Exhibit A

5G Telecommunications Modules That Use
Qualcomm Snapdragon X55 5G Modem

Manufacturer	Model Numbers	Range of Use Cases
Quectel Wireless Solutions	RG500Q[1] RM500Q[2] RG510Q[3] RM510Q[4]	Ideal for a variety of industrial and consumer IoT applications, including business routers, home gateways, customer premises equipment (CPE), MiFi, industrial IoT (IIoT), industrial laptops, PDAs, video surveillance, digital signage, 4K/8K live streaming and many other bandwidth-intensive use cases[5]
Sierra Wireless	EM9190 and EM9191[6]	Applicable to a wide range of IoT applications such as industrial routers, home gateways, industrial and consumer laptops, rugged tablet PCs, video surveillance and digital signage[7]
Telit	FN980 and FN980m[8]	Enterprise network appliances, branch and remote office routers and gateways, customer premises equipment (CPE), professional video broadcasting field cameras, private and public 5G for industrial automation (Industry 4.0 – "smart factories") routers, medical equipment for emergency pop-up field hospitals, and other bandwidth-intensive applications[9]
Tricascade	TRITOM 5G M.2 module[10]	High-speed, high-bandwidth applications, such as networking, high-end video, gaming and augmented reality[11]

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[1] https://perma.cc/8JWQ-2WEM.
[2] https://perma.cc/5DU9-Q8QA.
[3] https://perma.cc/GCK3-REUZ.
[4] *Id.*
[5] https://perma.cc/H8H7-F3BH.
[6] https://perma.cc/N5H5-6F7Y.
[7] https://perma.cc/NJ8G-RUTM. Sierra Wireless refers to the flexibility of their modules across a wide range of use cases as "future-proof form factors."
[8] https://perma.cc/PBL2-DXGB. Although this press release indicates that it has been certified on Verizon's network, it is important to remember that the X55 cellular modem used in each of these modules is compatible with all three wireless carriers (due to the range of supported frequency bands and built-in RF-front end that is interoperable across most carriers globally, including all major U.S. carriers).
[9] https://perma.cc/D7NA-4QQB.
[10] https://perma.cc/2S8L-78KG.
[11] *Id.*

Exhibit B

Table Showing Same Cellular Modems Used in 4G/LTE and 5G Laptops are Used in 4G/LTE and 5G Phones and Tablets

Modem	Laptops (including 2-in-1s)	Tablets / Phones
Qualcomm Snapdragon X55 (5G)	Lenovo Flex 5G[12] Dell Latitude 9510[13] Dell Latitude 9420/9520[14] HP Elite Dragonfly[15] HP Elite Folio[16] Acer Spin 7[17] Lenovo Thinkpad X1 Titanium Yoga 5G[18] Lenovo Ideapad 5G[19]	iPad Pro[20] Samsung Galaxy Tab S7+[21] Samsung Galaxy Tab S7[22] Samsung Galaxy Z Fold 2[23] iPhone 12 series[24] Samsung Galaxy S20 series[25] Samsung Galaxy Note 20[26] OnePlus 8 series[27] Motorola Edge/Edge+[28]
Qualcomm Snapdragon X20 (LTE)	HP Elite Folio[29] Samsung Galaxy Book2[30] Samsung Galaxy Book S[31] Lenovo Yoga C630[32] Microsoft Surface Pro7+[33]	Dell Latitude 7210[34] Samsung Galaxy S9/S9+[35] (and many more[36])
Qualcomm Snapdragon X16 (LTE)	Asus NovaGo TP370QL[37] HP Envy X2[38] Lenovo Miix 630[39]	Samsung Galaxy Tab S4[40] Samsung Galaxy S8/S8+/Note8 (and many more)[41]

[12] https://perma.cc/RK79-J4LH.
[13] https://perma.cc/NG2W-B5GA.
[14] https://perma.cc/C9W7-6SHZ.
[15] https://perma.cc/E7SR-L4BP. When you configure your laptop for purchase, you can select either an LTE modem (Intel XMM 7360) or a 5G modem (Qualcomm X55).
[16] https://perma.cc/Z47G-D6JA. When you configure your laptop for purchase, you can select either an LTE modem (Qualcomm X20) or a 5G modem (Qualcomm X55).
[17] https://perma.cc/RAL5-2QN5.
[18] https://perma.cc/4UDM-4TJ9.
[19] https://perma.cc/9JLS-PN8A.
[20] https://perma.cc/Z4TU-NK5D.
[21] https://perma.cc/2GL7-ZAQ3.
[22] Id.
[23] https://perma.cc/T97Y-CZ5A.
[24] https://perma.cc/6BS4-9L43.
[25] https://perma.cc/5NDC-PAKY.
[26] Id.
[27] https://perma.cc/8PUJ-9PU5.
[28] https://perma.cc/9RZU-WC67.
[29] https://perma.cc/S2GY-GPAV. When you configure your laptop for purchase, you can select either an LTE modem (Qualcomm X20) or a 5G modem (Qualcomm X55).
[30] https://perma.cc/6ESK-92PJ.
[31] https://perma.cc/97GY-7GT5.
[32] https://perma.cc/2JN7-FN9K.
[33] https://perma.cc/3MZG-XPPW. The Qualcomm X20 modem is listed under tech specs.
[34] https://perma.cc/NU96-34BG.
[35] https://perma.cc/H8UJ-BQL7.
[36] Id.
[37] https://perma.cc/D2Q3-LH3A.
[38] https://perma.cc/44A2-H9VL.
[39] https://perma.cc/G7WY-F8PS.
[40] https://perma.cc/L82P-LT9J.
[41] https://perma.cc/BW73-BZNP. The Snapdragon 835 mobile platform includes the X16 LTE modem. See https://perma.cc/8U3K-6RM9.

Qualcomm Snapdragon X15 (LTE)	Acer Chromebook Spin 513[42] JP.IK Turn Connect T101[43] JP.IK Leap Connect T304[44] Positivo Wise N1212S[45]	Samsung Galaxy Tab Active Pro[46] Motorola Razr[47] (and many more)[48]
Qualcomm Snapdragon X7 (LTE)	Panasonic Toughbook[49] Lenovo Thinkpad models[50] Dell Latitude 7000 series[51]	iPad Pro (2016) [52] iPad (6th Gen)[53] iPhone 6s/6s Plus[54]
Intel XMM 7560 (LTE)	HP Spectre Folio[55] Lenovo ThinkPad P15[56]	iPad Pro (2018)[57] iPhone XS/XS Max/XR[58]
Intel XMM 7360 (LTE)	Dell Latitude models[59] Lenovo ThinkPad models[60] Samsung Chromebook Plus[61] Sector 5 LTE Chromebook E4[62] HP Elitebook/ProBook/ZBooks[63] HP Elite Dragonfly[64]	HP Elite x2[65] HP Elitebook 700 series[66] iPhone 7/iPhone 7 Plus[67]

[42] https://perma.cc/ZZ9G-7KY2. The Snapdragon 7c mobile platform includes the X15 modem. *See* https://perma.cc/NK4Z-YBB6.

[43] https://perma.cc/VF2L-FCA7. The Snapdragon 7c mobile platform includes the X15 modem, *supra* note 42.

[44] https://perma.cc/J8CH-UZ22.

[45] https://perma.cc/Z6EW-SA43.

[46] https://perma.cc/36UZ-2GBP. The Snapdragon 710 mobile platform includes the X15 modem. *See* https://perma.cc/8H4T-6LXM.

[47] https://perma.cc/HC4X-69KM.

[48] *Id.*

[49] https://perma.cc/PQ93-8EKZ. The Sierra Wireless EM7455 module includes the Qualcomm X7 LTE modem. *See* https://perma.cc/985K-XYJH; https://perma.cc/T7RE-K92C.

[50] https://perma.cc/HNV9-K87B. The Lenovo Thinkpad X270 can be configured with either a Qualcomm X7 modem or an Intel XMM 7160 modem. Additionally, a number of other Lenovo Thinkpad models use the Sierra Wireless EM7455 module equipped with the Qualcomm X7 LTE modem. *See* https://perma.cc/FV2W-7P5Q.

[51] https://perma.cc/R46S-27UT; *see also* https://perma.cc/DX5T-AZKX; https://perma.cc/KXL7-37LM.

[52] https://perma.cc/AQG8-Z5F6. The model number MDM9635M is the Qualcomm X7 LTE modem (i.e., baseband chip). *See* https://perma.cc/HYR7-VQJ6 (at the top of the page, the "9x35/9x30" are the model numbers for the X7 modem). The X7 modem was also used in the Apple Watch Series 3. *See* https://perma.cc/68P9-DL6H.

[53] *Id.*

[54] *Id.*; *see also* https://perma.cc/9LGS-MCMN.

[55] https://perma.cc/NZ2B-ZMJW.

[56] https://perma.cc/NG5N-K9Q5. The Fibocom L860-GL module houses the Intel XMM 7560 LTE modem, along with additional hardware. *See* https://perma.cc/9QF3-R8B2.

[57] https://perma.cc/MKU5-BWSU.

[58] https://perma.cc/4NLT-784Y.

[59] https://perma.cc/3L86-F5BC. The Dell Latitude 5300 2-in-1 Chromebook is also among the Latitude models with an Intel XMM 7360 modem. *See* https://perma.cc/SSA2-JB49.

[60] https://perma.cc/7WFV-QGCK. The Fibocom L850-GL module houses the Intel XMM 7360 LTE modem, along with additional hardware. *See* https://perma.cc/Y9NH-BQTR.

[61] https://perma.cc/M9EV-G3ZP. The Fibocom L850-GL module houses the Intel 7360 modem, *supra* note 60.

[62] https://perma.cc/YZ4H-77HF.

[63] https://perma.cc/8CYC-WSLA (e.g., HP Elitebook 830, 836, 840, 846, 850, x360 notebook PCs, HP ProBook 640/650/x360, HP ZBook 14u, 15u, etc.).

[64] https://perma.cc/3H3V-NUYP. HP gives the option of an LTE (Intel 7360) or 5G (Qualcomm X55) modem.

[65] https://perma.cc/8CYC-WSLA (e.g., HP Elite x2 1013 G3, x2 G4 tablet PCs).

[66] https://perma.cc/8CYC-WSLA (e.g., HP Elitebook 735, 745, 755 tablet PCs).

[67] https://perma.cc/84UC-PXDK.

