MC
Product Marketing
Fibocom

Robin Duke-Woolley (RDW), CEO of Beecham Research, interviewed Shirley Tang (ST), Director of MC Product Marketing at Fibocom, to understand in more detail how Fibocom is introducing EdgeAI to the IoT market.

RDW: Looking at different application areas, What is it that Edge AI is doing? Let's look at three quite different sectors as examples – Smart Home, Healthcare and Smart Manufacturing

ST: Edge AI is the concept of applying artificial intelligence (AI) capabilities to the edge computing environment. It combines edge computing and artificial intelligence technology to enable intelligent data processing and decision-making on edge devices. Edge AI utilizes machine learning, deep learning, and other AI technologies to enable edge devices to autonomously perceive, understand, and respond to data without the need for continuous reliance on cloud or central servers. This can achieve real-time intelligent decision-making, intelligent control, and intelligent interaction, bringing a higher level of intelligence to edge environments.

Smart Home: A lot of sensors, cameras, smart home appliances and other devices need to be collected for data and do data analyzing, processing, and feedback.

Healthcare: Real time monitoring and remote healthcare to provide patients with more convenient and accurate medical services; Intelligent diagnosis and decision-making assistance; Timely emergency rescue and crisis management.

Smart Manufacturing: Through AI technology, it is possible to monitor and analyze various aspects of the production process, identify problems in a timely manner, and provide solutions; it can analyze and predict a large amount of data, providing a reasonable production plan; as well as to do equipment maintenance and supply chain management.

RDW: With AI being done at the edge, what do you need the connection to the cloud for? What are the characteristics of the connectivity required compared with AI in the cloud?

ST: For higher performance computing and storage capabilities to meet the needs of large-scale data processing and model training; Because the data and algorithms done at the edge are limited, it is non-complex and non-large-scale applications, mainly to improve the data processing and decision-making efficiency. The connectivity is faster and responds more quickly and can also save more bandwidth compared with Cloud AI connectivity.

RDW: How much computing power does EdgeAI need? What does that mean for types of applications that can/cannot be addressed?

ST: basically 1 TOP for entry level applications (sweeping robots, lawn mower, smart speaker), more complicated scenarios require more powerful computing capability:

- Smart IVI, PDA: 3TOPS to 9 TOPS
- Video conference, Live streaming: more than 10 TOPS
- Machine vision: 50TOPS
- Automatic driverless cars: more than 100TOPS

RDW: What degree of local learning can be achieved at the edge? Will this increase over time?

ST: actually, most of the daily AI applications can be achieved at the edge such as simple speech recognition (smart speaker, remote controller), facial recognition within a certain range (such as access control for a company), limited route planning; as well as some indoor robots, such as sweeping robots and lawn mower.
AIGC Big Model Training: needs cloud AI computing
For Vertical industries and segmented fields: can be done at the edge

Yes, this will increase over time, because the CPU, GPU and NPU will become increasingly advanced and powerful; and applications in vertical industries and segmented fields will also become increasingly powerful.

RDW: Which application scenarios do you think will be most important in the next few years?

ST: Robotics, Smart manufacturing, Healthcare and Automatic driverless cars

RDW: The trend is towards outdoor robots from indoor robots. Why is that?

ST: Objectively speaking, most of the environments we live in are forests, lakes, oceans, and deserts. There is a lot more 'outside' to contend with. More specifically there are:

- Intensification of the aging trend
- The problem of difficult employment
- Some harsh working environments
- Improve work efficiency in some environments
- Ensure the safety of workers

RDW: What are the facilities for outdoor robots that need to be built into the cellular modules?

ST: Mainly for GPS positioning, Real-time data / video uploading, data processing and remote monitoring, as well as Real-time emergency response.

RDW: Fibocom offers SC171, SC138 and SC126 cellular modules. What are the main differences between these?

ST: Modules SC171 (5G Smart) and SC138 – medium, SC126 – entry (4G Smart). From entry level to high level, from 4G to 5G, CPU and GPU performance, and TOPS are more and more powerful. So, the applicable product forms and application scenarios are also different.

RDW: What is Fibocom's Solution for Robot Intelligent Chassis?

ST: For robotics, Fibocom provides the body and chassis to our customers which we call our core robotics solution. This has three parts – sensor body, motion body and decision-making body. we call it Robot Intelligent Chassis, which is the core of robotics. And then different structural shells are put on to form different shapes for different robots.

6. Summary

Edge AI revenue is now expected to develop quickly over the next few years, with average growth of over 24% per annum. Applications being enabled by Edge AI in all IoT sectors and these will evolve further over the next few years. Fibocom is addressing this growing need with three different modules – SC171 for high level 5G applications, SC138 for medium level 4G applications and SC126 for entry level 4G applications. SC171 can support 12 to 13 TOPS of processing capability, while SC138 can support around 1.5 TOPS and SC126 around 0.3 TOP. Case studies for each of these working in the field are already available. These modules also support Open CPU, or module plus MCU as preferred by the customer.

