Mobile Device TRENDS

February 2024

An analysis of GCF device certifications in 2023

By combining conformance and interoperability tests undertaken in laboratories with field trials on multiple commercial networks, GCF Certification verifies the quality of the interoperability of mobile phones and other wireless devices with different network elements, vendors' infrastructure and services such as VoLTE, VoNR and Remote SIM provisioning for eSIM.

Each year, GCF certifies hundreds of different device models. This report is an analysis of GCF's certification listings which provides insight into current trends in the mobile device market, and some brief information on likely trends into 2024.

Executive SUMMARY

The Global Certification Forum (GCF) is the globally recognised quality mark for the interoperability of mobile phones and other devices that incorporate mobile connectivity. With over 350 members, GCF has helped shape the mobile communications industry since 1999 and is a 3GPP Market Representation Partner.

A record number of over 175 device manufacturers, across 26 countries, participated in GCF during 2023, as GCF moved to meet physically, with online access, following the COVID-19 pandemic. The GCF suite of certification solutions is recognised by network operators and service providers with interests in markets all around the world.

This February 2024 review of Mobile Device Trends is based on an analysis of device certifications published by GCF during 2023. The analysis provides insights into the mobile technologies and functionalities being requested by operators and end-users across markets worldwide.

In 2023, GCF certified a total of 503 devices, from 96 manufacturers – which is also a record number. The following outlines the key findings:

5G

- 191 devices (38%, up from 33% in 2022) of all 2023 certified devices included 5G. These 5G devices came from 57 vendors, up from 42 in 2022.
- Now in its 5th year, the integration of 5G into devices has continued to grow, but its speed of adoption has slowed. Compared with LTE, the speed of 5G adoption, considering all types of GCF certified devices, seems to be lower at the same stage.
- In the past, the number of devices supporting 5G standalone (SA) was relatively low – 34% of 5G devices in 2020. This grew to 65% in 2021 and 91% in 2022, and has continued its rapid growth, with 96% of 5G devices certified in 2023 supporting SA.
- Looking specifically at smartphones, in 2020, many smartphone models came in two variants (LTE and 5G), which were certified separately. However, in 2021, we started to see manufacturers just releasing variants, supporting both 5G and LTE, for their new smartphones, which contributed to the reduction in the number of total certifications from 2020 to 2022. This trend to a single variant has continued in 2023, as the lower cost of 5G SoCs meant it was cost-effective to include 5G functionality in all smartphone models, in many cases.

Device types

- Smartphone certifications dropped to 167 in 2023 (down from 260 in 2022), following an industry decline in total smartphone sales (down 3.5% YoY), and a consolidation of the smartphone portfolio (to 5.76 models per vendor, down from 12.3 in 2020).
- Module certifications dropped to 179 in 2023 (down from 238 in 2022). However, for the first time, modules surpassed smartphones as the category with the most certified devices.

LTE

- In 2023, as in 2022, LTE was the most used wireless communications standard in devices certified by GCF.
- LTE is a stable, mature technology, and in 2023, 90% of all devices (451) supported it.
- VoLTE operation (defined as IMS over LTE) was certified in 66% of LTE devices (296), which is a slight decrease from 2022 when 76% of devices supported it.
- An additional 36 devices incorporated the cellular IoT variant, LTE Cat. M1.

3G (UMTS/WCDMA)

- 3G certifications dropped slightly, with 71% of certified devices implementing the standard in 2023, compared to 78% in 2022. This decline reflects that operators in some markets are replacing 3G with LTE and 5G.
- There were no standalone 3G devices developed and certified by GCF in 2023 (as in 2022).
- The penetration of HSDPA (70%) and HSUPA (66%) was slightly down in 2023 compared to 2022.

GSM

- 56% of 2023 GCF certified devices incorporated GSM. This was down from 64% in 2022.
- Only six standalone GSM devices were certified in 2022, and all of them were feature phones.
- EDGE penetration also dropped to 49% of devices in 2023, down from 56% in 2022, 60% in 2021 and 56% in 2020.

Cellular IoT

- 2023 saw a decrease in the total number of devices incorporating a cellular LPWA (low-power wide area) IoT standard.
- As in 2022 and 2021, two standards dominated these certifications, NB-IoT and LTE Cat. M1 (FDD). These were each incorporated in 39 and 36 devices respectively.
- EC-GSM was not included in any certification in 2023.

Remote SIM Provisioning (RSP) for eSIM

- This was the 5th full year that the certification of Remote SIM Provisioning (RSP) for consumer devices has been possible as part of a device certification or as a standalone certification.
- In total 163 devices were certified that supported RSP for consumer devices. This compares with 133 devices that were certified in 2022 and 83 in 2021.

Complexity/multi-mode devices

- 88% of all devices certified in 2023 incorporated more than one radio bearer technology, down slightly from 91% in 2022.
- 66% of devices incorporated three or more technologies, down slightly from 73% in 2022 reflecting the sunset of 2G and 3G.
- This reflects the continued need to support end-users served by operators whose network infrastructures include more than one generation of mobile technology, or where new generations are deployed at a lower rhythm.
- The number of 5G and LTE frequency bands supported on average by devices declined to 20, from 28 in 2022, but up from just 10 in 2020.
- Legacy technologies, 3G and GSM, continue to decline in certification numbers, as operators sunset these services, and re-farm the frequency bands. GSM is proving more resilient than 3G, as it is retained as a backup technology for voice, emergency and M2M services. This aligns with the trend of more operators launching 5G services and more frequency bands (new or re-farmed from previous generations) being used for these services.

The Global Certification Forum (GCF) is the globally-recognised quality mark for the interoperability of mobile phones and other devices that incorporate mobile connectivity.

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1. General device trends

1.1. Year on year growth in manufacturers

2023 saw a **record number of device manufacturers (96)** undergoing certification of at least one device with GCF. This is up 14% versus 2022. The number of smartphone manufacturers remains stable at 29, which is approximately the level it has been for the last four years.

The number of devices certified (503) was 22% lower than in 2022, where 649 devices were certified. This compares with the record number of devices (715) in 2020.

This reduction in device numbers was mainly driven by a decline in the number of smartphones certified. There were 167 smartphones in 2023, down from 260 since 2022 (a drop of 35%).

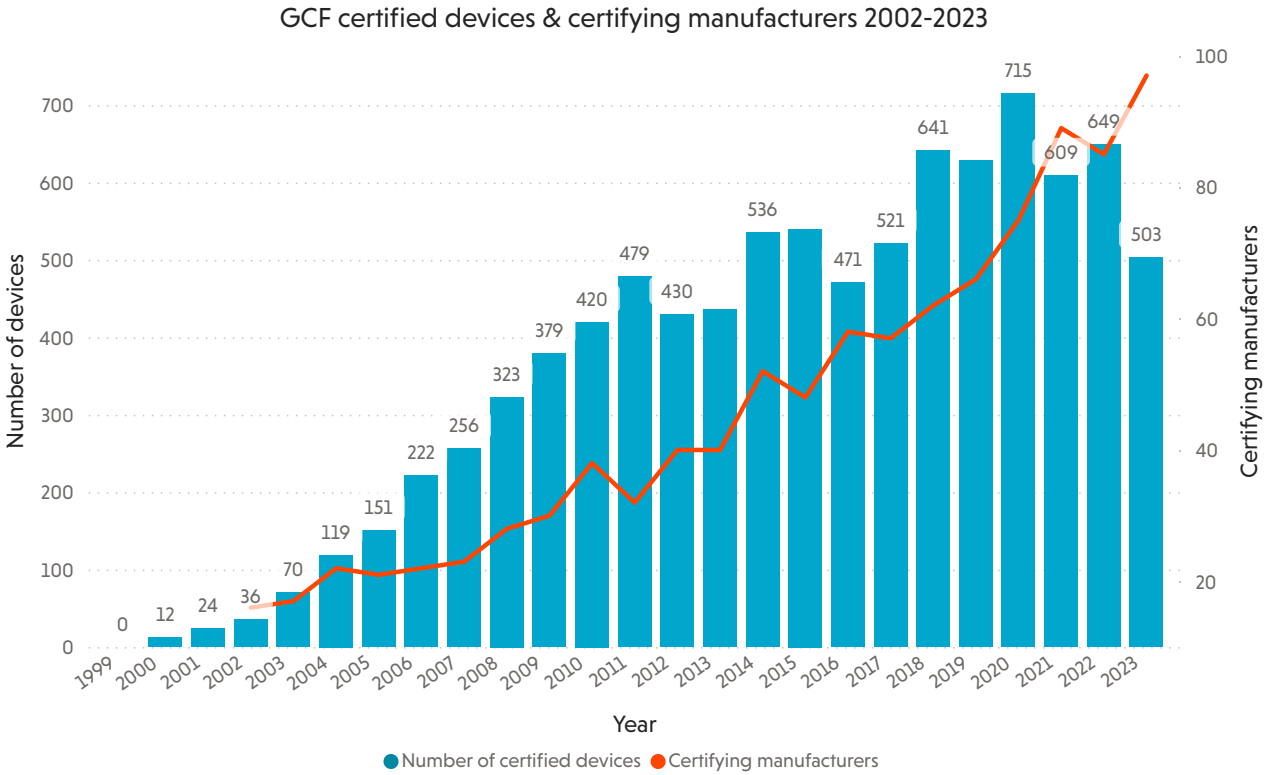


Fig 1: GCF certified devices & certifying manufacturers 2002 – 2023

With this number, we can see a clear trend of portfolio consolidation, with fewer devices being certified per manufacturer, going down from a range of between 8.1 and 11.3 devices per manufacturer in the years between 2012 and 2020, to just 5.2 in 2023.

For the numbers of smartphones, the decline is sharper – from 12.3 in 2020 to 5.8 in 2023.

GCF works with device manufacturers of all sizes, and five manufacturers certified 31 devices or more. Conversely, 67 manufacturers certified three devices or fewer. And of the 96 manufacturers certifying devices in 2023, 22 were from the 30 new members.

Comparing annual certifications against global device sales suggests there is a relationship between the choice of devices in the global market and overall market size. We have also tracked certifications against sales for the dominant class of device, smartphones, which shows a similar relationship (see Figure 2). All the world's top-10 smartphone manufacturers are members of GCF and adhere to its principles.

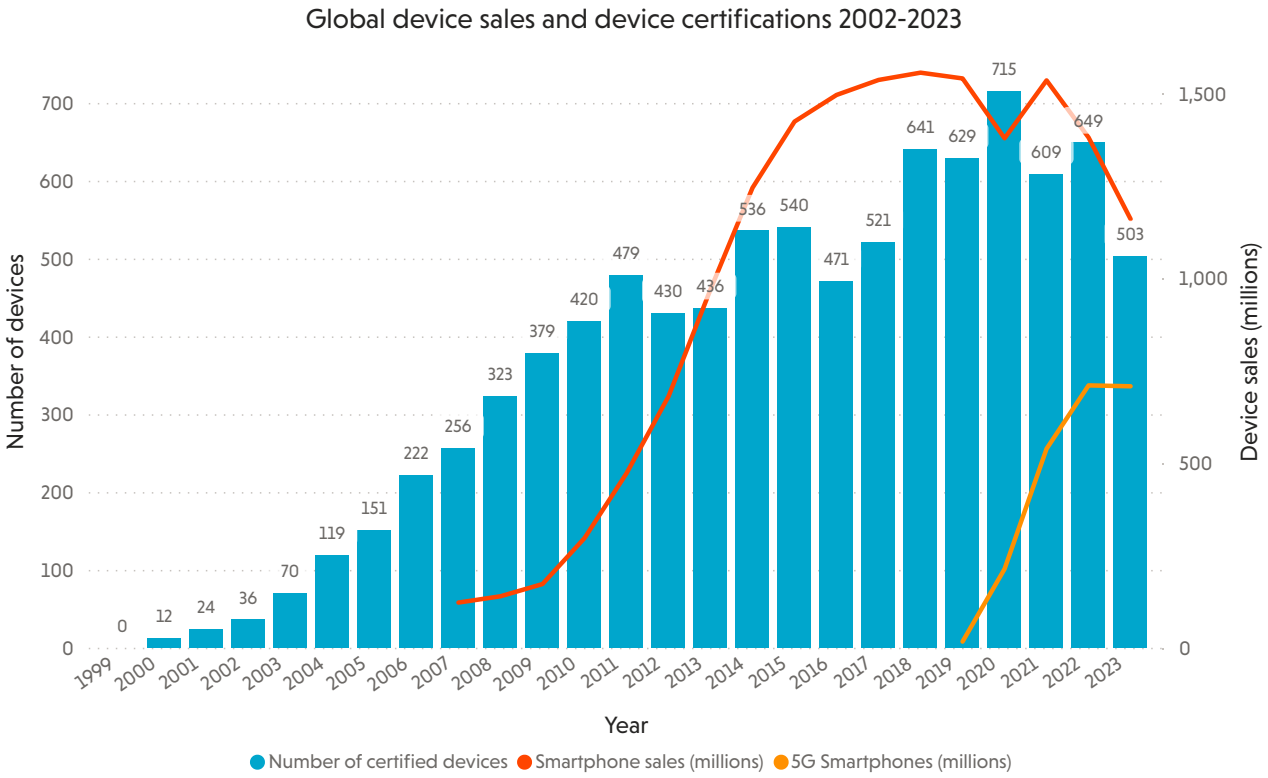


Fig 2: Global device sales and device certifications 1999 – 2023

Sources: "Gartner Worldwide Manufacturer Sales to End Users of Mobile Terminal Devices / Gartner Global smartphone sales to end users 2007-2021", and https://www.counterpointresearch.com/insights/2023-global-smartphone-shipments-to-hit-lowest-level-in-almost-a-decade/, collated by GCF.

1.2. Certified devices by type

This year, for the first time, smartphones were overtaken by modules as the largest class of devices certified. In 2023 they make up just 33% of the devices certified, down four percentage points in 2022, which in itself was a decline from 2021.

This decrease is likely due to changes in approach from manufacturers, as they consolidate their portfolios with fewer different product models released. There was also a decline in the total smartphone market of 3.5%.

The proportion of modules certified stayed approximately the same in 2023, at 35.6%. There were fewer IoT-specific modules within this number, making up only about one in seven of the total number of modules.

