acal bfi Developing an enhanced technological future together

4G-5G Mobile Broadband & IoT
User equipment, hardware and systems

Acal BFi Nordic

2023-05-16

hans.andersson@acalbfi.se ; paivi.estakari@acalbfi.fi

acal bfi

- Introduction
- 2G-3G sunset
- 4G and 5G networks and devices overview
- 5G technology and evolution
- 4G and 5G devices
- Thoughts from a birds perspective
- Summary, Questions
- End

Wireless IoT for digital transformation

5G-NR
4G-LTE
LTE LPWA
cat M1, NB2/NB-IoT

WiFi, Bluetooth, LoRa
GNSS, Navigation
Antennas

RF Semiconductors
Thermal imaging
Sensors

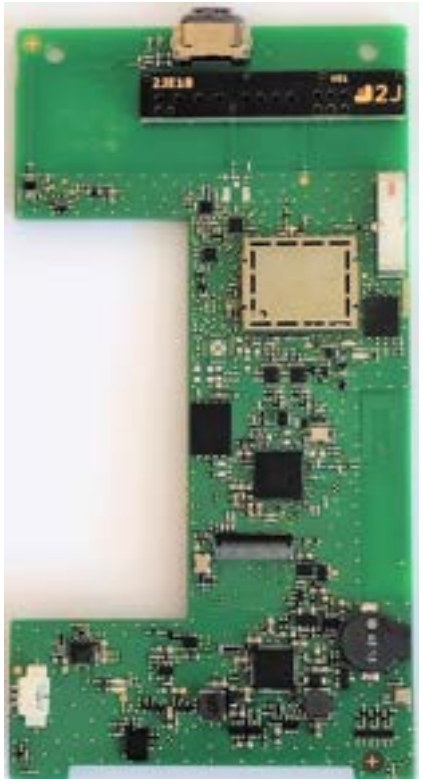
Device-to-Cloud
Connectivity (SIMs)
Device Management

European technology centres

IoT & Wireless technology centre

- Engineers with extensive R&D and RF experience
- Equipment for RF R&D in-house

- RF application support
- Design review
- Antenna matching
- Reference design



Customer project

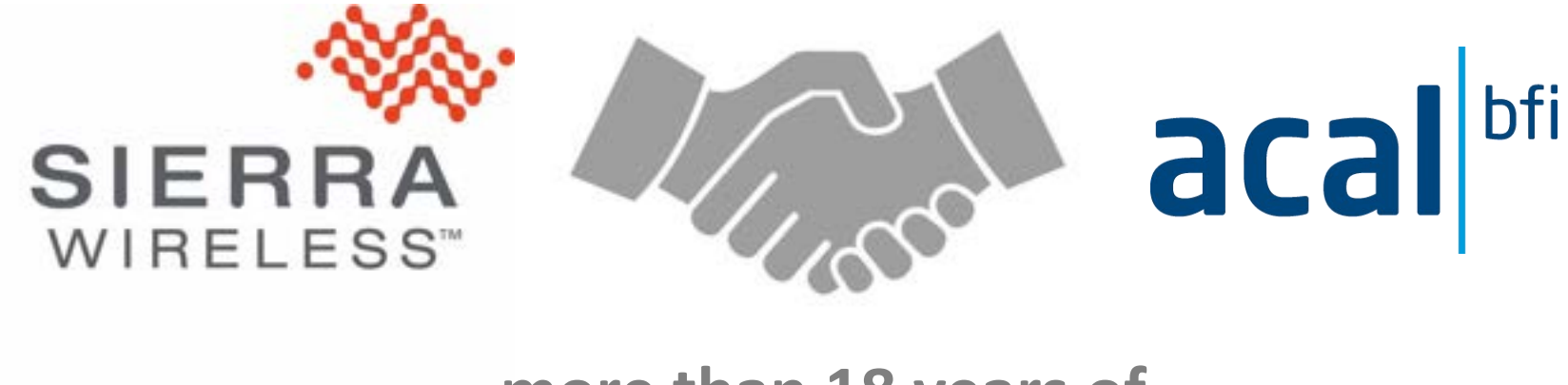
Radio
4G LTE cat M1/NB1
GNSS
BLE
RFID

Sensors
IMU, Light, Humidity, Pressure, Temperature

System
uP & Memory
Display
Buzzer
Power & Battery

Single sided PCBA
114 x 60 mm

Long experience with wireless and cellular



more than 18 years of
successful partnership

acal bfi

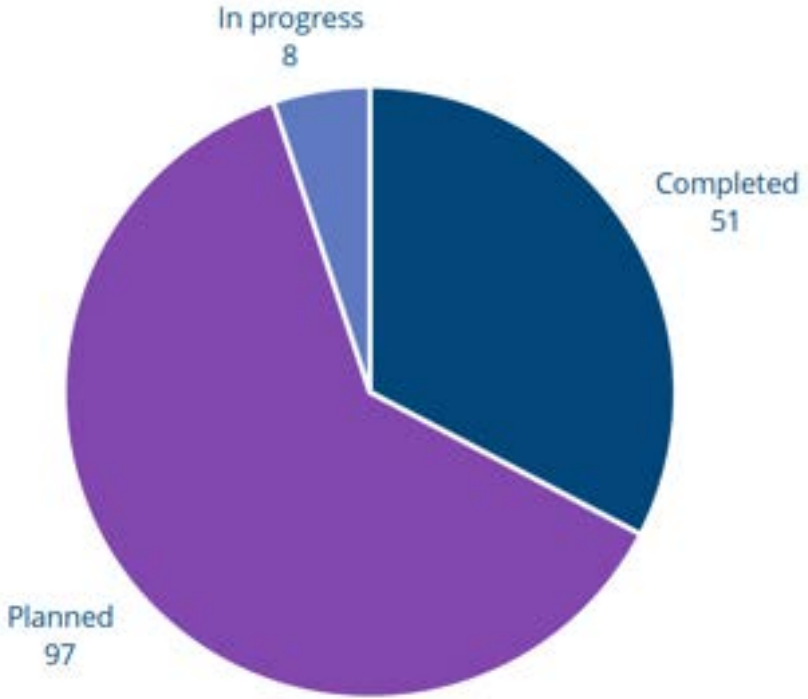
3GPP Cellular

2G, 3G, 4G, 5G

GSM, GPRS, WCDMA, LTE, HSPA, LPWA, MTC, LTE-M, NB-IoT, 5G-NR

2G and 3G Sunsets

October 2022 update

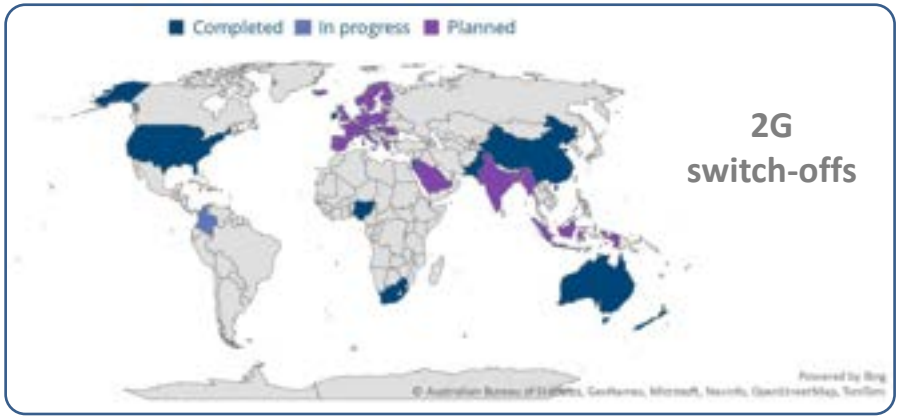


Count of network operators that have completed, planned or are in progress with 2G and 3G switch-offs.