In view of its perceived importance, Fibocom has invested further in outdoor robotics. The company now offers a Robot Intelligent Chassis comprising a Motion body, a Sensor body and a Decision-Making body. This chassis is suitable for use as a common robotics element for a wide variety of different robot applications, with the customer then adding the end application and shape.

Leading the 5G IoT Race: Key Industry Insights Series 5. 5G RedCap

By **Robin Duke-Woolley**, CEO, Beecham Research

3GPP has introduced three primary use cases for 5G New Radio (NR) – enhanced Mobile Broadband (eMBB), massive Machine Type Communications (mMTC), and ultra Reliable Low Latency Communications (uRLLC). But what if your IoT application doesn't really fit one of these primary cases – it actually needs a bit of each? That's where 5G RedCap (Reduced Capability) comes in – and it looks set for stardom.

1. What's so special about 5G RedCap?

Firstly, what's so special about 5G New Radio (NR) as far as IoT is concerned? Essentially, 5G NR was designed as a completely new air interface in order to support the wide variety of services, devices and deployments envisaged for 5G, and across a diverse spectrum. It also needed to be backwards and forwards compatible. In other words, it has been designed as much for IoT devices as for mobile handsets.

This is a far cry from earlier generations, where IoT and M2M (machine-to-machine) before it essentially had to look a bit more like mobile handsets, which added cost and complexity. Yet there are many IoT applications where each of the three primary use cases for 5G NR are an overkill in one way or another. 5G Redcap – also known as NR light (or lite) – provides the answer for this. There are also two of them on the way: RedCap Release 17 (R17) and RedCap Release 18 (R18).

Reduced Capability of 5G: offering additional capabilities compared to LTE

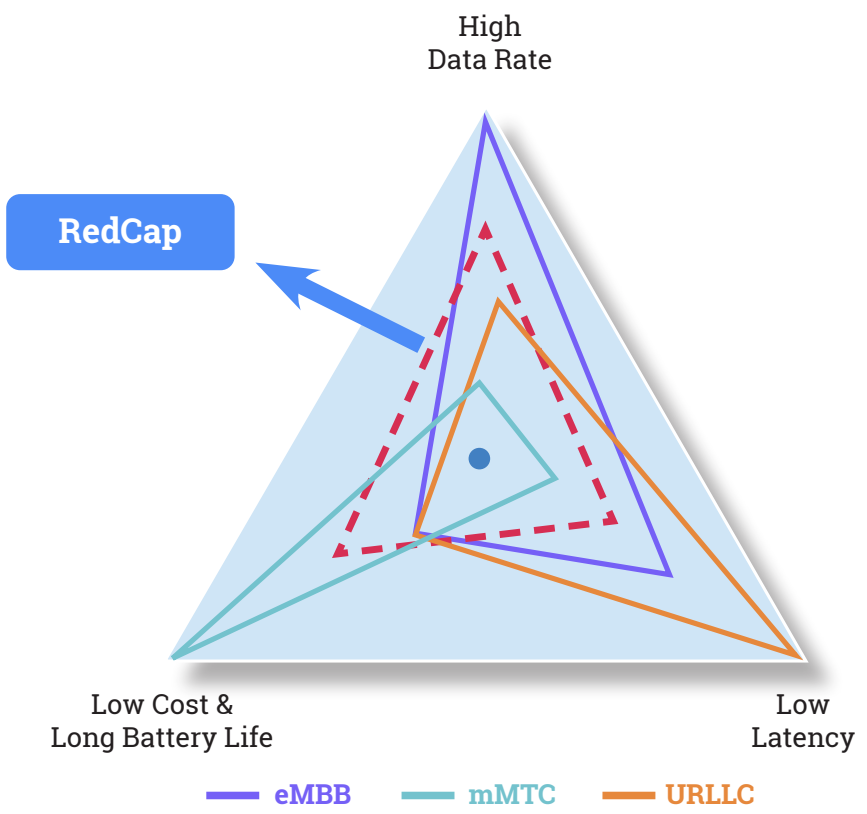


Figure 1: RedCap is in an IoT sweet spot

To get an idea of the significance of these, **Figure 2** below shows how these RedCaps compare with their equivalent LTE Categories – in particular Cat 1 and Cat 4.

So what does RedCap actually offer? **Figure 3** gives a quick guide. Essentially, those applications that require low latency and high reliability, but less bandwidth than eMBB and low power consumption.

