

RedCap/eRedCap for IoT

This is a whitepaper of the GSMA 5G IoT Community

Contents

About the GSMA

The GSMA is a global organisation unifying the mobile ecosystem to unlock the full power of connectivity so that people, industry and society thrive.

Led by our members, we represent the interests of over 1,100 operators and businesses in the broader ecosystem. The GSMA also unities the industry at world-leading events, such as MWC (in Barcelona, Kigali, Las Vegas and Shanghai) and the M360 Series.

Unlock the benefits of GSMA membership

As a member of the GSMA, you join a vibrant community of industry leaders and visionaries – helping to shape the future of mobile technology and its transformative impact on societies worldwide.

Our unique position at the heart of the mobile industry means you get exclusive access to our technical experts, data and analysis – as well as unrivalled opportunities for networking, innovation support and skills acceleration.

For more information, please visit:
http://www.gsma.com/membership/

Security Classification: Non-confidential

Access to and distribution of this document is restricted to the persons permitted by the security classification. This document is confidential to the Association and is subject to copyright protection. This document is to be used only for the purposes for which it has been supplied and information contained in it must not be disclosed or in any other way made available, in whole or in part, to persons other than those permitted under the security classification without the prior written approval of the Association.

Antitrust Notice

The information contained herein is in full compliance with the GSM Association's antitrust compliance policy.

Copyright Notice

Disclaimer

The GSM Association ("Association") makes no representation, warranty or undertaking (express or implied) with respect to and does not accept any responsibility for, and hereby disclaims liability for the accuracy or completeness or timeliness of the information contained in this document. The information contained in this document may be subject to change without prior notice.

Executive Summary

The initial 5G 3GPP Release (Release 15) targeted applications in three service categories – enhanced mobile broadband (eMBB), ultra-reliable low latency communications (uRLLC) and the low-throughput and battery-efficient massive machine-type communication (mMTC), as defined by the ITU Radiocommunication Sector's IMT-2020 specification. After the commercial roll-out of numerous 5G networks across the globe, a need has emerged for a variant of 5G in which the performance and costs are optimised for use cases that fall in-between these initial service categories.

To fill this gap, 5G RedCap (Reduced Capability[1]) was introduced in 3GPP Release 17 as a 5G variant (see Figure 1), and was followed by the even leaner 5G eRedCap (Enhanced Reduced Capability), specified in Release 18. Mobile network operators (MNOs) can now service the full spectrum of IoT use cases with the 5G standard, including those applications which are either too demanding to implement with the low power wide area (LPWA) connectivity of 5G mMTC (NB-IoT and LTE-M), or too basic for the over-performing eMBB and uRLLC capabilities of 5G New Radio.

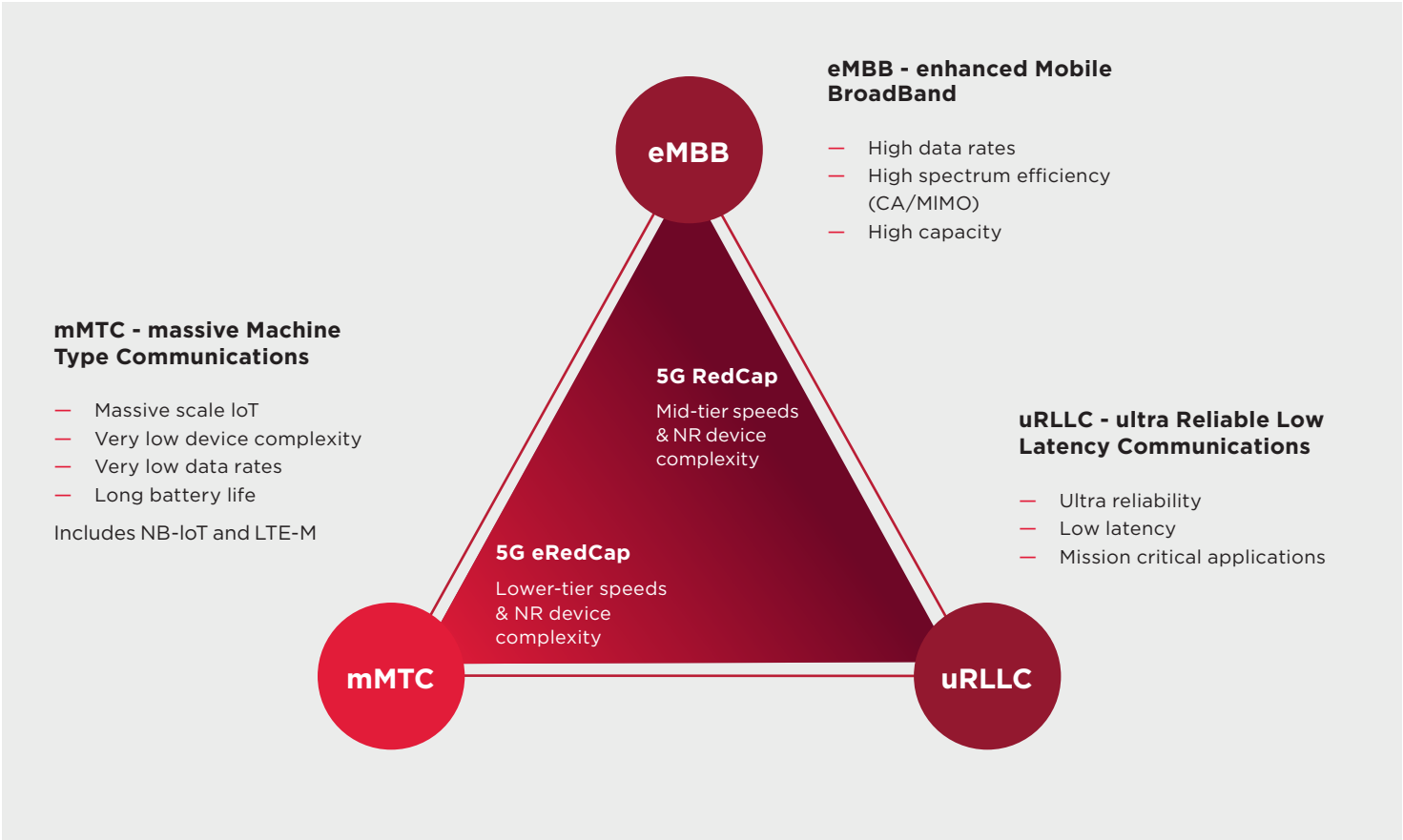


Figure 1, RedCap/eRedCap positioning against 5G use case groups defined in IMT-2020)

1 Alternatively known as New Radio-Light

RedCap and eRedCap are based on the 5G standalone (SA) architecture, and can thus convey a multitude of benefits to IoT applications, such as:

— Higher peak data rates: Superior data rates are offered than mMTC, comparable to lower LTE categories, meaning 5G RedCap can support smart grid monitoring, video surveillance and other more demanding applications.
— Reduced latency: Round-trip delays are lower than, or match those, of LTE, enabling applications that require the near real-time exchange of data, such as industrial automation, wireless sensors, wearables and even low-end extended reality devices.
— Reduced power consumption: Improved power efficiency enables an extended lifetime in battery-powered devices. This is extremely important for devices, such as wearables or sensors, for which the original 5G NR consumes too much energy.

