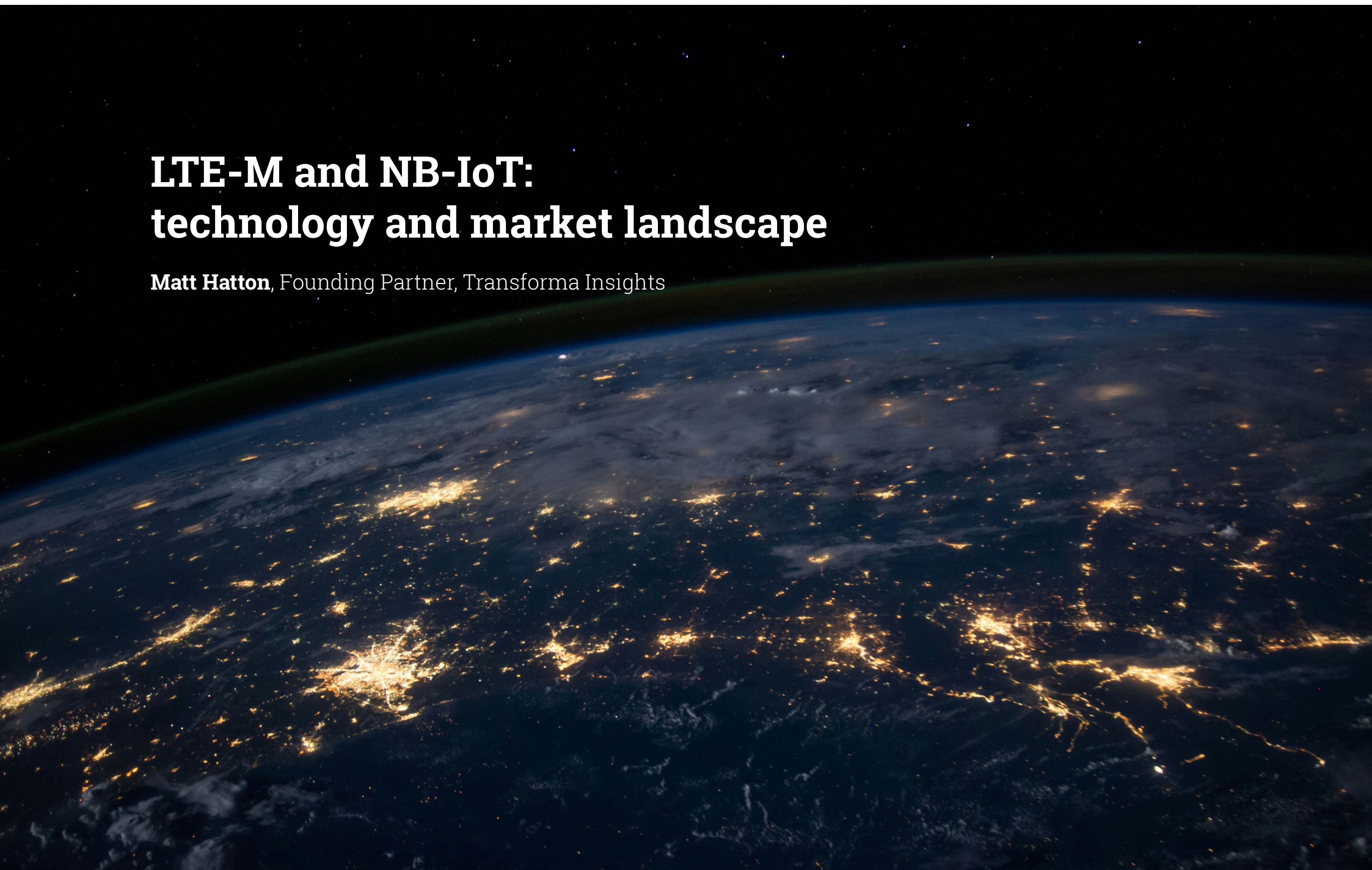


LTE-M and NB-IoT: technology and market landscape

Matt Hatton, Founding Partner, Transforma Insights



Introduction

Over the past 15 years, and particularly in the last 7, the mobile industry has developed cellular network technologies more appropriate for addressing the requirements of the Internet of Things, distinct from those technologies used for smartphones and other consumer connected devices. However, there is still a lot of uncertainty about the relative capabilities and merits of the different technologies.