This makes RedCap ideal for a wide range of applications – including smart grids, livestreaming, industrial automation and smart wearables. Fast data and power efficiency – a welcome addition to the IoT connectivity landscape.

Segment of RedCap within cellular devices

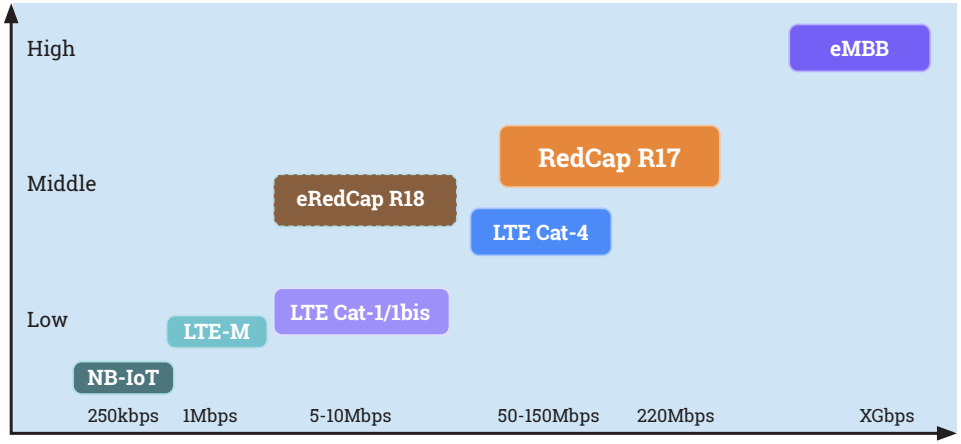


Figure 2: RedCaps R17 and R18 compared with LTE Cats 1 and 4

RedCap (Reduced Capability) = NR light (NR lite)

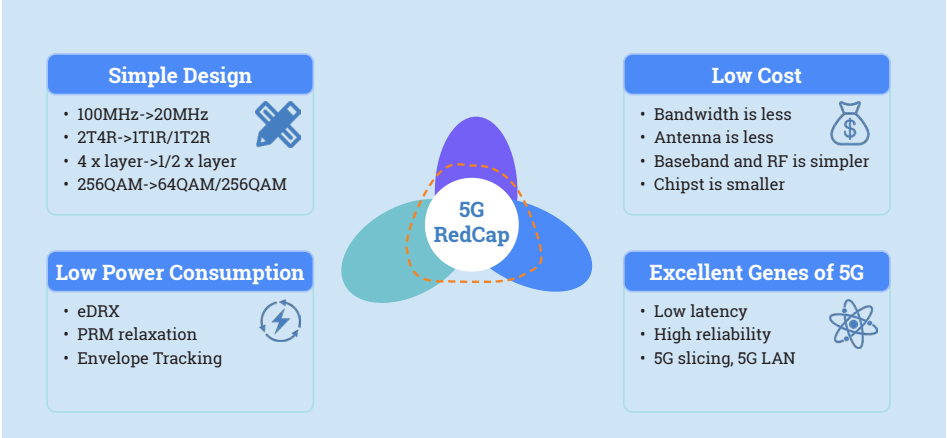


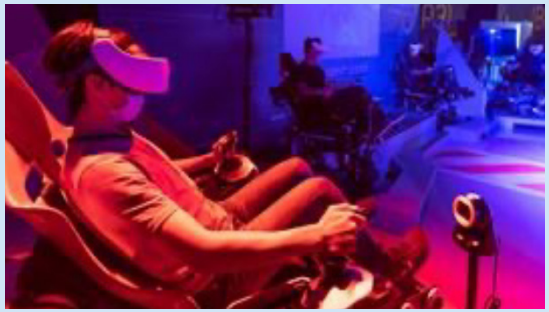
Figure 3: RedCap 'joins the dots' in IoT within the 5G landscape

2. Where will RedCap be used?

Wearable Devices

RedCap encompasses three key application categories: industrial wireless, video surveillance, and intelligent wearable devices. These applications prioritize stable, seamless data transmission rather than ultra-low latency. RedCap strikes a balance between enhanced Mobile Broadband (eMBB) and ultra Reliable Low Latency Communications (uRLLC), delivering optimal speed, energy efficiency, and cost performance.

VR Cinema



VR Cloud Gaming

AR Learning

Multiplayer VR Gaming

Cloud Assisted AR

Figure 4: RedCap covers a wide range of entertainment devices

Smart Grid

While RedCap's uplink speed may be lower than standard 5G, it meets the uplink requirements for 4K definition video, which cannot be fulfilled by either LTE Cat.4 or Cat.6. As a result, RedCap can be extensively used in applications like IPC (Internet Protocol Camera), UAV (Unmanned Aerial Vehicle) inspection, body-worn cameras, and 5G vehicles. In these scenarios, high-quality data uplink is the primary focus.