Source : GSA, October 2022

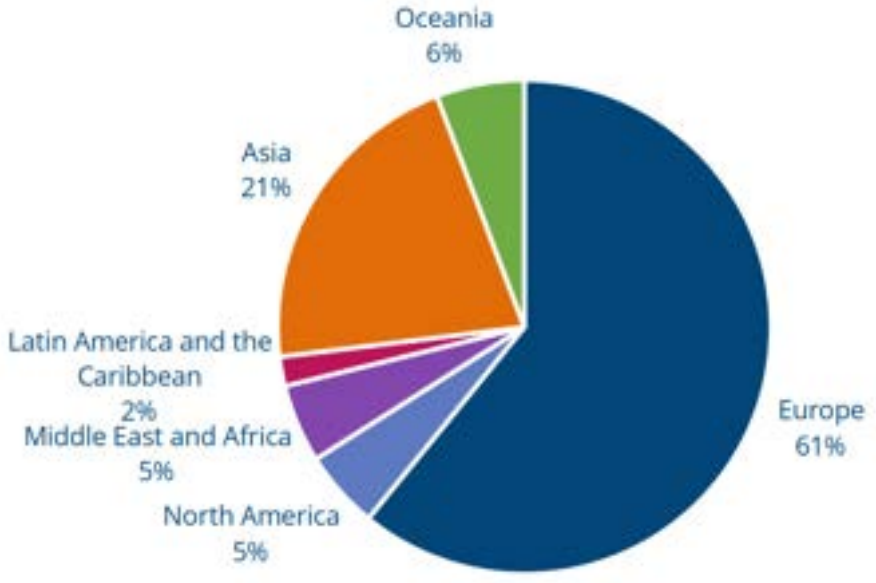
2G and 3G network switch-offs by region

October 2022 update



2G switch-offs

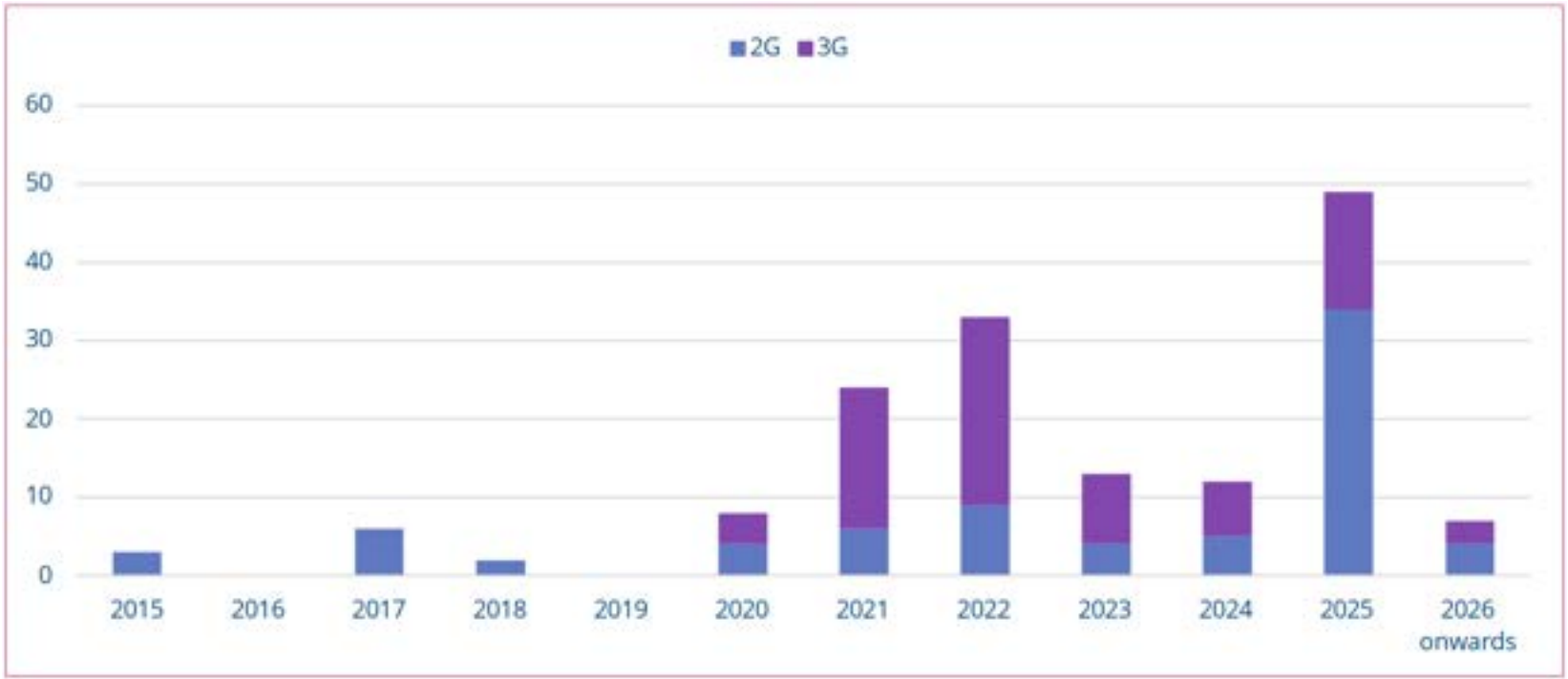
3G switch-offs



Source : GSA, October 2022

2G and 3G Sunset

October 2022 update



2G and 3G network switch-offs by year

Source : GSA, October 2022

2G and 3G Sunset

July 2022 update

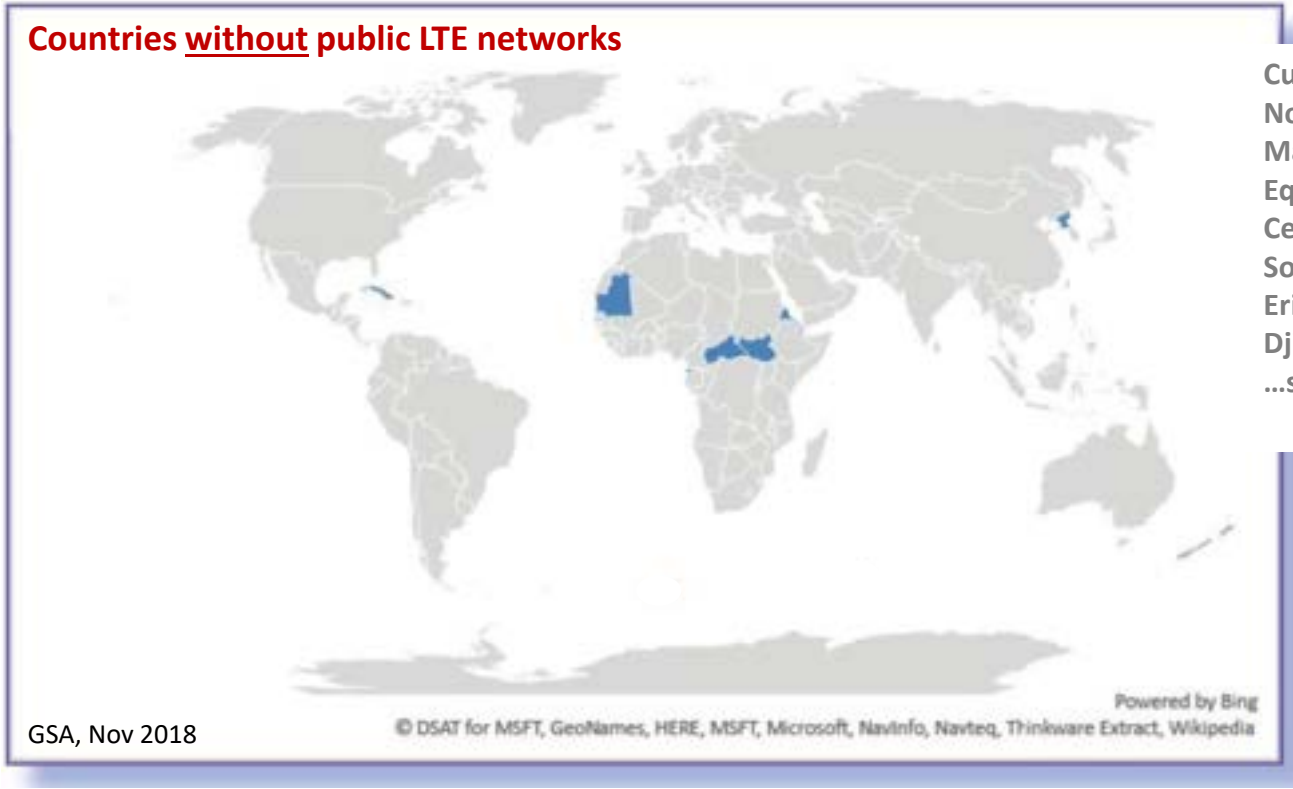
2025

Source : GSA, July 2022