In this report we focus particularly on the LTE Cat M (LTE-M) and NB-IoT technologies that are increasingly widely deployed around the world. The report examines them in the context of the wider development of IoT-oriented technologies (including LTE Cat 1bis and 5G RedCap), considering the technology roadmap, the capabilities of the technologies, network roll-outs, adoption, and key use cases. All of the technologies have been developed predominantly to address IoT devices. However, each has very different characteristics. The critical question for anyone considering whether to use LTE-M, NB-IoT or any of the other technologies is how it compares to other available technologies.

The wide area cellular LPWA landscape

The GSM Association (GSMA) launched the 'Mobile IoT Initiative' in June 2015 to accelerate the commercial availability of Low Power Wide Area (LPWA) solutions in licensed spectrum, aimed at addressing the growing demand for IoT devices for low cost, battery-powered devices. The mobile industry subsequently focused on two complementary licensed 3GPP standards: Long-Term Evolution for Machines (LTE-M) and Narrowband-Internet of Things (NB-IoT), both of which were initially introduced in 3GPP Release 13 in 2016, and refined in Release 14 (2017).

The two technologies have been subsequently homologated into 5G networks as the two initial technologies constituting the massive machine type (mMTC) component of 5G standards. Subsequently, the 3GPP has focused on developing native 5G variants in the form of 5G Reduced Capability (RedCap), unveiled as part of Release 17, with an enhanced version (eRedCap) on the roadmap for Release 18 with a plan that it will be the ultimate replacement for LTE Cat-1 and Cat-4, with LTE-M and NB-IoT maintained for low power/cost/throughput use cases.

As well as these 5G technologies, there was also work done within 3GPP to develop variants of LTE that were somewhat optimised for IoT. LTE Cat 1 was designed as a relatively low bandwidth and cheaper variant of the 4G technology. In Release 14, LTE Cat 1bis was introduced with further reduced complexity and the need to support only a single antenna, giving lower cost but reduced coverage.

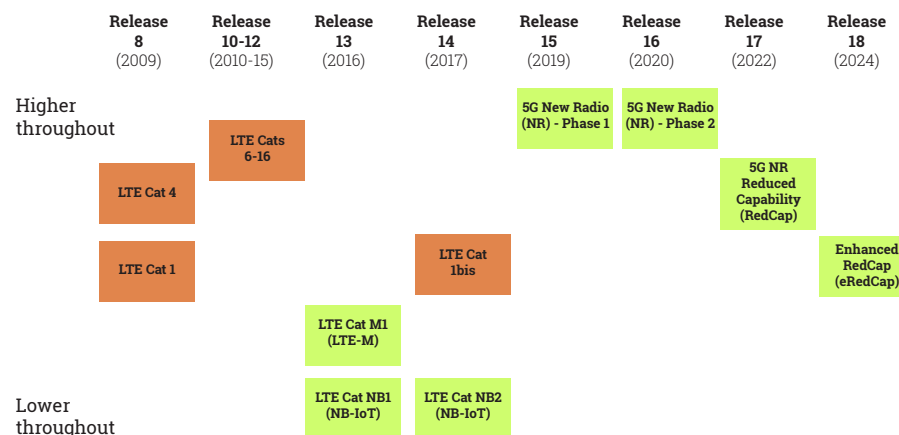


Figure: 3GPP cellular technology Releases

[Source: Transforma Insights and 3GPP, 2023]

Technology capabilities

In this section, we assess the characteristics and capabilities of the main cellular network technologies that are available today to address IoT. These are summarised in the chart below.

	LTE Cat 1	LTE Cat 1bis	LTE-M	NB-IoT	5G RedCap
Future-proofing					
Availability					
Range/Coverage					
Uplink/downlink speed					
Latency					
Power consumption					
Unit price					

Figure: Capabilities of IoT-oriented cellular technologies

[Source: Transforma Insights, 2023]

We should note that these are not the only considerations. For instance, some applications may require voice calling, which is not supported by all technologies.

As illustrated in the chart, there is no single technology that will be appropriate and optimised for every use case. Every decision is a trade-off between the demands of the application, the capabilities, and cost.