As a result, one notable application area for RedCap is the Smart Grid, where it can play a key role. With the low latency and high reliability of 5G, RedCap meets the safety and control requirements of the Smart Grid and significantly reduces the cost of 5G terminals. This makes it well-suited for applications such as inspection robots, drones, patrol cameras, and concentrators in power generation, transmission, and consumption scenarios.

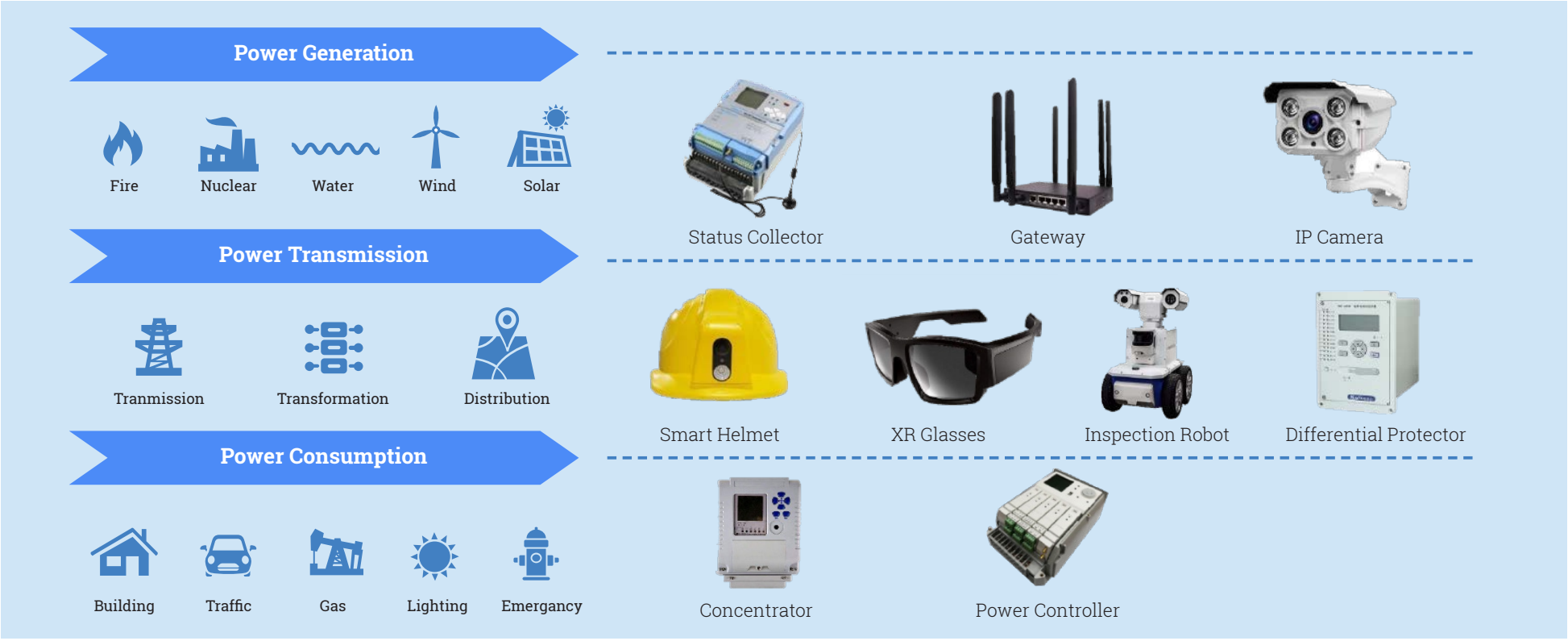


Figure 5: RedCap supports application across the smart grid

FWA (Fixed Wireless Access)

In 72% of countries globally, the average downlink experience speed for mobile users is below 50Mbps. Currently, 5G FWA products tend to be high-performance and high-priced, meaning there is a significant suppressed demand for entry-level market users. With a downlink peak of 223Mbps, RedCap presents a strong choice to meet the demands of this market segment.

5G Redcap is a strong contender as an ideal wireless solution for FWA device manufacturers such as mobile hot spot and PC to migrate 4G to 5G solutions. It offers an optimized 5G network experience and larger bandwidth capacity compared with the 4G solution.

Speedtest Global Index:

Statistics from July 2023 show the global average typical speeds for mobile users: DL (Downlink) 42.35Mbps / UL (Uplink) 10.04Mbps.