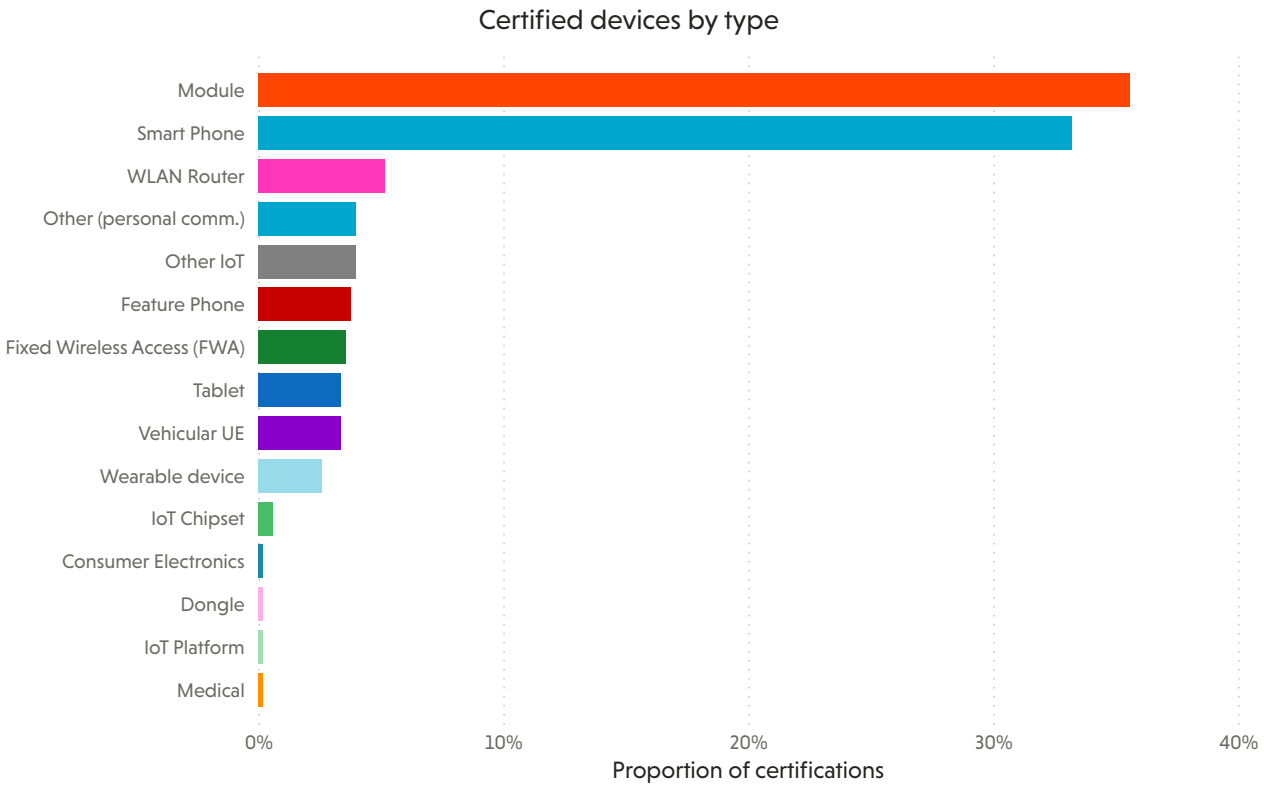


Fig 3: 2023 certified devices by type

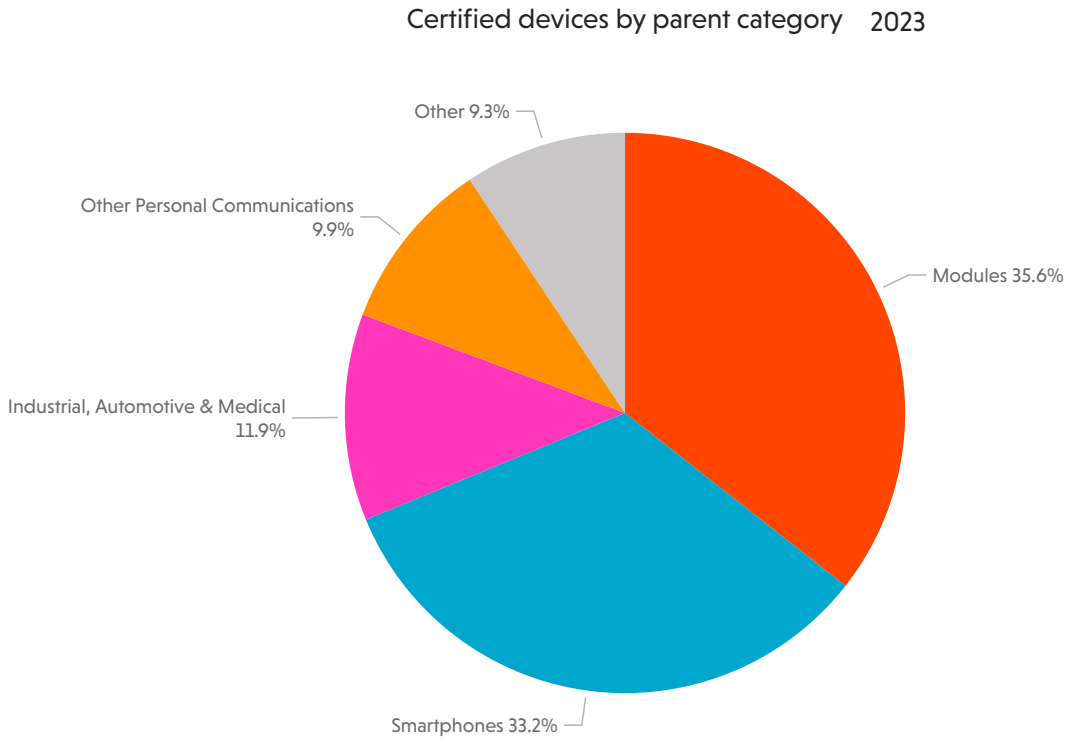


Fig 4: 2023 certified devices by parent category

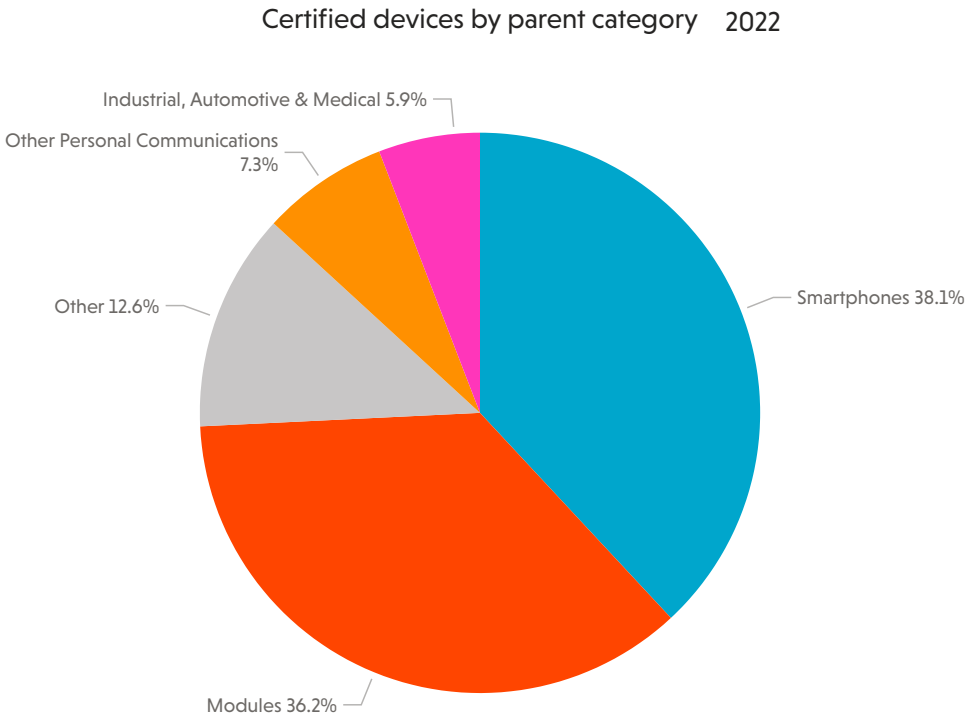


Fig 5: 2022 certified devices by parent category

The number of smartphones certified decreased to 167 in 2023, down from 260 in 2022 (and 340 in 2020). As previously mentioned, this is at least partly due to the continued trend of more devices being 5G-only version, rather than having separate LTE and 5G versions that would be counted twice. In addition, model variants support, on average, a higher number of frequency bands, and are therefore suitable for more markets.

Around 14% of certifications were feature phones, tablets, laptops, mobile gateways/portable hotspots, USB modems and other non-smartphone communication devices, up slightly from 13% in 2022.

This includes:

- Tablets with cellular connectivity, where the proportion of certifications rose slightly from 3.1% in 2022 to 3.4% in 2023 (although the actual number of devices certified fell from 20 to 17).
- Feature phones, where the proportion of certifications rose slightly from 3.2% in 2022 to 3.8% in 2023 (although the actual number of devices certified fell from 21 to 19).

The number of devices that were not smartphones declined from 386 devices in 2022 to 336 devices in 2023 (a drop of around 12%). However, the number for 2023 is not much different from 2021, when 347 non-smartphone devices were certified. Some categories grow significantly in 2023, such as fixed wireless access (FWA) and WLAN routers, where 19 manufacturers certified a record number of 32 devices.

1.3. Certified devices by mobile technology used

As in 2022, LTE has again retained its crown as the most commonly integrated standard – see section 3. While 3G and GSM are still supported by many certified devices, they are usually present in addition to other technologies, and there are very few devices where 3G or GSM are the highest level of RAN supported (none for 3G, and six for GSM), typically targeting low-cost devices with limited capabilities – in 2023, these six devices were all feature phones from a single manufacturer.

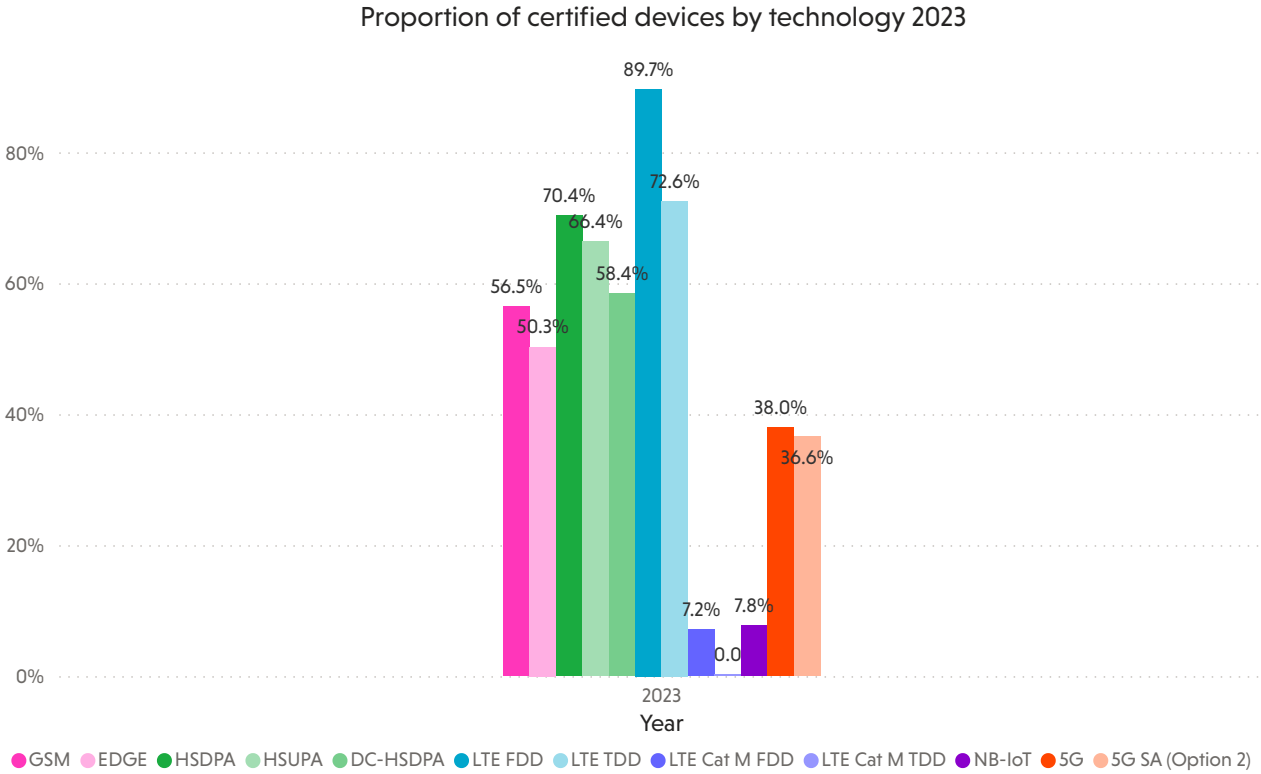


Fig 6: Proportion of 2023 certified devices incorporating each mobile technology

2. 5G

2.1. The rate of 5G incorporation

5G incorporation has continued to increase, with the standard included in 38% of devices certified, versus 33% in 2022, 31% in 2021, 21% in 2020, and just 2.5% in 2019.

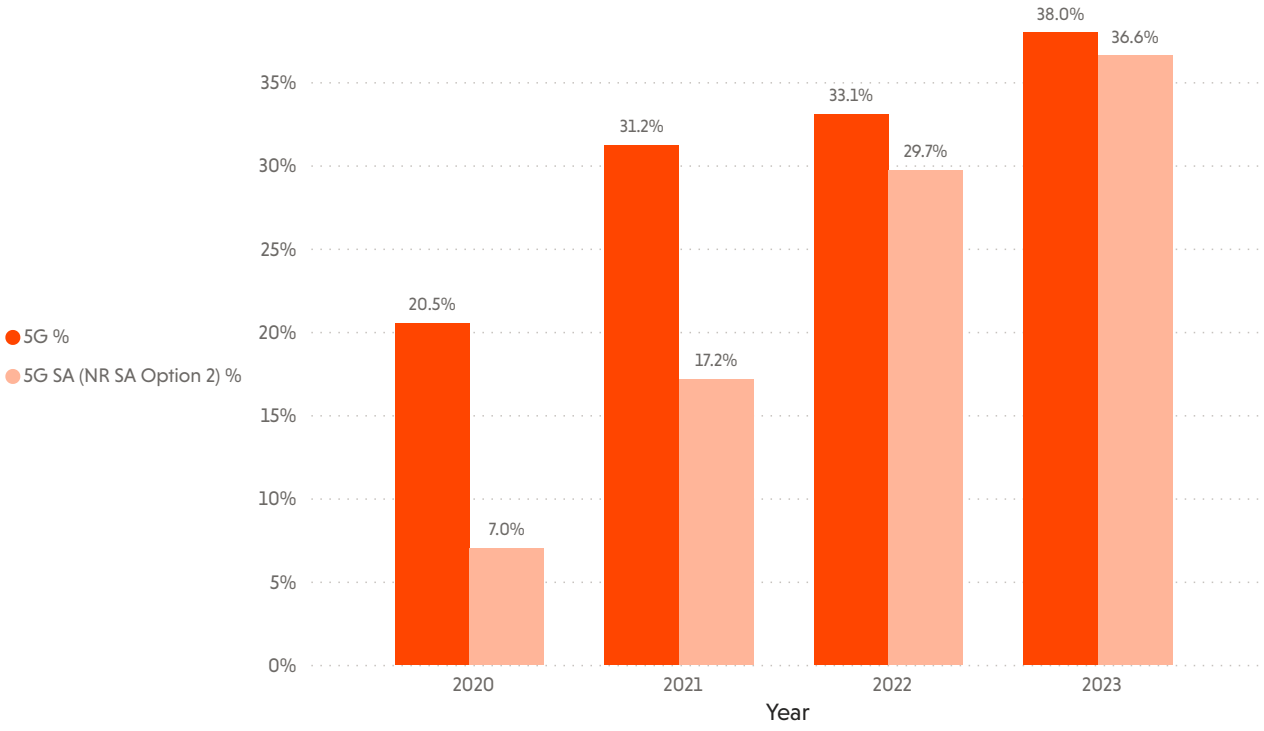


Fig 7: Evolution of 5G adoption, 2020-23

In the early stages of 5G deployment, there was a high proportion of devices just supporting NSA (Non-Standalone), while more recently there has been a shift with many more devices supporting 5G Standalone (SA) – now comprising 96% (184) of 5G devices certified, up from 91% in 2022. This reflects the planned rollout of more 5G SA networks by mobile operators, with further launches and service improvements in 2023.

There were seven 5G devices certified in 2023 which enabled access to FR2 5G frequencies, also referred to as mmWave.

GCF offers certification for standalone 5G (Option 2) as well as dual connectivity between 5G and LTE (Options 3 and 4) and the many inter-band configurations related to these.