Future-proofing

The final consideration is that of future-proofing. Many users, whether they are municipalities deploying smart city projects or utilities investing in smart meters, want technologies that are supported for the next 10-15 years. The question they will ask is: will the technology continue to be available to use for the foreseeable future? This will depend on whether the technology is supported on LTE or 5G networks, in parallel with mobile network operator plans for spectrum refarming.

LTE-M and NB-IoT are included in the 5G standard, as '5G massive Machine Type Communication (mMTC)' (along with 5G RedCap), with the ability to be supported on 5G core networks. As such, those technologies have an inherently extended operational life compared to 4G technologies such as LTE Cat 1 or Cat 1bis, which will not be so supported when LTE networks are eventually switched off. The importance of this depends on the likely roadmap for LTE switch-off.

Generally, there is little appetite for such refarming of LTE spectrum for use by 5G any time in the next 20 years. In Europe, for instance, MNOs are only just making inroads into switching off 3G, a technology that is ostensibly not required for either coverage or capacity and is rarely relied on for IoT. 2G switch-off is on the horizon, but for most major European countries support is likely to continue into the 2030s.

However, in the US, the major MNOs are showing increasing concern over pressure on spectrum and there is likely to be a move to refarm LTE spectrum for 5G within the next decade. As a result, Cat 1 and Cat 1bis will cease to be supported. We can anticipate that a few other countries may take a similar approach: Australia, Japan and South Korea have all been in the vanguard of 2G and 3G network refarming and may take a similar approach to the US. Most of the rest of the world will probably be at least a decade behind them.