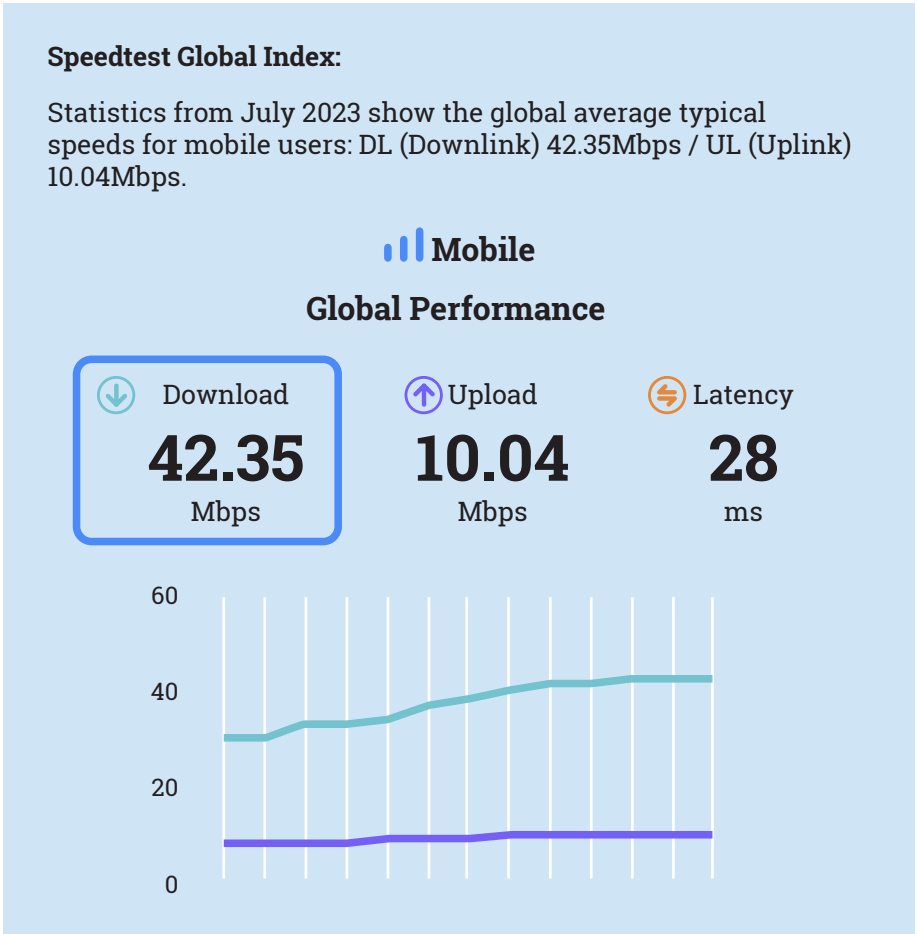


Figure 6: Downlink speeds for mobile users typically below 50Mbps

3. Fibocom recent announcements related to 5G RedCap

Fibocom Scales Up the 5G RedCap Module Series at MWC Shanghai 2023 with New FG131 Series Adding to the Portfolio

Fibocom showcases the new 5G RedCap modules portfolio including the new FG131 series and FG132 series at MWC Shanghai 2023. By addressing multiple key features of 5G RedCap, the FG131 module series allows the smooth and fast transition from 4G to 5G benefiting from the form factor design, and delivering a highly cost-effective solution for CPE, ODU, mobile hot-spot, USB Dongle users.

June 30th 2023 - Fibocom demonstrates the 5G RedCap module portfolio at MWC Shanghai 2023. Along with the FG132 module series, the brand new FG131 series is introduced to scale up the 5G NR light deployment for use cases such as CPE, ODU, mobile hot-spot, and USB Dongle, etc.

Leveraging ubiquitous cellular coverage, optimized power-saving, and reduced complexity, 5G RedCap is gaining more and more attention within the IoT industry. The newly launched Fibocom 5G RedCap module FG131 series offers a high-performance and ultra-reliable wireless solution for application scenarios that are cost-sensitive and power-enduring. Packaged in LGA form factor at the size of 37mm*39.5mm, Fibocom FG131 is pin-compatible with Fibocom LTE Cat 6 module FG101 and FG621 series that allows smooth migration from 4G to 5G RedCap. Compliant with 3GPP Release 17, it supports 5G SA and reaches peak rates of up to 226Mbps downlink and 120Mbps uplink theoretically. With these key features combined, the Fibocom 5G RedCap module FG131 series delivers a new level of 5G network experience while maintaining high reliability and cost-effectiveness, especially for terminal devices used in mobile scenarios.