acal bfi

4G-LTE & 5G-NR

LTE Not-spots November 2018



Cuba
North Korea
Mauretania
Equatorial Guinea
Central African Republic
South Sudan
Eritrea
Djibouti
…some remote islands

LTE Not-spots December 2022

Countries without public LTE networks

GSA, Dec 2022

North Korea
Central African Republic
Eritrea
…some remote islands

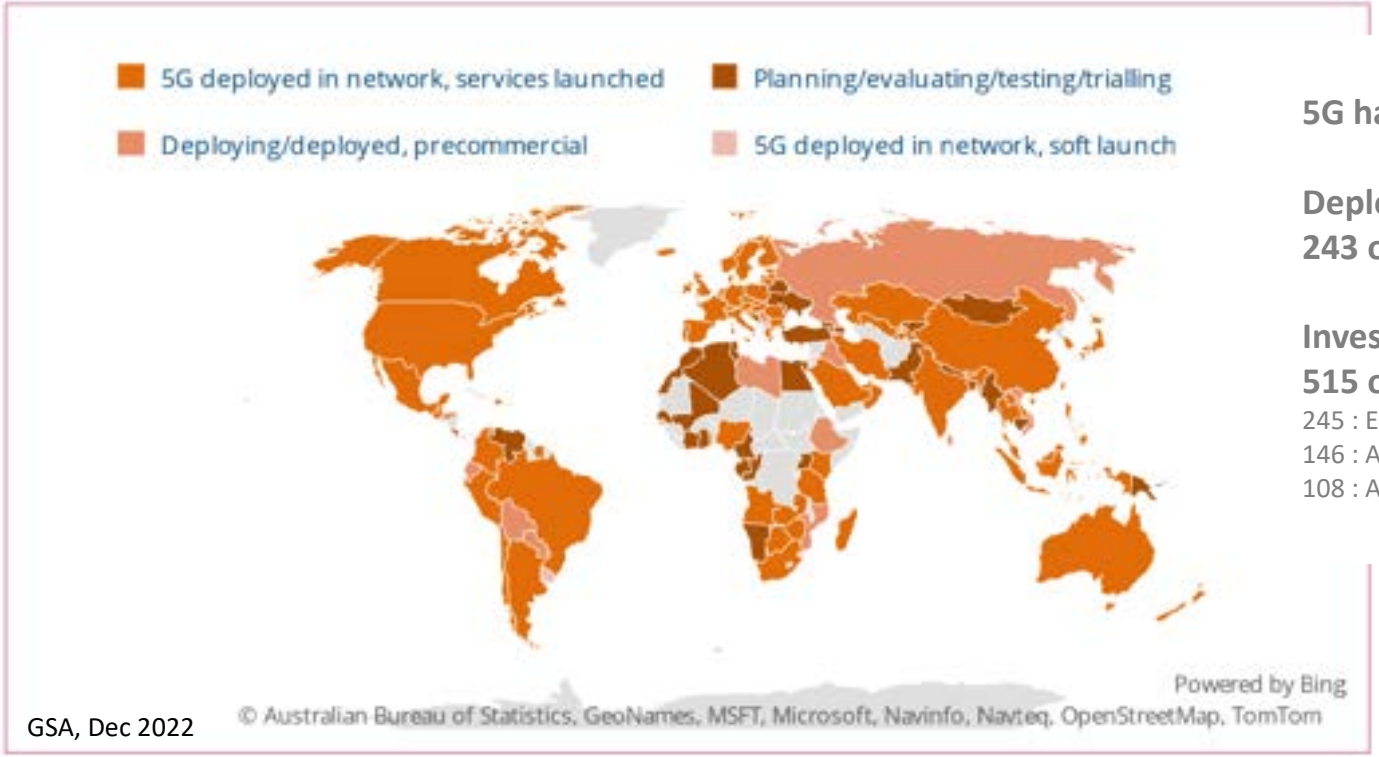
LTE has >6,6 billion subscribers
expected peak at ~7 billion 2023