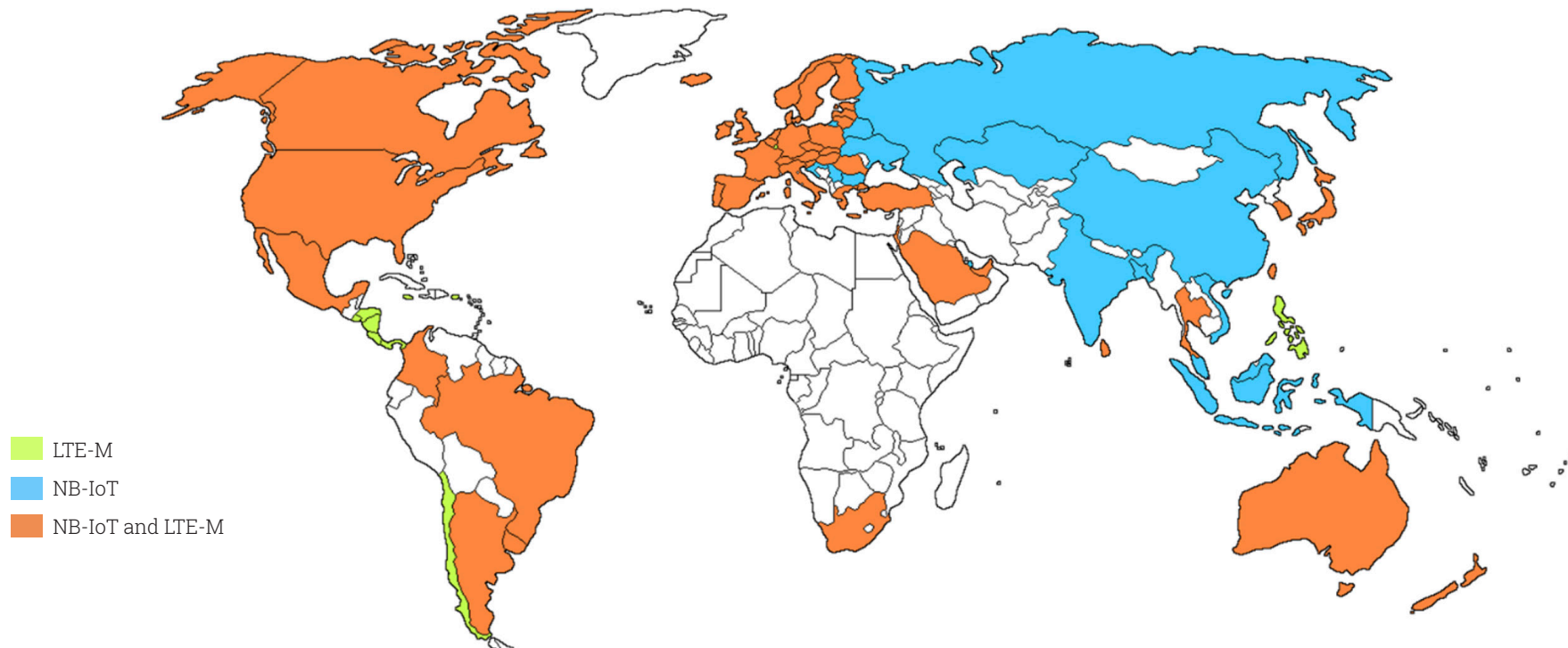
Technology capabilities

The foremost consideration when selecting network technologies will always be whether it has been deployed in the territories in which it is required.

Today LTE Cat 1 (and by extension Cat 1bis) has something of an advantage, being available in almost every territory around the world, wherever there is an LTE network. For a truly global deployment, this may prove to be a strong draw, notwithstanding issues of long-term longevity (see 'Future-proofing' section, below) and limitations on range and battery life. However, for deployments in a single country, or even region, the characteristics of alternatives such as NB-IoT and LTE-M will likely be favoured.

LTE-M and NB-IoT network deployments have been growing quite rapidly over the last few years. According to the GSM Association, in May 2023 there were 115 LTE-M networks deployed, almost comparable with the 137 NB-IoT networks active around the world. In recent years LTE-M has caught up noticeably. For instance, in October 2018 there were just 16 LTE-M networks, compared to 49 NB-IoT.

According to Transforma Insights forecasts, of the top 50 global IoT markets, 39 had both NB-IoT and LTE-M networks, 9 had just NB-IoT and two had neither.



Range/coverage

The existence of a network within a country, as noted in the previous section, does not necessarily guarantee availability for a particular device. Specifically, some technologies have superior characteristics for supporting in-building coverage. This is highly relevant for some IoT applications, for instance smart meters located deep inside a building, or agriculture applications in rural areas with spotty cellular coverage. LTE-M and NB-IoT are particularly strong here, and LTE Cat 1bis particularly weak.

While LTE Cat 1 might benefit from dual antennas, this advantage is compensated by other coverage enhancement features of LTE-M and NB-IoT which provides significant coverage boost (up to 15db). This becomes pronounced at the cell edge or deep indoors.

Uplink/downlink speed

The next consideration is whether the data link speeds are fast enough to support the application. Those applications demanding super-high data speeds will not opt for one of the IoT-oriented technologies considered here, but instead for 5G NR or a higher category LTE. However, for these technologies, there is a wide variation, from several hundred Mbit/s for RedCap, through to barely above 100Kbit/s for NB-IoT. LTE-M speeds are around 1Mbit/s. Sensitivity to capabilities here will depend entirely on the application being supported.

Latency

In parallel with uplink/downlink speed is latency. Some applications will require data to be sent and received in real-time, while for others several seconds (or even days) delay will be acceptable. Smart metering, for instance, may cope perfectly with very high latency, making LTE-M and NB-IoT appropriate technologies, but for smart grid load balancing, where real-time control is needed, a technology with sub-100ms latency will be required.

Power consumption

One of the key characteristics of these IoT-oriented technologies is the ability to be supported on a battery for multiple years. Both NB-IoT and LTE-M make use of Power Saving Mode (PSM) or EDRX (extended Discontinuous Reception) functionality which are the features that allow for the long battery life. While these features can be implemented for LTE (including Cat 1bis) they are not typically optimised for them. Furthermore, both LTE-M and NB-IoT use smaller portions of spectrum compared to LTE, allowing for lower power consumption.

Overall when considering power consumption, NB-IoT and LTE-M perform very well. The specifics of relative merits of different technologies will vary depending on the application here, including how often the device needs to report, the payload being delivered, and the requirement for firmware updates.

Unit price

Few IoT deployments are completely price insensitive. For various reasons, LTE-M and NB-IoT unit costs are lower. For instance, LTE-M uses Half-Duplex Frequency Division Duplex (HD FDD) in contrast with LTE Cat 1's use of Full-Duplex FDD. In the case of the latter, where transmit and receive work simultaneously, additional components are required, in the form of duplexer and filters. This adds to the hardware cost. Additionally, designers of Cat 1 devices need to know in advance which bands to support, requiring regional or operator-specific variants, meaning less flexibility in the design stage and less scale. The single antenna design of LTE-M and NB-IoT (and Cat 1bis) also help to reduce costs.