Exhibit C

GSA 5G Device Ecosystem Report
(March 2019)

5G Device Ecosystem

Prepared by GSA based on data from the GSA Analyser for
Mobile Broadband Devices (GAMBoD)

March 2019

Key facts

While 5G trials have used prototype user equipment (UE), commercial services need commercial devices. Consequently the 5G device ecosystem rapidly started to emerge as the first (limited) commercial 5G services were announced. As more services go live during 2019, we can expect the device ecosystem to grow quickly. GSA will be tracking and reporting regularly on 5G device launch announcements. Its GAMBoD database will contain key details about device form factors, features, and support for spectrum bands. Summary statistics will be released in this new monthly publication.

As of mid-March GSA had identified:

- seven announced form factors (phones, hotspots, indoor CPE, outdoor CPE, modules, snap-on dongles/adapters and USB terminals)
- twenty-three vendors that have announced available or forthcoming 5G devices
- 33 officially announced devices (plus regional variants)
    - twelve phones (plus regional variants)
    - five hotspots (plus regional variants)
    - eight CPE devices (indoor and outdoor)
    - five modules
    - two snap-on dongles / adapters
    - one USB terminal
- 5G chipsets from five vendors (Huawei, Intel, Mediatek, Qualcomm and Samsung).

Not all devices are available immediately and specification details remain limited for some devices.

Details

Table 1 lists devices we have identified so far.

Table 1: 5G devices

Vendor	Device name	Form factor	Chipset	Details
D-Link	DWR-2010	CPE Indoor	Qualcomm Snapdragon X55 modem	LTE and 5G NR. Sub 6 GHz and mmWave. 3GPP Rel 15 NSA. Available 2H 2019.
Doogee	5G Docker for the Doogee S90	Snap-on dongle	Mediatek Helio P60	28 GHz. 5G NR Rel 15. 3.5 Gbps DL. Expected 3Q 2019.

GSA Report | March 2019 | 5G Device Ecosystem

Vendor	Device name	Form factor	Chipset	Details
Fibocom	FG100	M.2 Module	Intel XMM 8160 5G Modem	3G, 4G and 5G, 5G NR FDD and TDD, NSA and SA. Sub 6 GHz supported internally, mmWave with external antenna module. Up to 6 Gbps DL on mmWave, and 4 Gbps on sub 6 GHz. Commercial availability 2020.
HTC	5G hub (US bands)	Hotspot	Qualcomm Snapdragon 855 platform with X50 5G modem	LTE and 5G NR. 5G Band n41. Up to 2.63 Gbps DL and 287 Mbps UL. Available from Q2 2019.
HTC	5G hub (Europe and Asia)	Hotspot	Qualcomm Snapdragon 855 platform with X50 5G modem	LTE and 5G NR. 5G Band n78. Up to 2.63 Gbps DL and 287 Mbps UL. Available from Q2 2019.
Huawei	5G CPE 2.0 (mmWave)	Outdoor & Indoor CPE	Balong 5000	28 GHz (N257). Up to 4Gbps DL rate. LTE+5G Dual Connectivity. 5G NSA and SA.
Huawei	5G CPE 2.0 (Sub 6 GHz)	Outdoor & Indoor CPE	Balong 5000	700 MHz/ 2.6 / 3.5 / 3.7 / 4.5 / 4.9 GHz. Up to 3.5Gbps DL rate. LTE+5G Dual Connectivity. 5G NSA and SA.
Huawei	5G CPE Win	Outdoor / window CPE	Balong 5000	Up to 4 Gbps speed at sub 6 GHz 200 MHz. Wall, pole, windowsill instalment options.
Huawei	5G Mobile WiFi	Hotspot	Balong 5000	4G/5G. Theoretical up to 4.8 Gbps DL.
Huawei	5G CPE Pro	Indoor CPE	Balong 5000	4G and 5G. Up to 3.2 Gbps DL test rates, up to 1 Gbps DL shown at MWC. 3.4–3.8 GHz and 26–28 GHz.

Vendor	Device name	Form factor	Chipset	Details
Huawei	Mate X	Phone	Balong 5000	Foldable. Theoretical DL speeds of 4.6 GHz. Supports LTE and 5G, SA and NSA. Sub-6GHz bands.
Inseego	R1000 Home Router/MiFi IQ 5G Fixed Wireless	Indoor CPE	No data	On Verizon.
Inseego	MiFi IQ 5G Mobile Hotspot	Hotspot	Qualcomm Snapdragon 855 platform with X50 modem	For North America, Asia-Pacific and Europe. Supports 5G NR in sub 6 GHz and mmWave bands.
LG	V50 ThinQ	Phone	Qualcomm Snapdragon 855 platform with X50 modem	3G, LTE-A and 5G NR.
Motorola	5G Moto Mod	Snap-on dongle	Snapdragon X50 5G NR, Qualcomm SM8150	LTE and 5G NR. 5G bands n261 and n260. Up to 4.5 Gbps DL (tethered to laptop), up to 2.4 Gbps attached to Moto z3 phone.
Netgear	Nighthawk M5 Fusion MR5000	Hotspot	Snapdragon X50 modem	LTE and 5G. Band n260 (39GHz). Up to 5 Gbps.
Nokia	Fastmile 5G Gateway	CPE with indoor/ outdoor receiver options	No data	LTE and 5G. Sub 6 GHz 5G NR. Up to 1 Gbps DL.
Nubia	Mini 5G	Phone	Qualcomm Snapdragon 850 platform with X50 modem	No additional data
OnePlus	OnePlus5G	Phone	Qualcomm Snapdragon 855 platform	Available in 2Q 2019.
Oppo	Find X 5G	Phone	Snapdragon 855 platform with X50 5G modem	Prototype only.
Quectel	5G RG500Q	Module	No data	LTE and 5G. Sub 6 GHz 5G NR module for IoT. 3GPP Rel 15. SA and NSA modes.
Samsung	SFG-D0100	Indoor CPE	No data	5G (Verizon 5GTF) 27.5–28.35 GHz.
Samsung	Galaxy Fold 5G	Phone	No data	Expected in South Korea from April 2019.

Vendor	Device name	Form factor	Chipset	Details
Samsung	Galaxy S10 5G (North America)	Phone	Qualcomm Snapdragon X50 modem	Available H1 2019 on Verizon, elsewhere summer 2019. 2G, 3G, 4G and 5G NSA. Multiple versions according to operator and market. Up to 2 Gbps DL and 150 Mbps UL. Sub 6 GHz, 28 GHz and 39 GHz frequencies.
Samsung	Galaxy S10 5G (Europe and Asia)	Phone	Samsung Exynos	Summer 2019. Up to 2 Gbps DL and 150 Mbps UL. Sub 6 GHz, 28 GHz and 39 GHz frequencies.
Sierra Wireless	AirPrime module	M.2 Module	Qualcomm Snapdragon X55 modem	LTE and 5G including sub 6 GHz and mmWave spectrum. Conforms with 3GPP Rel. 15
Sony	Xperia 5G	Phone	Qualcomm Snapdragon 855 platform with X50 modem	Prototype only
TCL	Alcatel7 5G	Phone	No data	Demonstration version shown at MWC. Expected availability 2019.
TCL	Alcatel 5G USB data terminal	USB terminal	MediaTek Helio M70	LTE and 5G. Expected to ship Q2 2019. 4 Gbps DL and 2 Gbps UL for PC users. N41 and n78.
Telit	FM980	Module	Qualcomm Snapdragon X55 modem	One supports 5G and LTE sub 6 GHz in TDD and FDD modes and one also supports mmWave bands (matching US deployments). Available for sampling from early Q2 2019.
Telit	FM980M	Module	Qualcomm Snapdragon X55 modem	

Vendor	Device name	Form factor	Chipset	Details
Vivo	Apex 2019	Phone	Qualcomm Snapdragon 855 platform	Expected Q2 2019
WNC	5G mobile hotspot	Hotspot	No data	Sub-6 GHz and mmWave bands
Xiaomi	Mi Mix 3 5G	Phone	Qualcomm Snapdragon 855 platform with X50 5G modem	2G, 3G, 4G and 5G. 5G band n78. Up to 2 Gbps DL.
ZTE	Axon 10 Pro 5G	Phone	Qualcomm Snapdragon 855 platform with X50 5G modem	Expected H1 2019.

Other potential, but – as far as GSA has been able to determine – not officially announced, 5G devices, include:

- Netgear Nighthawk M2 5G Hotspot – reported by secondary sources as planned for Telstra's network
- Samsung Galaxy Note 10 5G – secondary source confirmation only, based on analysis of Galaxy Note 10 Kernel code.

In addition, earlier versions of the Huawei indoor CPE containing the Balong 5G01 chipset are, according to the vendor, still being used in selected pre-commercial trials.

GSA would welcome information or news about any new 5G devices. Please send any details to research@gsacom.com.

About GSA

GSA (the Global mobile Suppliers Association) is a not-for-profit industry organisation representing companies across the worldwide mobile ecosystem engaged in the supply of infrastructure, semiconductors, test equipment, devices, applications and mobile support services.

GSA actively promotes the 3GPP technology road-map – 3G, 4G, 5G – and is a single source of information resource for industry reports and market intelligence. GSA Members drive the GSA agenda and define the communications and development strategy for the Association.

Membership of GSA is open to any supplier of products; systems or services related to the mobile industry and brings many benefits including access to the GAMBoD and NTS database. The range of benefits includes enhanced discussion, networking and influencing opportunities on the key industry topics, and unique promotional/visibility opportunities for your company name, capabilities, positioning and messages. More details can be found at https://gsacom.com/gsa-membership/

News/updates: RSS Feed: https://gsacom.com/rss-feeds/

GSA LinkedIn group: www.linkedin.com/groups?gid=2313721

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NOTE: Errors and omission excepted

Exhibit D

GSA 5G Ecosystem Report Executive Summary
(March 2020)

5G DEVICE ECOSYSTEM
REPORT
EXECUTIVE SUMMARY

MARCH 2020

GSA

Executive Summary

Key facts on 5G devices

A flurry of device launches (all originally timed to coincide with MWC 2020) meant a big leap in the number of announced 5G devices in February and early March. In January 2020, the number of announced 5G devices exceeded 200 for the first time; by early March[1] over 250 devices had been announced.