These enhancements, also come with a considerable reduction in device complexity and cost, making RedCap/eRedCap the new technology of choice for a range of IoT applications, such as:

— Wireless industrial sensors: Monitoring and controlling remote equipment to improve efficiency and safety in industrial settings.
— Video surveillance: Transmitting real-time video feeds to improve security and deter crime.
— Smart grids: Monitoring and managing the power grid to help improve the efficiency and reliability of energy supplies.
— Smart wearables: Connecting wearable devices for lone workers, public safety officers, and assisted living, or health and fitness trackers.

Finally, 5G RedCap and eRedCap are well-positioned to play an important role in future IoT deployments, emerging as the primary migration path for services still communicating today over legacy 2G, 3G and 4G networks. As RedCap will only gradually become widely available, and roaming frameworks still to be put in place for global coverage, both RedCap and LTE will co-exist for a while, catering to the needs of the aforementioned IoT applications. The pace of technology migration will largely depend on individual MNOs' strategies and some regions will adopt RedCap faster than others.

Introduction

In today's fast-changing world of wireless communications, RedCap (Reduced Capability) and eRedCap (enhanced Reduced Capability) are emerging as game-changing technologies on the path to 6G. By offering a more advanced alternative to 2G (GSM), 3G (UMTS) and 4G (LTE), they enable the IoT industry to modernise and leverage the benefits of cloud-native 5G standalone (SA) technology. RedCap and eRedCap fill the gap between the high-performance, higher-cost enhanced mobile broadband (eMBB) and ultra-reliable low latency communications (uRLLC) 5G service categories and the lower-cost, power-optimised massive machine-type communication (mMTC) of NB-IoT and LTE-M devices. RedCap/eRedCap offer a well-rounded solution that meets the needs of the vast majority of IoT devices– everything from point of sale (PoS) equipment and smart meters to mid-tier industrial gateways and routers.

RedCap and eRedCap successfully balance capability and cost effectiveness. Devices supporting these protocols will use less bandwidth and processing power, making the technology ideal for applications that don't need the very high data rates of 5G New Radio (NR), but do need lower power consumption and higher cost-efficiency. On the network side, RedCap/eRedCap will enable MNOs to support even higher numbers of 5G SA devices within a given amount of spectrum.

With the advent of 5G SA, 3GPP network capabilities have significantly improved, thanks to numerous new features:

- Cloud-native network: Disaggregated core network functions run as applications in Kubernetes containers, thereby allowing for rapid scaling of network resources to tackle high traffic and signalling loads.
- 5G NR radio protocol: An optimised user plane that supports far greater data throughputs
- Ultra-low latencies: The ability to deploying Internet connectivity at data centres closer to the end-customer, or even at the network edge.
- Network slicing: Reservation and prioritisation of radio resources for individual users.
- Network as an API: Allowing IoT applications to make API calls to request network features and services, as enabled by the GSMA's Open Gateway initiative.

These SA capabilities promise to also enhance a wide variety of traditional IoT applications, from smart cities to industrial automation. Yet, the relatively high cost of 5G SA-capable hardware has limited access to this innovation to-date. RedCap and eRedCap can change this, extending 5G SA's advantages to a wider set of IoT devices. MNOs will finally be able to serve all business and consumer IoT applications - from low-data-rate sensors and wearables, to more complex devices - with their 5G networks. It also ultimately reduces the dependency on 4G infrastructure for future network strategy decisions, while assuring end-customers that their hardware is future-proof well into the era of 6G.

In summary, RedCap and eRedCap will play an increasingly critical role in the landscape of 5G IoT. These two technologies open the door to all services handled to-date via 4G, so that they can profit from the advances of 5G technology, while delivering scalability, cost-effectiveness, and improved power-efficiency. In this way, RedCap and eRedCap are set to accelerate future growth and diversification of 5G SA IoT applications across various industries.

Abbreviations

Term	Description
3GPP	3rd Generation Partnership Project
AN	Access network
DL	Downlink
DRB	Data radio bearer
DRX	Discontinuous reception
eDRX	Extended discontinuous reception
eMTC	Enhanced machine type communication
eRedCap	Enhanced RedCap
FDD	Frequency Division Duplex
FR1	Frequency Range 1 (410 MHz - 7125 MHz)
FR2	Frequency Range 2 (24250 MHz - 52600 MHz - 71000 MHz)
GSM	Global System Mobile
GSMA	GSM Association
HD-FDD	Half-duplex FDD
IoT	Internet of Things
IP	Internet protocol
kHz	Kilohertz
LPWA	Low power wide area
LTE	Long-Term Evolution
LTE-M	Long-Term Evolution - Machine Type Communications
M2M	Machine-to-machine
MHz	Megahertz
MIMO	Multiple input multiple output
MNO	Mobile network operator

Term	Description
MTC	Machine type communications
mMTC	Massive machine type communications
NB-IoT	Narrowband IoT
NR	New Radio
NSA	Non-standalone
PDSCH	Physical downlink shared channel
PRB	Physical resource block
PUSCH	Physical uplink shared channel
QAM	Quadrature amplitude modulation
RAT	Radio access terminal
RedCap	Reduced Capability protocol
RRC	Radio resource control
RRM	Radio resource management
RX	Receive
SA	Standalone
SAW	Surface acoustic wave
SCS	Sub carrier spacing
SIB	System information block
SKU	Stock keeping unit
TDD	Time Division Duplex
TX	Transmit
UL	Uplink
URLLC	Ultra-reliable low latency communications
VoIP	Voice over IP
VoNR	Voice over New Radio

Technical considerations

The introduction of new cellular technologies into existing mobile networks is highly dependent on the long-term business, network and spectrum strategies of MNOs. This is particularly true in the case of NB-IoT and LTE-M, where user equipment is designed to have a service lifetime of up to 10 years. Furthermore, as the installed base of IoT devices grows and diversifies, it becomes ever more challenging for MNOs to simultaneously address their diverging needs. Ultimately, maintaining multiple legacy cellular networks, each serving disparate device types, as well as the use of outdated telecommunication protocols, results in gradually increasing operational costs and a significant proportion of the IoT customer base using spectrally-inefficient legacy networks.

Although it characterises many markets across the globe, this picture is now changing, in a shift that will secure the future viability of the connectivity business. Many MNOs are planning to gradually reduce 2G and 3G capacity, or even a complete decommissioning of such networks. Furthermore, as new capabilities are rolled out in the 5G infrastructure, opening the door for innovative and attractive business models, analysts expect 4G adoption to stagnate over the coming years. For these reasons, it is essential to understand the possibilities offered by RedCap and eRedCap.