Module unit prices range from less than USD5 for NB-IoT devices, to USD8-12 for LTE-M and Cat 1bis, through to USD15-20 for Cat 1, and perhaps USD50 for RedCap (although the latter is not really available at scale today). There is some variation in pricing depending on specific requirements, but these figures illustrate the relative pricing levels.

Additionally, considering an IoT deployment as a whole, the reduced power consumption of NB-IoT and LTE-M reduces the power cost, either through using smaller batteries or through reduced requirements to replace or recharge.

Market Growth and Applications

The use of 5G mMTC will be extensive and will be applicable for most cellular IoT use cases. Transforma Insights maintains highly granular forecasts of the IoT market opportunity, including breakdowns by hundreds of applications, every country and all of the main types of technology. In the chart below we present the number of 5G mMTC connections, including both NB-IoT and LTE-M as well as further evolutions, including 5G RedCap.

The total number of 5G mMTC connections will grow from 436 million at the end of 2022 to 3.6 billion at the end of 2032. Today, over two-thirds of connections are accounted for by China, and specifically the extensive NB-IoT deployments there. However, over the forecast period, other markets will catch up, using a combination of NB-IoT and LTE-M. By 2032, China will account for 38% of connections, with 15% in the United States, 18% in Europe, 6% in Japan and 22% elsewhere in the world. Overall, 5G mMTC accounts for 28% of cellular connections, a figure which will grow to 58% by 2032. Outside of China the growth in market share is even more pronounced, from 16% to 54%.

The chart on the right illustrates the top Application Groups in which the 5G mMTC technologies will be most widely used. The use of other cellular technologies (e.g. LTE Cat 1 and above, 5G NR and residual 2G/3G) are presented alongside. As can be seen from the chart, there is a diverse range of use cases that will naturally favour the mMTC technologies, including track & trace, smart metering, and connectivity for white goods. Key use cases that will favour LTE-M include usage-based insurance (UBI) and assisted living. And, while NB-IoT might often be favoured for smart metering deployments, in many markets LTE-M will still be used for significant volumes of connections. Many use cases within the Track & Trace category will also use LTE-M. It is worth noting that NB-IoT will tend to be used for lower value tracking and monitoring.

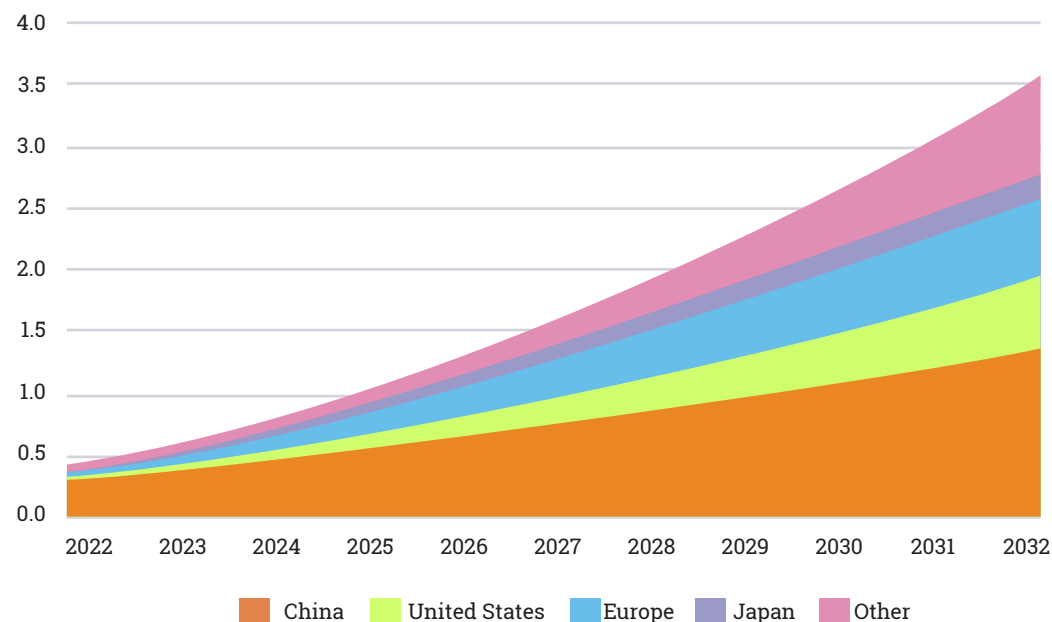


Figure: 5G mMTC (including NB-IoT, LTE-M and evolutions) IoT connections 2022-32

[Source: Transforma Insights, 2023]

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Major 5G mMTC use cases within the 'Other' category include Access Control and Intercoms, Road Transport, Vehicle Rental, Leasing and Sharing Management, Assisted Living, and Crop & Aquaculture Management.