Deployed networks,
817 operators in 242 countries

Investing,
980 operators in 245 countries

5G-NR deployments

December 2022 update



GSA, Dec 2022

5G had ~1 billion subs end 2022

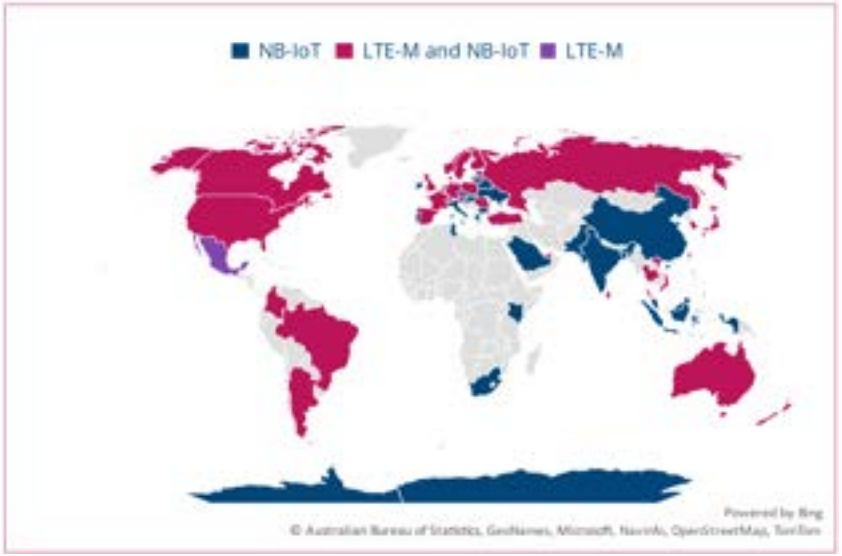
Deployed networks,
243 operators in 96 countries

Investing,
515 operators in 155 countries

245 : EMEA
146 : Americas
108 : APAC

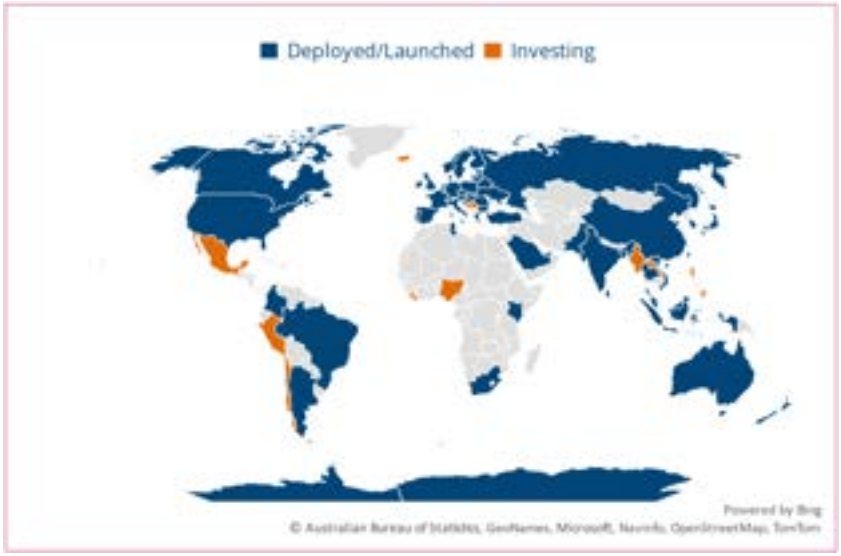
LTE-M and NB-IoT deployments

March 2023



Live and planned networks,

- **180 operators in 81 countries**
- **NB-IoT : 125 operators**
- **LTE-M : 56 operators**



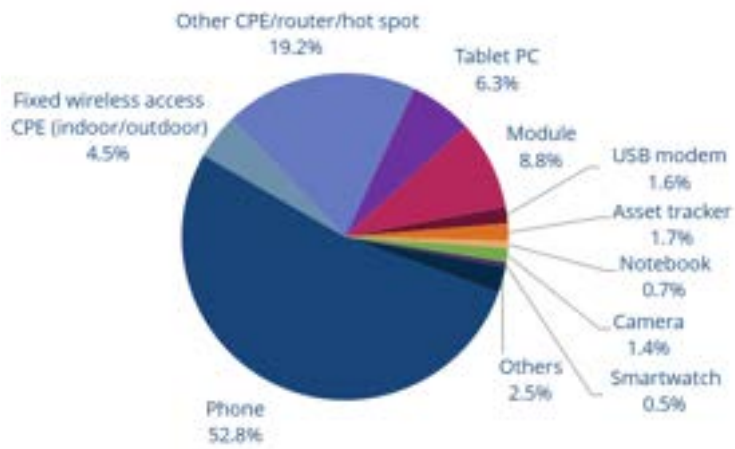
Investing,

- **NB-IoT : 168 operators in 102 countries**
- **LTE-M : 76 operators in 42 countries**