By mid March 2020, GSA had identified:

sixteen announced form factors (phones, head-mounted displays, hotspots, indoor CPE, outdoor CPE, laptops/notebooks, modules, snap-on dongles/adapters, industrial grade CPE/routers/gateways, drones, robots, tablets, TVs, a switch, modems and a vending machine).

- eighty-one vendors that had announced available or forthcoming 5G devices.

- two hundred and fifty-three announced devices (including regional variants, and phones that can be upgraded using a separate adapter, but excluding prototypes not expected to be commercialised and operator-branded devices that are essentially rebadged versions of other phones), including at least 67 that are commercially available

- eighty-seven phones, (up 25 from end January), at least 40 of which are now commercially available (up from 35 at end January). Includes three phones that are upgraded to offer 5G using an adapter.

- seventy-six CPE devices (indoor and outdoor, including two Verizon-spec compliant devices not meeting 3GPP 5G standards), at least 13 of which are now believed to be commercially available

- forty-three modules

- seventeen hotspots (including regional variants), at least nine of which are now commercially available
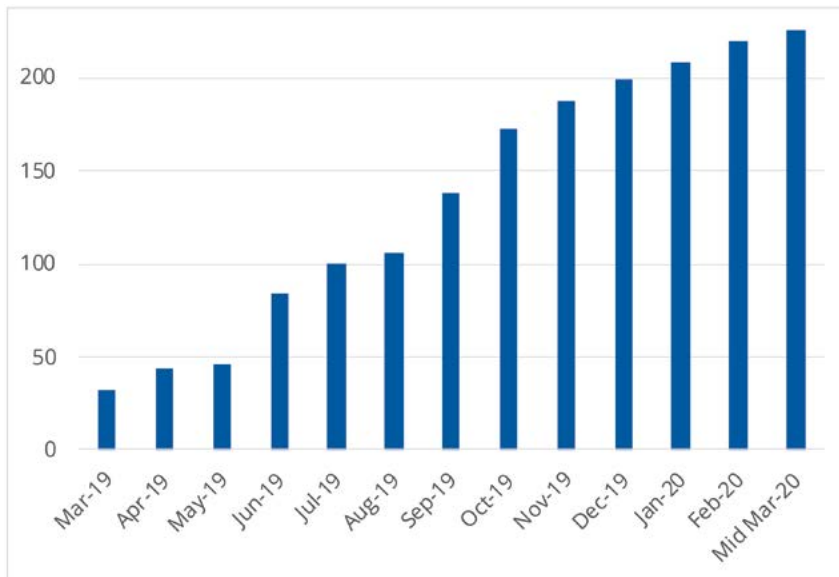
- five laptops (notebooks)

1. Data reflects database status as at 6 March 2020

Figure 1: Growth of announced 5G devices (not all commercially available)

- five industrial grade CPE/routers/gateways

- three robots

- three televisions

- three tablets

- three USB terminals/dongles/modems

- two snap-on dongles/adapters

- two drones

- two head-mounted displays

- one switch

- one vending machine.

Not all devices are available immediately and specification details remain limited for some devices.
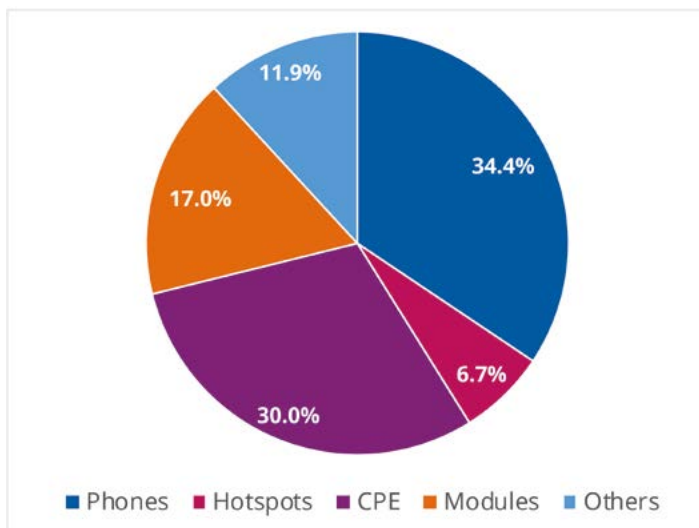

Figure 2: Announced 5G devices, by form factor

Spectrum band support of 5G devices

Availability

Availability of information about spectrum support is improving as a greater number become commercially available. Just over two-thirds (68.0%) of all announced 5G devices are identified as supporting sub-6 GHz spectrum bands and just under one-third (30.8%) are understood to support mmWave spectrum. Just under 25% of all announced devices are known to support both mmWave and sub-6 GHz spectrum bands.

Only 17 of the commercially available devices (25.4% of them) are known to support services operating in mmWave spectrum, but 83.6% of the commercially available devices are known to support sub-6 GHz spectrum.

The bands known to be most supported by announced 5G devices are n78, n41, n79 and n77.

We can expect the device ecosystem to continue to grow quickly and for more data to become available about announced devices as they reach the market. Based on vendors' statements, we can expect more than 50 additional announced devices to become commercially available before the end of June 2020. GSA will be tracking and reporting regularly on these 5G device launch announcements. Its GAMBoD database contains key details about device form factors, features and support for spectrum bands. Summary statistics are released in this regular monthly publication.

Comparison to 4G LTE

In February 2015, 5 years after LTE launched, GSA was tracking 2,218 devices, of which 1,045 were smartphones (including frequency/carrier variants). 978 new devices were added to the GSA GAMBoD database in the previous 12 months.

At the predicted rate of growth, 5G devices will reach the 2,000 figure during the summer of 2021, some 2 years earlier than 4G. Clearly 5G is recognised as a disrupting technology by the mobile ecosystem and mobile operators are gaining in confidence regarding the potential of 5G to change the industrial, business, public and consumer landscapes.

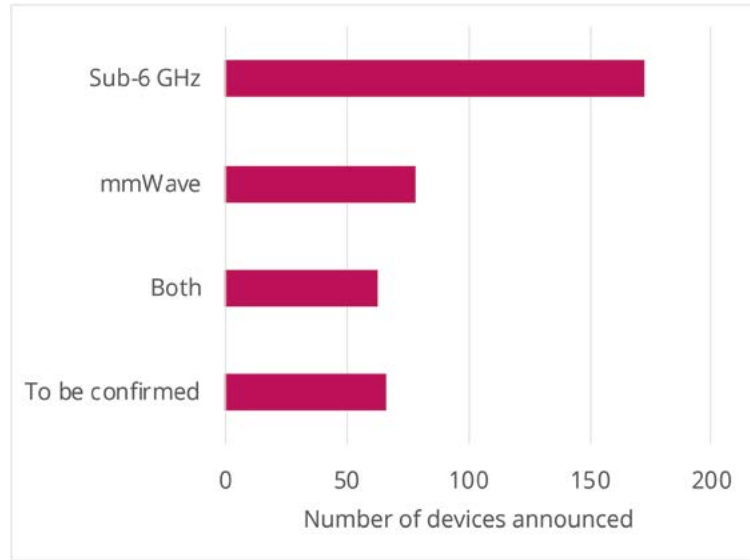**A complete list of devices is available for GSA Members and Associates in the full report.**

Figure 3: Announced devices with known spectrum support, by broad category (data not available for all devices)
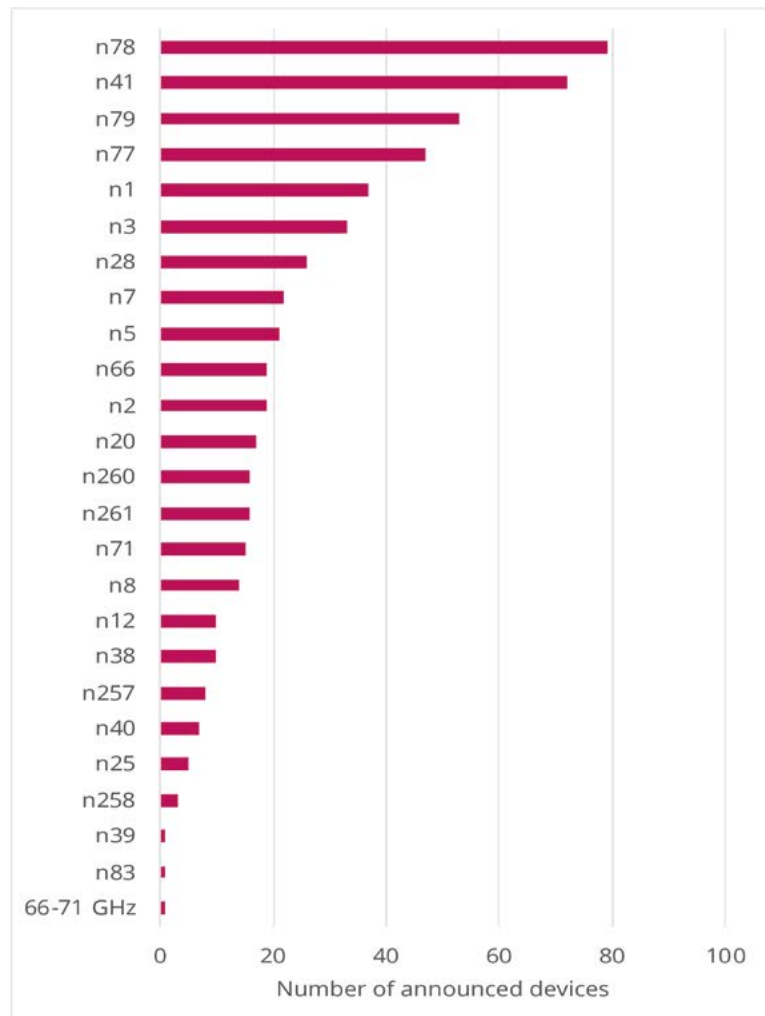

Figure 4: Announced devices with known spectrum support, by specific band (data not available for all devices)

ABOUT GSA

GSA is the voice of the global mobile ecosystem and has been representing mobile suppliers since 1998.

GSA GAMBoD Database

Reports are based on data contained in the GSA GAMBoD databases which is a resource available to GSA Members and Associates. Companies and policy makers can subscribe as a GSA Associate to the database to gain insights into the source data behind reports for their own research purposes.

Discounted annual subscription are available to regulators, government agencies and mobile operators.

Please email info@gsacom.com for more information.