Closely studying this evolving situation, the GSMA 5G IoT Community recently published the **Mobile IoT in a 5G Future** white paper. This document provides a high-level description of RedCap and eRedCap technologies, and how they compare to established 5G and 4G equivalents (see Figure 2). A key message is that RedCap and eRedCap are not replacement technologies for the lower-bandwidth 5G mMTC technologies LTE-M and NB-IoT. Instead, the goal of the new 5G SA variants is to bring the bulk of the legacy business, including use cases currently serviced with 2G, 3G and 4G (Cat 4 and Cat 1/1bis) on to the cutting-edge 5G SA network. By adopting RedCap, enterprises can future-proof their fleet of IoT devices well into the mid-2030s, beyond the lifetime of many existing 4G network operations.

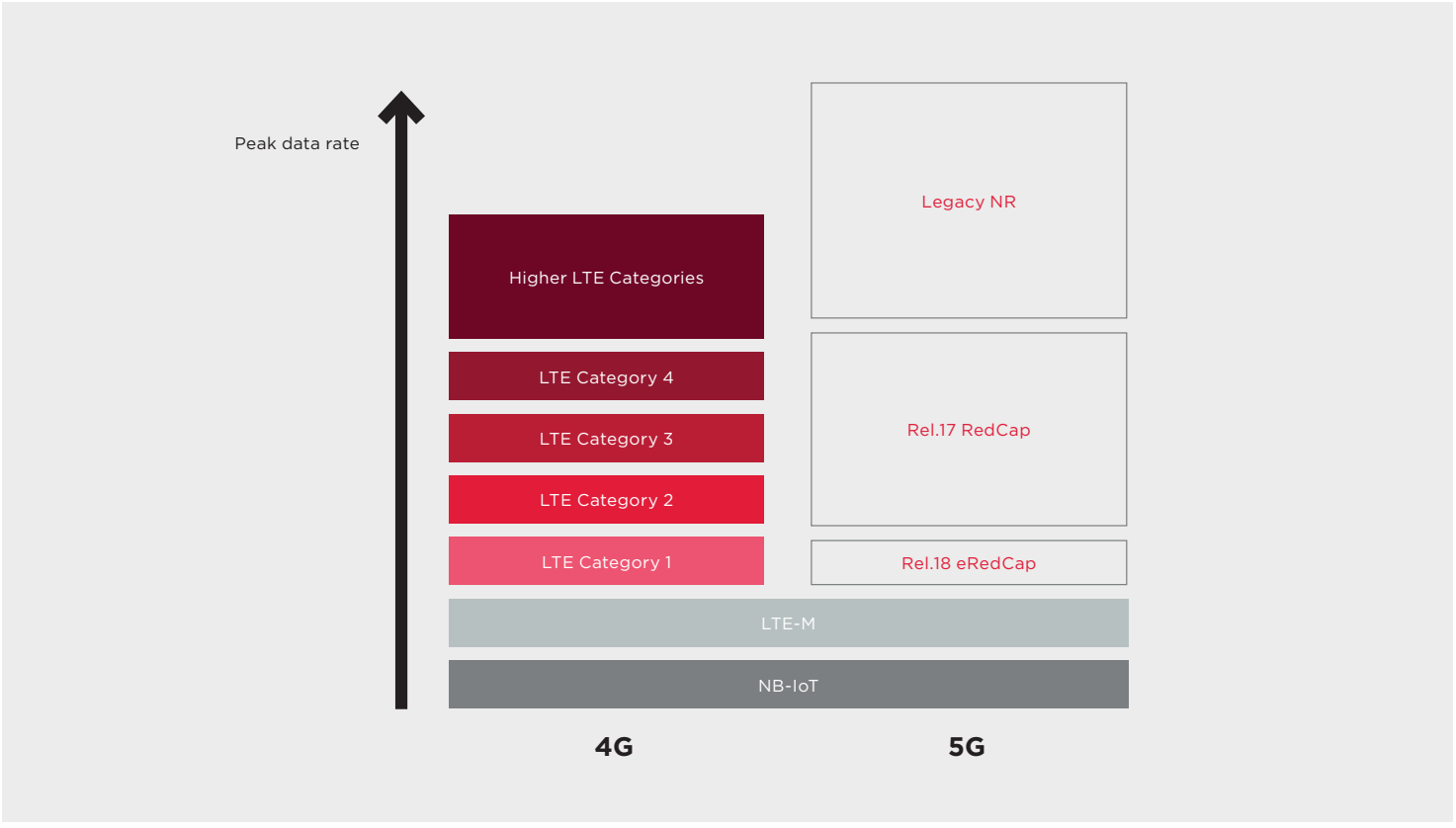


Figure 2, NB-IoT, LTE-M, RedCap, and eRedCap in the context of 5G

While RedCap devices may have “reduced capabilities” versus legacy 5G NR, they retain the ability to send and receive significant amounts of data – comparable to LTE Cat 4, support SMS messages, and even handle VoNR calls. Furthermore, 5G RedCap devices are cost-competitive with their LTE Cat 4 counterparts, while supporting smaller form factors and longer battery lives than legacy 5G NR devices. 5G eRedCap, in comparison, is expected to further reduce device cost and extend battery life while ensuring higher speeds than LTE-M and NB-IoT and similar speeds to LTE Cat 1 (see Figure 3).

Overall, it is important to keep in mind that the performance of all 5G IoT devices may vary across different networks as MNOs are likely to activate different network capabilities and configurations. Individual MNOs will be able to provide IoT customers with details of what network capabilities are available and the device requirements that need to be implemented for a specific use case.

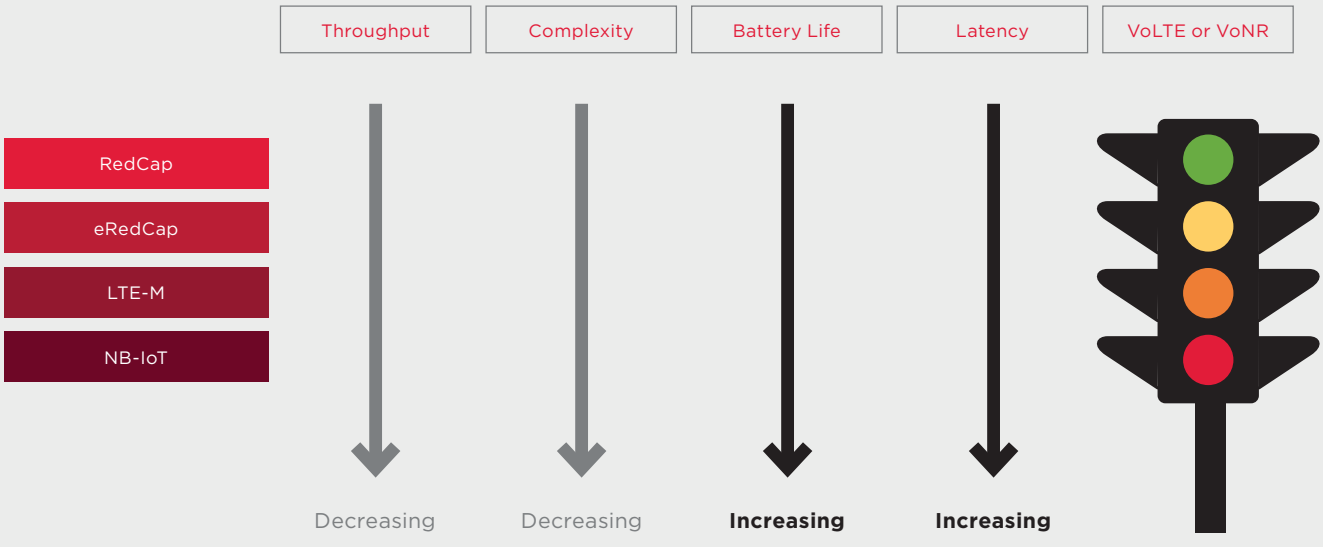


Figure 3, Performance Comparison of non-NR 5G Technologies

RedCap

5G Reduced Capability was initially defined in the 3GPP Release 17 specification. The goal was to minimise the hardware and software complexity to drive down cost and compete with legacy 4G and its established ecosystem: to date, enterprises have had few incentives to adopt 5G NR, which is typically more expensive and over-dimensioned for most IoT use cases. RedCap enables power optimisations that deliver far longer battery lives for B2B and consumer IoT devices, as well as simplifying the device's baseband and radio frequency architecture.