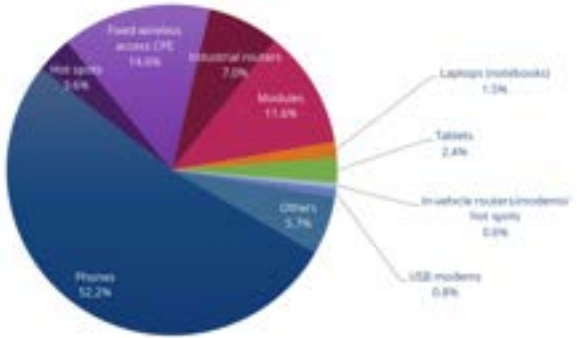
4G & 5G devices

GSA : 2023-Q1

4G-LTE



5G-NR



More than **22,000** LTE devices catalogued

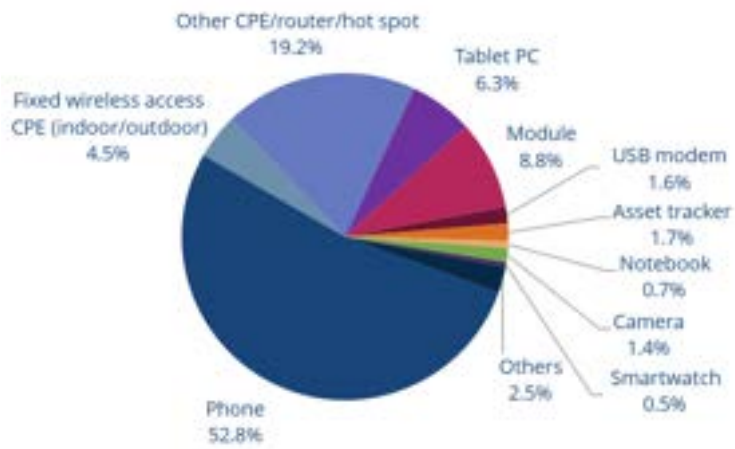
At least **1,750** 5G devices recorded

More than **1,150** device vendors tracked

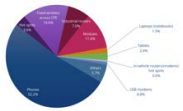
4G & 5G devices

GSA : 2023-Q1

4G-LTE



5G-NR



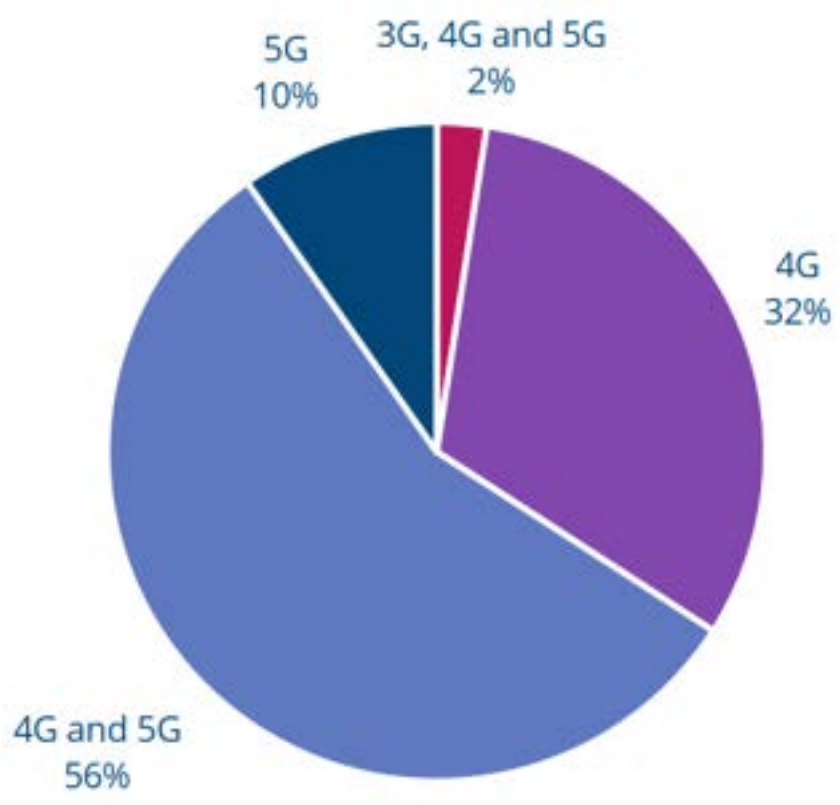
More than **22,000** LTE devices catalogued

At least **1,750** 5G devices recorded

More than **1,150** device vendors tracked

Operators are upgrading networks

October 2022 update



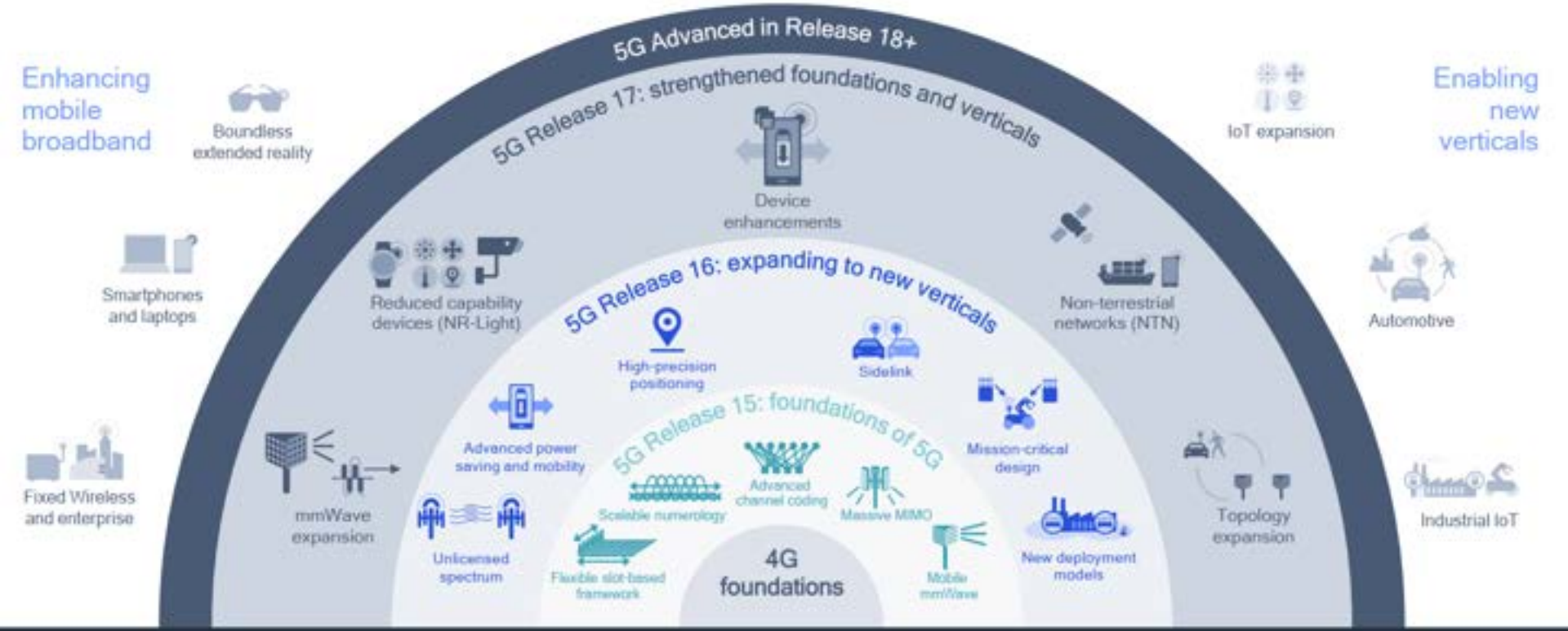
Source : GSA, October 2022

acal bfi

5G is designed to co-exist with 4G

4G will be around for a long, long time

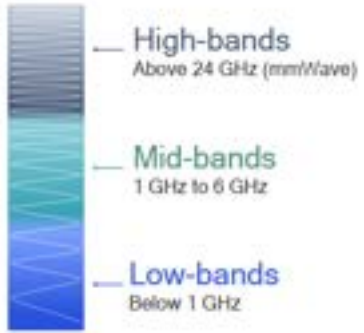
5G evolution



Source : Qualcomm

5G-NR is a unified, more capable air interface

Diverse services



Diverse spectrum

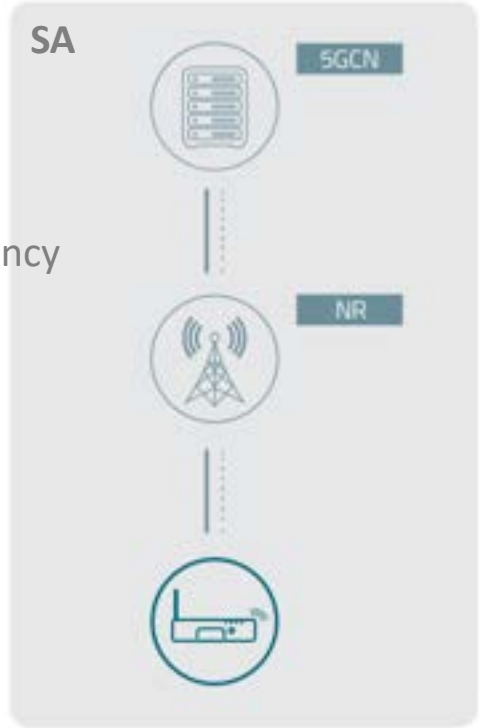
Diverse deployments

10x	10x	3x	100x	100x	10x
Decrease in end-to-end latency	Experienced throughput	Spectrum efficiency	Traffic capacity	Network efficiency	Connection density