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Exhibit E

GSA 5G Ecosystem Report Executive Summary
(April 2021)

Executive Summary

Key facts

The number of announced 5G devices continues to grow rapidly, this month exceeding the 700 mark for the first time to reach 703 announced 5G devices. This is more than 25% higher than the number of announced devices at the end of Q4 2020 and is an increase of 11.9% over the last month alone. Meanwhile, the number of 5G devices understood to be commercially available has risen by more than 28% over the last quarter, now standing at 431 commercial 5G devices, which represents 61.3% of all announced 5G devices.

By end-March 2021, GSA had identified:

- twenty-two announced form factors.

- one hundred and twenty-two vendors who had announced available or forthcoming 5G devices.

- seven hundred and three announced devices (including regional variants, but excluding operator-branded devices that are essentially rebadged versions of other phones), including 431 that are understood to be commercially available:

  - three hundred and fifty-one phones (up 45 from February), at least 298 of which are now commercially available (up 24 in a month).

  - one hundred and thirty-two FWA CPE devices (indoor and outdoor), of which 50 are now commercially available.

  - ninety-one modules.

  - thirty-seven industrial/enterprise routers/gateways/modems.

  - thirty-six hotspots.

  - fourteen laptops (notebooks).

  - eight tablets.

  - thirty-four other devices (including drones, head-mounted displays, in-vehicle routers/modems/hotspots, robots, TVs, USB terminals/dongles/modems, cameras, femtocells/small cells, repeaters, vehicle OBUs, a snap-on dongle/adapter, a switch, a vending machine and an encoder).

Figure 1: Growth of 5G devices (announced and commercially available)
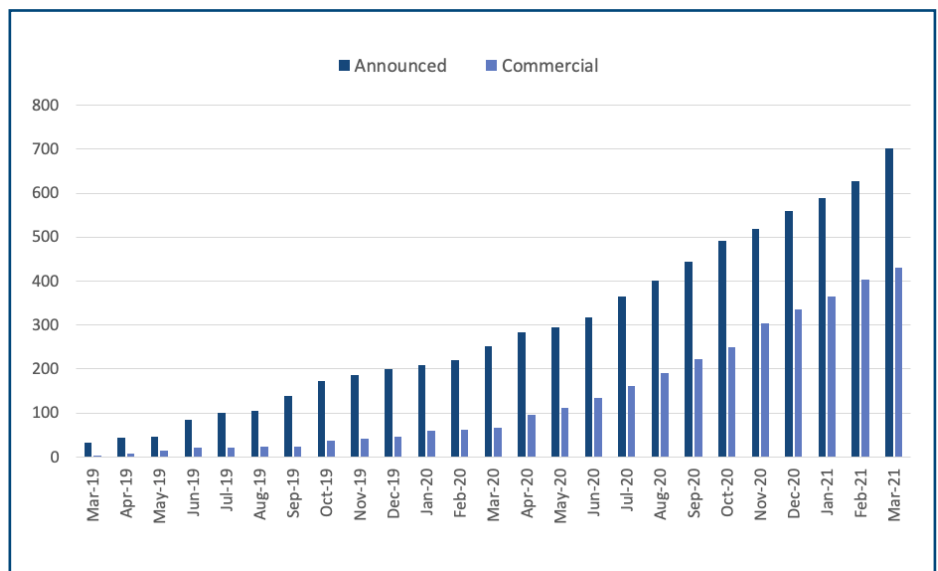
Not all devices are available immediately and specification details remain limited for some devices. For this update, GSA has removed from its counts a number of devices announced to be in development in 2019 but which have not made it to market, as well as in some cases the companies announced as developing those devices. Numbers have been restated to reflect these changes.

Figure 2: Announced 5G devices, by form factor
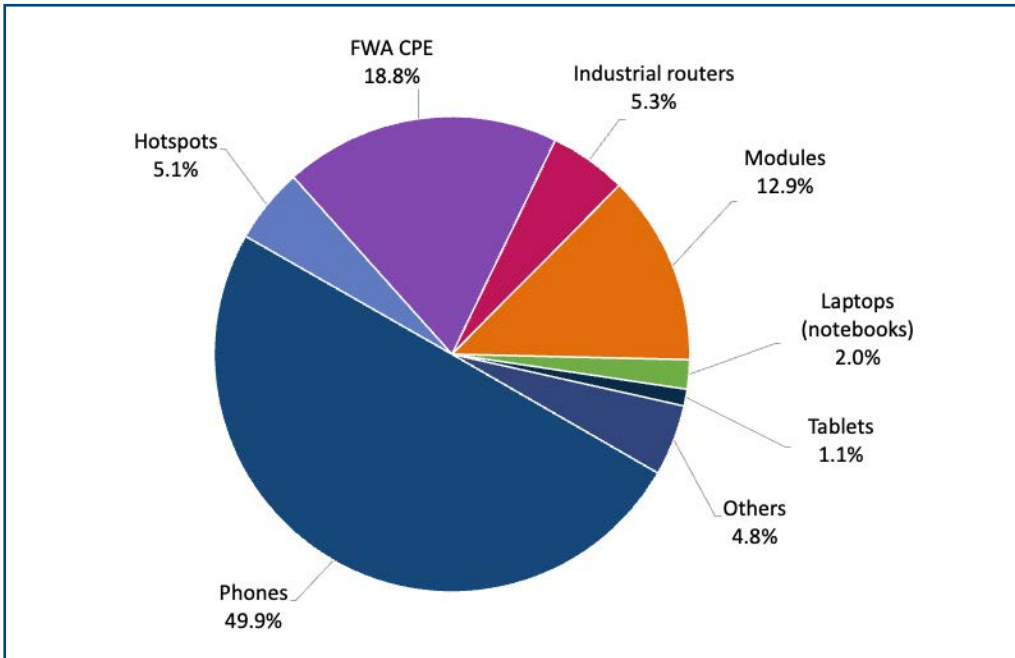
We can expect the device ecosystem to continue to grow quickly and for more information about announced devices to become available as they reach the market. Based on vendors' previous statements and recent rates of device release, we might expect to see the number of commercial devices surpassing the 500 mark by the end of Q2 2021. GSA will be tracking and reporting regularly on these 5G device launch announcements. Its GAMBoD database contains key details about device form factors, features and support for spectrum bands. Summary statistics are released in this regular monthly publication.

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Discounted annual subscription are available to regulators, government agencies and mobile operators.

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GSA

Exhibit F

Excerpts from
GSA LTE, 5G, and 3GPP IoT Chipset Report
(Nov. 2019)

LTE, 5G and 3GPP IoT Chipsets: Status Update

LTE and 5G report based on intelligence gathered as part of GSA's industry research programme

November 2019

Introduction

GSA continuously tracks the mobile industry and reports on adoption of 3GPP standardised technologies and the expansion of the mobile ecosystem. This report complements the broader *Status of the LTE Ecosystem* reports based on the GSA GAMBoD devices database (which covers modules as well as end-user devices of multiple types).

The focus of this report is discrete cellular modem chipsets, mobile processors and platforms used in devices with LTE (and 5G) connectivity, and chipsets designed for devices using 3GPP-defined IoT technologies.

Three vendors have launched 5G chipsets. More are expected to enter the market.

Note that we do not include information on separate baseband processors, DSP chips or separate RF front-end transceivers, nor silicon designed primarily for base stations used as network infrastructure. However, we do include chipsets designed for enterprise and residential small cells and FWA applications as these can be considered devices (femtocells are included in the GAMBoD database). Nor do we track reference designs for complete platforms or discrete components where the vendor has no involvement beyond creation of IP for licensing (e.g. some designs from ARM and CEVA).

Technology background and definitions

Chipset vendors use different terms to describe their products. In this report we define three specific types, as follows.

- **Discrete cellular modem** A modem chipset in a single package designed primarily to handle the transfer of data across the air interface. It will contain the transceiver, filters and power amplifier, and handle signal modulation/demodulation, duplexing modes and carrier aggregation. Modem chipsets are often – but not always – built to support specific regional requirements, in different variants (SKUs, or stock-keeping units): we do not systematically track all variants separately. Generally, a cellular modem chipset will not deliver capabilities such as GNSS positioning or powerful processors for applications or graphics.

- **Mobile processor/platform** A chipset that encompasses a cellular modem along with additional processors to deliver more functionality in a single package. Again, region-specific variants may be produced. Our definition includes chipsets described as 'system on chip' (SoC), and 'single chip' packages as long as they include RF and modem capabilities. The extent of the additional capabilities varies significantly between

models; some, but not all, contain powerful graphics processors for image and video applications. Mobile processors/platforms chipsets may be designed for specific types of devices (such as automotive components, smartphones, tablets or laptops). This category includes chipsets designed for FWA devices (routers, gateways) as well as those for mobile devices.

- **3GPP IoT chipset** A modem or mobile processor/platform designed primarily for use in IoT devices and, in our database, supporting 3GPP IoT-oriented user equipment categories (specifically, LTE Cat-1, Cat-M1 and Cat-NB1/NB2). While capabilities vary, these chipsets do not generally support as full a range of features as other chipsets in our database. Other chipsets may also be used for IoT applications. Note that we do not capture information about uplink/downlink speed separately (3GPP's user equipment (UE) device category definitions state the relevant maximum data rates). Again, we exclude chipsets without RF and modem capabilities.

GSA has identified 24 commercial discrete cellular LTE modem chipsets from six vendors

DL/UL data speeds and UE categories

We have collected data from vendors on stated support for 3GPP LTE UE categories as well as stated maximum peak downlink and uplink speeds. Some, but not all, vendors state both. We have not filled gaps in the DL/UL speeds from stated categories where no speeds are given. UE categories have been assigned on the basis of speeds and other information given, using our best efforts, to ensure that the UE categories fields are as complete as possible.

Spectrum band support

We have not collected spectrum band support data for LTE chipsets in the database; readers should refer to the vendors' own information. However, we do track availability of chipset support for new, emerging bands and those being used for 5G networks. New 5G modems and mobile processors/platforms will often support mmWave frequencies as well as sub-6 GHz frequencies to enable multimode devices.

5G silicon status

Since our last report there has been further activity in the 5G chipset arena.

- Hi-Silicon (Huawei) has launched its first generation 5G-only **Balong 5G01** cellular modem and, more recently, its second generation LTE/5G **Balong 5000** cellular modems. A 5G version of its Kirin processor, the **Kirin 990**, has also been launched.