Additionally, the Fibocom FG132 series has adjusted to three form factor designs and multiple regional versions that align with customers' requirements to accelerate the deployment of 5G RedCap worldwide. It is worth noting that these compact designs are pin-compatible with Fibocom LTE Cat 4 module NL668 and L716 series, and the dimension of FG132 (29mm*32mm in LGA form factor) account for only half the size of standard 5G module (41*44mm), significantly reducing the complexity of hardware design at the early stage of 5G RedCap adoption into terminals that shaped variously, for example, IP cameras, drones, wearable XR, etc. Moreover, the M.2 and miniPCIe form factors are the popular selections among manufacturing customers as both of them allow flexible connectivity ports while maintaining the compact size, thus making it easier for manufacturing customers to upgrade the existing LTE devices quickly without changing the hardware design. For example, industrial gateways, utility meters, etc.

Fibocom Introduces the FG132-NA RedCap Module Series towards Mid-tier 5G IoT Connectivity at Computex 2023

Fibocom introduces the 5G RedCap module series FG132-NA to its cellular product portfolio during Computex 2023.It is designed to offer downscaled connectivity service to mid-tier applications under the 5G landscape by bringing a realm of key advancements such as smaller compact size, optimized power efficiency and lower cost efficiency.

Taipei, Taiwan – May 30th 2023 - Fibocom announces the global launch of the new RedCap module series FG132-NA during Computex 2023. Compliant with 3GPP Release 17 standard, FG132-NA series adopt the key features from 5G in both network reliability and spectrum utilization, while significantly improving the performance in energy efficiency and expanding the diversity of IoT scenarios.

5G has achieved remarkable milestones in the past few years by accelerating the digital transformation of manufacturing, private networks, online education and more use cases with its ultra-fast speed, low latency and high reliability. As technology evolves, 5G RedCap is introduced to connect the "dots" in IoT under the 5G landscape, which of them are the scenarios that require ultra-low latency and high reliability, but less bandwidth and long battery life. Therefore, RedCap is the technology tailor-made for smart grids, livestreaming, industrial automation and smart wearables with its great performance in speed transmission and power efficiency, unleashing the full potential of 5G in IoT.

Fibocom FG132-NA series modules are compliant with 3GPP Release 17 standard, supporting 5G SA and are backward compatible with LTE Cat 4 networks. In terms of hardware architecture, the module series is adopting 1T2R antenna design along with LCC+LGA and M.2 form factors to satisfy the customers' expectations in a diverse of use scenarios. The size of LCC+LGA form factor can be measured at 29*32mm, which is pin-compatible with Fibocom LTE Cat 4 modules for customers to upgrade to 5G smoothly. While the plug-and-play M.2 form factor offers a comprehensive solution for tablets and industrial gateways with a compact size at 30*42mm. By leveraging the 5G key advancements, FG132-NA supports up to 220Mbps downlink speed and 100Mbps uplink speed, as well as 5G slicing, 5G LAN, assuring the speed performance and network reliability in the daily operation of manufacturing factory, IPC, smart grids, etc.

In addition to a set of innovations, Fibocom FG132-NA also supports Open CPU with OpenWRT software, which allows customers to develop FWA applications such as CPE, Mobile hotspot, and DTU flexibly.

4. Fibocom module range for 5G RedCap

Fibocom currently has two series of 5G RedCap modules – FG131 and FG132. Both of these are compliant with 3GPP Release 17 and both utilise the Qualcomm SDX35 modem.

The FG131 has the following main characteristics:

- **Target Terminals: IDU/ODU/Mobile hot-spot and other FWA devices**

- **Packaging and Pin Configuration:**
  - LGA form factor
  - Pin-to-Pin Cat.6 series
  - Enhanced compatibility with all Cat.4 pin functionalities (different size and position)
  - Expose chip platform capabilities valuable for FWA terminal forms, such as SGMII, etc.

- **Product Highlights**
  - Choosing Cat.6 packaging highlights FWA characteristics and value creation
  - Shared Wi-Fi solution with Cat.6, allowing mobile hot-spot customers to upgrade directly from 4G to 5G
  - FG131 enhances compatibility with all Cat.4 pin functionalities
  - Based on mature RedCap chip
    - SA 20MHz 256QAM: 220Mbps/120Mbps
    - LTE Cat.4+:195Mbps/75Mbps
  - Focus on FWA
  - Open CPU with OpenWRT
  - CPE/Mobile hot-spot:Wi-Fi 5 & Wi-Fi 6Solution
  - CPE/ODU:SGMII interface

- **Enhanced FWA Capability**
  - Higher Power Design for the Uplink
  - Supports SRS Functionality
  - RFFE Adopts Design with LNA
  - Expanded Flexibility

The FG132 has the following main characteristics:

- **Target Terminals:**
  - PC/Industrial Routers/Concentrators, etc.
  - Next-generation IoT applications under Cat.1, Cat.4, Cat.6

- **Packaging and Pin Configuration**:
  - 3 alternative form factors: LGA, M.2, MiniPCIe
  - Pin-to-Pin Cat.4 series (mainstream market packaging, pin compatibility with NL668/L716)