Simplification of the 5G device transceiver

RedCap user equipment supports a maximum bandwidth part of up to 20 MHz in FR1 and 100 MHz in FR2. Therefore, in 5G carrier deployments with larger bandwidths, a dedicated bandwidth part of 20 MHz (or lower bandwidth) should be configured on the 5G radio access network (RAN) for RedCap. However, depending on the MNO's RAN infrastructure, it may also be possible to deploy RedCap within smaller carrier bandwidths, for example, in 10 MHz spectrum. By comparison, a fully featured 5G NR device supports a maximum bandwidth part of up to 100 MHz in FR1 and 200 MHz in FR2.

Additionally, RedCap user equipment can't combine simultaneous data transmissions on multiple frequency carriers to increase bandwidth (i.e., carrier aggregation). RedCap devices also don't support evolved non-standalone dual connectivity (EN-DC) with simultaneous 4G and 5G bearers, nor new radio dual connectivity (NR-DC) with multiple, simultaneous 5G bearers. Finally, the 5G NR requirement to implement at least two receive branches does not apply.

To reduce the complexity of the device, 3GPP made several changes to the device transceiver architecture. RedCap devices support only one transmit antenna, abbreviated as "1T". "Uplink transmit (TX) diversity and Uplink MIMO are therefore not supported. Depending on the frequency range, up to two receive branches can be implemented ("2R" or "1R"). In FR2 spectrum, it is mandatory to use 2R. The number of downlink MIMO layers in FR1 can vary from 1 to 2 layers, whereby a 2R configuration always uses 2 downlink MIMO layers. In FR2, devices can flexibly support up to 2 layers. On account of this, end users of 1T1R RedCap devices may experience only half the peak downlink throughput compared to using an equivalent 1T2R device. Note, the RedCap cell in the 5G RAN continues to support a more complex transceiver, such as 2T4R.

As RedCap is designed to be used for medium bitrate IoT services on the 5G network, products that stream large amounts of data, such as high-throughput industrial routers, are best implemented as traditional 5G NR eMBB devices. Although implementing these complex devices with RedCap could lower the bill of materials and allow for a smaller form factor, MNOs may implement policies actively restricting their usage on the network, including assigning these devices a lower priority, relegating them to a network slice, rate capping them, or even blocking them altogether. This is because RedCap devices (1T2R or 1T1R) consume more radio resources on the MNO's network compared to 5G NR eMBB devices ("1T2R or 1T4R"). If left unchecked, the impact of such devices on cell uplink capacity may deteriorate the service quality of other 5G users in the same geographic area. Whereas the overall network spectral efficiency does not degrade significantly if lower bitrates are used by RedCap devices, the effect does becomes pronounced with high throughput applications that continuously stream data, or devices used for high bitrate IoT services.

Similarly, if a RedCap device is implemented with 1R configuration, it will have the same impact on cell downlink capacity as seen today with LTE Cat 1bis devices. The higher received bit error rates with one receive antenna result in greater transmit power being needed on the gNB infrastructure to compensate for the user equipment's lack of downlink receive diversity. The amount of power needed per downlink connection increases slightly, eating away at the total power available to distribute among all served users. In specific geographies, MNOs may restrict access of 1R devices to their networks using the mechanisms listed above; this is done as a precaution to ensure that network capacity is conserved and optimally used by end customers.

Optimisations enabling lower 5G data throughputs

When used on frequency division duplex (FDD) spectrum, a RedCap device may optionally support either full duplex or half-duplex modes of operation, the latter of which reduces hardware requirements further, thereby lowering costs through further complexity reduction.

While operating in FDD half-duplex mode, where the device and network transmit and receive data at different times, in different frequencies, the peak throughput experienced is approximately half of that if using FDD full duplex mode, where the sending and receiving of data occur at the same time, in different frequencies. Based on previous experience with LTE-M and NB-IoT devices, users of half-duplex RedCap devices may potentially experience mutual interference issues when co-located near other half duplex RedCap devices. For example, this may occur in smart metering, which is typically installed at high-density within multi-tenant dwellings.

It is mandatory for RedCap devices to 64 quadrature amplitude modulation (QAM) as the highest order modulation scheme. Optionally, as in the case of a fully featured 5G NR device, a RedCap device may support 256 QAM. In that case, one can expect an increase in peak throughput of up to 33%, as compared to a similar RedCap device that employs only 64 QAM.

As with fully-featured NR user equipment, a RedCap device may also support 16 data radio bearers (DRB); however, it must implement 8 DRB at least. Companies intending to adopt RedCap for their IoT services should consider if the throughput offered by 8 DRB is sufficient for their chosen application before committing to a specific device.

In theory, RedCap can support up to 226 Mbps on the downlink and 120 Mbps on the uplink, when using 256 QAM. But, in practice, peak data rates and average throughputs depend on multiple factors, including the amount of spectrum that MNOs make available for RedCap user equipment (i.e., the number of allocated physical resource blocks - PRBs) – which may vary across the different 5G carriers, and the number of MIMO layers on the downlink. External factors, such as overall network load and signal strength, will affect throughput, as well.

Network coverage aspects

IoT customers should consult their connectivity providers regarding the extent to which RedCap is deployed in specific markets. A MNO may restrict RedCap service to specific frequencies, geographies, network slices, etc. Access to RedCap service may also not be covered under existing 5G tariffs or roaming agreements, as discussed further below.

In those areas where RedCap is available, its coverage performance is similar to that of LTE and best quantified using the maximum coupling loss (MCL) value from their link budgets. MCL is the highest tolerable signal attenuation between a transmitter and a receiver, at which reliable communication is still possible within the specified performance criteria of the wireless system. It is a suitable benchmark for comparing the coverage performance of different technologies, as it excludes the antenna gains at either end, which may vary from device-to-device. RedCap offers a similar MCL to LTE Cat.4.