- Mediatek has announced the **Helio M70** modem and more recently in May 2019 a multi-mode 5G system-on-chip (incorporating the M70 modem). Devices containing the chipset are expected to come to market in 2020.

- Qualcomm has launched the **Snapdragon 855 and 855+** mobile platforms and the **Snapdragon X50** modem. Its x55 modem is coming soon. It also announced its **8cx 5G** platform for laptops And recently confirmed that 5G chips will become available in its Snapdragon 6 and 7 series devices next year.

- Samsung has launched its **Exynos 5100 (S5T5100)** modem and recently announced the Exynos 980 mobile processor and complementary Exynos 5123 modem. Mass production is expected by the end of 2019.

- UNISOC (formerly Spreadtrum) has been widely reported for launching its **IVY510** 5G modem chipset (also called IVYO510 in some literature). In November, it announced that the modem had completed testing in China.

- U-Blox has announced a 5G-upgradeable chipset. Its **UBX-R5 IoT** chipset will be ultimately capable of supporting 5G, but it will need an OTA software upgrade to do this.

Of these, we consider Qualcomm's Snapdragon 855 and 855+ platforms and its X50 modem, the Samsung Exynos 5100 and Hi-Silicon Balong 5G01, and 5000 modems and Kirin 990 processor to be commercially available; all other 5G silicon listed we consider to be at a pre-commercial stage, though some samples may be shipping. The precise commercial status of these chipsets, and of mobile platforms that integrate with these modems, is difficult to confirm. MediaTek says that devices using its Helio M70 modem will be commercially available in 2019; while the SoC is expected to appear in devices in Q1 2020. The Qualcomm X55 modem is available for sampling and is due to be in commercial devices by late 2019.

Intel meanwhile has confirmed its withdrawal from the smartphone modem market. Its previously announced **XMM8060** and **XMM8160** 5G modems will not now be produced. Apple has agreed to acquire the majority of Intel's smartphone modem business. When the transaction closes (expected before the end of 2019), it seems likely that Intel smartphone modems will cease to be commercially available, as Apple does not make its chipsets available to third parties.

Information on performance of 5G chipsets is partial, but the peak downlink speeds for the vendors' top-end commercial 5G modems range from 5000 Mbps (for Qualcomm's X50), to 6000 Gbps (Samsung's Exynos 5100) to 6.5 Gbps (for Hi-Silicon's Balong 5000 using mmWave). Of the pre-commercial modems, Qualcomm's Snapdragon X55 is expected to have a peak theoretical throughput of 7 Gbps; Samsung's Exynos 5123 is expected to have a peak DL throughput of 7.35 Gbps (using mmWave); while Mediatek's Helio M70 is expected to offer 4.7 Gbps DL. Maximum peak theoretical uplink speeds (where we have data) range from 1.5 Gbps to 3.5 Gbps. At least half the commercially available 5G-capable chipsets can support LTE as well as 5G services.

Discrete LTE cellular modems

Excluding 5G-capable chipsets, GSA has counted 24 commercial discrete cellular LTE modem chipsets from six vendors: Hi-Silicon, Intel, Qualcomm, Samsung, Sanechips (formerly ZTE Microelectronics) and UNISOC (formerly Spreadtrum). Other modems are produced but these are integrated with other processors in mobile platforms.

In terms of downlink speeds, the fastest current LTE modem chipsets are:

- Qualcomm's Snapdragon X20 and X24 modems (DL category 18 and 20 respectively; 1.2 Gbit/s and 2 Gbit/s respectively with 5 and 7 carrier aggregation respectively and 256QAM on the downlink).

- Intel's XMM 7560 and 7660 modems (DL category 16 and 19 respectively; 1 Gbit/s and 1.6 Gbit/s respectively, again with 5 and 7 carrier aggregation respectively, with 256QAM modulation on the downlink).

- Hi-Silicon's Balong 765 (DL category 19; 1.6 Gbit/s, with four-channel carrier aggregation, 256QAM DL modulation and 8x8 MIMO on the DL).

Figure 3: Numbers of chipsets supporting 3GPP IoT standards, with percentage of total (32)
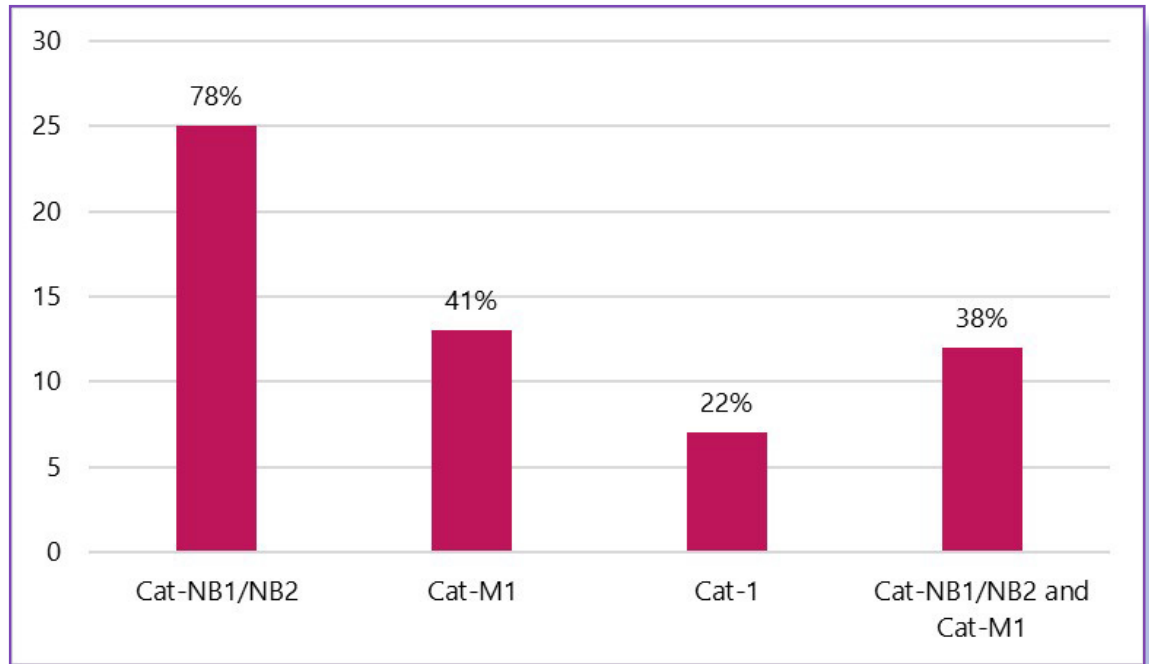
Chipset tables

The tables below list the commercially launched 5G and LTE chipsets analysed for this report. Tables 1 and 2 exclude chipsets designed primarily for 3GPP IoT applications; these are shown in Table 3.

Table 1: Discrete 5G and LTE cellular modem chipsets

Vendor	Model	UE Category (DL)	5G?
Hi-Silicon	Balong 5000	No data	Yes
Hi-Silicon	Balong 5G01	No data	Yes
Hi-Silicon	Balong 700	No data	
Hi-Silicon	Balong 710	4	
Hi-Silicon	Balong 711	4	
Hi-Silicon	Balong 720	6	
Hi-Silicon	Balong 750	12	
Hi-Silicon	Balong 765	19	
Intel	XMM 7160	4	
Intel	XMM 7260/7262	6	
Intel	XMM 7360	10	
Intel	XMM 7480	12	
Intel	XMM 7560	16	
Intel	XMM 7660	19	
Qualcomm	Snapdragon X12	12	
Qualcomm	Snapdragon X16	16	
Qualcomm	Snapdragon X20	18	
Qualcomm	Snapdragon X24	20	
Qualcomm	Snapdragon X5	4	

Vendor	Model	UE Category (DL)	5G?
Qualcomm	Snapdragon X50	No data	Yes
Qualcomm	Snapdragon X7	6	
Samsung	Exynos 5100 (S5T5100)	19	Yes
Samsung	Exynos Modem 303	6	
Samsung	Exynos Modem 333	10	
Samsung	Exynos Modem 359		
Sanechips Technology	ZX297510	4	
Sanechips Technology	ZX297520	4	
UNISOC	SC9620	4	

Table 2: LTE and 5G mobile processors/platforms

Vendor	Model	UE Category (DL)	5G?
Altair Semiconductor	Alt3800	4	
Altair Semiconductor	Alt4800	12	
GCT	GDM7243A	15	
GCT	GDM7243Q Quad	7	
GCT	GDM7243QT	7	
GCT	GDM7243S	4	
GCT	GDM7243ST	4	
Hi-Silicon	Kirin 620	4	
Hi-Silicon	Kirin 650	7	
Hi-Silicon	Kirin 655	6	
Hi-Silicon	Kirin 658	6	
Hi-Silicon	Kirin 659	13	
Hi-Silicon	Kirin 710	12	
Hi-Silicon	Kirin 810	12	
Hi-Silicon	Kirin 910	4	
Hi-Silicon	Kirin 920	6	
Hi-Silicon	Kirin 930	6	
Hi-Silicon	Kirin 950	6	
Hi-Silicon	Kirin 960	12	
Hi-Silicon	Kirin 970	18	
Hi-Silicon	Kirin 980	21	
Hi-Silicon	Kirin 990	No data	
Hi-Silicon	Kirin 990 5G	No data	**Yes**
Innofidei	Warp Drive 5000	4	
Intel	Atom x3-M7272	6	
Leadcore	InnoPower LC1860	4	
Leadcore	InnoPower LC1860C	4	
Mediatek	Helio A20	6	
MediaTek	Helio A22	4	
Mediatek	Helio G90	12	
MediaTek	Helio P10	6	
MediaTek	Helio P18	6	
MediaTek	Helio P20	6	

About GSA

GSA (the Global mobile Suppliers Association) is a not-for-profit industry organisation representing companies across the worldwide mobile ecosystem engaged in the supply of infrastructure, semiconductors, test equipment, devices, applications and mobile support services.

GSA actively promotes the 3GPP technology road-map – 3G, 4G, 5G – and is a single source of information resource for industry reports and market intelligence. GSA Members drive the GSA agenda and define the communications and development strategy for the Association.