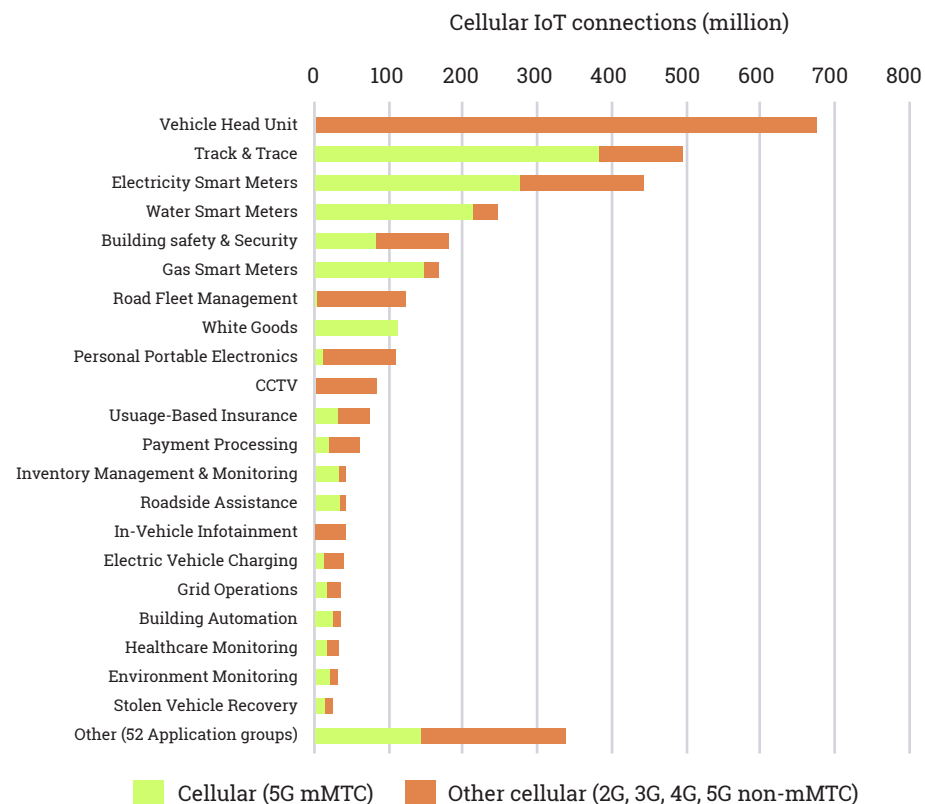


Figure: Cellular IoT connections 2027, split between 5G mMTC (including NB-IoT, LTE-M and evolutions) and other cellular generations

[Source: Transforma Insights, 2023]

Conclusion

There is a wide range of technology options available for enterprises wishing to connect relatively low data IoT applications; and most IoT applications are low data. The much reduced power consumption capabilities of the likes of LTE-M and NB-IoT also opens up new use cases that may have been otherwise not possible. It can be tricky for enterprises to work out which of the technologies will be most appropriate for them, not least because new ones are being added almost annually, for instance with RedCap and eRedCap.

There are really three considerations when selecting a technology: Are there networks available to connect my devices? Will those networks be supported for the duration of my deployment? Do the capabilities match those I need for the application?

In most countries today LTE-M and NB-IoT networks are available, with more coming on stream every year. While LTE Cat 1 (and Cat 1bis) may have an advantage in terms of global coverage as part of 4G, the capabilities are generally inferior, other than for applications needing high bandwidth. Furthermore, typically LTE-M and certainly NB-IoT will represent a lower cost option. Add to this the long-term ongoing support for NB-IoT and LTE-M as part of 5G, which may become quite significant over the next decade, relative to other 4G options.