By supporting a maximum total radiated power (TRP) of 23 dBm/200 mW, RedCap user equipment operates as power class 3 (PC3) devices in FR1 spectrum, like their LTE Cat 4 equivalents. Please note that, although deployed in a rather limited context, RedCap user equipment can also operate in FR2 spectrum as power class 7 (PC7) devices, supporting the same radiated power of 23 dBm, but with a significantly lower user equipment spherical coverage requirement on the minimum effective isotropic radiated power at 50%-tile cumulative distribution function.

As is the case with NB-IoT and LTE-M devices, implementing a carefully-designed antenna solution for RedCap devices will be essential to ensure there will be no additional losses to the link budget and to increase the chances of maintaining communications on the uplink and downlink.

Multi-mode usage of 4G/LTE for roaming and fallback

5G RedCap roaming will only gradually come into place during the coming years. RedCap devices identify themselves to the network using a dedicated RAT (radio access technology) type, enabling MNOs to manage billing, roaming, access authorisation, and network quality management in a dedicated manner. Network access restrictions can also be implemented at cell-level to match network resources to specific RedCap devices based on their capabilities (e.g., 1RX or half-duplex support). Both mechanisms may be used by MNOs to control which RedCap devices attempt to attach to their network for the reasons outlined above. Having identified a device as being RedCap-capable, the MNO may, for example, map the device to a new RAT type "NR_REDCAP" for the purposes of applying roaming restrictions. This may occur in case the MNO does not yet have RedCap-specific roaming agreements in place with other operators. For these reasons, as well as the increased complexity of integrating 5G SA cloud native core networks over backbone IPX-networks for inter-PLMN 5G SA roaming, end customers using RedCap may not have many options for international and national roaming (even with non-geographic SIM cards) in the initial time frame of MNO RedCap network deployments.

However, most RedCap radio frequency chipsets and modules will support 4G/LTE fallback in the absence of RedCap coverage. It is advisable to integrate a 5G RedCap modem that can reselect to the older 3GPP technology. In addition to limited roaming coverage, mobile networks in remote areas may use energy-saving features during off-peak times, such as early mornings. For instance, MNOs might shift devices, such as 5G NSA, 5G SA, and RedCap into a smaller chunk of spectrum, or temporarily switch off 5G, offering only 4G. This typically doesn't affect medium bitrate services, but highlights the need for 4G fallback to maintain connectivity for RedCap devices in such regions.

The availability of multimode chipsets and modules brings additional advantages for the emerging RedCap ecosystem. As IoT service providers roll-out their RedCap devices, they may choose between two distinct deployment strategies for the connectivity layer, which can be easily managed by applications via the access terminal-interface:

RedCap as the primary bearer – IoT services which currently use LTE to communicate may upgrade their capabilities to leverage the performance enhancements of 5G RedCap by integrating a RedCap-capable chipset or module, where RedCap is configured as the preferred technology. In specific locations where 5G coverage is not available, or in an international and national roaming context, the devices may reselect 4G to continue transferring data over the fallback technology.

LTE as the primary bearer – Many IoT services today reliably use LTE, and their deployment indoors often means that there can be no com promises in terms of coverage quality. Whereas most of these devices currently use GSM as a fallback bearer to transfer data whenever LTE coverage deteriorates, these may now adopt RedCap-capable chipsets or modules. As GSM services are being systematically phased out in most major markets worldwide, RedCap becomes a very attractive and future-proof alternative. With the introduction of 6G on the horizon, one can reasonably expect some 4G sunsets within a decade's time. In this scenario, IoT devices with 5G RedCap as a fallback technology will be able to continue operating well into the 6G future.

Energy consumption reduction

To help reduce energy consumption, RedCap leverages three key capabilities (eDRX, relaxed monitoring and wake-up signal) that allow for dramatically longer battery lives than conventional 5G NR. Thanks to these capabilities, RedCap wearables should be able to last over a week on a battery charge, whereas specific RedCap B2B IoT uses cases may have a battery life of a few years, assuming wide time windows between communication events.

Extended discontinuous reception (eDRX) was introduced in 3GPP Release 13 and integrated into the NB-IoT and LTE-M specification. To-date, though, not all LPWA networks have activated this feature for the B2B IoT business, leading to a roaming landscape of fragmented feature support that affects battery life for downlink-centric LPWA applications. However, eDRX for RedCap will likely take a different path, given the commercial pressure as tier-1 suppliers of consumer wearables bring RedCap devices to the market as early as 2025. This will hopefully result in a situation where most RedCap networks globally will support this key power saving feature. 5G eDRX allows a device transceiver to suspend its receiver in periodic low-energy sleep mode for periods of a maximum of 10,485.76 seconds (2.91 hours) in RRC_IDLE state and up to 10.24 seconds in RRC_INACTIVE state. The minimum duration of the suspension in either state is 2.56 seconds. Both the network and the device negotiate the start and duration of these cycles, thereby ensuring that the network knows when the device will wake up to listen for incoming pages. Note, the use of eDRX leads to an increase in downlink latency, as the device won't receive data during the duration of its eDRX sleep cycle.

Fully-featured NR devices continuously monitor the radio environment to support handover in inter-frequency, intra-frequency or inter-RAT contexts, searching for and reporting the strongest cell reference signal received through frequent radio resource management (RRM) measurements of serving and neighbouring cells. This is essential in moderate to high-velocity uses cases, such as vehicles, drones and elevators. RedCap devices, however, will either remain static or typically move with low velocity (wearables used by consumers or fixed-installation devices) or are deployed in densely covered, urban environments (e.g., not at a cell edge). This gave the standardisation groups an incentive to improve the older Release 16 feature "relaxed RRM monitoring". Under the new Release 17 implementation, RedCap devices can take even fewer adjacent cell signal measurements, reducing energy consumption. This goes hand-in-hand with the larger DRX cycles described above.

The last relevant feature that may be deployed on RedCap networks is the optional Release 15 wake-up signal (WUS). Also introduced for LTE-M and NB-IoT, this capability uses information in the paging indication channel to inform the 5G RedCap device if it should exit its sleep mode, resynchronise with the network, and demodulate higher layer control information in the PDCCH channel. Specified in 3GPP to detect the WUS signal, this mechanism is a low-energy process for the device's baseband receiver, as it does not require any demodulation and decoding. This enhancement allows for user equipment to remain in a prolonged sleep mode during specific parts of the day or week, for example during the night or outside of business hours, thereby extending battery life.

eRedCap

3GPP Release 18 introduces eRedCap (enhanced RedCap), which further simplifies 5G RedCap, limiting throughput to 10 Mbps, further reducing costs and energy usage.

Additional device complexity reduction

eRedCap focuses solely on FR1 spectrum, reducing further the peak data throughput for more constrained use cases. Irrespective of other features that may be activated, an eRedCap device will only be able to achieve a peak throughput of 10 Mbps in the uplink or downlink direction.

One way to reduce the throughput is simply by limiting the peak data rate without reducing the baseband bandwidth. Alternatively this can be achieved by limiting the number of PRBs available to the PUSCH and PDSCH channels. When 15 kHz SCS (sub carrier spacing) is used, the number of PRBs is limited to 25; however, if 30 kHz SCS is used, the number of PRBs drops to 12. This reduced number of deployed PRBs provides an equivalent baseband bandwidth of 5 MHz. The PRBs are only limited in the PDSCH and PUSCH channels with the maximum RF bandwidth part used by an eRedCap device remaining at up to 20 MHz (as in the first approach).