In 2023, GCF certified 102 devices that support IMS over 5G NR (VxNR). Of these devices 65 were smartphones.

2.2. How 5G compares with LTE

This is the 5th year in which 5G services have been available to the public. In comparison, LTE was launched at the end of 2009, with the first LTE device certifications completed by GCF in Q1 2011, and the technology becoming a dominant standard in 2017.

GCF announced its first 5G certification in Q2 2019, with 16 devices certified through the year (2.5% of all certifications). In 2020, we saw a big jump to 20.8% of certified devices supporting 5G, thus outpacing the rise of LTE.

While the adoption of 5G is still fast, it is lagging LTE's progress if we consider the total number of certified devices. While most smartphones support 5G nowadays, the demand is not that high for wireless modules, with many use cases not requiring high bandwidths and being delivered over LTE or LPWA cellular standards.

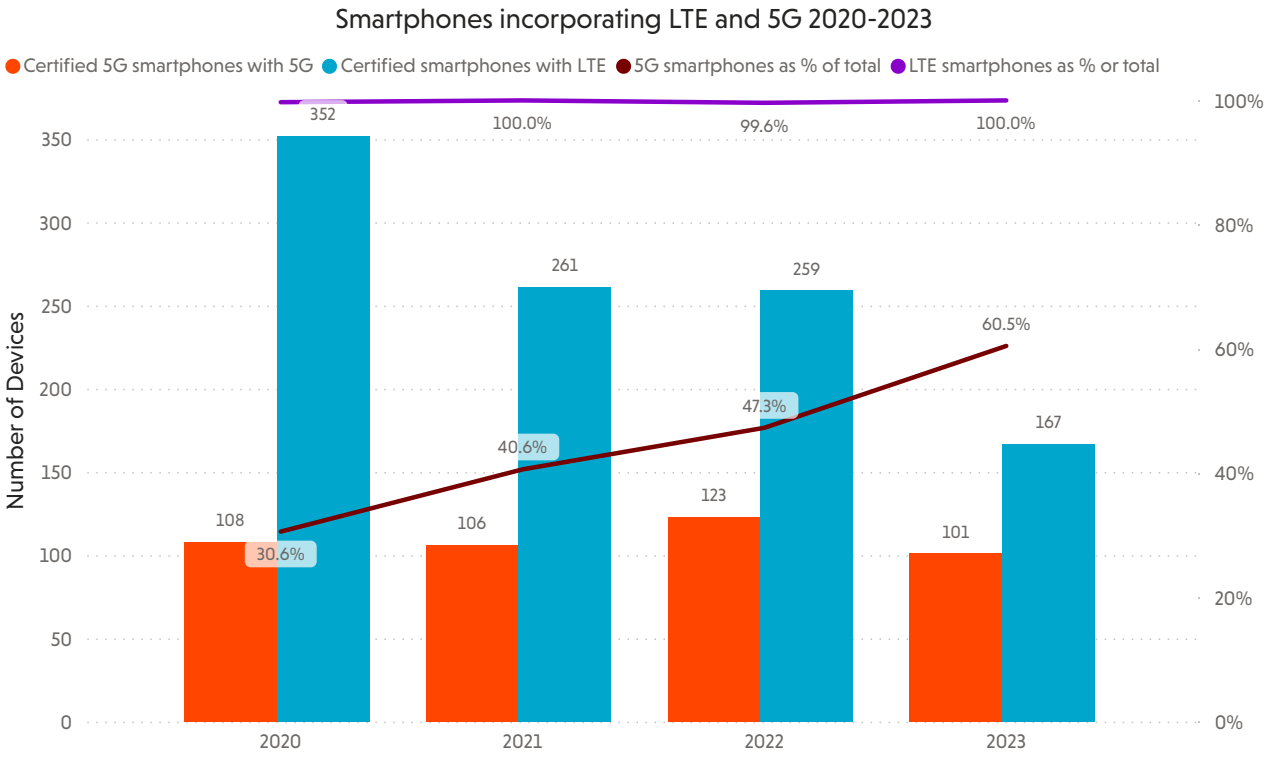


Fig 8: How 5G adoption compares to LTE

2.3. Number of 5G device manufacturers

In 2023, 57 device manufacturers certified 5G devices with GCF, and 35 submitted at least two. Twelve manufacturers certified five or more.

This is a substantial increase compared to 2022, when 42 device manufacturers developed and certified 5G devices with GCF, and over two thirds of these companies (30) submitted at least two. In 2022, eighteen manufacturers certified five or more.

2.4. 5G devices by type

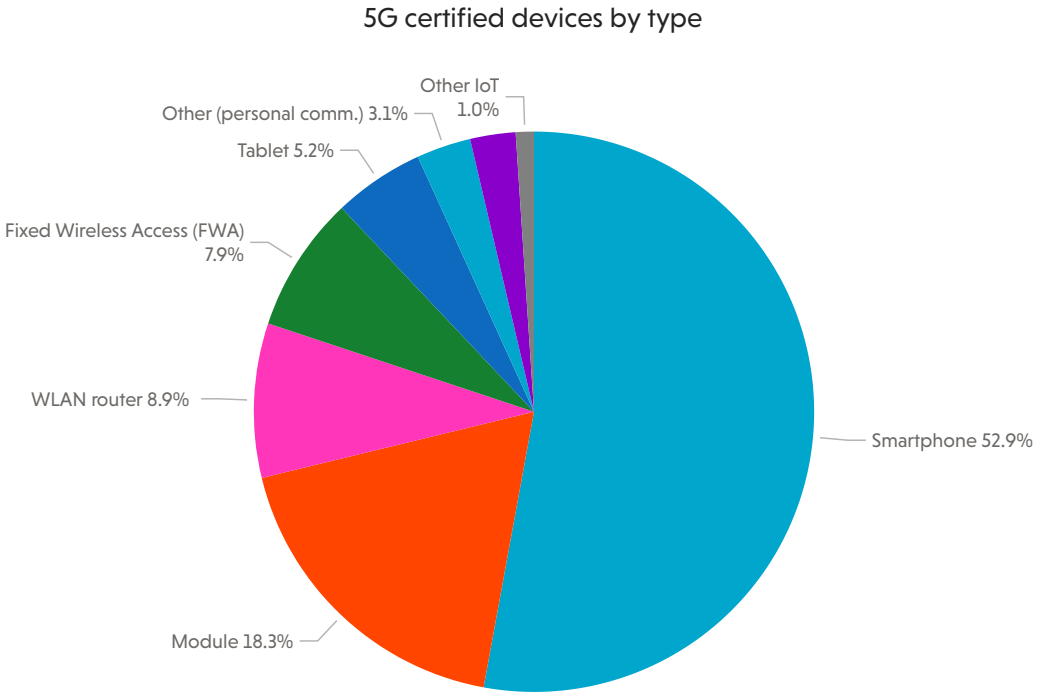


Fig 9: 5G certified devices by type 2023

In 2023, the largest number of 5G certifications was for smartphones (101 of 191 certified 5G devices, 53%), while modules (35 devices, 18%) represented the second largest group.

This is a continuation of a trend over the last few years, where smartphones have accounted for the majority of 5G certifications, but there is an increasing number of modules, WLAN routers, and other devices with 5G capabilities. For example, in 2020, most (84%) of 5G certifications were for smartphones, and modules accounted for just 13%.

2.5. 5G NR bands

Incorporating multiple bands expands the potential market for a given device. With certification actively underway for 18 of the NR standalone bands defined by 3GPP, and another 14 5G bands used in 5G NSA combinations, GCF is being used to certify devices destined for use in all the leading mobile markets worldwide.

The GCF programme enables the certification of devices designed to operate in both FR1 and FR2 (also referred to as low and high bands), for both 5G SA and 5G NSA usage.

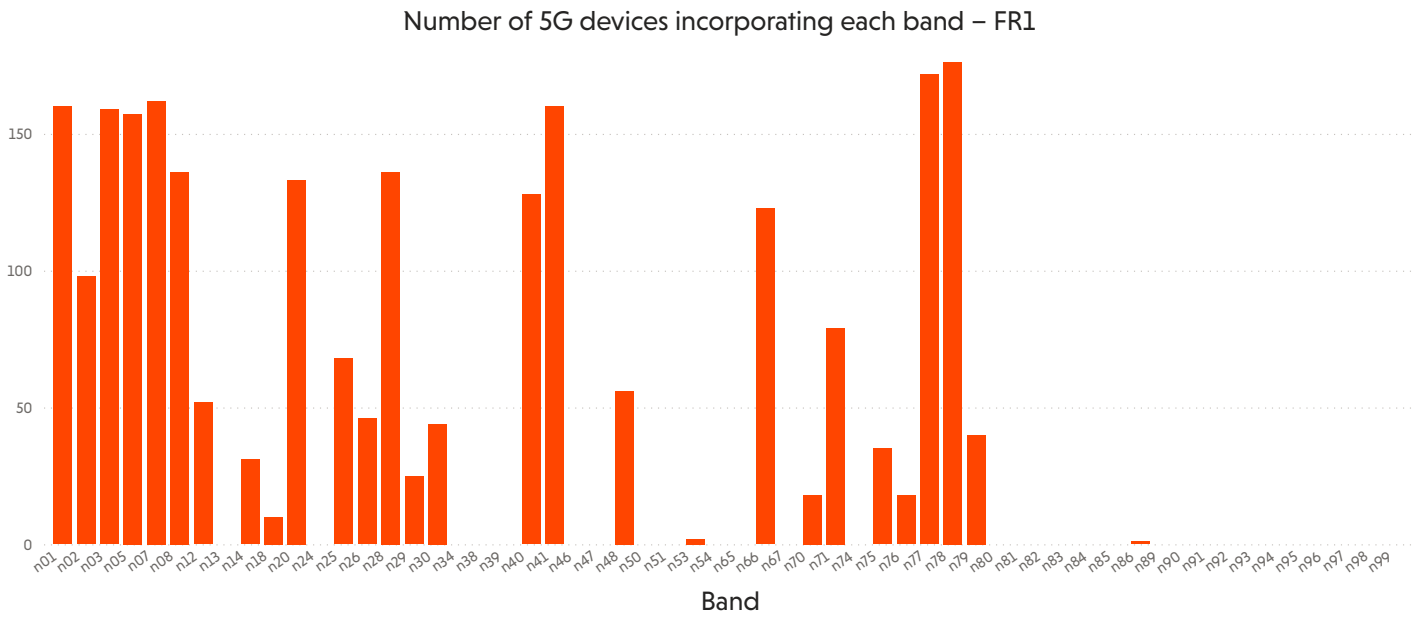


Fig 10: Number of 5G devices incorporating each band (FR1)

FR1 bands of particular note include:

- n78 (3500 MHz), which was in 154 certified devices (81% of 5G devices), was the most commonly incorporated band.
- n77 (3700 MHz) was the second most commonly incorporated band in certified devices, featuring in 148 certified devices (77% of 5G devices).
- n1 (2100 MHz) was the next most commonly incorporated band in certified devices, featuring in 145 certified devices (76% of 5G devices).
- There is strong support for bands n1, n3, n5, n7, n41, n77, and n78, which are supported in almost every 5G device.

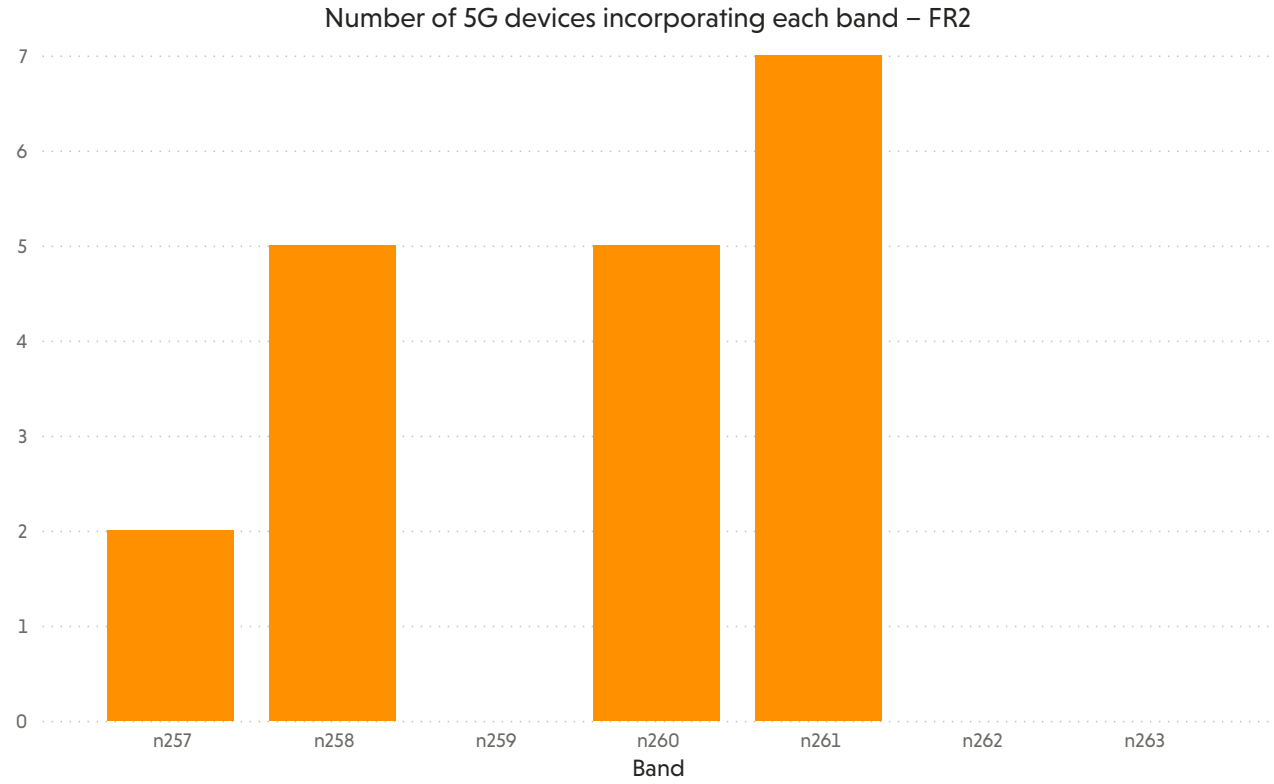


Fig 11: Number of 5G devices incorporating each band (FR2)

In the FR2 spectrum, band n261 (28 GHz) and band n260 (39 GHz) were both incorporated in five of the seven FR2 devices. The number of networks supporting FR2 (mmWave) is not growing significantly, which is leading to a slow adoption of FR2-capable devices, with only four manufacturers certifying FR2 devices in 2023.

In 2023, band n86 was supported for the first time, and band n28 was certified for the first time. Since 2022, GCF has started tracking of 5G NR bands supported (not included in the certification) and certified. In 2023:

- 28 FR1 bands were supported in the certifications, with an additional 4 FR1 bands supported by devices but not included in the certifications.
- 4 FR2 bands were supported and certified.

2.6. 5G device complexity

All of the 191 certified 5G devices supported E-UTRA-NR Dual Connectivity (Non-Standalone EN-DC) with 184 devices supporting 5G Standalone (5G SA). Certification of 5G Non-Standalone connectivity option 4 (NE-DC) was introduced in 2022 but no devices were certified.

Looking at 5G SA devices that were certified, we can see that the mean number of 5G bands per 5G SA device was 14.2, up from 13.0 in 2022, with 139 devices supporting 12 or more 5G bands, up from 113 devices in 2022.

Seven devices were able to use the FR2 frequency bands.