- **Product Highlights:**
  - Various solutions based on customer demand: Open CPU & MCU+Module
  - Support for SRS (Self-Refreshing Screen) technology
  - Low power consumption capability: APT (Advanced Power Management)
  - Based on mature RedCap chip
    - SA 20MHz 256QAM: 223Mbps/123Mbps
    - LTE Cat.4+:195Mbps/105Mbps
  - Wide Application Set
    - Replacement for Mainstream Size Cat.4
    - Rich Interface
    - Open CPU & MCU+Module Solutions
  - Highly Reliable Network Capability
    - Adaptation to Industrial IoT Protocols
    - Ensuring High-Definition Video Uplink Transmission
  - Low Power Consumption
    - Optimized Power Management
    - Support for APT (Advanced Power Management)

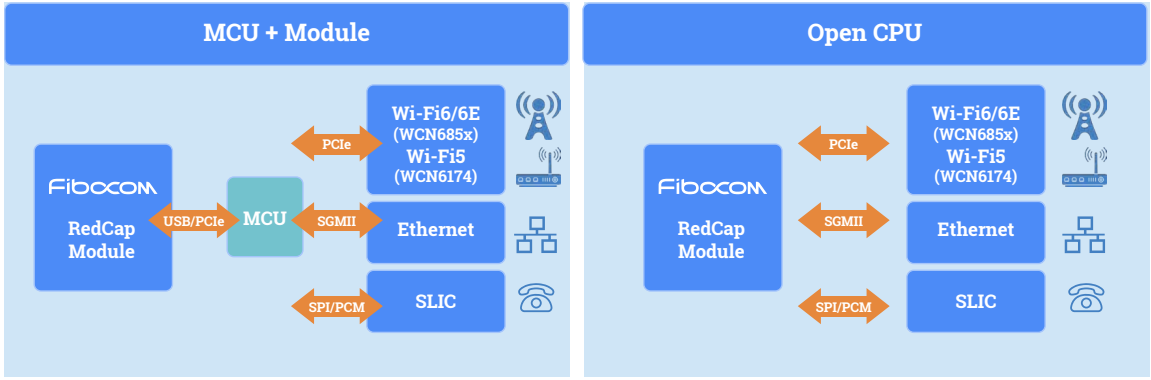


Figure 7: Application Architecture of Fibocom RedCap Modules

5. One-on-one interview with Fibocom

Robin Duke-Woolley
CEO
Beecham Research

Alex Zhu
Director of MTC Product Marketing Department
Fibocom

Robin Duke-Woolley (RDW), CEO of Beecham Research, interviewed Alex Zhu (AZ), Director of MTC Product Marketing Department at Fibocom, on how Fibocom is supporting the introduction of 5G RedCap in the market.

RDW: When do you expect RedCap R17 and then RedCap R18 to become significant in the IoT market?

AZ: As a relatively new technology, RedCap is still in its early stages of development, so technical market players such as the network operators, the chipset suppliers, module suppliers and terminal suppliers are still exploring this direction. As a result, the perspective we share here represents just the understanding of Fibocom with the hope it may provide insights for everyone.

We can evaluate the commercial development of RedCap based on the global rollout of 5G networks. The global development of 5G networks especially in the ongoing development of Standalone (SA) networks is the important element. NSA (Non-Standalone) is not sufficient as RedCap is a technology for SA networks. We anticipate RedCap in 3GPP Release17 (R17) will gradually start appearing in IoT terminals in small batches in 2024. Starting from 2025 the R17 version of RedCap is expected to enter a period of rapid development. As for 3GPP Release18 (R18), predicting timescales is quite challenging due to the technical standards not yet being finalised. We currently expect RedCap R18 IoT terminals to start coming to market in 2026.

RDW: How do you see them rolling out geographically?

AZ: The global development of 5G across regions is uneven. For RedCap it depends on the rollout of SA networks. We are initially focusing on China and US markets, All 3 main operators in China are actively supporting RedCap networks. Many Chinese cities already have SA base stations, so support for RedCap is expected to be widely available in 2024. Also in North America, we see that operators also have plans for promoting RedCap in 2024 – AT&T, T-Mobile and Verizon. Promotion in Europe is looking to be slower as their networks are mainly NSA at the moment. We are also looking closely at the Middle East and India markets. These markets also have SA networks.

RDW: Which LTE Categories with Redcap R17 and R18 replace?