Membership of GSA is open to any supplier of products; systems or services related to the mobile industry and brings many benefits including access to the GAMBoD and NTS database. The range of benefits includes enhanced discussion, networking and influencing opportunities on the key industry topics, and unique promotional/visibility opportunities for your company name, capabilities, positioning and messages. More details can be found at https://gsacom.com/gsa-membership/

News/updates: RSS Feed: https://gsacom.com/rss-feeds/

GSA LinkedIn group: www.linkedin.com/groups?gid=2313721

LTE User Devices LinkedIn group: www.linkedin.com/groups?gid=4146472

LTE-Unlicensed LinkedIn group: www.linkedin.com/groups/8601576

Twitter: www.twitter.com/gsacom

Facebook: https://www.facebook.com/Global-mobile-Suppliers-Association-GSA-123462771012551/

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Exhibit G

GSA LTE, 5G, and 3GPP IoT Chipset Report
(Sep. 2020)

LTE, 5G & 3GPP IoT
CHIPSET REPORT:

Status Update September 2020

GSA

Introduction

GSA continuously tracks the mobile industry and reports on adoption of 3GPP standardised technologies and the expansion of the mobile ecosystem. This report complements the broader Status of the LTE Ecosystem reports based on the GSA GAMBoD devices database (which covers modules as well as end-user devices of multiple types).

The focus of this report is discrete cellular modem chipsets, as well as mobile processors, SoCs and platforms (only those containing modems) used in devices with LTE (and 5G) connectivity, as well as chipsets designed for devices using 3GPP-defined IoT technologies.

Note that we do not collate information on separate baseband processors, DSP chips or separate RF front-end transceivers, nor silicon designed primarily for base stations used as network infrastructure. However, we do include chipsets designed for enterprise and residential small cells and FWA applications, as these can be considered devices (femtocells are included in the GAMBoD database). Nor do we track reference designs for complete platforms or discrete components where the vendor is not involved beyond creation of IP for licensing.

5G silicon status

There is an increasing choice of chipsets for 5G devices, with products commercially available from Hi-Silicon (Huawei), Mediatek, Qualcomm, Samsung and UNISOC (formerly Spreadtrum).

All five players have been expanding their product ranges.

By September 2020, GSA had identified 20 commercially available 5G mobile processors/platforms and eight commercially available discrete 5G modems from the five semi-conductor companies mentioned above. In addition, GSA had identified two pre-commercial 5G modems. The maximum peak theoretical speed claimed to be offered by any of the commercial discrete 5G modems currently reaches 7.5 Gbps DL and 3.67 Gbps UL.

A full list of commercially available and pre-commercial 5G mobile processors/platforms and discrete 5G modems is available in GSA's GAMBoD database, updated in September 2020.

A clear market trend has been the recent rise in the number of mobile processors/platforms, using the available 5G modems.

Figure 1: Commercially available 5G modem chipsets, end 2018 to present
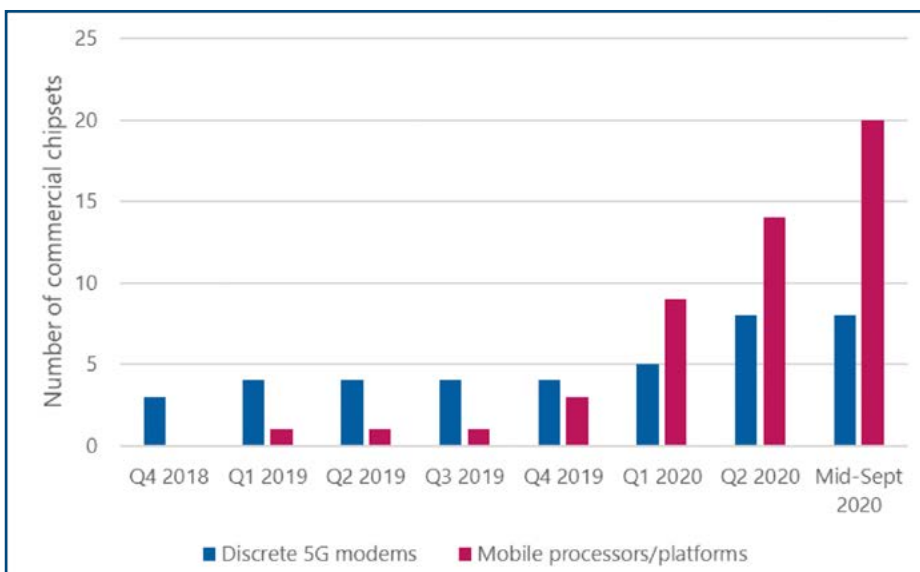
5G silicon status

There is an increasing choice of chipsets for 5G devices, with products commercially available from Hi-Silicon (Huawei), Mediatek, Qualcomm, Samsung and UNISOC (formerly Spreadtrum).

LTE mobile processors/platforms

Commercially launched LTE mobile processors/platforms comprise the largest category of chipsets in the GSA database; we have counted 159 (other than those specifically designed for IoT applications and excluding those capable of 5G) from 12 vendors: Altair Semi-conductor, GCT, Hi-Silicon, Innofidei, Leadcore, MediaTek, Qualcomm, Renesas Mobile, Samsung, Sequans, UNISOC and Xiaomi.

A number of other mobile processors/platforms from GCT, Hi-Silicon, MediaTek, Qualcomm and UNISOC are still at the pre-commercial stage and not included in our analysis.

Our total of commercial LTE mobile processors/platforms includes some market-specific variants (such as chipsets designed to meet automotive industry standards), but regional/band-specific variants are not systematically captured in the database.

Figure 2: Support for eMBMS and VoLTE[1]

[1] Numbers restated since last report, as they now include 5G chipsets

VoLTE, eMBMS and unlicensed spectrum support

GSA is tracking the ecosystem for specific LTE features. Figure 3 shows the number of commercially available mobile processors/platforms and discrete cellular modems, supporting VoLTE and eMBMS (LTE Broadcast/Multicast).

The numbers of mobile processors/platforms and discrete cellular modems identified by GSA to support LTE in unlicensed spectrum – LAA – are fifteen and four, respectively. Ten mobile processors/platforms and one discrete cellular modem have now also been identified as supporting CBRS.

Discrete LTE cellular modems

Excluding 5G-capable chipsets, GSA has counted 19 commercially available discrete cellular LTE modem chipsets from five vendors: Hi-Silicon, Qualcomm, Samsung, Sanechips (formerly ZTE Microelectronics) and UNISOC. This number has not changed since our previous issue of this report. Other modems are produced but these are integrated with other processors in mobile platforms.

In terms of downlink speeds, the fastest current LTE modem chipsets are:

- Qualcomm's **Snapdragon X20** and **X24** modems (DL category 18 and 20 respectively; 1.2 Gbps and 2 Gbps respectively with five- and seven-channel carrier aggregation respectively and 256QAM on the downlink).

- Hi-Silicon's **Balong 765** (DL category 19; 1.6 Gbps, with four-channel carrier aggregation, 256QAM DL modulation and 8x8 MIMO on the DL).

Other modems are also powering fast mobile platforms such as the **Samsung Exynos 9 Series (9820)** and **Hi-Silicon's Kirin 980** which support downlink speeds of 2 Gbps and 1.4 Gbps respectively. Six other mobile platforms (from Hi-Silicon, Qualcomm and Samsung) all support DL speeds of 1 to 1.2 Gbps.
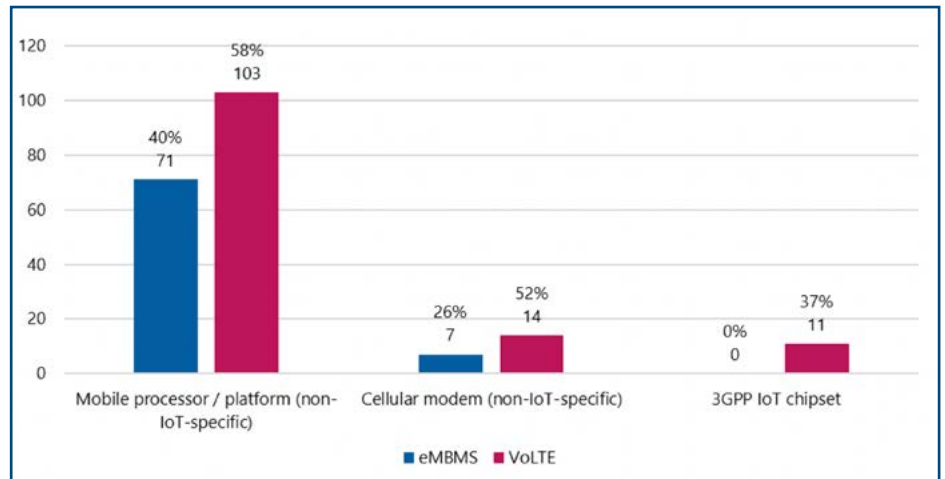
3GPP IoT chipsets

GSA has identified 30 chipsets (modem chipsets and integrated processors/platforms) designed specifically to address M2M and IoT applications and which support any of LTE Cat-1, Cat-M1 and Cat-NB1/NB2 user equipment.

Figure 3 shows the percentage of chipsets supporting UE Cat-NB1/NB2, Cat-1 and Cat-M1.
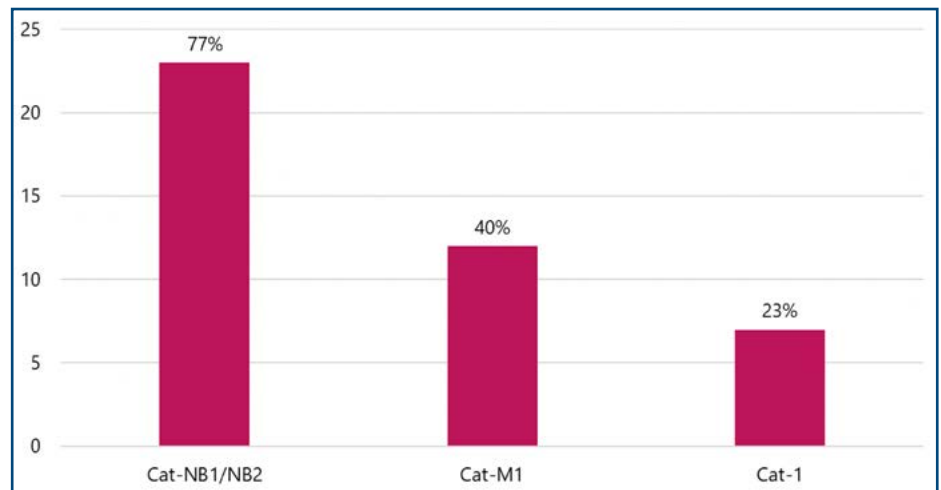
Chipset outlook

The number of 5G chipsets looks set to increase steadily during 2020 with new modems and mobile processors/platforms due from a number of players. Meanwhile, the variety of LTE chipsets has also continued to increase (despite the withdrawal of a major player from the market).