The average complexity of FR2 capable devices increased slightly, with these seven devices allowing the use of 11.6 5G bands on average, down from 11.2 in 2022 and 12.7 in 2021.

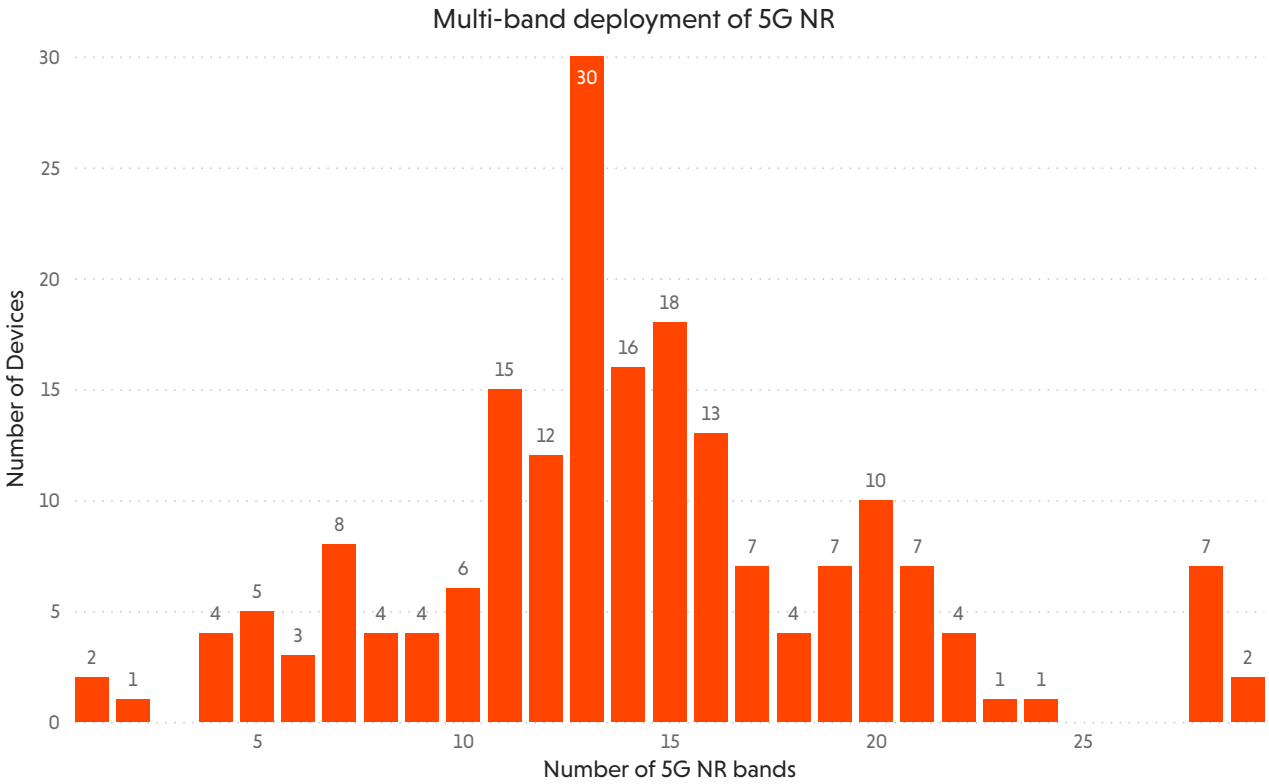


Fig 12: Multi-band deployments of 5G NR (5G SA device)

3. LTE

3.1. LTE appears to have plateaued

The penetration of LTE in certified devices has continued to plateau in 2023, with the standard being integrated into nearly 90% of all certified devices (almost since 2019), and LTE retaining its position as the most integrated wireless communication standard.

While it is holding steady for now, it will be interesting to see when or if this share falls as 5G continues its growth, or if it stays almost ubiquitous to facilitate coverage and roaming worldwide.

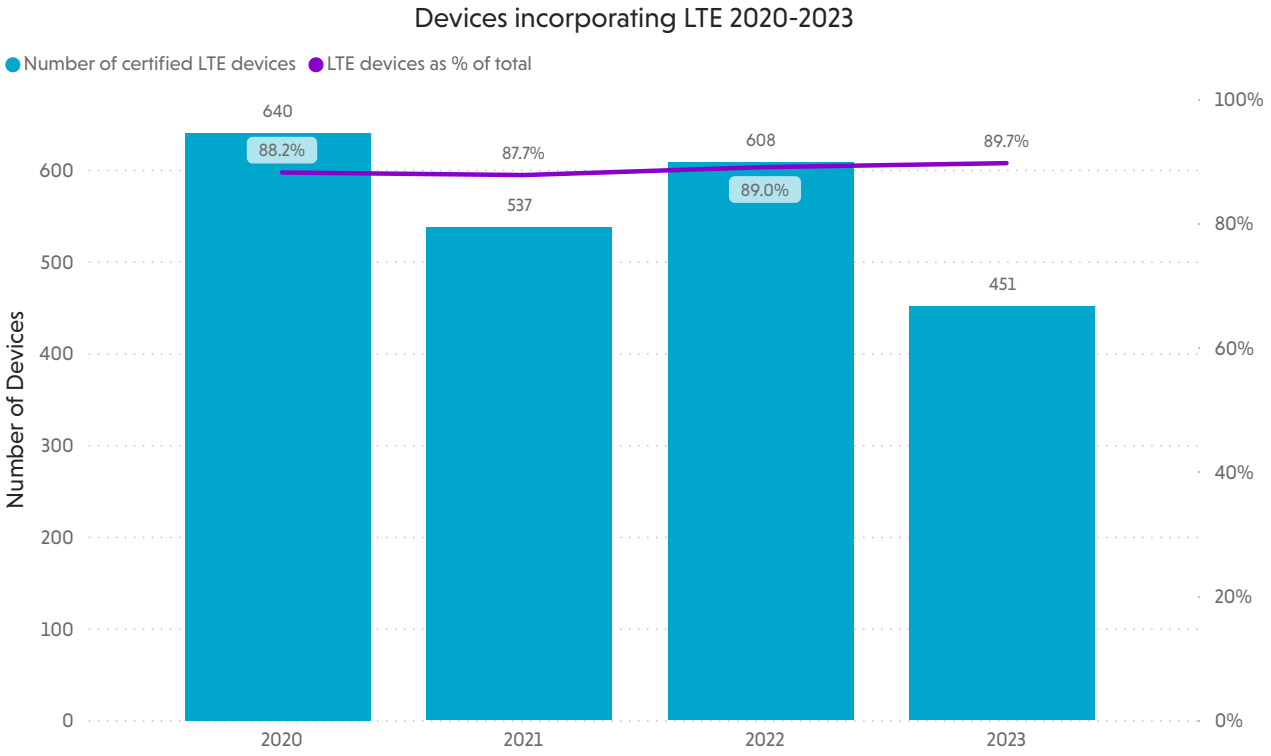


Fig 13: Devices incorporating LTE 2020-2023

In 2023, 451 certified devices supported LTE. An additional 34 devices incorporated LTE Cat. M1 as a cellular IoT variant.

As in 2021 and 2022, FDD-LTE was supported in all these devices. TDD-LTE was incorporated into 72% of them (365 devices), down from 81% in 2022, 78% in 2021, 70% in 2020 and 66% in 2019. And while all TDD-LTE capable devices also incorporated FDD-LTE, the proportion of LTE devices supporting simultaneous FDD/TDD operation is 56% (284 devices). This is down from 62% in 2022 and is similar to 55% in 2021.

There was also a slight decrease in certifications supporting Gigabit LTE, with 89 devices certified with Category 16 or higher. This is down from 111 devices in 2022, but up as a percentage of all certified devices from 16% to 18%. This percentage has stayed approximately the same since 2020, but is up substantially since 2017, when only six Gigabit LTE devices were certified at GCF.

VoLTE operation was certified in 66% of LTE devices (296), which is a slight decrease from 2022 when 76% of devices supported it. But its support in smartphones continues growing, showing a significant number of devices, such as modules, supporting LTE just for data communications.

3.2. LTE bands used

The GCF scheme enables the certification of devices designed to operate in 25 FDD-LTE and sub bands (from Band 1 to Band 32 inclusive, and Band 66) and nine TDD-LTE bands (from Band 34 to Band 48 inclusive).

During 2023, all bands covered by the GCF scheme had devices certified. Bands of note include:

- Band 7 (2600 MHz) was the most certified LTE band, the same as in 2022. It was incorporated in 401 devices (89% of LTE devices and 80% of all devices).
- Band 5 (850 MHz) was the second most certified LTE band, up from 2022. It was incorporated in 389 devices (86% of LTE devices and 77% of all devices).
- Band 3 (1800 MHz) dropped down to become the third most certified LTE band. It features in 373 LTE devices (83% of LTE devices and 74% of all devices).
- Band 1 (2100 MHz) dropped from third to fourth most incorporated band. It featured in 371 devices (82% of LTE devices and 74% of all devices).
- Band 28, the APT 700 MHz band, which has been allocated in major markets in Latin America and Asia Pacific for usage in LTE, was certified in 337 devices (75% of LTE devices and 67% of all devices), an increase on 2022 (which saw 70% of LTE devices able to utilise the band).

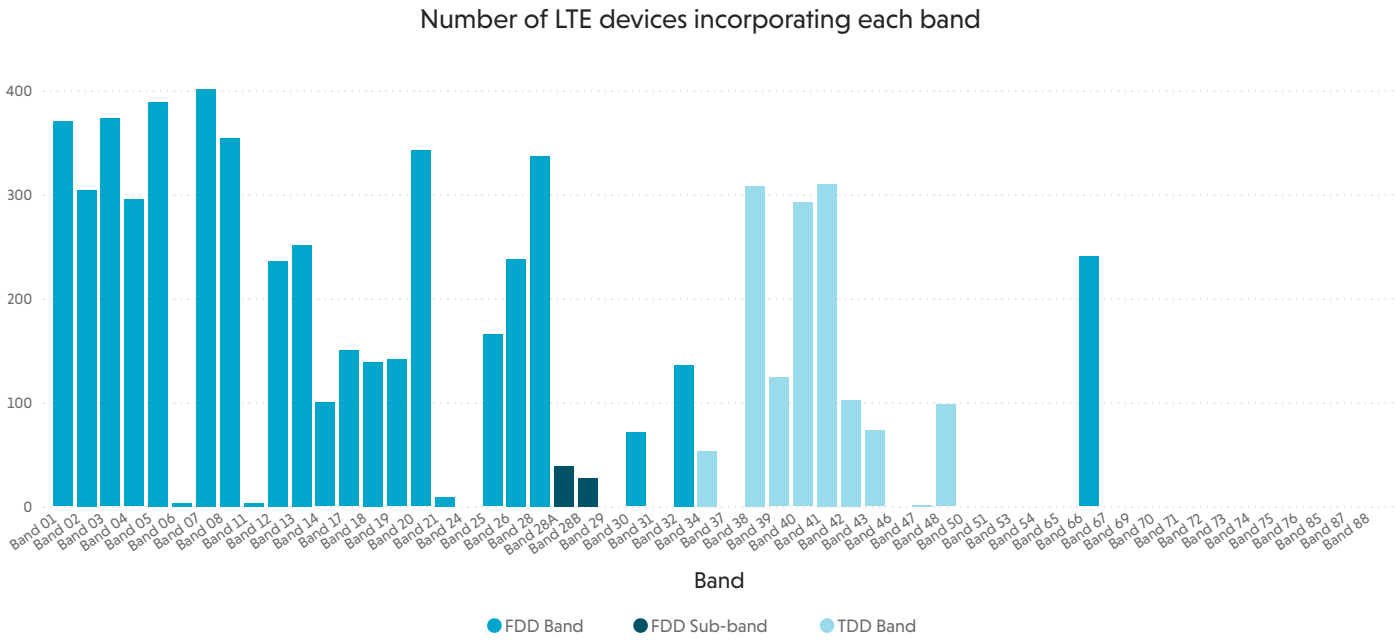


Fig 14: Number of LTE devices incorporating each band

3.3. LTE device complexity

In general, the number of supported bands in LTE devices continued to increase during 2023.

Of the 451 devices incorporating LTE, 450 (99% of LTE devices – the same percentage as since 2020) incorporated three or more LTE bands, while 98% incorporated five or more bands (also stable since 2020), and (slightly over) half of LTE devices incorporated 13 or more bands.

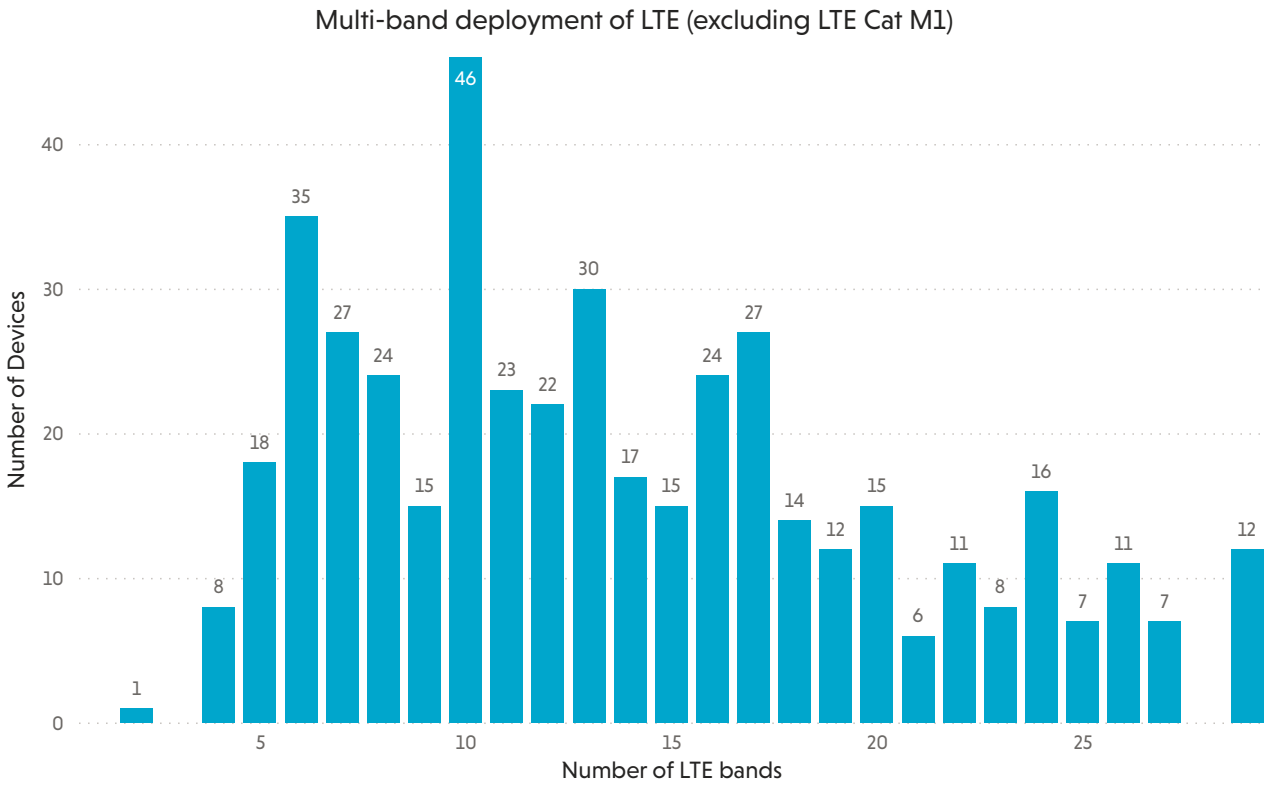


Fig 15: Multi-band deployment of LTE (excluding LTE Cat. M1)

The modal number of LTE (excluding LTE Cat. M1) bands is ten (like 2022 and 2021), and a slightly bimodal distribution is occurring, with 72 devices deploying 22 or more bands (down from 89 in 2022). 323 (72% of LTE devices) incorporated 10 or more LTE bands, up from 48% in 2022 and 69% in 2021. 185 (41% of LTE devices) supported 15 or more LTE bands; up from 23% in 2022.