The reduction in PRBs may impact the gNodeB's ability to transmit broadcast-related information. This is not an issue for SIB (system information block) transmission or paging messages, but rather for random access. As the number of PRBs required for Msg2 may exceed 25/12 PRBs, an additional slot may be required. As a consequence, the timeline for random access was relaxed for eRedCap devices. For that relaxed timeline to be enabled, the device needs to signal to the gNodeB that is it an eRedCap device. If it doesn't, the additional slot delay may lead to random access failure.

As with Redcap, a new eRedcap RAT type has been introduced which MNOs may use for roaming management. MNOs also have an ability to restrict access to eRedCap devices based on the UE's number of RX branches supported.

The Release 18 eRedCap specification allows MNOs to deploy any combination of FDD and/or HD-FDD operation.

Additional energy consumption reduction

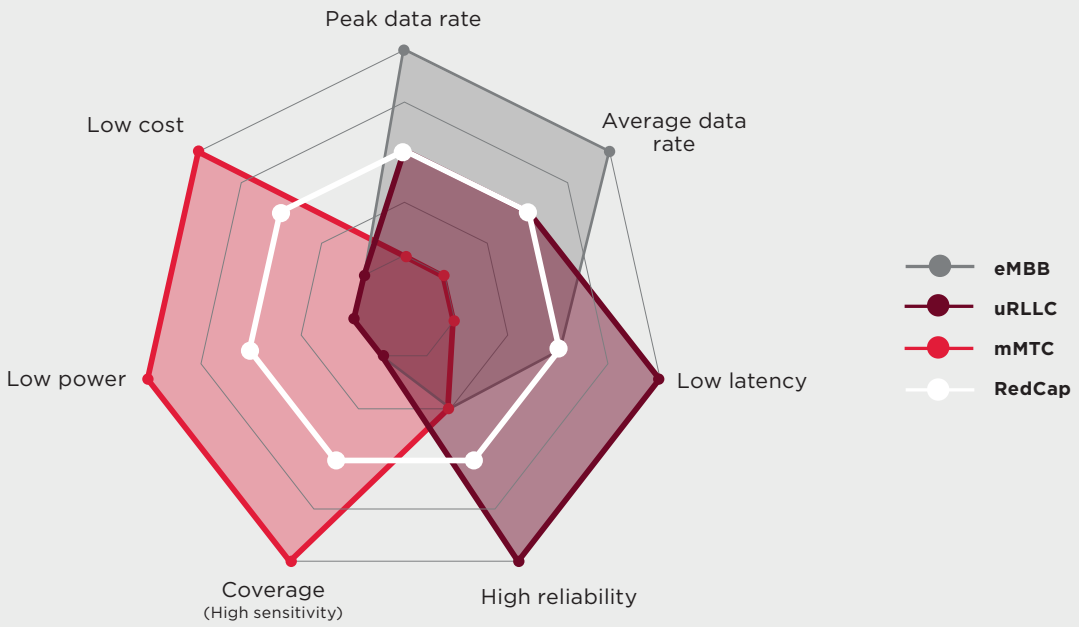
For eRedCap, the configurable eDRX time for a device in the RRC inactive state has been increased from 10.24 seconds to approximately 3 hours - the same amount used for devices in an RRC idle state. This allows for further energy savings to be achieved. Note, eRedCap also benefits from the aforementioned power saving features of RedCap.

RedCap/eRedCap use cases

The advent of 5G RedCap and eRedCap technologies marks a pivotal moment in the evolution of IoT ecosystems away from legacy 2G/3G/4G systems, by addressing the need for scalable, energy-efficient, and cost-effective solutions. Both RedCap and eRedCap are set to have wide adoption, playing a crucial role in enabling diverse IoT use cases on 5G SA networks, from industrial automation to consumer applications. This chapter explores the high-level segmentation and strategic positioning of 5G RedCap and eRedCap within the broader IoT landscape, emphasising their impact on various industry verticals and application scenarios.

RedCap is intended to address IoT applications with mid-tier requirements, such as wearables, surveillance cameras, alarm panels, digital signage, mid-end industrial gateways and routers, smart grid, network bridges and vehicle telematics, among the others. More than a LTE Cat.4 replacement, 5G RedCap brings multiple key advantages:

- **Longer lifecycle –** Being a 5G-native technology, which will be available after upcoming LTE sunsets, RedCap can connect IoT applications that need to be operational for many years after they are deployed in the field, such as connected heavy equipment machinery.
- **Higher data throughput –** Through the use higher order modulation schemes, RedCap can transfer more data than lower LTE categories, especially in the uplink. This is particularly interesting for uplink-centric use cases, such as connected cameras for smart cities, for video telematics, or for industrial use.
- **Lower latency –** As a 5G SA-based technology, RedCap supports stricter requirements for applications that need to be remotely controlled in real-time, such as smart grid switches for precise load balancing in electrical networks.



SG relies on three main pillars all running inside the SG Core: enhanced Mobile Broadband (eMBB), ultra-Reliable Low Latency Communication (uRLLC) and massive Machine Type Communication (mMTC). SG RedCap addresses applications that fall between these extremes. (Source: 3GPP)

Figure 4, 5G RedCap positioning with respect to eMBB, uRLLC and mMTC

- **Lower power consumption –** Equipped with advanced power saving features, RedCap can extend the operation time between charging windows for battery-powered consumer wearables, such as smart watches and smart glasses. RedCap is designed to support up to a few years of battery life for industrial sensors and up to two weeks for wearables.
- **Additional user equipment power classes (PC) –** In the 5G FR1 bands, RedCap brings support for new device classes with lower and greater maximum total radiated power. This includes 20 dBm (PC5), 23 dBm (PC3), 26 dBm (PC2), and 29 dBm (PC1.5), thereby supporting a broader range of device types – from vehicular and handheld to high-power non-handheld user equipment, compared to the LTE Cat.4, which is optimised for PC3 handheld equipment. In FR2 bands, RedCap also supports PC7, which has even less radiated power and reference sensitivity.

RedCap and eRedCap, featuring VoNR, can also support IoT applications that do not require high bandwidth and data throughput, but must use voice, such as connected elevator alarm panels.
Figure 5 showcases the versatility of RedCap/eRedCap technologies in enabling a wide range of IoT and consumer devices with lower data throughput and energy needs, while maintaining reliable and efficient communication.

Figure 5, Examples of 5G RedCap/eRedCap use cases

Network deployment and device ecosystem maturity

Status of 5G RedCap / eRedCap for IoT ecosystem (chipset, module, devices)

RedCap is gaining recognition within the IoT sector due to significant advances by chipset industry leaders (see Table 1). These companies are spearheading the development of specialised chipsets tailored specifically for RedCap, with a strong emphasis on enhancing power efficiency and cost-effectiveness while ensuring robust connectivity. Although there is not much publicly-available information from chipset and module vendors about their plans for eRedCap.