AZ: RedCap R17 is expected to gradually replace LTE Cat 4 and Cat 6 products in the market. These will cover the various product forms for CPE, cameras, wearable devices, power equipment and in-vehicle smart devices. Some of these product markets have already transitioned to 5G from LTE but there remains a significant proportion that has not, mainly due to cost considerations. RedCap addresses this issue with its characteristics of low latency and high reliability. In the future, RedCap R18 version – also known as eRedCap or enhanced RedCap – will address a more extensive range of industry markets. Particularly those using LTE Cat 1 at present. Cat 1 is one of the fastest growing IoT product standards. It has very large volume in the China market. So RedCap R18 presents many significant opportunities for the next generation of devices.

We see that LTE networks are still great for many different parts of the market, for example Cat 1bis.

RDW: Do you see 4G LTE networks and 5G networks coexisting for some time?

AZ: Yes. We see LTE and 5G networks coexisting for a considerable time.

RDW: how will RedCap R17 and R18 compare in cost terms with current LTE Cats they are destined to replace?

AZ: This is an important point. Despite RedCap being positioned as the 5G solution for these 4G LTE Cats, the cost will initially be relatively high compared with those. At present, we see that the module cost of 5G RedCap R17 is at about double that for LTE Cat 4. However, as 5G RedCap products mature and the chipset and the module costs decline, this gap will narrow. The same trend is expected in the US. LTE products will not continue to be developed, whereas 5G products will be, so iteration of those products will bring them closer together in the future.

RDW: So when RedCap R17 comes to market, if it is considerably more expensive than LTE Cat 4 for example, why would people buy it?

AZ: we see our future customers buying the 5G RedCap R17 in 2024 or 2025, with a product that is much more expensive than Cat4 or Cat6 products, but these customers have said they need the 5G products because of their future plans. For 5G we have 5G LAN, low battery consumption and low latency promised by RedCap. It is not so much about the price for these customers.

RDW: When Redcap R18 comes, will that be more expensive that Cat 1?

AZ: Yes, it will still probably be more expensive than Cat1. But maybe the cost of R18 products will be more competitive than Cat 4.

RDW: Turning to Fibocom modules, there are two different ones launched so far – FG131 and FG132. What is the difference between them in terms of applications they serve?

AZ: These modules are designed for different markets. FG131 is primarily suitable for the FWA Fixed Wireless Access market, while the FG132 is intended for the general IoT market. The main distinction between the two is in the packaging size, with the FG131 inheriting more closely from the Fibocom Cat 6 product line, so pin compatible with our Cat 6 products. On the other hand, FG132 leans towards the Cat 4 product and is pin compatible with that. Of course there are also some differences in functions between these two. For example, the FG131 is more focused on the accelerated network usage. They have much higher speeds for gaming, for example.

RDW: What features like OpenCPU are included in RedCap modules?

AZ: we see that the features are very important for our industrial customers. So Fibocom RedCap products have numerous features – for example support of OpenCPU on both modules. This is particularly important for the FWA market and it has been widely adopted in numerous 5G FWA products. Additionally, RedCap products support GPS positioning functionality. Both these products support both of these features. However, it is worth noting that certain features like Bluetooth are not supported. But Fibocom will gradually enhance its products based on market demand to meet the needs of various customer applications.

RDW: are there any other features that they have, or are those the two main features?

AZ: We also have low power consumption features. FG132 has power save features eDRX, RRM relaxation and Envelope Tracking. This is more important in FG132 for IoT use, where customers are often using batteries. It is not so important for FG131 use in the FWA market.

RDW: Will iSIM be included in RedCap modules?

AZ: iSIM is not currently supported in FG131 or FG132. But we do provide support for eSIM. This allows our customers to have greater flexibility in different networks for a better experience. Of course, we do not rule out the possibilities of adding support for iSIM in the future.

FG131 and FG132 are available now for engineering samples for our customers and we have the LGA form factor for FG131. We have 3 form factor alternatives for the FG132 – LGA, M.2 and MiniPCIe. Both are for R17 and both are based on the Qualcomm SDX35 chipset. In the future with R18, we will evaluate other chipsets when they are available. iSIM is probably more relevant for R18 than R17 in fact. At present we don't see many requests for it so whether that is included in future or not is a decision that can be made later.

RedCap is still developing and the modules and technologies will evolve with more products available. My main focus now is on eRedCap (R18) – the next generation of RedCap. The requirement for this will be much greater than for today's RedCap R17.

6. Summary

5G RedCap, also known as New Radio lite (NR lite), provides an innovative solution to address the varying needs of different industries when adopting 5G technology. While primary use cases for 5G offer extensive capabilities, specific sectors require a more affordable and simplified alternative that still delivers essential 5G features.

RedCap also presents a significant commercial opportunity, particularly in the IoT market. Operators have well-defined plans for RedCap network iteration. RedCap can also be applied to vehicle terminals, industrial sensors, medical monitoring devices, and more. Overall, the future looks promising for RedCap.