A full list of commercially available and pre-commercial 5G mobile processors/platforms and discrete 5G modems is available to subscribers in the new chipset section of GSA's GAMBoD database, updated in September 2020.

Contact admin@gsacom.com for more information.

We intend to continue to update the chipset database and this report; additions or correction are welcomed. Please contact research@gsacom.com.

Figure 3: Numbers and percentage of 3GPP IoT chipsets supporting the different 3GPP IoT standards (base 30 chipsets, each potentially counted more than once)

ABOUT GSA

GSA is the voice of the global mobile ecosystem and has been representing mobile suppliers since 1998.

GSA GAMBoD Database

Reports are based on data contained in the GSA GAMBoD databases which is a resource available to GSA Members and Associates. Companies and policy makers can subscribe as a GSA Associate to the database to gain insights into the source data behind reports for their own research purposes.

Discounted annual subscription are available to regulators, government agencies and mobile operators.

Please email info@gsacom.com for more information.

GSA

Exhibit H

GSA LTE, 5G, and 3GPP IoT Chipset Report
(Jan. 2021)

LTE, 5G & 3GPP IoT
CHIPSET REPORT:

**Status Update
January 2021**
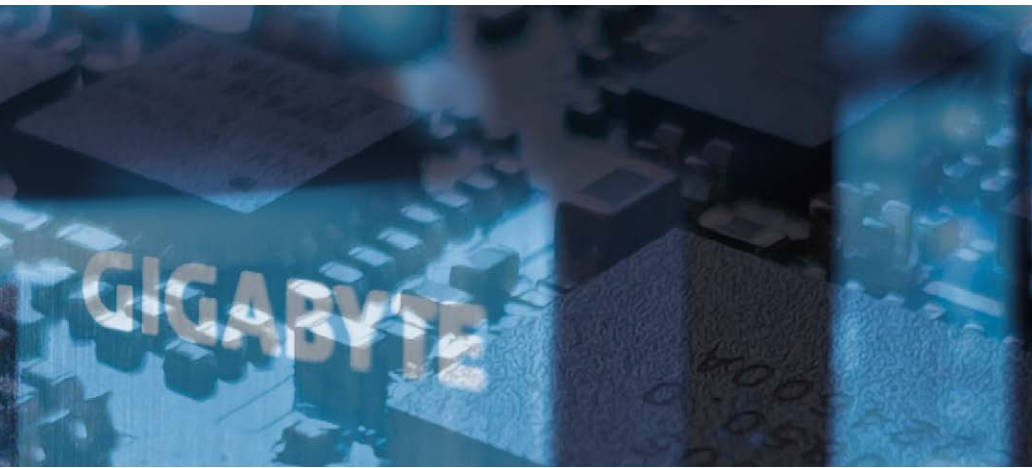
Introduction

In the past year, the market for cellular modem chipsets has evolved quickly, with 5G chipsets in particular becoming more widely available. In fact, the number of discrete 5G modems more than doubled in 2020 and the number of 5G processors/platforms grew nine-fold! At the same time, the choice of LTE and 3GPP IoT chipsets has also continued to expand.

GSA's online GAMBoD database now includes the ability to search for chipsets and selected features by company and by chipsets type. This paper highlights the current state of the cellular modem chipset market based on the data in the database.

The focus of this report is discrete cellular modem chipsets, as well as mobile processors, SoCs and platforms (only those containing modems) used in devices with LTE (and 5G) connectivity, plus chipsets designed for devices using 3GPP-defined IoT technologies.

Note that we do not collate information on separate baseband processors, DSP chips or separate RF front-end transceivers, nor silicon designed primarily for base stations used as network infrastructure. However, we do include chipsets designed for enterprise and residential small cells and FWA applications, as these can be considered devices (femtocells are included in the GAMBoD database). Nor do we track reference designs for complete platforms or discrete components where the vendor is not involved beyond creation of IP for licensing.

5G silicon status

There is an increasing choice of chipsets for 5G devices, with products commercially available from Hi-Silicon (Huawei), Mediatek, Qualcomm, Samsung and Tsinghua Unigroup (UNISOC, and formerly Spreadtrum).

All five players have been expanding their product ranges.

By January 2021, GSA had identified 29 commercially available 5G mobile processors/platforms and 11 commercially available discrete 5G modems from the five semi-conductor companies mentioned above. In addition, GSA had identified one pre-commercial 5G modem and three pre-commercial 5G processors/platforms.

A full list of commercially available and pre-commercial 5G mobile processors/platforms and discrete 5G modems is available in GSA's GAMBoD database, updated in January 2021.

A clear market trend has been the recent rise in the number of mobile processors/platforms, using the available 5G modems.

Figure 1: Commercially available 5G modem chipsets, end 2018 to present
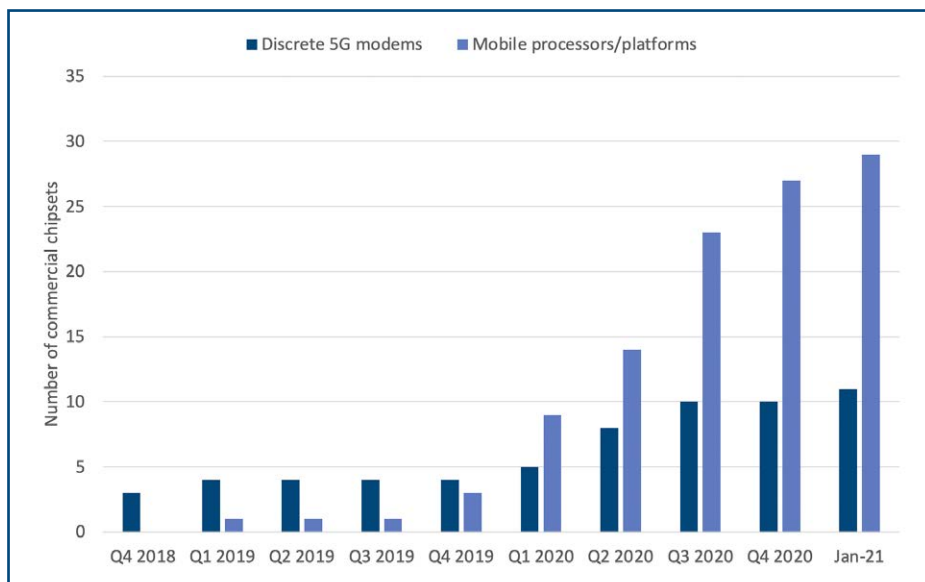
LTE silicon status

Excluding the 5G-capable chipsets that are also capable of supporting LTE, GSA has recorded 19 commercially available discrete cellular LTE modem chipsets from five vendors: Hi-Silicon, Qualcomm, Samsung, Sanechips (formerly ZTE Microelectronics) and Tsinghua Unigroup (UNISOC, and formerly Spreadtrum). Other modems are produced but these are integrated with other processors in mobile platforms.

Commercially launched LTE mobile processors/platforms comprise the largest category of chipsets in the GSA database; we have counted 178 (other than those specifically designed for IoT applications and excluding those capable of 5G) from 11 vendors: GCT, Hi-Silicon, Innofidei, Leadcore, MediaTek, Qualcomm, Samsung, Sequans, Sony Semiconductor Israel (formerly Altair Semiconductor), Tsinghua Unigroup (UNISOC, and formerly Spreadtrum) and Xiaomi.

A number of other mobile processors/ platforms from GCT, Qualcomm and Tsinghua Unigroup (UNISOC, and formerly Spreadtrum) are still at the pre-commercial stage and not included in our analysis.

VoLTE, eMBMS and unlicensed spectrum support

GSA is tracking the ecosystem for specific LTE features. Figure 2 shows the number of commercially available mobile processors/ platforms and discrete cellular modems, supporting VoLTE and eMBMS (LTE Broadcast/Multicast).

The numbers of mobile processors/ platforms and discrete cellular modems identified by GSA to support LTE in unlicensed spectrum – LAA – are seventeen and five, respectively. Fourteen mobile processors/platforms and two discrete cellular modems have now also been identified as supporting CBRS.

Figure 2: Support for eMBMS and VoLTE[1]
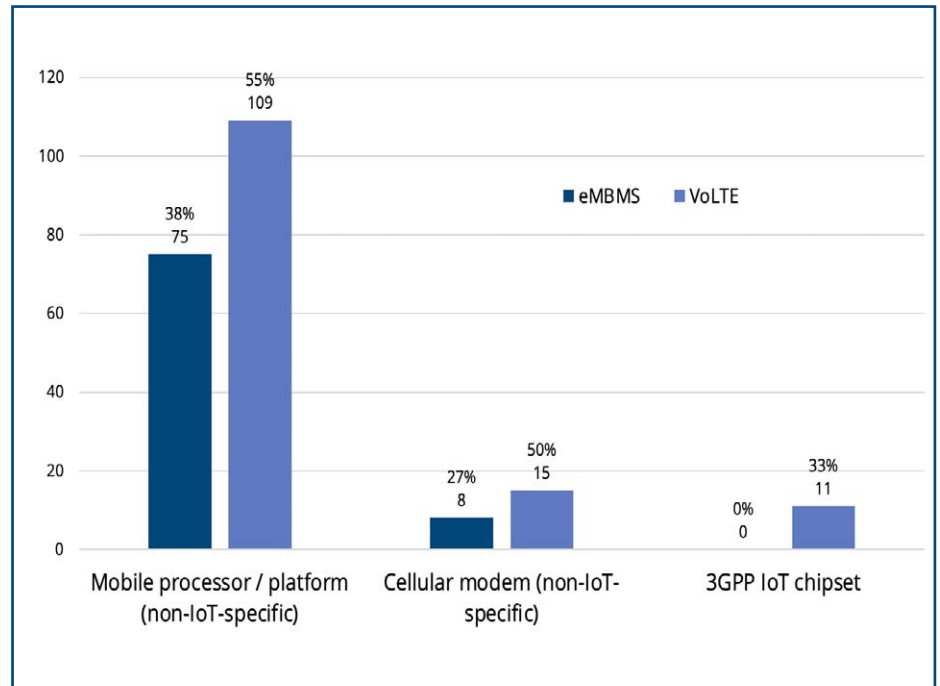
¹ Numbers restated since last report, as they now include 5G chipsets

3GPP IoT chipsets

GSA has identified 36 chipsets designed specifically to address M2M and IoT applications and which support any of LTE Cat-1, Cat-M1 and Cat-NB1/NB2 user equipment.