In 2023, the average (mean) LTE device incorporated 13.8 LTE bands, up slightly from 13.3 in 2022.

With such a wide diversity of bands, the number of potential inter-band and intra-band Carrier Aggregation (CA) combinations is enormous. GCF has developed a flexible certification framework which enables manufacturers to demonstrate their devices will work effectively in CA band combinations deployed by network operators. The number of devices deploying Carrier Aggregation stayed around the same in the past year with 268 devices certified (59% of LTE device certifications, a percentage similar to the previous year).

4. 3G and GSM

4.1. Support of 3G

Manufacturers are still embracing 3G, despite operators prioritising LTE and 5G for data delivery. Certifications for 3G (UMTS/WCDMA) stood at 71% (368 devices) in 2023, down from 78% in 2022.

3G is usually included as a fallback technology for LTE devices, with no standalone 3G devices being certified during 2023 (down from one device in 2022).

Certification of HSDPA and HSUPA were down slightly versus 2022, with 70% (354 devices) and 66% (334 devices) incorporating each respectively. This represents 96% and 91% of 3G devices. The penetration of dual-cell HSDPA dropped in 2023, at 58% of all devices, compared to 68% in 2022.

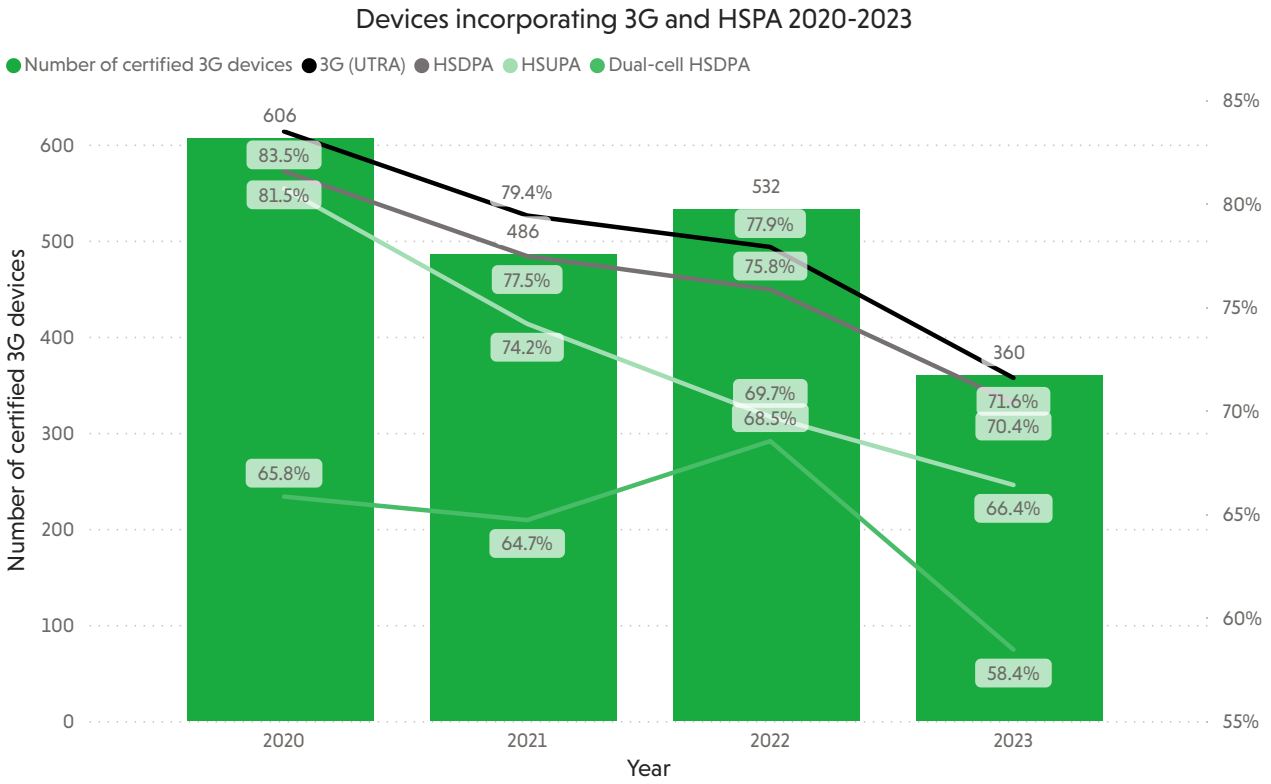


Fig 16: Devices incorporating 3G and HSPA 2020-2023

4.2. GSM decline continues

The penetration of GSM declined steadily from 2008 and 2009 (when 100% of devices included the standard) to 2021 (when just 64% of devices did). 2022 saw the decline stabilise, again with 64% of devices including GSM, but in 2023 the number decreased again to 56% (341 devices). There were only six GSM standalone devices certified.

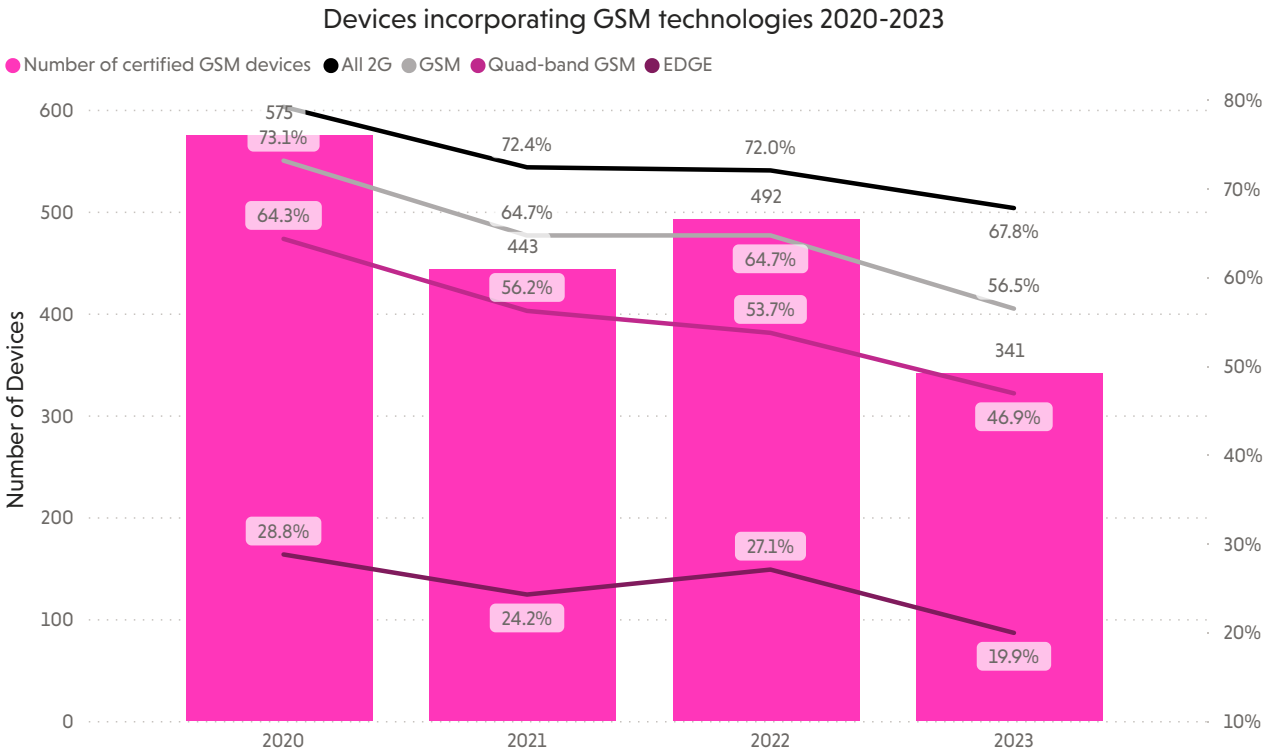


Fig 17: Devices incorporating GSM technologies 2020-2023

4.3. EDGE and quad-band GSM

EDGE was certified in 246 devices (49% of all devices, down from 56% in 2022, 60% in 2021, and 67% in 2020).

Certifications for quad-band GSM devices decreased slightly, with 236 certifications (47% of all devices, versus 53% in 2022, 54% in 2021, 62% in 2020 and 65% in 2019).

5. Cellular IoT

5.1. The adoption of cellular IoT standards pauses

Cellular IoT technologies have been widely adopted globally, and those devices based on 2G, 3G and 4G technologies are set to be enhanced further with the growth of 5G networks and the introduction of 5G RedCap (reduced capability) in 3GPP Release 17: improving not just in terms of speed, but also in latency and reliability.

This is the 7th year that GCF has certified the cellular LPWA IoT standards: LTE Cat. M1 (LTE-M) (both FDD and TDD), NB-IoT and EC-GSM. In this time the number of devices has increased significantly, with NB-IoT certifications increasing more than 10-fold, and LTE-M (FDD) increasing more than 20-fold.

However, both of these figures decreased in 2023:

- NB-IoT was featured in 39 devices certified this year (down from 53 in 2022, and 65 in 2021)
- LTE-M (FDD) featured in 36 devices (down from 57 in 2022, and 65 in 2021)

But, these two standards dominate. LTE-M (TDD) was only included in one device certified in 2023 (there were just two in 2022); and EC-GSM was not in any devices certified in 2023 (there were also two in 2022).

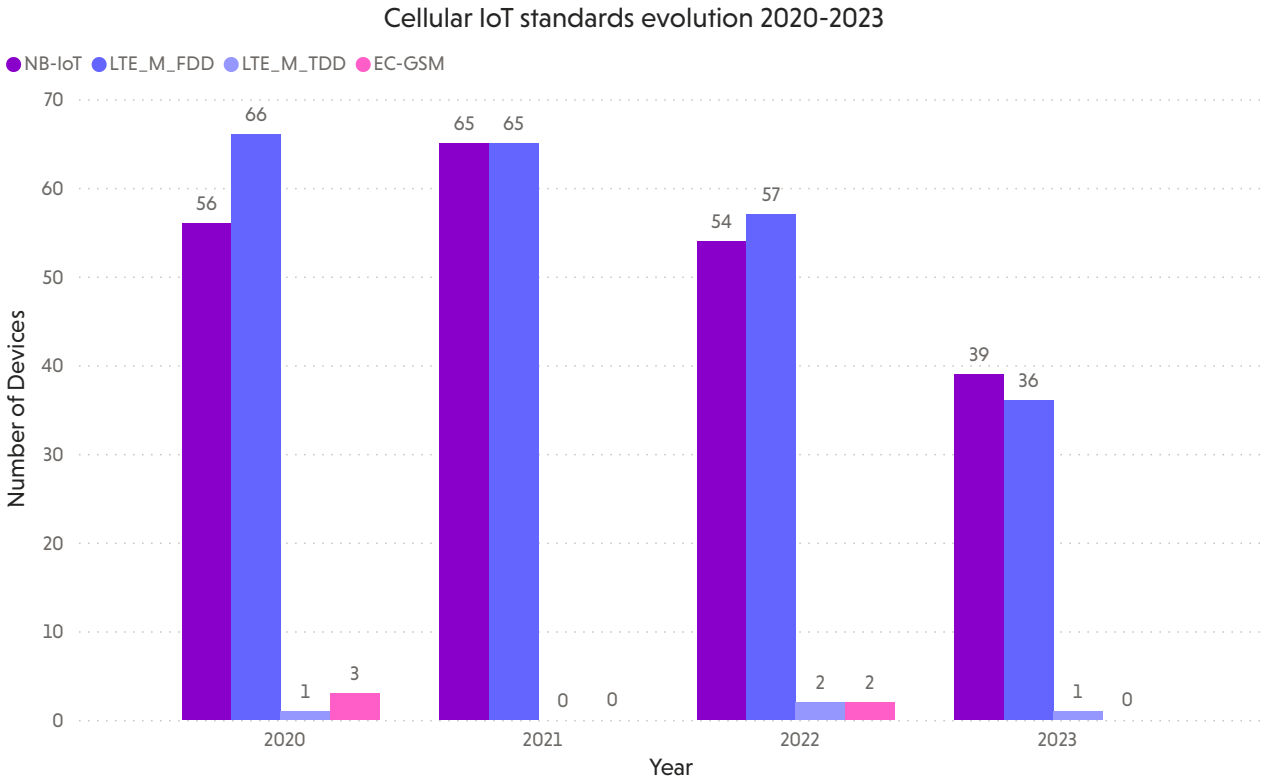


Fig 18: Cellular IoT standards evolution 2020-2023

Figure 19 breaks down the LTE-M devices in more detail, showing how many devices were certified that incorporate each band.

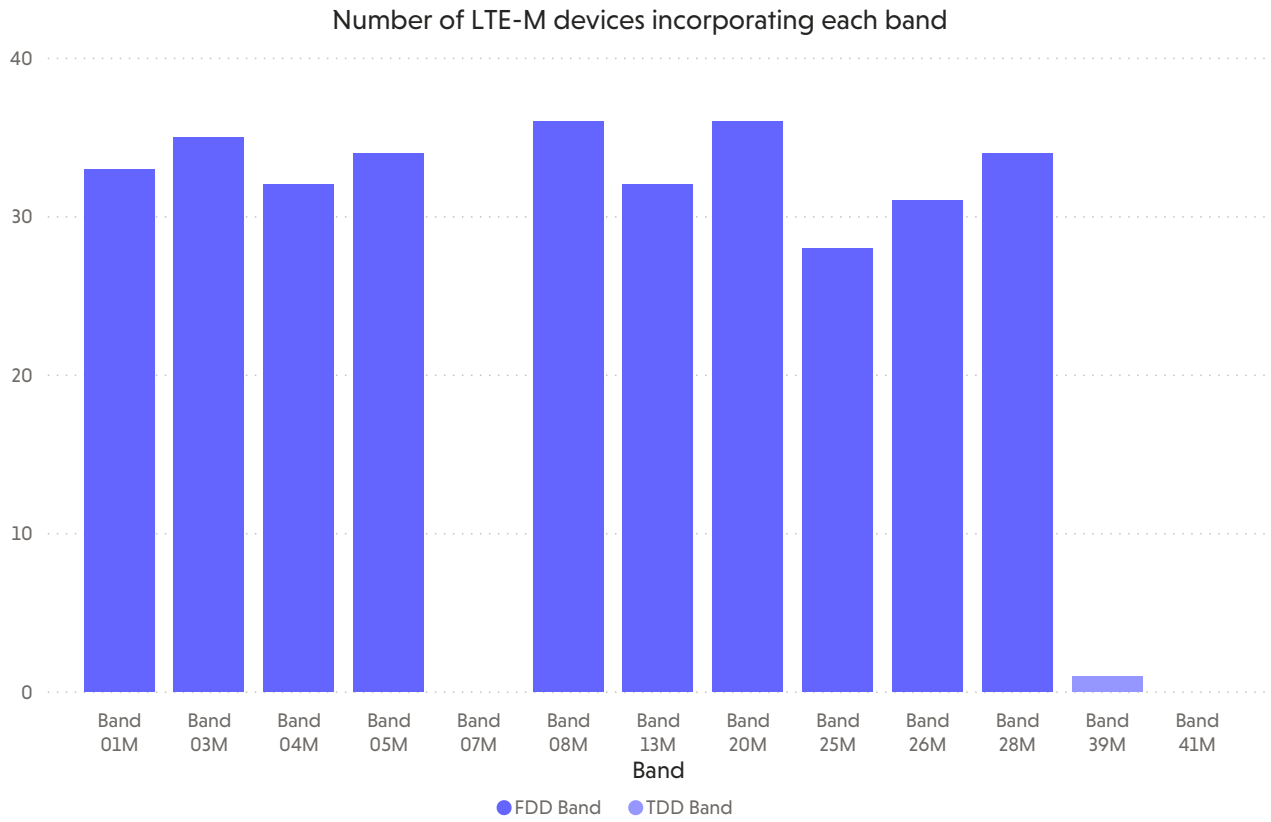


Fig 19: Number of LTE-M devices incorporating each band

6. Device complexity

6.1. A further rise in overall complexity

Devices on average have continued to increase in complexity for several years.