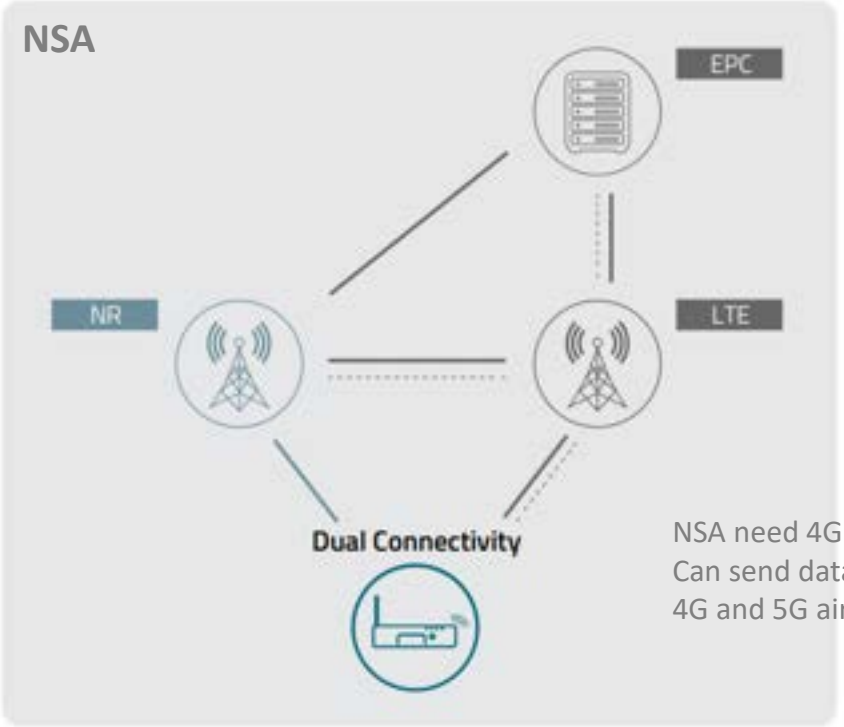
Based on ITU vision for IMT-2020 compared to IMT-advanced; URLLC: Ultra Reliable Low Latency Communications; IAB: Integrated Access & Backhaul

5G, Stand Alone (SA) vs. Non-Stand Alone (NSA)

SA for
Low Latency



NR : New Radio (5G)
5GCN : 5G Core Network

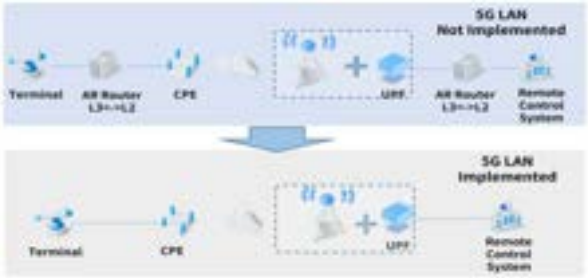


NSA need 4G as ”Anchor”
Can send data over both
4G and 5G air interfaces

LTE : Long Term Evolution (4G)
EPC : Evolved Packet Core (4G)

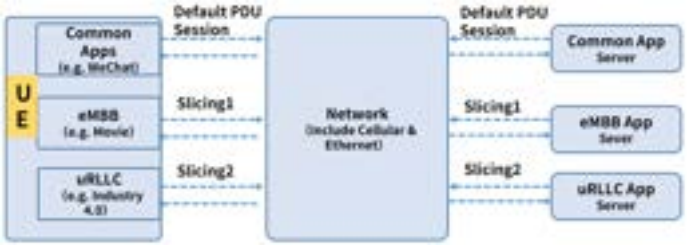
A few 5G key technologies

5G LAN



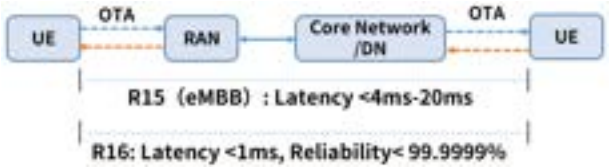
Reduces the difficulty of networking in private networks.
The core data does not leave “the factory“.

Network Slicing



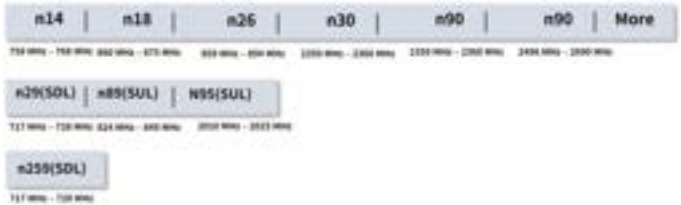
Differentiated, high-certainty, high-reliability networks to facilitate digital transformation of industries.

Latency Reliability



Target delay is less than 1 ms,
and reliability is 99.9999%.