COMPANY	PRODUCT NAME	LINKS
ASR	ASR 5G RedCap chipset	Link
MediaTek	MediaTek T300 chipset series	Link
MediaTek	MediaTek M60 5G RedCap Modem	Link
Qualcomm	Snapdragon® X35 5G Modem-RF System	Link
Sequans	Sequans Taurus LT chip	Link
UNISOC	UNISOC 5G RedCap chip platform V517	Link

Source: based on public announcements

Table 1, Non-exhaustive list of 5G RedCap Chipsets (R17) as of end November 2024

This progress extends seamlessly into IoT modules as shown in Table 2, where manufacturers are integrating these advanced chipsets into their product offerings. This integration paves the way for seamless connectivity solutions across a diverse array of sectors, such as smart cities, industrial IoT, and consumer electronics. The first 5G RedCap modules were certified by the Global Certification Forum (GCF) in Q3 2024. On the other hand, there is still no eRedCap module that has been publicly announced as of end November 2024.

COMPANY	PRODUCT NAME	LINKS
Cavli Wireless	Cavli CQM220 5G RedCap IoT Module	Link
China Mobile	OneMO MR880A 5G RedCap module	Link
China Unicom	Yanfei NX307 module	Link
Fibocom	Fibocom FG131 module series	Link
Fibocom	Fibocom FG132 module series	Link
Fibocom	Fibocom FM330 module series	
Lierda	Lierda NR90-HCN series	
MeiG Smart	MeiG Smart SRM813Q series	Link
NEOWAY	NEOWAY N512A-CN module	Link
Quectel	Quectel 5G RedCap RG255AA series	Link
Quectel	Quectel 5G RedCap RG255C series	Link
Quectel	Quectel 5G RedCap RG255G series	Link
SIMCom	SIMCom SIM8230X and SIM8230X-M2 module series	Link
TD-Tech	TD-Tech MT5710 Series	Link
Telit Cinterion	Telit Cinterion FE910C04	Link
Telit Cinterion	Telit Cinterion FN920C04	Link

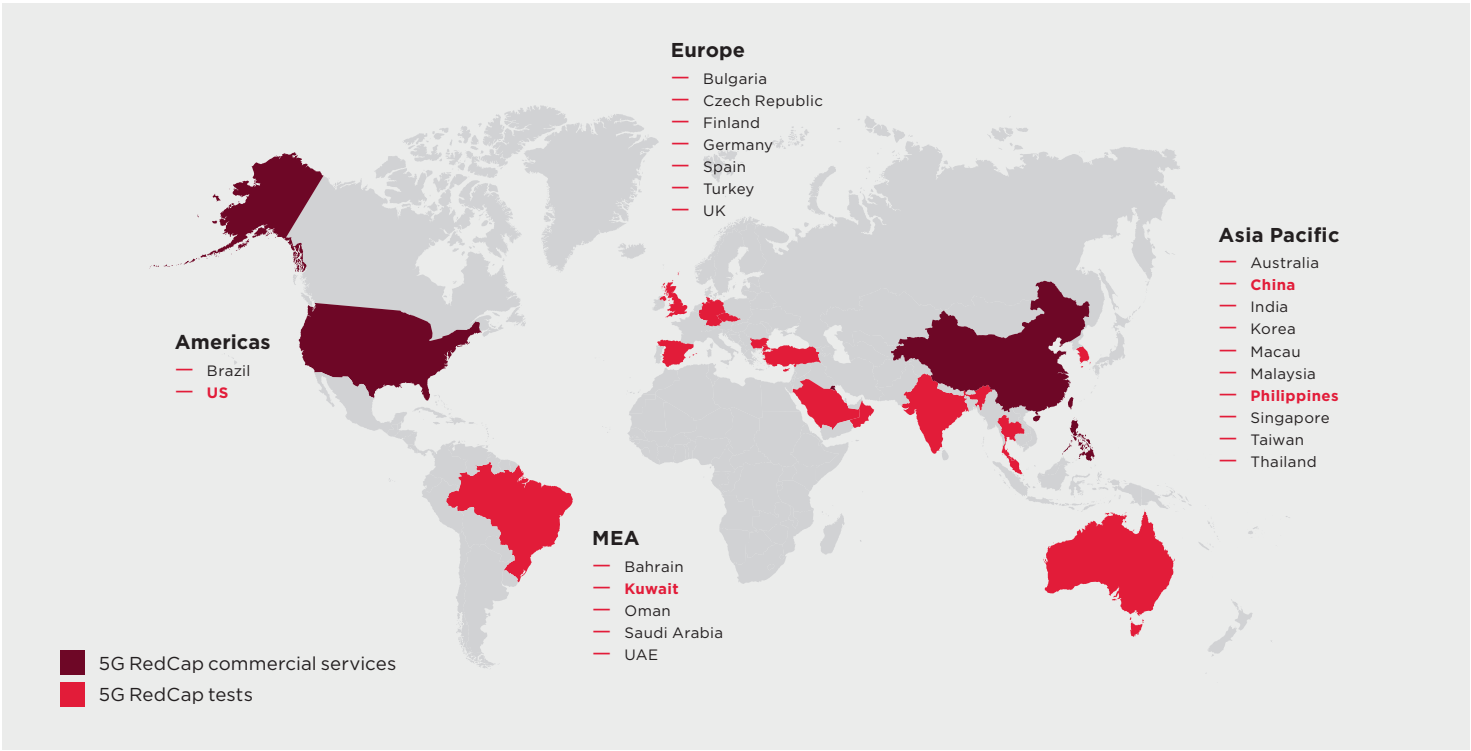
Source: based on public announcements

Table 2, Non-exhaustive list of 5G RedCap Modules (R17) as of end November 2024

Status of 5G RedCap for IoT deployments (tests, pilots & commercial)

Research at the end of November 2024 found public references to RedCap commercial launches in four countries, with tests ongoing in more than 20 additional countries globally. 5G RedCap services have been commercially available in China since mid-2024. At the end of Q3 2024, there were a total of 600,000 5G base stations supporting RedCap in China, according to the **TDIA** (Telecommunication Development Industry Alliance). Of these more than 430,000 are operated by China Mobile, covering more than 200 cities in China. Continuous coverage has been achieved in 17 provinces, including Guangdong, Jiangsu, Zhejiang, Hubei, Beijing, Liaoning, Sichuan, and Yunnan. China Unicom and China Telecom operate 170,000 RedCap base stations in 17 provinces. During MWC Shanghai 2024, the GSMA published a **report** providing an overview of a range of pioneering 5G RedCap use cases in China.