2023 continued this trend overall, and the proportion of certifications for devices supporting four or more bearer technologies rose to 27%, from 23% in 2022 (and 20% in 2021).

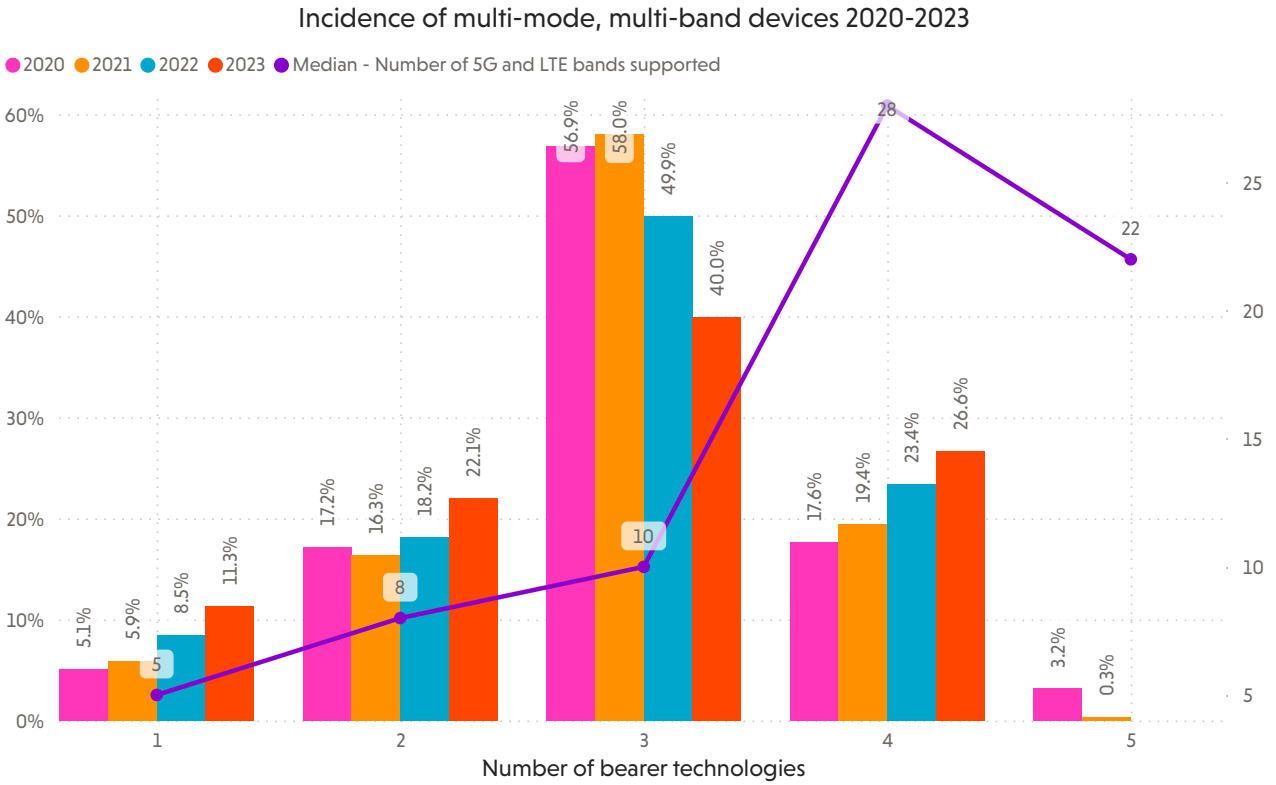


Fig 20: Incidence of multi-mode, multi-band devices 2020-2023

Bearer technologies have been classified as 2G (GSM/EDGE), 3G (WCDMA/UTRA/HSDPA/HSUPA), 4G (LTE FDD/LTE TDD), 5G, NB-IoT, LTE M1 (TDD/FDD) and EC-GSM

6.2. Single mode devices

The proportion of single mode devices (just one radio bearer supported) rose slightly in 2023, up to 46 (9%) compared to 8% of devices in 2022. These single mode devices are predominantly Cellular IoT, GSM (6 devices), and LTE systems (38 devices).

There were no standalone 3G devices in 2023 (devices that only support 3G and no other modes), down from two in 2022.

6.3. Multi-mode devices

The complexity of devices, in terms of the number of radio bearer technologies, is once again rising.

As in 2021, 2020, 2019 and 2018, the modal number of radio bearer technologies per device was three, however the proportion of systems employing four or more bearer technologies has more than tripled

in the last few years, from 8.5% in 2019 to 27% in 2023. In 2023, 66% of devices incorporated three or more technologies, down slightly from 73% in 2022, and quite likely related with the sunset of 3G and 2G technologies, that are now on a declining phase.

The number of implemented bands used in the average device is growing. Certified 5G and LTE devices in 2023 supported a median of 22 frequency bands, compared to 28 in 2022, but up from just 10 in 2020. Within this average, we can also see that the complexity of smartphones continues to grow, while modules are becoming more tailored to specific applications, and not experiencing a similar increase in complexity.

7. Smartphones

7.1. Smartphone growth

Smartphones have consistently represented the largest category of devices certified by GCF. In 2023, for the first time, smartphones were overtaken by modules as the largest category.

In 2023, smartphones represented 33% of all certifications, down from 37% in 2022, and 42.5% in 2021.

A total of 167 smartphones were certified in 2023, down significantly from 260 in 2022.

These 167 devices came from 29 manufacturers. 32% of the certified smartphones were developed by just two manufacturers, although this is down from 40% in 2022, and 45% in 2021.

And 63% of smartphones certified were made by just five manufacturers, the same as in 2022, and down from 70% in 2021.

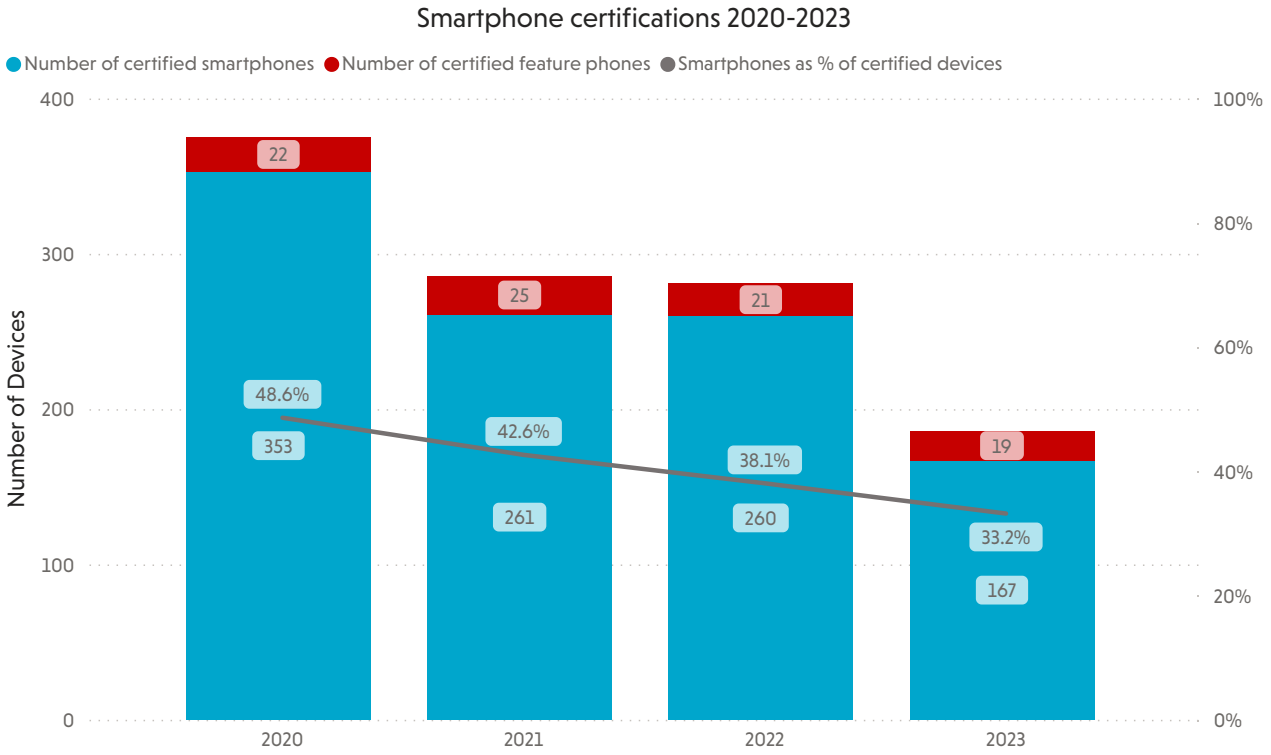


Fig 21: Smartphone certifications 2020-2023

7.2. Smartphone complexity

Smartphones are also significantly more complex than the average device, with 91% of smartphones (slightly down on 95% in 2022) integrating three or more radio bearer technologies, versus 54% for non-smartphone devices (up slightly from 53% in 2022).

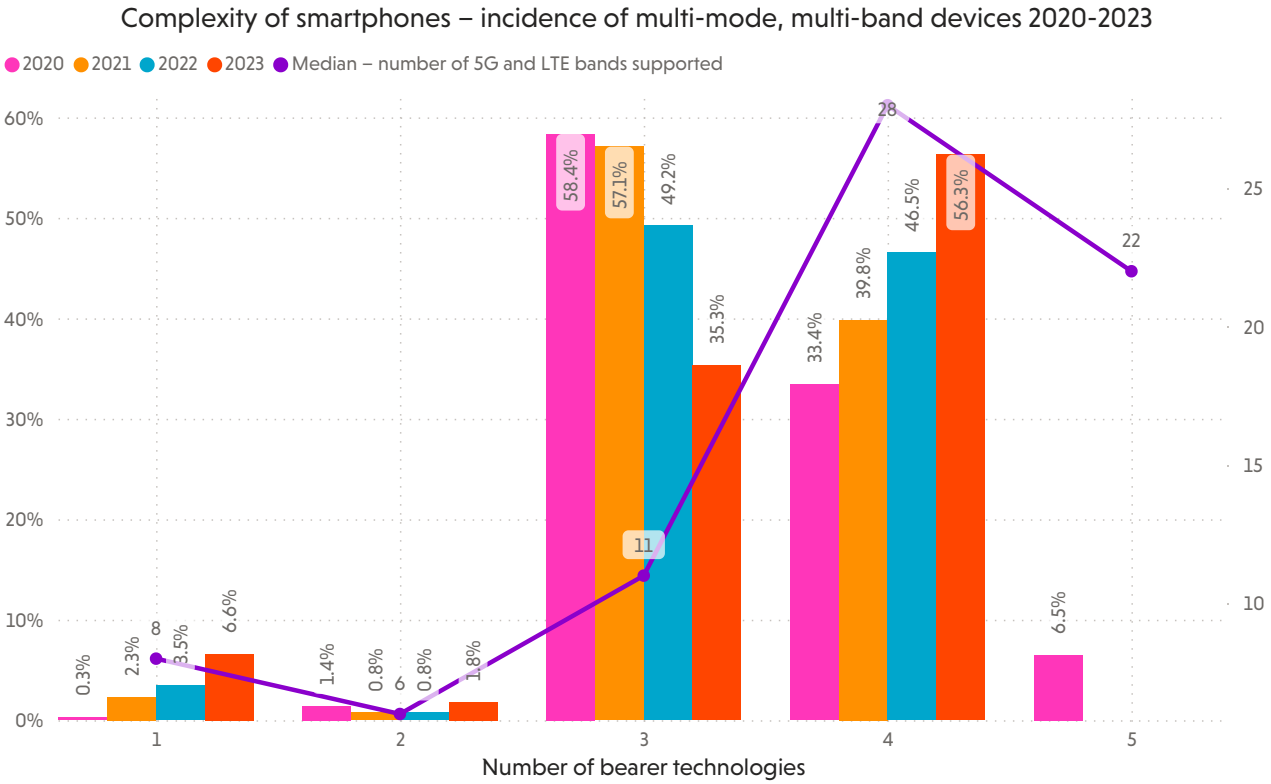


Fig 22: Complexity of smartphones – incidence of multi-mode, multi-band devices 2020-23