>Bands ENDC, DSS

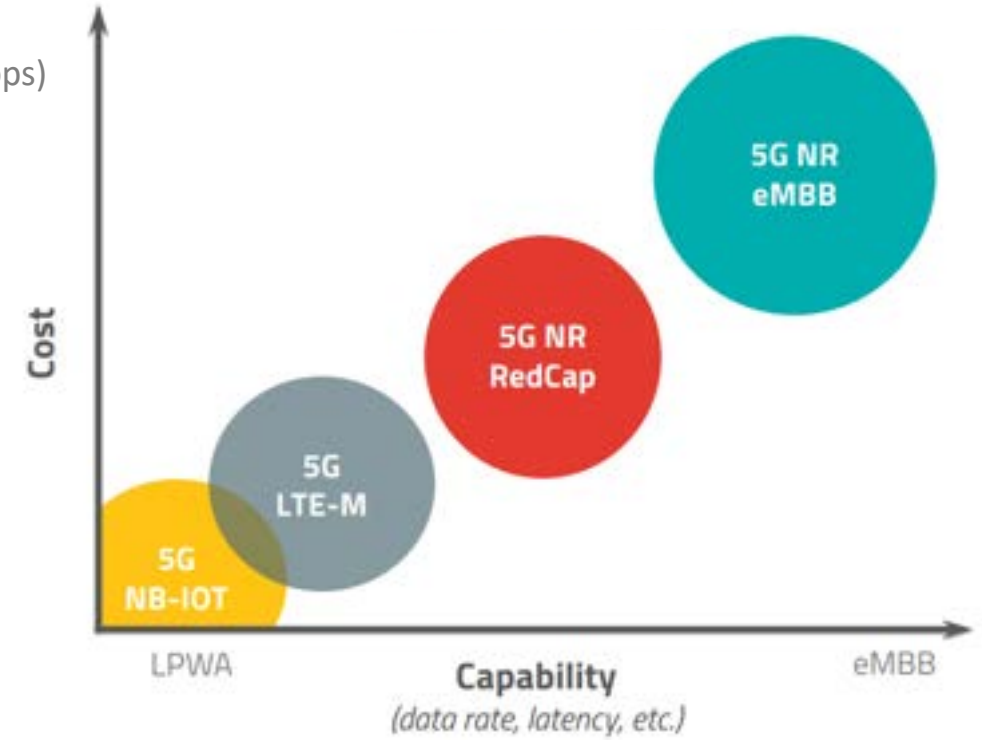


More spectrum, ENDC combining 4G & 5G,
Dynamic Spectrum Sharing between 4G & 5G

5G-NR Reduced Capability – RedCap
(NR Light)

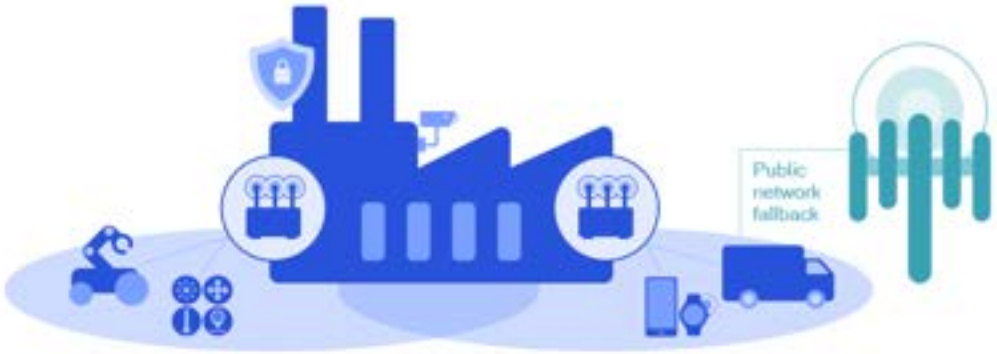
- Target use cases
  - Wearables and high end IoT
  - R17 : 4G-LTE cat 4 replacement (50-150 Mbps)
  - R18 : 4G-LTE cat 1 replacement
- Cost & capability reductions
  - Only 1 antenna needed
  - Lower min BW requirements
  - Half duplex FDD

- Feature from Release 17 and on
- Requires new network functionality
- Commercial ~2024-2025



5G private networks

Brings benefits to industry and enterprise



Private network[1]

Dedicated

Local network, dedicated resources, independently managed

Secure

Cellular grade security, sensitive data stays on-premise

Optimized

Tailored performance for local applications, e.g., low latency, QoS[2]

5G

Coverage, capacity, and mobility

Outdoor/indoor, high data speeds, seamless handovers, public network fallback

Reliability and precise timing

Industrial grade reliability, latency and synchronization (eURLLC[3] and TSN[4])

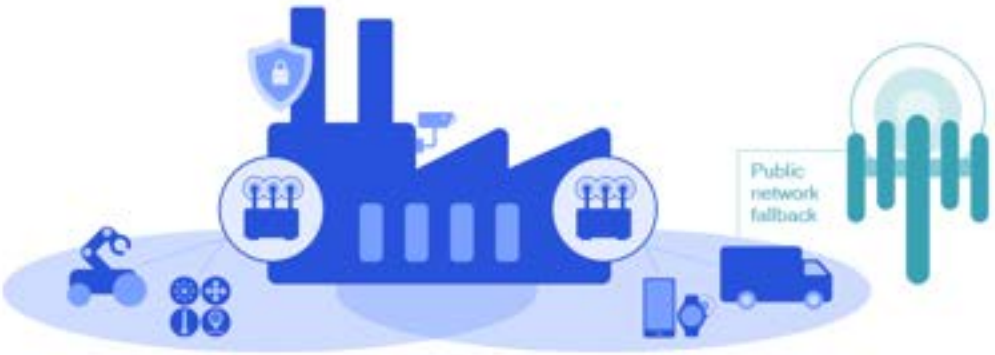
Interoperability

Global standard, vast ecosystem, future proof with rich 5G roadmap

1. Also referred to as non-public network (NPN). 2. Quality of service. 3. Enhanced ultra-reliable low-latency communication. 4 Time sensitive network

5G private networks

Brings benefits to industry and enterprise



5G

Coverage, capacity, and mobility

Outdoor/indoor, high data speeds, seamless handovers, public network fallback

Reliability and precise timing

Industrial grade reliability, latency and synchronization (eURLLC[3] and TSN[4])

Interoperability

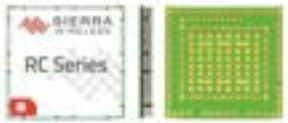
Global standard, vast ecosystem, future proof with rich 5G roadmap

1. Also referred to as non-public network (NPN). 2. Quality of service. 3. Enhanced ultra-reliable low-latency communication. 4 Time sensitive network

4G & 5G devices

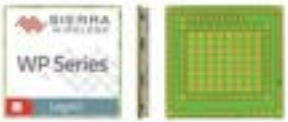
4G-LTE and LPWA modules

SMD-LGA



SMD-LGA, 22 x 23 mm

RC71xx, LTE cat 1 bis, Regional
RC76xx-1, LTE cat 1, Regional
10 Mbps DL / 5 Mbps UL
RC76xx, LTE cat 4, Regional
150 Mbps DL / 50 Mbps UL



SMD-LGA, 22 x 23 mm
Linux Application Framework, Legato

WP76xx-1, LTE cat 1, Regional
10 Mbps DL / 5 Mbps UL
WP76xx, LTE cat 4, Regional
150 Mbps DL / 50 Mbps UL
WP7702, LTE cat M1/NB1, Global
20 kbps DL / 60 kbps UL

SMD-LGA, 15 x 18 mm

HL7810, LTE cat M1/NB2, Global
HL7812, LTE cat M1/NB2+2G, Global
HL7845, LTE cat M1/NB2, Metering
590 kbps DL / 1100 kbps UL, 3GPP rel 14
HL7xxx, LTE cat M1/NB2
590 kbps DL / 1100 kbps UL, 3GPP rel 15-17

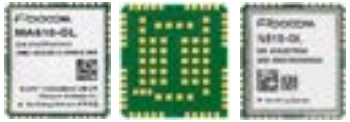
SMD-LGA, 32 x 29 mm

MC116-xxx, LTE cat 1, Regional
L610-xxx, LTE cat 1 bis, Regional
L610-GL, cat 1 bis, Global
10 Mbps DL / 5 Mbps UL