Figure 3 shows the percentage of chipsets supporting UE Cat-NB1/NB2, Cat-1 and Cat-M1.

Chipset outlook

The number of 5G chipsets looks set to increase steadily during 2021 with new modems and mobile processors/platforms due from a number of players. This will continue to underpin the increasingly broad choice of commercially available 5G devices.

A full list of the identified commercially available and pre-commercial LTE and 5G mobile processors/platforms and discrete modems is available, along with data on 3GPP IoT chipsets, to subscribers in the new chipset section of GSA's GAMBoD database last updated in January 2021.

Data fields available (where information is publicly available) include:

· Chipset name

· Vendor

· Chipset type

· Commercial status

· Network support

· 5G capabilities (NSA or SA, Sub-6 GHz or mmWave, 5G carrier aggregation)

· Max DL and UL speeds

· LTE UE Cat rating

· Devices containing the chipset (5G chipsets and devices only)

· Dual SIM capability

· Support for MIMO, QAM, dynamic spectrum sharing

· Support for VoLTE, VoWiFi or VoNR

· Support for CBRS

· Support for Cat-0, Cat-1, Cat-M1, or Cat NB1/NB2

· Support for C-V2X or eMBMS.

Contact **admin@gsacom.com** for more information.

We intend to continue to update the chipset database and this report; additions or correction are welcomed. Please contact **research@gsacom.com**.

Figure 3: Numbers and percentage of 3GPP IoT chipsets supporting the different 3GPP IoT standards (base 36 chipsets, each potentially counted more than once)

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Exhibit I

Excerpts from
GSA Status of the LTE Ecosystem Report
(June 2019)

Status of the LTE Ecosystem

Prepared by GSA based on data from the GSA Analyser for Mobile Broadband Devices (GAMBoD)

June 2019

Outline

GSA (Global mobile Suppliers Association) monitors and researches worldwide mobile broadband developments and publishes facts, statistics and trends. This report confirms 14,520 LTE user devices identified as launched, from 710 manufacturers, and provides an analysis of the main developments and trends. This new total is 25% higher than the number of devices reported by GSA in June 2018. This report covers LTE FDD and TDD (TD-LTE) models and LTE-related cellular IoT devices standardised by 3GPP as UE Cat-M1/M2 and UE Cat-NB1/NB2.

LTE user devices

There are 752 operators with commercially launched mobile or broadband fixed wireless access networks (GSA: *NTS Database June 2019*). There were 4.4 billion LTE subscriptions globally by the end of Q1 2019 (Ovum WCIS provided to GSA in June 2019). LTE accounts for just over 50% of mobile subscriptions globally.

There are 14,520 LTE user devices including frequency and operator variants from 710 suppliers verified in GSA's GAMBoD database – a 25% increase since June 2018. The number of devices has continued to grow rapidly – at an average growth rate of 2,975 devices per year for the past three years.

Figure 1: LTE user devices growth (count of devices in database)
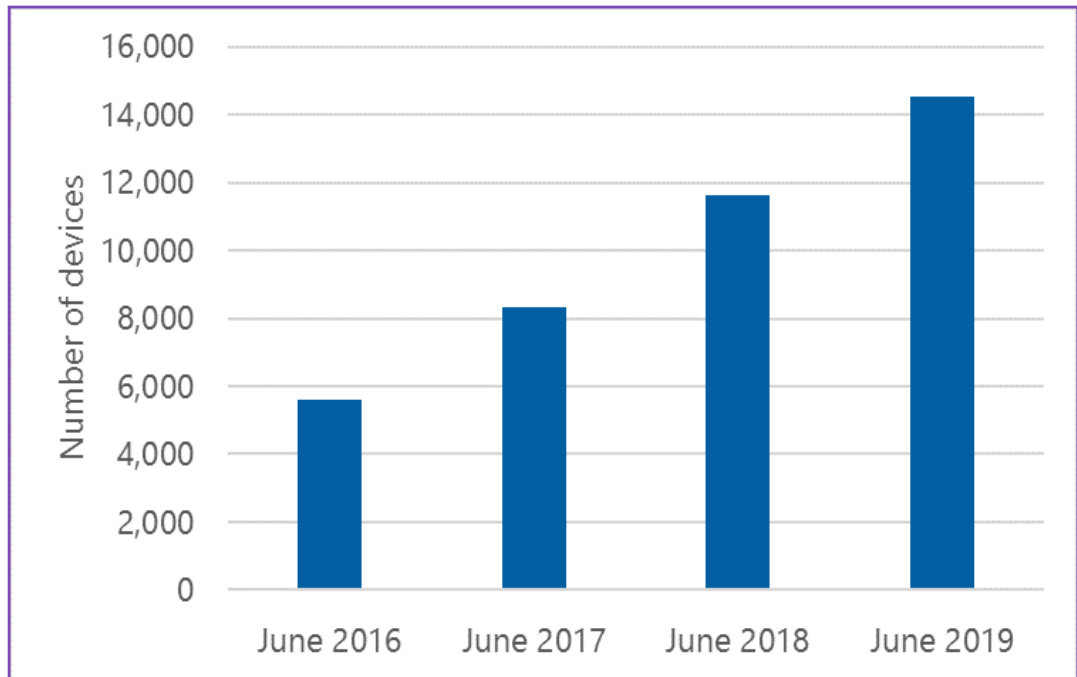
Form factor

The phone form factor has the largest ecosystem with 9,230 phones announced, including operator and frequency variants, giving a 63.6% share of all LTE devices. The LTE router, LTE-connected tablet PC and LTE module segments (2,570; 1,016 and 959 devices respectively) are also large. USB modems are the next largest group at 307 devices identified. Other categories being tracked include asset trackers (98), notebooks (94), cameras (49), smart watches (48), femtocells (41), fixed wireless terminals/phones (25), as well as car hotspots, drones, indoor and outdoor CPE, kiosk terminals, PC cards, POS machines, projectors, smart home devices, vehicle accessories, vehicle on-board units and voice translators.

Figure 2: 14,520 LTE user devices by form factor, June 2019
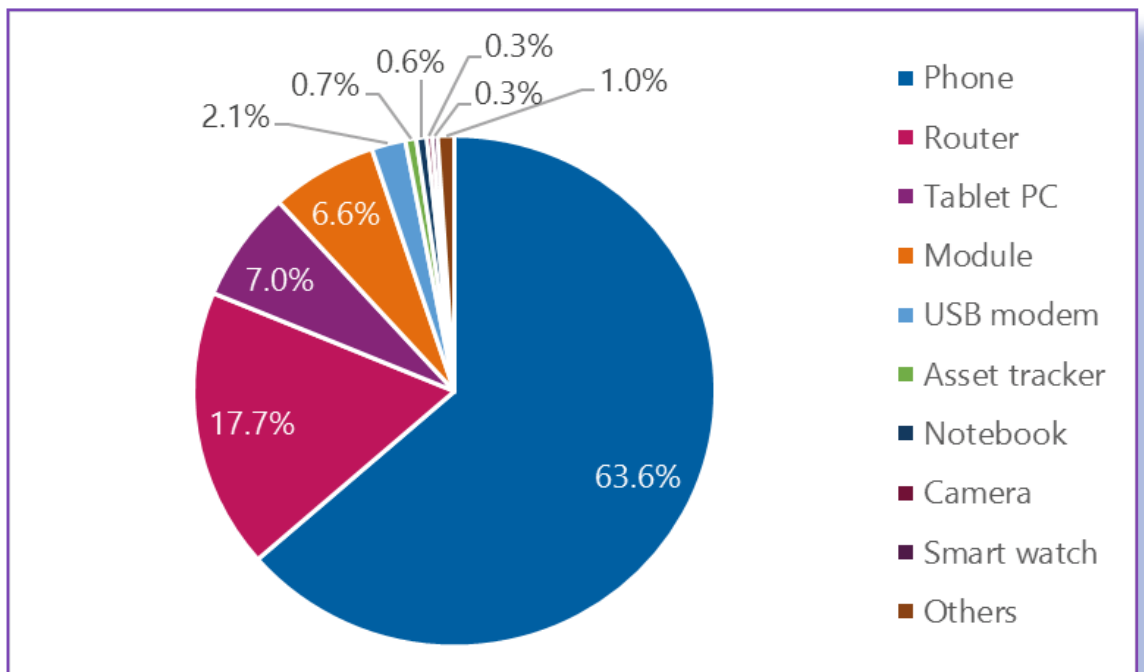
9,230 LTE phones, 2,570 LTE routers, 1016 LTE tablets and 959 LTE modules have been launched

LTE device frequency bands

Most devices operate in the FDD mode (13,401 devices out of 14,520 – over 92%), while the number of terminals that support LTE TDD (TD-LTE) continues to grow: 6,313 (43.5% of) LTE devices support the LTE TDD (TD-LTE) mode.

LTE networks are operating commercially in many bands. Table 1 (LTE-FDD) and Table 2 (LTE-TDD) confirm the frequency bands that are most supported by the devices ecosystem.

About GSA

GSA reports are compiled from data stored in the GSA Analyser for Mobile Broadband Devices/Data (GAMBoD) database, which is a GSA Member and Associate benefit. For more information on accessing the GSA GAMBoD database please contact GSA at info@gsacom.com

GSA (the Global mobile Suppliers Association) is a not-for-profit industry organisation representing companies across the worldwide mobile ecosystem engaged in the supply of infrastructure, semiconductors, test equipment, devices, applications and mobile support services.

GSA actively promotes the 3GPP technology road-map – 3G, 4G, 5G – and is a single source of information resource for industry reports and market intelligence. GSA Members drive the GSA agenda and define the communications and development strategy for the Association.

Membership of GSA is open to any supplier of products; systems or services related to the mobile industry and brings many benefits including access to the GAMBoD and NTS database. The range of benefits includes enhanced discussion, networking and influencing opportunities on the key industry topics, and unique promotional/visibility opportunities for your company name, capabilities, positioning and messages. More details can be found at https://gsacom.com/gsa-membership/

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NOTE: Errors and omissions excepted