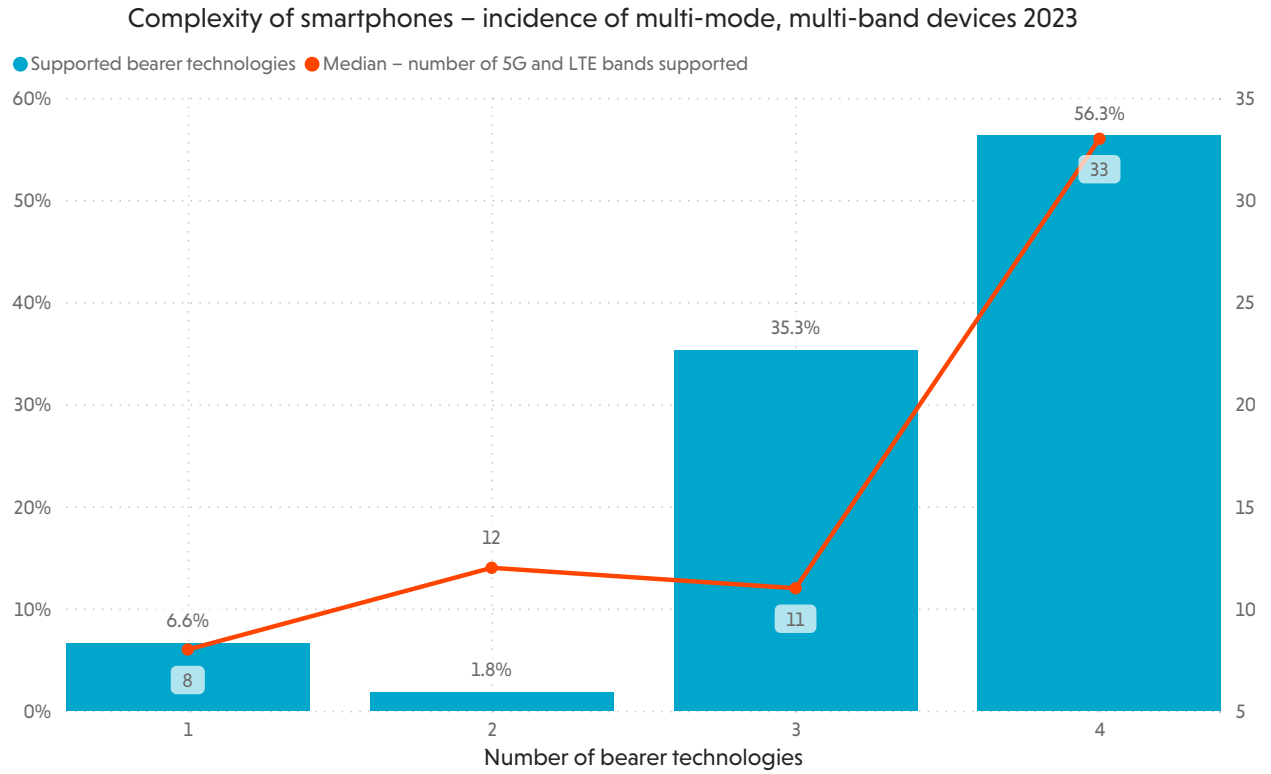
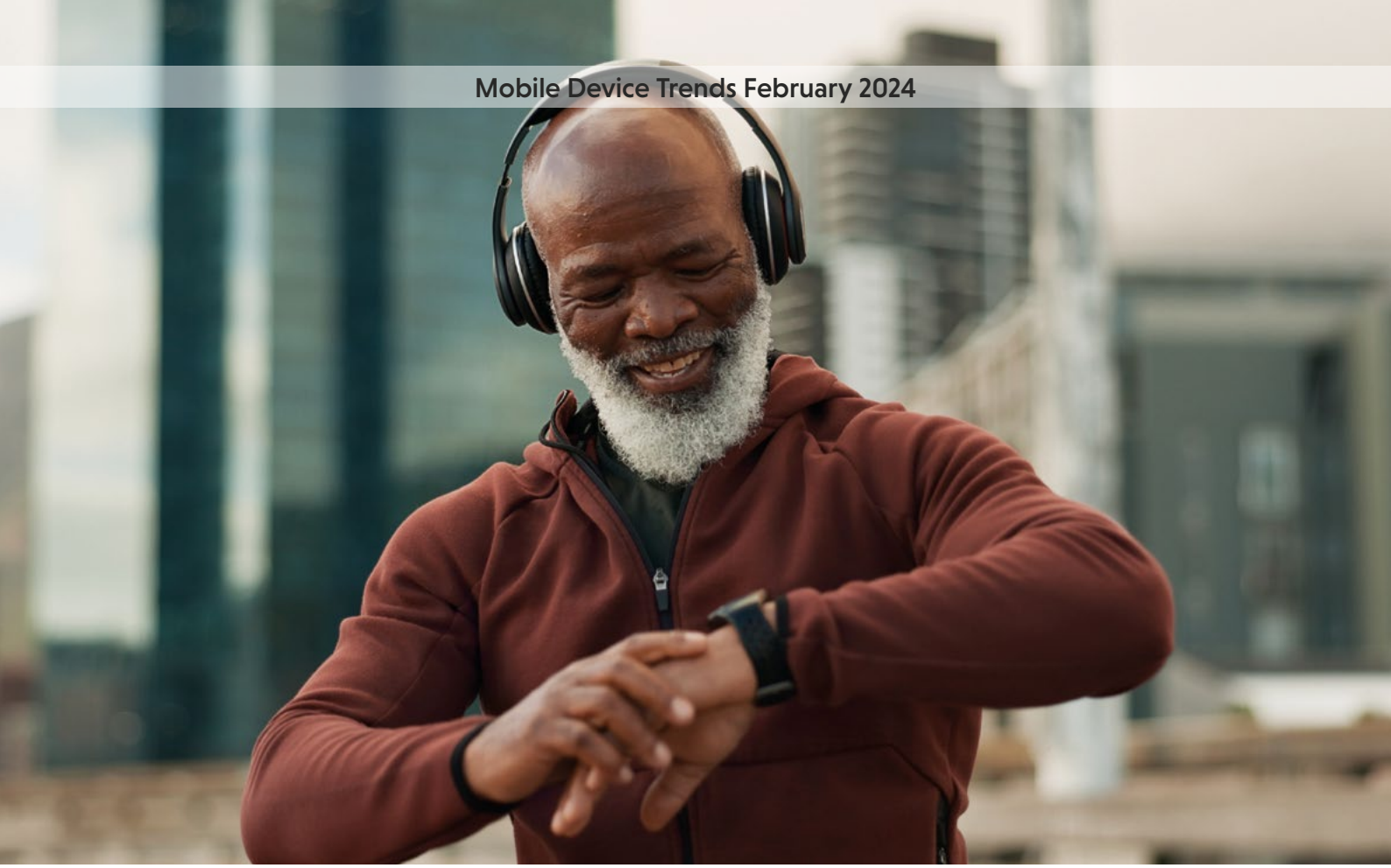


Fig 23: Complexity of smartphones – multi-mode, multi-band devices by bearer technology 2023



7.3. Mobile technologies incorporated

The increased level of complexity of smartphones can also be highlighted by examining the proportion of devices using each mobile technology, and comparing it against non-smartphone devices.

FDD LTE is again the dominant mobile technology, supported by all certified smartphones. Additionally, 101 smartphone devices (60%) support 5G, up significantly from 47% in 2022.

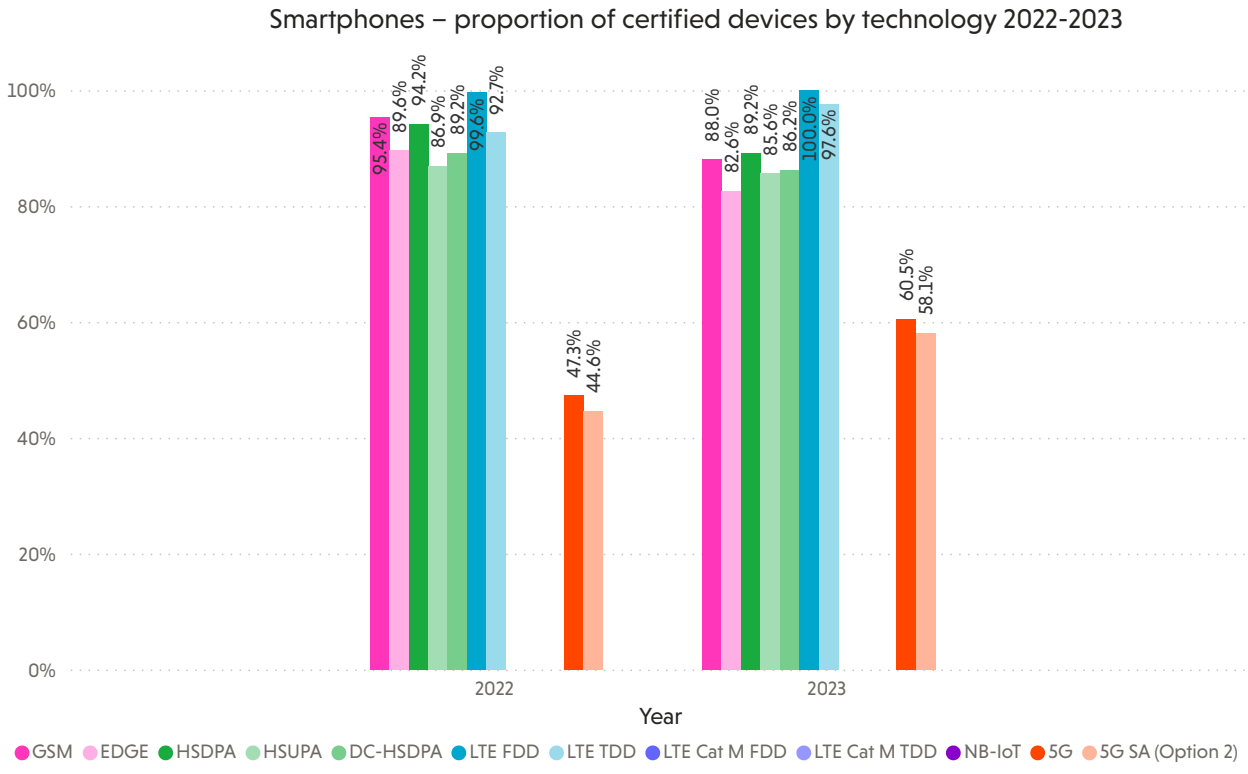


Fig 24: Smartphones – proportion of certified devices by technology 2022-2023

8. Wireless modules

8.1. Wireless module growth

Since 2020, GCF has included IoT-oriented modules among the more general module category. In total, there were 179 modules certified in 2023, representing just under 36% of the total number of certified devices, almost identical to the figure in 2022.

In 2023, the number of manufactures certifying wireless modules was 23, 6 down from the previous year. 71% of certifications came from four companies who certified more than 10 modules.

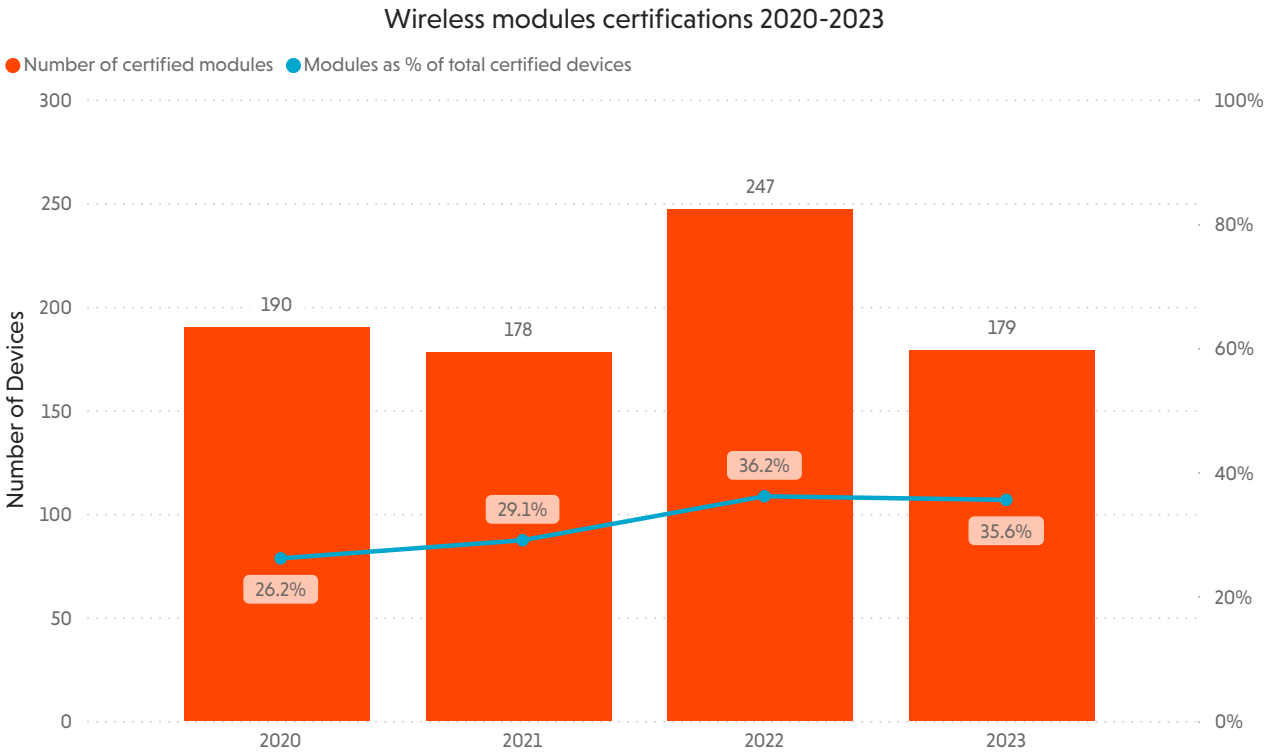


Fig 25: Wireless modules certifications 2020-2023

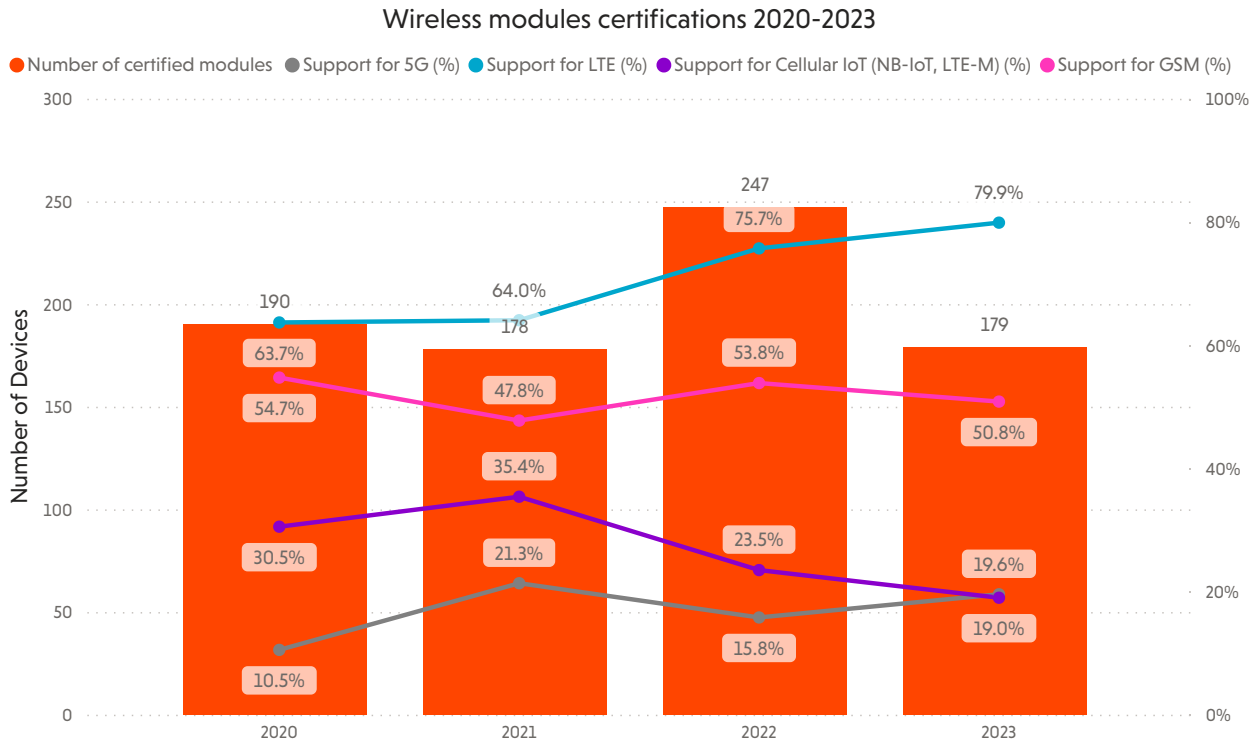


Fig 26: Wireless modules certifications by bearer technology 2020-2023

8.2. Module complexity

As with certified devices generally, a variety of multi-mode, multi-band modules are currently being offered to the market.

29 of the 179 certified modules (16%) were single-mode, the same as in 2022. 32% in 2023 incorporated two radio bearer technologies (down slightly on 35% in 2022) and 42% in 2023 included three (down slightly on 46% in 2022). There were also 17 modules incorporating four radio bearer technologies, compared to 8 in 2022 and none in 2021.