NL668-xxx, LTE cat 4, Regional
L716-xxx, LTE cat 4, Regional
150 Mbps DL / 50 Mbps UL

SMD-LGA, 24.2 x 26.2 mm

MC610-xxx, LTE cat 1 bis, Regional
10 Mbps DL / 5 Mbps UL

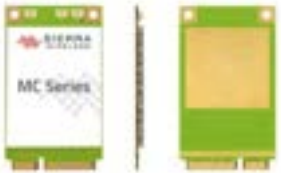


SMD-LGA, 22.2 x 20.2 mm

MC665-xxx, cat 1 bis, Regional (2023-Q1)
10 Mbps DL / 5 Mbps UL
MA510-GL, LTE cat M1/NB2 (+2G), Global
590 kbps DL / 1100 kbps UL, 3GPP rel 14
N510-GL, NB-IoT, Global
65 kbps DL / 145 kbps UL

4G-LTE modules

Mobile Broadband & Industrial, mPCIe and M.2



mPCIe, 30 x 51 mm

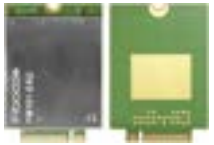
MC74x1, LTE cat 7/13, Regional
300 Mbps DL / 150 Mbps UL

mPCIe, 30 x 51 mm

L610-xxx, LTE cat 1, Regional
10 Mbps DL / 5 Mbps UL
NL668-xxx, LTE cat 4, Regional
150 Mbps DL / 50 Mbps UL

M.2, 30 x 42 mm

EM74x1, LTE cat 7/13, Regional
300 Mbps DL / 150 Mbps UL
EM7590, LTE cat 13, Global
400 Mbps DL / 150 Mbps UL
MP 2022-Q4
EM7565/7511, LTE cat 12/13, Global
600 Mbps DL / 150 Mbps UL



M.2, 30 x 42 mm

FM101-xxx, LTE cat 6, Regional
300 Mbps DL / 50 Mbps UL

M.2, 30 x 52 mm

EM7690, LTE cat 20, Global
2 Gbps DL / 211 Mbps UL

M.2, 30 x 52 mm

NL952-xxx, LTE cat 12, Regional
600 Mbps DL / 150 Mbps UL

5G-NR modules, R15-16

Mobile Broadband & Industrial, M.2 30x52 mm

EM9190, 5G-NR, 3GPP-R15, Global
Sub 6 GHz & mm-wave, SDX55
5,5 Gbps DL / 3 Gbps UL

EM9191, 5G-NR, 3GPP-R15, Global
Sub 6 GHz, SDX55
4,5 Gbps DL / 660 Mbps UL

EM9290, 5G-NR, 3GPP-R16, Global
Sub 6 GHz & mm-wave, SDX65
5,5 Gbps DL / 3 Gbps UL

EM9291, 5G-NR, 3GPP-R16, Global
Sub 6 GHz, SDX62
4,9 Gbps DL / 660 Mbps UL

EM9293, 5G-NR, 3GPP-R16, Global
Sub 6 GHz, SDX65
4,9 Gbps DL / 900 Mbps UL

FM150-xxx, 5G-NR, 3GPP-R16, Regional
Sub 6 GHz, SDX55
2,1 Gbps DL / 900 Mbps UL

FM160-xxx, 5G-NR, 3GPP-R16, Regional
Sub 6 GHz, SDX62
2,47 Gbps DL / 900 Mbps UL

5G SMD modules in LGA package are available as well

acal bfi

5G-NR modules, R17

MBB & RedCap based on Qualcomm

5G-NR, devices based on SDX72/SDX75,

M.2 form factor and SMD modules in LGA package

Commercial 2023-Q4 / 2024-H1

5G-NR RedCap, devices based on SDX35,

Commercial probably around 2025-H1

…how does Network Operators view 5G-NR RedCap ?

Investment plans ?

4G & 5G routers and gateways

Rugged units for mission critical applications

4G routers

LX60, RV55

FX30 (programmable gateway)

5G routers

XR80, XR90

acal bfi

…my look from above

A birds perspective on 2G-GSM/GPRS

Dear 2G & 3G,

You did a Great job for us all – But, it's time to say farewell.

To all users,

- Networks are going away quickly, devices are being obsoleted as well.
- If you did not start a migration to 4G (or 5G) already : Now is the time !
  …call us..;+)

A birds perspective on 4G-LTE

4G-LTE - cat 1 and up

- A True Global technology : Almost ubiquitous and will remain in operation many years to come.
- Stable technology and very large eco system.
- Designed to co-exist with 5G
- Low to medium cost devices for moderate up to high data rates (500 kbps to 1 Gbps).
- Medium complexity radio, need two antennas for best performance. Some network operators require two antennas.
- LTE cat 1 bis - one antenna only, and lower cost - attractive for use cases with moderate data rate requirements.

There are almost no 4G-LTE Not-spot countries in the world

4G-LPWA - cat M1, NB1, NB2

- Low complexity radio, one antenna only. Lowest device cost and power consumption of all 3GPP cellular technologies.
- Up to 164 dB link budget => Coverage 5…10x compared to std LTE.
- Cat M is ideal for mobile tracking devices.
- Network deployments kind of slow since operators are picky with business cases.
- Roaming is still not generic as it is for LTE cat 1 and up.
- Network functionality vary between operators/networks and countries. I.e PSM/eDRX may work in one country but not in another.

Important to consider coverage and feature availability on your target markets !

A birds perspective on 5G-NR

5G-NR

- Complex technology, devices generally require 4 antennas.
- Rapid growth but networks are still “city centric”
- Mobile phones is the main volume driver for devices (currently >52%) – Marketing hype.
- FWA growing rapidly, especially in areas with poor wired infrastructure.
- High capacity routers for public WiFi on trains/buses is excellent, but limited in volume.
- Private 5G networks, many trials and pilots ongoing but not a volume market short term.
- High cost devices which are still too expensive for generic industrial applications.

It will take a while for 5G to become ubiquitous.

5G-NR RedCap

- Less complex NR radio, one antenna is enough
- R17 RedCap thought as an alternative to LTE cat 4, R18 RedCap to cat 1
- Devices to become available 2024/2025. Could trigger volume growth in generic industrial applications.
- Lower cost, comparable to mid capacity LTE (cat 4/6)

Will RedCap be generally supported in networks or will the situation be similar to the one for 4G-LPWA ?

acal bfi

5G is designed to co-exist with 4G

DSS : 4G and 5G can Dynamically share the same spectrum

ENDC : Combination of 4G and 5G to increase bandwidth

4G will be around for a long, long time

Efficient and cost effective with a huge amount of stakeholders

There are almost no 4G-LTE Not-spot countries in the world

Thanks for listening

hans.andersson@acalbfi.se ; paivi.estakari@acalbfi.fi