Elsewhere, looking specifically at IoT, there are 5G RedCap tests ongoing in North America, Europe, Middle East and Asia. According to an **interview** with Jason Sikes, AVP of Device Architecture at AT&T, during the summer of 2024, the US operator launched 5G RedCap in portions of its commercial network in Dallas in order to conduct tests with its chipset and module suppliers. The executive also mentioned plans to conduct additional tests in innovation zones on the West Coast before expanding RedCap network coverage in 2025. Verizon publicly **announced** 5G RedCap tests in 2023, while T-Mobile US already **markets** a 5G RedCap connectivity offer using the TCL Linkport IK511 mobile hotspot device. In the Middle East, several MNOs in GCC countries have conducted various RedCap trials and some have announced plans for commercial launches in the near future. For example, during the GSMA 5G Futures Summit at MWC Barcelona 2024, Zain Saudi Arabia **revealed** plans to launch IoT RedCap CCTV for public security governance requirements in the 2024-26 period. In Europe, tests have taken place in a dozen countries and the first commercial launch is likely in 2025. Figure 5 provides an overview of the MNO's 5G RedCap deployments and tests at the end of November 2024, while the Annex of this paper provides further examples



Source: based on public information as of end November 2024

Figure 5, MNO 5G RedCap deployments and tests

Conclusion

The increasing momentum to adopt recently standardised RedCap and eRedCap technology highlights the growing importance of 5G in reshaping the IoT landscape. As well as providing future-proof alternatives to 4G Cat 4 and Cat 1/1bis, these radio access technologies offer a seamless migration path for services reliant on even older legacy technologies, such as 2G and 3G. Both RedCap and eRedCap simplify the hardware requirements for 5G devices and bring performance enhancements, including low latencies and energy saving capabilities that extend device battery life. Their optimisation for medium bit rate services means that more 5G devices can be supported in any given amount of spectrum than ever before.

Furthermore, RedCap and eRedCap leverage the cloud-native 5G SA architecture, which enables IoT service providers to monetise and scale new value-added services for connectivity, including network slicing and network services via API. Together with LTE-M and NB-IoT, RedCap and eRedCap will address the next generation of low-end and mid-end devices as part of the evolving 5G standard.

RedCap's and eRedCap's lower cost of ownership, compared to conventional 5G New Radio technology, democratises access to 5G for a broader range of use cases and customers. That will make it easier to bring scalable 5G connectivity to a myriad of products, including industrial sensors, factory and building automation, public safety monitoring, connected drones, smart grids, aggregation gateways, telematics, and much more. RedCap and eRedCap are well positioned to play the leading role in supporting the next generation of connected 5G devices and applications, while driving innovation and efficiency in the IoT industry.

In this white paper, we examined the technical aspects of RedCap and eRedCap, including how the 5G device transceiver was simplified to lower the cost of ownership and how both technologies are optimised to support the necessary data throughputs for medium bitrate services. We also discussed network coverage considerations, as well as the features and configurations manufacturers may choose to leverage to create more resilient RedCap and eRedCap devices. Additionally, we explored the energy-saving enhancements that contribute to extended battery lives for a new generation of advanced 5G products, for instance, wearables. Finally, we highlighted the expanding ecosystem of component manufacturers and mobile network operators that are driving the adoption of RedCap and eRedCap solutions and connectivity in the IoT market.

Annex

Non-exhaustive list of 5G RedCap tests based on public information (outside China, as of end November 2024)

OPERATORS	TEST ACTIVITIES	USE CASES MENTIONED	SOURCE
Optus (Australia)	Demonstration of an enhanced pedestrian safety system in factories leveraging 5G RedCap and AI cameras	RedCap to help provide better pedestrian safety in **industrial** environments	October 2024 - **link**
CETIN (Czech Republic)	Demonstration in Prague of a RedCap-capable router and camera connected to an O2 5G BTS	Use cases of a **camera** using RedCap to transmit data and of a RedCap **router** aggregating data from a range of non-RedCap devices	October 2024 - **link**
Omantel (Oman)	Laboratory trial of RedCap	Designed to meet the evolving demands of IoT applications, RedCap offers high speeds and energy efficiency, making it ideal for a range of devices, from **smart wearables** to **advanced industrial equipment**	September 2024 - **link**
e& UAE	Completed E2E verification of the RedCap software solution on e& UAE's 5G SA network. The next stage is to scale the RedCap implementation across e& UAE's commercial network	RedCap can effectively scale down the complexity, size, and capabilities of a new array of 5G IoT devices, such as **wearables, and industrial sensors**	July 2024 - **link**
CTM (Macau)	As part of the commercial launch of 5.5G on 22 July 2024, CTM will also concentrate on RedCap IoT applications	-	July 2024 - **link**
O_2 Czech Republic	Completed lab testing of the 5G RedCap technology and continues further preparations for its commercial launch	Important milestone for the development of the Internet of Things including **wearables** and **sensors**, and the further expansion **of factory automation, industry 4.0,** and for **augmented or virtual reality**	July 2024 - **link**
O_2 Telefonica (Germany)	RedCap testing on the O2 Telefónica 5G public network is opened to lead customers and partners	5G RedCap is interesting for mid-tier B2B applications such as **smart metering gateways, wireless surveillance cameras** and **industrial routers**	April 2024 – **link**

OPERATORS	TEST ACTIVITIES	USE CASES MENTIONED	SOURCE
Singtel (Singapore)	Tested RedCap compatibility with Singtel's 5G network	RedCap is specifically designed to support mid-tier IoT devices, like **smartwatches** and **industrial sensors**	Dec 2023 –
du (UAE)	Tested RedCap compatibility with du's 5G commercial network	Specifically targeting compact IoT devices, such as **wearables** and **health trackers, video surveillance, wireless industrial sensors**, as well as **ruggedised routers**	Dec 2023 – **link**
Vodafone (Spain)	Demo in Ciudad Real using Vodafone Spain's live testing 5G network 'CREATE' (Ciudad Real España Advanced Testing Environment)	For low powered devices, such as **smart watches, credit card readers, portable routers, lighter virtual reality glasses, smoke alarms** or **handheld retail inventory machines**	Nov 2023 – **link**
Airtel (India)	Tested RedCap compatibility with Airtel's 5G network	Enable futuristic IoT broadband adoption for devices including **wearables** and **industrial sensors**	Oct 2023 – **link**
AT&T (US)	RedCap data call in both lab and on live 5G SA network	To support mid-tier IoT use cases like **wearables** (smartwatches, AR glasses), **IoT devices** for **healthcare, asset tracking, smart home, fleet management,** ...	August 2023 – **link**
Optus (Australia)	RedCap data call on Optus' 5G network	**Wearables** (e.g. smartwatches), **health monitors, AR devices** (e.g. glasses), industrial applications such as **video surveillance**, and **industrial sensors**	August 2023 – **link**
Telstra (Australia)	VoNR call using RedCap on Telstra's commercial 5G network and a MediaTek RedCap testing device	VoNR over Redcap interesting for **wearables** such as smartwatches	August 2023 – **link**
SKT (South Korea)	Field tests of commercial pilot networks at the test bed in Bundang	**Wearables, connected cars, smart factories** and C**CTVs**	August 2023 – **link**
Verizon (US)	Completion of data and VoNR sessions over Verizon's 5G network using RedCap	Consumer **wearables** and **audio-enabled enterprise solutions**	August 2023 – **link**
STC Kuwait	Completed the technical prototype validation of RedCap	**Industrial Internet, electricity power industry, wearables, video surveillance, smart vehicles**	March 2023 – **link**

Source: Press releases

GSMA Head Office
1 Angel Lane
London
EC4R 3AB
UK

Email: info@gsma.com