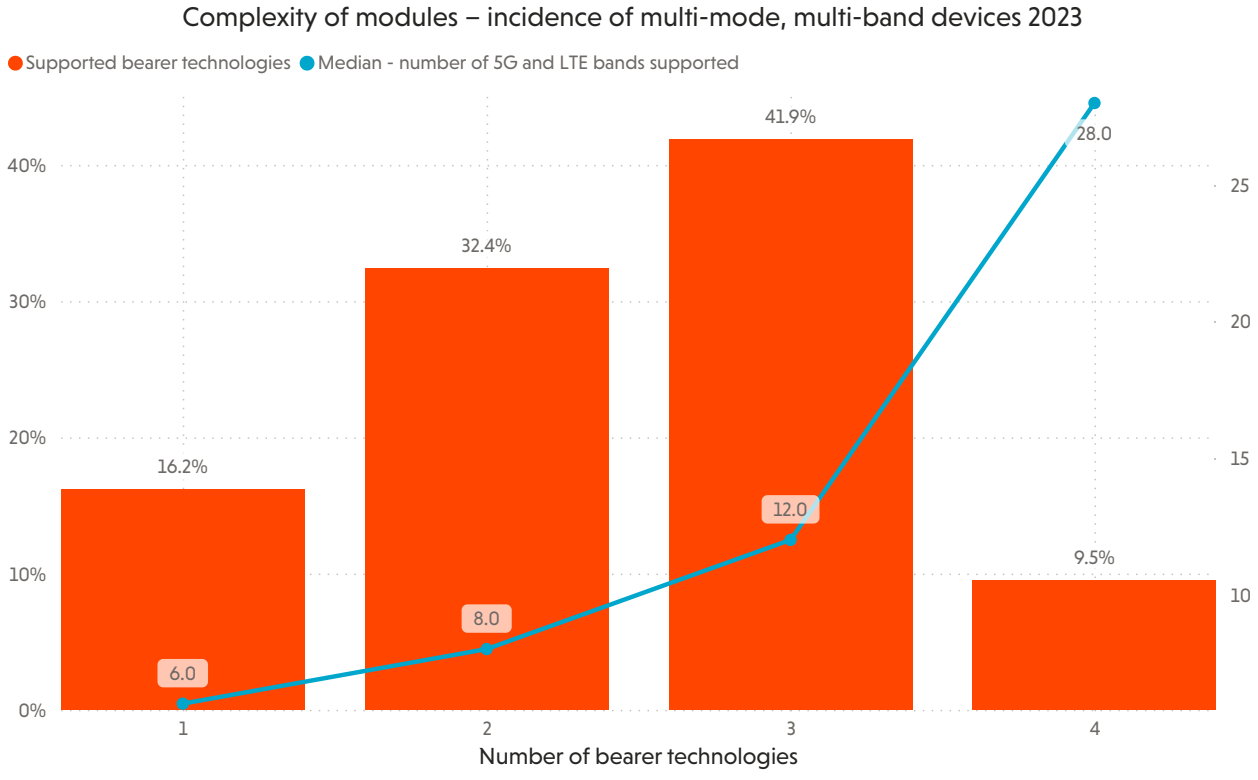


Fig 27: Complexity of modules – incidence of multi-mode, multi-band devices 2023

The median number of LTE and 5G frequency bands per module certified has risen slightly, now standing at 11 per module (up from 8 in 2022). The maximum number of frequency bands for a module was 56.

8.3. Mobile technologies incorporated

The average module is significantly less complex than the average device, and this can also be observed in the proportion of devices supporting each mobile technology.

As in 2022, FDD LTE is the most commonly certified bearer technology in modules, with 80% of modules incorporating it in 2023, compared to 76% in 2022. In 2023, 61% of modules incorporated 3G (UTRA) versus 62% in 2022, and in 2023, 40% incorporated GSM, versus 45% in 2022.

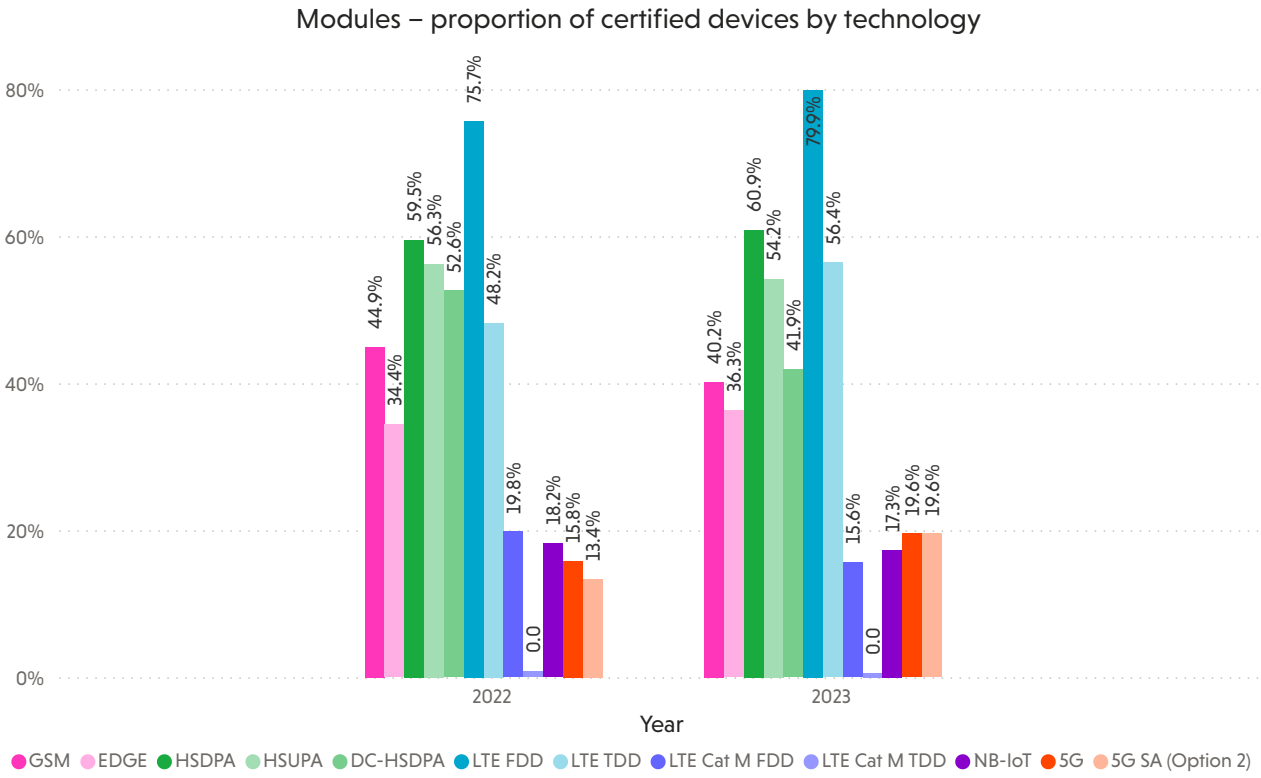


Fig 28: Modules – proportions of certified devices incorporating each mobile technology, 2022-2023

9. Conclusion

In a global mobile ecosystem that now embraces multiple distinct radio bearer technologies deployed across numerous frequency bands, GCF certification provides a practical and industry-recognised means of ensuring devices will interoperate correctly with networks and meet the performance expectations of end-users.

In 2023 several major trends impacted the certification activity at GCF:

- **Record number of manufacturers:** the number of manufacturers certifying devices at GCF reached a peak number of 96 (up 14% year on year) with 30 new manufacturers joining GCF in 2023.
- **Consolidation of portfolios:** the average number of certified devices per manufacturer continued its decline to 5.2 certifications per manufacturer (down 31% year on year).
- **Smartphone decline:** the number of certified smartphones saw a significant decline (down 35% year on year), following an industry decline in total smartphone sales (down 3.5%), and a consolidation of the smartphone portfolio (5.76 models per vendor, down from 12.3 in 2020). Analysis of quarterly data gives an early indication that decline may have stopped in Q4 2023 after six quarters with a declining number of certifications.
- **Module growth:** modules represented 35.6% of total certifications in 2023, surpassing smartphones (33.3%) as the most certified product category.
- **LTE ubiquity:** LTE is present in all certified smartphones and reached almost four of every five certified modules.
- **5G growth:** 5G is now present in more than three of every five certified smartphones, and one of every five modules. Almost all 5G devices support the standalone modes, which was not the case in previous years.
- **2G and 3G sunset:** legacy 2G and 3G wireless technologies accelerated their decline. Their presence on all types of devices reduced significantly, with almost one third of all devices not incorporating any of these technologies. In total, the number of certified devices supporting either 2G or 3G reduced in 2023 by more than 30%.

In 2023, a GCF-certified device incorporated on average 2.82 radio bearer technologies (compared to 2.88 in 2022) and operated across 17.78 5G and LTE frequency bands (this was 15.86 in 2022).

Demonstrating the conformance and interoperability of today's sophisticated multi-mode, multi-band smartphones, modules and vehicles to the satisfaction of the world's mobile operators and governments is therefore essential. And this GCF analysis of mobile device trends shows that its solutions remain relevant to the pre-launch testing of devices.

10. Looking ahead

There are several significant technology evolutions we expect for 2024:

- Smartphone growth: after several years of sales declines in the smartphone market, with users extending the life cycles of devices above four years, and a significant growth of the second-hand and refurbished devices market, the adoption of new AI-based technologies and improvement in fold form factors of smartphones will boost the appetite for newer devices. This trend will lead to growth in smartphone shipments worldwide after two years of significant declines and should imply a recovery in the number of GCF certified devices during 2024.
- Consolidation of 5G as a mature technology: reaching most networks worldwide, and almost every certified smartphone and nearly half of all certified modules. It is expected to be driven by the roll out of 5G SA in more networks.
- Certification of 5G RedCap modules and devices: while the certification was introduced in mid-2023, it is expected that vendors will incorporate the functionality during 2024 for the certification of low cost 5G modules.
- Activation of Non-Terrestrial Networks (NTN) NB-IoT connectivity in GCF certification: direct device-to-satellite connectivity for NTN NB-IoT devices is expected to happen during 2024. First, smartphones are likely to be certified incorporating this technology for basic messaging and emergency service use cases when out of coverage from terrestrial networks coverage.
- Activation of GCF certification for mission critical broadband (LTE-based) access, starting with 3GPP MC-PTT client certification.
- Device complexity changes: while more 5G and LTE bands will be certified per device, including carrier aggregation of many different bands, it is expected that more devices will stop supporting legacy 2G and 3G technologies.

11. How GCF ensures compliance and interoperability

11.1. About GCF

Founded in 1999, the Global Certification Forum (GCF) is the globally-recognised quality mark for the interoperability of mobile phones and other devices that incorporate mobile connectivity.

GCF Certification is based on test cases defined by recognised standards organisations such as 3GPP, ETSI, GSMA, OMA, and NFC Forum. GCF operator and manufacturer members identify and agree a selection of available test cases for each technology and functionality to be brought within the scope of the scheme to deliver a robust but pragmatic testing regime that meets market needs.

GCF Certification comprises lab-based conformance and interoperability testing complemented by field trial testing on live commercial networks.

11.2. Who GCF works with

As of February 2024, over 175 device manufacturers are participating in GCF. The GCF suite of certification solutions is also recognised by operators with interests in global markets and the first 3GPP NTN satellite operators joined GCF as operator members in 2023.

On the development of the certification requirements for mission critical services GCF and TCCA have established a joint working group for the members of the two organisations.

GCF members are spread across the globe.

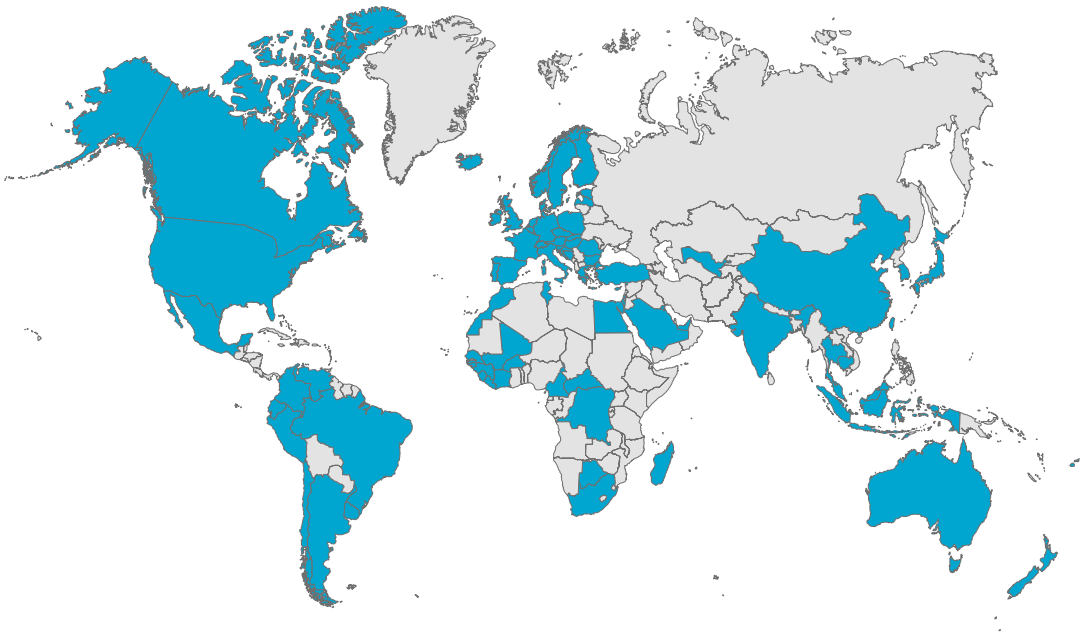


Fig 29: GCF members worldwide by country

11.3. The GCF process

Common, rigorous and trusted certification criteria promote harmonisation of operator acceptance testing schemes. By minimising duplication, GCF Certification reduces acceptance testing costs and contributes to improved economies of scale and faster access to market for device manufacturers.

The initiative provides a consistent, optimised, flexible, scalable framework for certifying any mobile device: from a simple single-mode low-cost handset to sophisticated multi-mode and multi-band smartphones, tablets, wireless routers, IoT modules and other IoT products.

11.4. The benefit of GCF Certification

By adopting GCF Certification into its quality management system, a manufacturer can be marketed to the customers of multiple network operators worldwide. In markets where operators are not directly involved in the marketing of devices, distributors can reduce their after-sales service overheads by prioritising products that have been shown to meet GCF's globally recognised benchmark of conformance and interoperability.

Originally developed for GSM, GCF certification broadened to support newer technologies as they were adopted and now covers most LTE and 5G technologies and bands, including FR1, FR2 frequencies and 5G NR Light (RedCap), as well as NB-IoT for terrestrial and NTN bands and legacy wireless technologies (2G and 3G). GCF also certifies capabilities such as Remote SIM Provisioning for Consumer eSIM (mainly for smartphones and wearables) and IMS Services (VoLTE, VoNR).

The effective use of frequency bands, and the handling of the growing number of band combinations available in devices/networks is assisted by the GCF initiative, which provides an effective method for verifying the correct operation of Carrier Aggregation currently up to five simultaneous frequency bands (5CC).

The quality of interoperability assured by the programme facilitates successful international and national roaming for end users.

12. Key GCF milestones

Date	Event
February 2024	GCF introduces NB-IoT support for Non-Terrestrial Networks (NTN)
July 2023	GCF and TCCA work together to certify devices for mission-critical services
February 2023	5G RedCap certification launched
June 2021	C-V2X Automotive programme launched
March 2020	First IoT chipset certified
July 2019	First 5G device capable of accessing FR2 bands certified
April 2019	First 5G device certified
February 2018	RSP eSIM certification for consumer devices introduced
September 2017	First LTE-M device certified
March 2017	First NB-IoT device certified
March 2011	First LTE device certified
February 2006	First 3G device certified
May 2000	Certification of first device – GSM
1999	GCF founded

13. GCF device certifications

Certified devices are listed on the GCF website at:
https://www.globalcertificationforum.org/gcf-certified-products.html

14. Table of figures

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